Cardiovascular Revascularization Medicine 49 (2023) 7–12

Contents lists available at ScienceDirect

Cardiovascular Revascularization Medicine

Invasive Management and In-Hospital Outcomes of Myocardial Infarction Patients in United States Safety-Net Hospitals

Hussein Bashar [a,b,c,1], Aditya Bharadwaj [d,1], Andrija Matetić [c,e], Waqas Ullah [f], Dorian L. Beasley [g], Renee P. Bullock-Palmer [h], Nick Curzen [a,b], Mamas A. Mamas [c,*]

[a] Faculty of Medicine, University of Southampton, United Kingdom
[b] Coronary Research Group, University Hospital Southampton NHS Foundation Trust, United Kingdom
[c] Keele Cardiovascular Research Group, Centre for Prognosis Research, Institute for Primary Care and Health Sciences, Keele University, United Kingdom
[d] Division of Cardiology, Loma Linda University, California, United States
[e] Department of Cardiology, University Hospital of Split, Split, Croatia
[f] Thomas Jefferson University, Philadelphia, PA, United States
[g] Adult General and Interventional Cardiology, Community Health Network, Indianapolis, IN, United States
[h] Department of Cardiology, Deborah Heart and Lung Center, Browns Mills, NJ, United States

ARTICLE INFO

Article history:
Received 15 October 2022
Received in revised form 7 November 2022
Accepted 9 November 2022
Available online 18 November 2022

Keywords:
Acute myocardial infarction
Safety-net hospitals
Invasive management
Outcomes

ABSTRACT

Aim: Safety-net hospitals (SNHs) look after a higher proportion of uninsured patients and are often located in deprived areas. This study aimed to determine whether there are differences in the clinical characteristics, treatments and outcomes of patients presenting with acute myocardial infarction (AMI) in SNHs versus non-SNHs (N-SNHs).
Methods: All hospitalizations with a principal diagnosis of AMI in the United States' National Inpatient Sample between 2016 and 2019 were stratified by safety-net hospital status. Multivariable logistic regression with adjusted odds ratios (aOR) and 95 % confidence intervals (95 % CI) was conducted to investigate invasive management and clinical outcomes.
Results: A total of 2,544,009 weighted discharge records were analyzed, including 601,719 records from SNHs (23.7 %). Compared with N-SNHs, SNH AMI patients were younger (median 66 years vs. 67 years, $p < 0.001$), and had a higher proportion in the lowest quartile of median household income (37.3 % vs. 28.5 %, $p < 0.001$). Patients from SNHs were less likely to receive coronary angiography (aOR 0.92, 95 % CI 0.91–0.93, $p < 0.001$), percutaneous coronary intervention (aOR 0.94, 95 % CI 0.93–0.95, $p < 0.001$), and coronary artery bypass grafting (aOR 0.93, 95 % CI 0.92–0.94, $p < 0.001$). In addition, they had increased all-cause mortality (aOR 1.11, 95 % CI 1.09–1.12, $p < 0.001$), major adverse cardiovascular/cerebrovascular events (composite of mortality, stroke and reinfarction) (aOR 1.11, 95 % CI 1.09–1.12, $p < 0.001$), and stroke (aOR 1.11, 95 % CI 1.08–1.14, $p < 0.001$), while there was no difference in major bleeding (aOR 1.02, 95 % CI 1.00–1.04, $p = 0.107$).
Conclusion: Among AMI patients, treatment in SNHs was associated with lower utilization of coronary angiography and revascularization and worse clinical outcomes.

1. Introduction

According to the National Health Statistics Report, 31.6 million (9.7 %) Americans did not have health insurance in 2020 [1]. The absence of health insurance is associated with greater incidence of poorly managed cardiovascular comorbidities. These patients are more likely to present with an acute medical emergency [2,3]. Among all patients admitted to a hospital, lack of health insurance is directly associated with increased all-cause mortality after adjusting for age and sex [4,5]. A disproportionately high number of these uninsured patients in the US are treated at the so-called safety-net hospitals (SNHs). Allowing for some variability in definitions, SNHs are those that have an 'open-door' policy to all patients, irrespective of their medical insurance [6]. SNHs are often located in poor and underserved areas that cater to populations with a high proportion of racial and ethnic minorities.

* Corresponding author at: Keele Cardiovascular Research Group, Centre for Prognosis Research, Institute for Primary Care and Health Sciences, Keele University, Stoke-on-Trent, United Kingdom.
E-mail address: mamasmamas1@yahoo.co.uk (M.A. Mamas).
[1] Joint first authors.

https://doi.org/10.1016/j.carrev.2022.11.006
1553-8389/

In the United States (US), an estimated >600,000 cases of acute myocardial infarction (AMI) occur each year [7]. A significant number of uninsured patients presenting with AMI are treated at SNHs. The baseline characteristics of this group, their management and outcomes at SNHs have not been previously described in a nationwide context. Previous studies have (i) focused solely on patients presenting with ST-segment elevation myocardial infarction (STEMI) complicated by cardiogenic shock [8], (ii) analyzed overall outcomes of percutaneous coronary intervention (PCI) only [9] or (iii) focused on Medicare beneficiaries treated at urban SHN only [10]. In addition, there have been a number of single center reports evaluating AMI outcomes at specific SNHs [11–13]. Therefore, we sought to describe patient characteristics, management and outcomes of AMI patients presenting to SNHs in comparison with non-SNHs (N-SNHs), utilizing the National Inpatient Sample (NIS) database.

