Heliyon 10 (2024) e32218

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

The COVID-19 impact on STEMI disparities

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ARTICLE INFO

Keywords:
Health disparities
ST-Segment elevation myocardial infarction
Interventional cardiovascular care
COVID-19

ABSTRACT

ST-segment elevation myocardial infarction (STEMI) is a significant source of morbidity and mortality. Despite guideline-driven management and increased awareness of social determinants of health, there are persistent disparities in diagnosis, management, and outcomes. The coronavirus disease 2019 (COVID-19) pandemic has greatly affected emergency department visitation, conditions and throughput. The aim of this study was to find any potential health disparities in patients who presented with STEMI during the COVID-19 pandemic by reviewing STEMI care data from April to September 2019 (pre-pandemic) and April to September 2020 (during the pandemic) for our hospital system.

Patients with STEMI within 12 h of presentation were included in this study, and subdivided by age, gender, and race/ethnicity. We compared the turnaround times between emergency department arrival to intervention (electrocardiogram or catheterization) within the patient subgroups to find any notable differences. No statistically significant changes in turnaround times during either study period were found based on age, gender, or race/ethnicity for the STEMI interventions despite shifts in emergency department resources during the pandemic. This study helped assess the status quo in STEMI intervention for our health system and serves as a baseline for us to monitor gaps in care or areas of improvement. As healthcare systems institute new measures to promote equitable care, such as improving the accuracy of demographic data capture, establishing a baseline is an essential first step in evaluating the impact of these measures.

1. Introduction

Although the incidence rate has declined nationally, acute ST-segment elevation myocardial infarction (STEMI) remains a significant source of morbidity and mortality [1–