2. Methods

2.1. National Inpatient Sample database

Sponsored by the Agency for Healthcare Research and Quality (AHRQ), the Healthcare Cost and Utilization Project (HCUP) developed the NIS which is the largest publicly available inpatient database. It represents >97 % of the U.S. population and estimates a 20 % stratified sample of community hospitals discharges, excluding rehabilitation and long term acute care facilities [14].

2.2. Study sample

The NIS database was searched for records with a primary diagnosis of AMI in the period between 2016 and 2019 using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes. A total of 5920 cases (0.2 %) were excluded from the analysis due to age <18 years and/or missing data (Supplementary Fig. S1, study flow diagram). Identification of safety-net hospitals (SNHs) was based on a 2014 HCUP statistical brief that has been adapted to regional (Northeast, Midwest, South, and West) rather than state level, as the NIS no longer include state identifiers [15]. The proportion of uninsured and Medicaid inpatients out of all AMI admissions for each hospital was calculated throughout the study period and used to rank the hospitals in each region. SNHs were defined as those in the top quartile (for Medicaid and uninsured admissions) within each region. This method allowed emphasis on SNHs that looked after patients with AMI diagnosis, was consistent with the methodology of previous publications [8,16–18] and overcoming possible misidentification of SNHs by using regional rather than national cut-off [19].

All procedures, operations, morbidities and outcomes were similarly identified using ICD-10-CM, and the full list of the codes that have been utilized is included in Supplementary Table S1. In order to improve the quality of this observational study, a STROBE checklist (*Strengthening The Reporting of Observational Studies in Epidemiology*) has been included in Appendix A.

2.3. Outcomes

The primary outcome of this observational analysis was all cause in-hospital mortality. The utilization of invasive coronary angiography (CA), percutaneous coronary intervention (PCI), and coronary artery bypass graft (CABG) surgery were included as secondary outcomes. Other secondary outcomes included major adverse cardiovascular and cerebrovascular events (MACCE; a composite of all-cause mortality, acute ischemic stroke and reinfarction), major bleeding (defined as haematemesis, melaena, gastrointestinal haemorrhage, nontraumatic intracranial haemorrhage, and unspecified haemorrhage), and acute ischemic stroke. The type of AMI was used to conduct sensitivity analysis of the above-mentioned outcomes.

2.4. Statistical analysis

IBM SPSS statistics software version 26 was used for the conduction of all statistical analyses. Qualitative data is presented as percentages while quantitative data is described as median with interquartile range (IQR). Variables were compared using the Pearson's chi square and the Mann–Whitney *U* tests, as applicable. The association of SNH status with outcomes was presented as adjusted odds ratios (aOR) with their corresponding 95 % confidence interval (CI). These were calculated using multivariable binomial logistic regression models that were adjusted for: age, sex, weekend admission, hospital bed size, hospital location/teaching status, hospital region, diabetes, dyslipidaemia, smoking, heart failure, atrial fibrillation, thrombocytopaenia, hypertension, anemia, chronic lung disease, liver disease, severe chronic kidney disease (defined as CKD stage 4–5 or needing dialysis), metastatic disease, valvular heart disease, cardiogenic shock, ventricular tachycardia, ventricular fibrillation, acute myocardial infarction type, peripheral vascular disease, obesity, previous myocardial infarction, previous PCI, previous CABG, and previous cerebrovascular accident (CVA).

3. Results

A total of 2,544,009 discharge records with primary diagnosis of AMI were included in the study. N-SNHs accounted for the majority of the cases (1,942,290) while SNHs accounted for 23.7 % of the study sample (Table 1).

3.1. Baseline characteristics

In contrast with N-SNHs, AMI patients in SNHs were younger (median of 66 years vs. 67 years, $p < 0.001$) and had a higher proportion in the lowest quartile of the median household income (37.3 % vs. 28.5 %, $p < 0.001$). In addition, AMI patients in SNHs (vs. N-SNHs) had higher incidence of cardiogenic shock (6.8 % vs. 6.4 %, $p < 0.001$) and cardiac arrest (3.2 % vs. 2.9 %, $p < 0.001$). Similarly, the prevalence of comorbidities such as anemia (19.0 % vs. 17.9 %, $p < 0.001$), heart failure (36.5 % vs. 34.1 %), diabetes mellitus (29.8 % vs. 27.4 %, $p < 0.001$), severe CKD (8.2 % vs. 7.0 %, $p < 0.001$) and smoking (14.2 % vs. 12.5 %, $p < 0.001$) were higher in SNHs in comparison to N-SNHs (Table 1).

AMI patients at N-SNHs were more likely to be from an ethnically White background (76.8 % vs. 63.3 %, $p < 0.001$) and in the highest quartile of the median household income (19.5 % vs. 14.5 %, $p < 0.001$). In addition, they had higher prevalence of atrial fibrillation (18.1 % vs. 16.8 %, $p < 0.001$), dyslipidaemia (68.0 % vs. 65.0 %, $p < 0.001$) and peripheral vascular disease (9.3 % vs. 8.5 %, $p < 0.001$) compared with SNHs (Table 1).

3.2. Outcomes

Analysis of the unadjusted clinical outcomes demonstrate that SNHs had significantly higher rates of all cause in-hospital mortality (4.9 % vs. 4.6 %, $p < 0.001$), MACCE (5.9 % vs. 5.5 %, $p < 0.001$), major bleed (1.7 % vs. 1.6 %, $p = 0.008$), and acute ischemic stroke (1.0 % vs. 0.9 %, $p < 0.001$) compared with N-SNHs (Table 2 and Supplementary Fig. S2). In addition, SNHs had a lower utilization of invasive management in the form of invasive coronary angiography (68.0 % vs. 69.1 %, $p < 0.001$), PCI (48.4 % vs. 49.6 %, $p < 0.001$), and CABG (8.3 % vs. 8.9 %, $p < 0.001$) in comparisons to N-SNHs.

After adjustment for patients' baseline characteristics and comorbidities, AMI patients managed in SNHs had consistently higher all cause in-hospital mortality (aOR 1.11, 95 % CI 1.09–1.12, $p < 0.001$), MACCE (aOR 1.11, 95 % CI 1.09–1.12, $p < 0.001$), and acute ischemic stroke (aOR 1.11, 95 % CI 1.08–1.14, $p < 0.001$), compared with N-SNHs (Table 3 and Fig. 1). Furthermore, the odds of undergoing invasive management in SNHs in the form of coronary angiography (aOR 0.92, 95 % CI 0.91–0.93, $p < 0.001$), PCI (aOR 0.94, 95 % CI 0.93–0.95, $p < 0.001$), and CABG (aOR 0.93, 95 % CI 0.92–0.94, $p < 0.001$) were significantly lower

Table 1
Baseline patient characteristics.

Characteristics	Non-safety-net hospitals (N = 1,942,290; 76.3 %)	Safety-net hospitals (N = 601, 720; 23.7 %)	p-Value
Age (years), median (IQR)	67 (58–77)	66 (56–76)	<0.001
Female sex, %	37.2	37.9	<0.001
Ethnicity, %			<0.001
White	76.8	63.3	
Black	9.9	15.5	
Hispanic	7.5	12.8	
Asian/Pacific Islander	2.6	3.6	
Native American	0.6	0.5	
Other	2.6	4.3	
Weekend admission, %	26.4	26.6	<0.001
Median household income (percentile), %			<0.001
0–25th	28.5	37.3	
26th–50th	27.6	27.0	
51st-75th	24.4	21.2	
76th–100th	19.5	14.5	
Bed size of hospital, %			<0.001
Small	17.9	17.1	
Medium	30.8	29.7	
Large	51.3	53.2	
Hospital location/teaching status, %			<0.001
Rural	7.3	8.4	
Urban non-teaching	23.4	21.6	
Urban teaching	69.3	70.0	
Hospital region, %			<0.001
Northeast	17.3	17.6	
Midwest	21.3	26.2	
South	42.5	36.7	
West	18.9	19.5	
Record characteristics, %			
STEMI	22.2	22.0	0.011
Cardiogenic shock	6.4	6.8	<0.001
Cardiac arrest	2.9	3.2	<0.001
Ventricular tachycardia	6.8	6.5	<0.001
Ventricular fibrillation	3.2	3.3	<0.001
Comorbidities, %			
Atrial fibrillation	18.1	16.8	<0.001
Dyslipidaemia	68.0	65.0	<0.001
Thrombocytopenia	5.1	4.9	<0.001
Smoking	12.5	14.2	<0.001
Previous PCI	17.2	17.5	<0.001
Previous CABG	10.1	9.9	<0.001
Previous MI	16.0	15.6	<0.001
Previous CVA	7.9	8.2	<0.001
Anemia	17.9	19.0	<0.001
Heart failure	34.1	36.5	<0.001
Valvular disease	5.9	5.3	<0.001
Hypertension	64.2	64.8	<0.001
Peripheral vascular disease	9.3	8.5	<0.001
Diabetes mellitus	27.4	29.8	<0.001
Obesity	19.6	19.8	0.003
Chronic pulmonary disease	18.4	19.0	<0.001
Coagulopathy	6.2	6.2	0.458
Dementia	5.4	5.4	0.974
Chronic liver disease	2.9	3.2	<0.001
Severe CKD	7.0	8.2	<0.001
Metastatic cancer	0.9	0.8	<0.001

Abbreviations: CABG – coronary artery bypass graft; CVA – cerebrovascular accidents; IHD – ischemic heart disease; IQR – interquartile range; PCI – percutaneous coronary intervention; STEMI – ST-elevation myocardial infarction; CKD – chronic kidney disease.

Table 2
Unadjusted utilization of invasive management and in-hospital clinical outcomes.

Characteristics	Non-safety-net hospitals (N = 1,942,290; 76.3 %)	Safety-net hospitals (N = 601,720; 23.7 %)	p-Value
Invasive management, %			
CA	69.1	68.0	<0.001
PCI	49.6	48.4	<0.001
CABG	8.9	8.3	<0.001
Clinical outcomes, %			
All-cause mortality	4.6	4.9	<0.001
MACCE	5.5	5.9	<0.001
Major bleeding	1.6	1.7	0.008
Ischemic stroke	0.9	1.0	<0.001
Length of stay (days), median (IQR)	3 (2–5)	3 (2–5)	<0.001
Total charges (USD), median (IQR)	66,629 (37,152-114,687)	70,736 (39,406-124,899)	<0.001

Abbreviations: CA – coronary angiography; IQR – interquartile range; MACCE – major adverse cardiac and cerebrovascular events (composite of mortality, acute ischemic stroke and reinfarction); PCI – percutaneous coronary intervention; CABG – coronary artery bypass graft; USD – United States dollar.

in comparison to N-SNHs. There was no statistical difference in the adjusted risk of major bleeding between the two groups (aOR 1.02, 95 % CI 1.00–1.04, $p = 0.107$).

3.3. Sensitivity analysis by AMI type

When accounting for the AMI type, the findings were consistent to the overall sample, except that STEMI patients managed in SNHs manifested higher risk of major bleeding (aOR 1.09, 95 % CI 1.04–1.13, $p < 0.001$) which is not the case for NSTEMI patients (Supplementary Table S2).

4. Discussion

This study has several important findings. AMI patients presenting to SNHs, as compared with those presenting to N-SNHs, (a) represent a younger and lower income population, (b) have more chronic comorbidities, (c) with a higher prevalence of cardiogenic shock and cardiac arrest at presentation, (d) were less likely to receive coronary angiography, PCI, and CABG and (d) have higher all cause in-hospital mortality, MACCE and acute ischemic stroke even after adjusting for baseline characteristics and comorbidities. Additionally, these findings were seen irrespective of STEMI vs. NSTEMI presentation.

SNHs are, by definition, those hospitals that treat a higher number of Medicaid and uninsured patients. It is important to note the phenotype of such AMI patients that were treated at SNHs. There was a significantly higher number of females, younger patients, those with lower median household income and with greater comorbid conditions compared with AMI patients at N-SNHs. These findings are important given that

Table 3
Adjusted odds ratios (aOR) of safety-net hospitals invasive management and in-hospital clinical outcomes.

Characteristics	Safety-net hospitals aOR [95 % CI]	p-Value
Invasive management		
CA	0.92 [0.91–0.93]	<0.001
PCI	0.94 [0.93–0.95]	<0.001
CABG	0.93 [0.92–0.94]	<0.001
Clinical outcomes		
All-cause mortality	1.11 [1.09–1.12]	<0.001
MACCE	1.11 [1.09–1.12]	<0.001
Major bleeding	1.02 [1.00–1.04]	0.107
Ischemic stroke	1.11 [1.08–1.14]	<0.001

Reference group: non-safety-net hospitals.
Abbreviations: aOR – adjusted odds ratios; CA – coronary angiography; CI – confidence interval; MACCE – major adverse cardiac and cerebrovascular events (composite of mortality, acute ischemic stroke and reinfarction); PCI – percutaneous coronary intervention; CABG – coronary artery bypass graft.
Multivariable analysis – the following variables were adjusted for: age, sex, weekend admission, hospital bed size, hospital location/teaching status, hospital region, diabetes, dyslipidaemia, smoking, heart failure, atrial fibrillation, thrombocytopaenia, hypertension, anemia, chronic lung disease, liver disease, severe chronic kidney disease, metastatic disease, valvular heart disease, cardiogenic shock, ventricular tachycardia, ventricular fibrillation, acute myocardial infarction type, peripheral vascular disease, obesity, previous myocardial infarction, previous PCI, previous CABG, previous CVA.

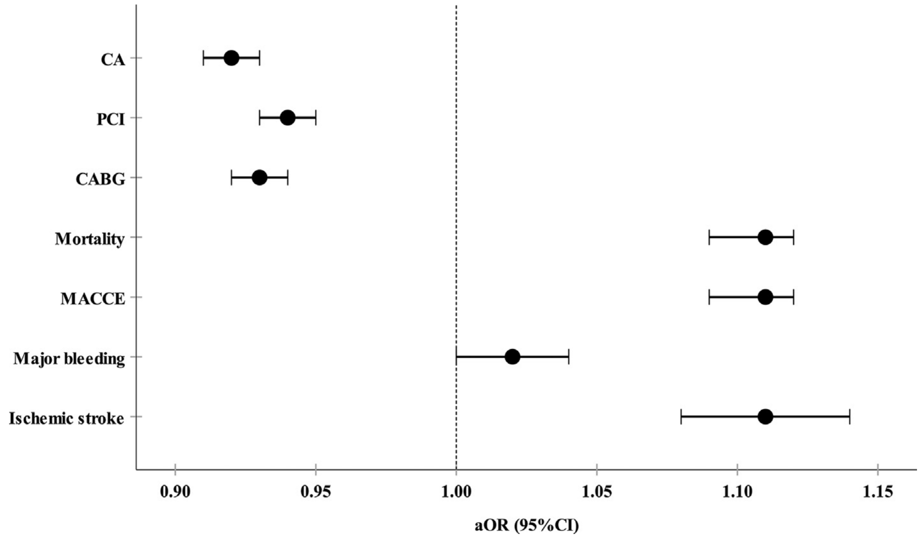

Fig. 1. Adjusted odds ratios (aOR) of invasive management and in-hospital clinical outcomes in safety-net hospitals.
*Reference group: non-safety-net hospitals.
Abbreviations: aOR – adjusted odds ratios; CA – coronary angiography; CABG – coronary artery bypass graft; CI – confidence interval; MACCE – major adverse cardiac and cerebrovascular events (composite of mortality, acute ischemic stroke and reinfarction); PCI – percutaneous coronary intervention.
Multivariable analysis – the following variables were adjusted for: age, sex, weekend admission, hospital bed size, hospital location/teaching status, hospital region, diabetes, dyslipidaemia, smoking, heart failure, atrial fibrillation, thrombocytopaenia, hypertension, anemia, chronic lung disease, liver disease, severe chronic kidney disease, metastatic disease, valvular heart disease, cardiogenic shock, ventricular tachycardia, ventricular fibrillation, acute myocardial infarction type, peripheral vascular disease, obesity, previous myocardial infarction, previous PCI, previous CABG, previous CVA.

females, lower income patients and ethnic minorities have traditionally been underrepresented and undertreated and this is known to be associated with worse clinical outcomes. For example, female patients with AMI are underrepresented in clinical trials [20], less likely to undergo cardiac catheterization and timely reperfusion, less likely to be treated with guideline directed medical therapy and have worse clinical outcomes compared with their male counterparts [21,22]. Likewise, we have previously demonstrated that AMI patients with lower socio-economic status, as characterized by lower median household income, are less likely to receive invasive management and have worse in-hospital outcomes compared with those with higher socio-economic status and these differences were also seen in STEMI patients [23]. Previous studies have also shown that underrepresented patient populations such as Black and Hispanic AMI patients have more comorbidities, experience delays in care and have worse clinical outcomes as compared with White patients [24]. Furthermore, AMI patients presenting to SNHs also had a greater burden of comorbidities including anemia, heart failure, diabetes, severe CKD and smoking, which have been shown to increase likelihood of worse in-hospital outcomes [25,26].

This analysis also reveals that AMI patients who were treated at SNHs had worse all cause in-hospital mortality, MACCE and acute ischemic stroke, and lower utilization of coronary angiography, PCI and CABG even after adjusting for baseline characteristics and comorbidities, compared with N-SNHs. These findings were consistent regardless of presentation (i.e., NSTEMI vs. STEMI). These findings are consistent with previous data, Specifically, a study by Ando et al, based on NIS dataset focusing on STEMI patients with cardiogenic shock treated at SNHs, also reported a higher mortality and lower utilization of PCI compared with N-SNHs [8]. A study by Ross et al sought to evaluate the outcomes of Medicare beneficiaries who presented with AMI and were specifically treated at urban SNHs. They reported that overall SNHs did have lower adherence to quality-of-care performance measures and higher risk adjusted 30-day mortality rates compared with N-SNHs. However, they also noted significant heterogeneity among SNHs [10].

The ACC/AHA/SCAI guidelines for coronary revascularization afford a Class 1 indication for emergency coronary angiography and appropriate revascularization for patients presenting with STEMI, NSTEMI complicated by cardiogenic shock, refractory chest pain or electrical instability. They also provide a Class 2a indication for urgent angiography and possible revascularization within 24 h for NSTEMI patients with high-risk features [27]. Even though we cannot conclude from this analysis that lower utilization of angiography and revascularization led to poorer outcomes at SNHs, the significant difference in utilization of invasive management between SNHs and N-SNHs is likely to contribute to the mortality difference, given the strength of the evidence for early revascularization in acute MI. This is especially true given that AMI patients at SNHs represent a higher risk group (greater incidence of cardiogenic shock, VT/VF, congestive heart failure, diabetes) who therefore may have potentially benefited more from timely angiography and revascularization. Interestingly, Acharya et al have demonstrated that in-hospital outcomes of PCI at SNHs are comparable to N-SNHs with only marginally higher mortality, despite SNHs treating a significantly higher percentage of uninsured patients with acute presentations [9].

The financial pressure on SNHs, given they manage a higher proportion of uninsured patients, could translate into issues accessing the latest medical technologies and clinical resources, as well as indirectly worsening unconscious bias [28–30]. These factors, which likely to contribute to the disparity seen in this analysis, could be alleviated to an extent by greater investment in SNHs on a federal level through legislative and policy changes, competitive incentives for physician to work in these centers, and raising the awareness of implicit bias in healthcare. The findings of the current analysis also highlight the importance of developing transition of care pathways and establishing outpatient care in this vulnerable uninsured population in order to ensure medication adherence and decrease unplanned readmissions following AMI [11].

This analysis demonstrates disparities in outcomes and invasive management in SNHs, however it has a retrospective design. To help implement targeted health policies at local and national level, this research area would benefit from prospective registries or focused cohort studies that regularly audit the adherence of SNHs to the clinical guidelines in managing AMI patients.

We acknowledge several limitations of this paper, which are mostly inherent to the NIS database. NIS dataset does not have formal adjudication of outcomes and events such as major bleeding are not defined based on standardized definitions [31]. The NIS database also does not capture the exact cause of death and lacks data regarding long term outcomes thereby limiting this analysis to in-hospital events. There is also no data regarding the type of antiplatelets and anticoagulants used, angiographic findings or PCI techniques. Additionally, like with any administrative database, coding errors and underreporting of secondary diagnoses are always a potential source of bias. Finally, although there has been controversy regarding the definition of SNHs [6] and suggestion of heterogeneity among SNHs [10], we used the most commonly used definition, maintaining consistency with previous studies [8,16–18].

In conclusion, AMI patients treated at SNHs represent a vulnerable population with a higher percentage of females, underrepresented patient populations and those with lower median household income, compared with those who are treated at N-SNHs. This vulnerable group with presumably poor access to care due to lack of insurance and lower socioeconomic status, present with greater comorbid burden and are subject to higher risk presentation. Despite this, these patients receive less coronary angiography and revascularization when compared with their risk-adjusted counterparts at N-SNHs. Finally, irrespective of STEMI or NSTEMI presentation, these SNH patients have worse clinical outcomes, including in-hospital mortality, MACCE and acute ischemic stroke.

Sources of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Hussein Bashar: Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Aditya Bharadwaj:** Writing – original draft, Writing – review & editing. **Andrija Matetić:** Data curation, Methodology, Formal analysis, Validation, Writing – review & editing. **Waqas Ullah:** Writing – review & editing. **Dorian L. Beasley:** Writing – review & editing. **Renee P. Bullock-Palmer:** Writing – review & editing. **Nick Curzen:** Supervision, Resources, Project administration, Writing – review & editing. **Mamas A. Mamas:** Supervision, Conceptualization, Methodology, Resources, Project administration, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Aditya Bharadwaj reports a relationship with Abiomed, Cardiovascular Solutions Inc. and Shockwave that includes: consulting or advisory and speaking and lecture fees. Nick Curzen reports a relationship with Boston scientific, Heartflow, Beckman coulter, Haemonetics. that includes: funding grants. Nick Curzen reports a relationship with Boston, Abbott, Edwards. that includes: consulting or advisory and speaking and lecture fees. Nick Curzen reports a relationship with Medtronic, Biosensors, Edwards, Abbott. that includes: travel reimbursement. All other Authors report no conflicting interests.

Acknowledgments

Graphical Abstract created with BioRender.com.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.carrev.2022.11.006.

References

[1] Cha AE, Cohen RA. Demographic variation in health insurance coverage:United States. Natl Health Stat Report 20221-15; 2020.
[2] Weber EJ, Showstack JA, Hunt KA, Colby DC, Callaham ML. Does lack of a usual source of care or health insurance increase the likelihood of an emergency department visit? Results of a national population-based study. Ann Emerg Med. 2005;45:4–12. https://doi.org/10.1016/j.annemergmed.2004.06.023.
[3] Newton MF, Keirns CC, Cunningham R, Hayward RA, Stanley R. Uninsured adults presenting to US emergency departments: assumptions vs data. JAMA. 2008;300: 1914–24. https://doi.org/10.1001/jama.300.16.1914.
[4] Hadley J, Steinberg EP, Feder J. Comparison of uninsured and privately insured hospital patients. Condition on admission, resource use, and outcome. JAMA. 1991;265: 374–9.
[5] Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, Himmelstein DU. Health insurance and mortality in US adults. Am J Public Health. 2009;99: 2289–95. https://doi.org/10.2105/AJPH.2008.157685.
[6] Popescu I, Fingar KR, Cutler E, Guo J, Jiang HJ. Comparison of 3 safety-net hospital definitions and association with hospital characteristics. JAMA Netw Open. 2019;2: e198577. https://doi.org/10.1001/jamanetworkopen.2019.8577.
[7] Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, Chiuve SE, Cushman M, Delling FN, Deo R, de Ferranti SD, Ferguson JF, Fornage M, Gillespie C, Isasi CR, Jimenez MC, Jordan LC, Judd SE, Lackland D, Lichtman JH, Lisabeth L, Liu S, Longenecker CT, Lutsey PL, Mackey JS, Matchar DB, Matsushita K, Mussolino ME, Nasir K, O'Flaherty M, Palaniappan LP, Pandey A, Pandey DK, Reeves MJ, Ritchey MD, Rodriguez CJ, Roth GA, Rosamond WD, UKA Sampson, Satou GM, Shah SH, Spartano NL, Tirschwell DL, Tsao CW, Voeks JH, Willey JZ, Wilkins JT, Wu JH, Alger HM, Wong SS, Muntner P, American Heart Association Council on E, Prevention Statistics C, Stroke Statistics S. Heart disease and stroke statistics-2018 update: a report from the American Heart Association. Circulation. 2018;137:e67-492.
[8] Ando T, Akintoye E, Adegbala O, Ashraf S, Shokr M, Takagi H, Grines CL, Afonso L, Briasoulis A. In-hospital outcomes of ST-segment elevation myocardial infarction complicated with cardiogenic shock at safety-net hospitals in the United States (from the Nationwide inpatient Sample). Am J Cardiol. 2019;124:485–90. https://doi.org/10.1016/j.amjcard.2019.05.037.
[9] Acharya T, Salisbury AC, Spertus JA, Kennedy KF, Bhullar A, Reddy HKK, Joshi BK, Ambrose JA. In-hospital outcomes of percutaneous coronary intervention in America's safety net: insights from the NCDR Cath-PCI registry. JACC Cardiovasc Interv. 2017;10:1475–85. https://doi.org/10.1016/j.jcin.2017.05.042.
[10] Ross JS, Cha SS, Epstein AJ, Wang Y, Bradley EH, Herrin J, Lichtman JH, Normand SL, Masoudi FA, Krumholz HM. Quality of care for acute myocardial infarction at urban safety-net hospitals. Health Aff (Millwood). 2007;26:238–48. https://doi.org/10.1377/hlthaff.26.1.238.
[11] Ashraf H, Warren E, Latner JP, Shah KB, Bell J, Lowe S, Phillips RG, Martinez K, Pommett C, Lindsay T, Adkins J, Sheffield L, Richter J, Keeley EC. Effect of medication adherence and early follow-up on unplanned readmission post-myocardial infarction: quality improvement in a safety net hospital. Crit Pathw Cardiol. 2021;20: 71–4. https://doi.org/10.1097/HPC.0000000000000231.
[12] Shah IT, Keeley EC. Unplanned readmissions after acute myocardial infarction: 1-year trajectory following discharge from a safety net hospital. Crit Pathw Cardiol. 2019;18:72–4. https://doi.org/10.1097/HPC.0000000000000170.
[13] Khalili H, Singh R, Wood M, Edwards A, Cooper M, Ayers C, Moss E, Berry JD, Vongpatanasin W, de Lemos JA, Das SR. Premature clopidogrel discontinuation after drug-eluting stent placement in a large urban safety-net hospital. Am J Cardiol. 2016;117:522–5. https://doi.org/10.1016/j.amjcard.2015.11.037.
[14] HCUP National Inpatient Sample (NIS). Healthcare Cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality; 2004-2018. www.hcup-us.ahrq.gov/nisoverview.jsp.
[15] Healthcare Cost and Utilization Project (HCUP) Statistical Briefs; 2006.
[16] Genther DJ, Gourin CG. The effect of hospital safety-net burden status on short-term outcomes and cost of care after head and neck cancer surgery. Arch Otolaryngol Head Neck Surg. 2012;138:1015–22. https://doi.org/10.1001/jamaoto.2013.611.
[17] Reiter KL, Jiang HJ, Wang J. Facing the recession: how did safety-net hospitals fare financially compared with their peers? Health Serv Res. 2014;49:1747–66. https://doi.org/10.1111/1475-6773.12230.
[18] Werner RM, Goldman LE, Dudley RA. Comparison of change in quality of care between safety-net and non-safety-net hospitals. JAMA. 2008;299:2180–7. https://doi.org/10.1001/jama.299.18.2180.
[19] Mehta AB, Douglas IS. Misclassification of safety net hospitals with national data. Chest. 2021;160:e372–3. https://doi.org/10.1016/j.chest.2021.05.060.
[20] Jin X, Chandramouli C, Allocco B, Gong E, Lam CSP, Yan LL. Women's participation in cardiovascular clinical trials from 2010 to 2017. Circulation. 2020;141:540–8. https://doi.org/10.1161/CIRCULATIONAHA.119.043594.
[21] Jneid H, Fonarow GC, Cannon CP, Hernandez AF, Palacios IF, Maree AO, Wells Q, Bozkurt B, Labresh KA, Liang L, Hong Y, Newby LK, Fletcher G, Peterson E, Wexler L, With Get, the Guidelines Steering C Investigators. Sex differences in medical care and early death after acute myocardial infarction. Circulation. 2008;118: 2803–10. https://doi.org/10.1161/CIRCULATIONAHA.108.789800.
[22] Mehta LS, Beckie TM, HA DeVon, Grines CL, Krumholz HM, Johnson MN, Lindley KJ, Vaccarino V, Wang TY, Watson KE, Wenger NK, American Heart Association Cardiovascular Disease in W, Special Populations Committee of the Council on Clinical Cardiology CoE, CoC Prevention, Stroke N, Council on Quality of C, Outcomes R. Acute myocardial infarction in women: a scientific statement from the American Heart Association. Circulation. 2016;133:916–47. https://doi.org/10.1161/CIR.0000000000000351.
[23] Matetic A, Bharadwaj A, Mohamed MO, Chugh Y, Chugh S, Minissian M, Amin A, Van Spall H, Fischman DL, Savage M, Volgman AS, Mamas MA. Socioeconomic status and differences in the management and outcomes of 6.6 million US patients with acute myocardial infarction. Am J Cardiol. 2020;129:10–8. https://doi.org/10.1016/j.amjcard.2020.05.025.

[24] Graham G. Racial and ethnic differences in acute coronary syndrome and myocardial infarction within the United States: from demographics to outcomes. Clin Cardiol. 2016;39:299–306. https://doi.org/10.1002/clc.22524.

[25] Chen HY, Saczynski JS, McManus DD, Lessard D, Yarzebski J, Lapane KL, Gore JM, Goldberg RJ. The impact of cardiac and noncardiac comorbidities on the short-term outcomes of patients hospitalized with acute myocardial infarction: a population-based perspective. Clin Epidemiol. 2013;5:439–48. https://doi.org/10.2147/CLEP.S49485.

[26] Zhang F, Bharadwaj A, Mohamed MO, Ensor J, Peat G, Mamas MA. Impact of charlson co-morbidity index score on management and outcomes after acute coronary syndrome. Am J Cardiol. 2020;130:15–23. https://doi.org/10.1016/j.amjcard.2020.06.022.

[27] Lawton JS, Tamis-Holland JE, Bangalore S, Bates ER, Beckie TM, Bischoff JM, Bittl JA, Cohen MG, DiMaio JM, Don CW, Fremes SE, Gaudino MF, Goldberger ZD, Grant MC, Jaswal JB, Kurlansky PA, Mehran R, Metkus Jr TS, Nnacheta LC, Rao SV, Sellke FW, Sharma G, Yong CM, Zwischenberger BA. 2021 ACC/AHA/SCAI guideline for coronary artery revascularization: executive summary: a report of the american College of Cardiology/American Heart Association joint committee on clinical practice guidelines. Circulation. 2022;145:e4-17. https://doi.org/10.1161/CIR.0000000000001039.

[28] Wakeam E, Hevelone ND, Maine R, Swain J, Lipsitz SA, Finlayson SR, Ashley SW, Weissman JS. Failure to rescue in safety-net hospitals: availability of hospital resources and differences in performance. JAMA Surg. 2014;149:229–35. https://doi.org/10.1001/jamasurg.2013.3566.

[29] Horton S. The double burden on safety net providers: placing health disparities in the context of the privatization of health care in the US. Soc Sci Med. 2006;63:2702–14. https://doi.org/10.1016/j.socscimed.2006.07.003.

[30] Marcelin JR, Siraj DS, Victor R, Kotadia S, Maldonado YA. The impact of unconscious bias in healthcare: how to recognize and mitigate it. J Infect Dis. 2019;220:S62–73. https://doi.org/10.1093/infdis/jiz214.

[31] Mehran R, Rao SV, Bhatt DL, Gibson CM, Caixeta A, Eikelboom J, Kaul S, Wiviott SD, Menon V, Nikolsky E, Serebruany V, Valgimigli M, Vranckx P, Taggart D, Sabik JF, Cutlip DE, Krucoff MW, Ohman EM, Steg PG, White H. Standardized bleeding definitions for cardiovascular clinical trials: a consensus report from the bleeding academic research consortium. Circulation. 2011;123:2736–47. https://doi.org/10.1161/CIRCULATIONAHA.110.009449.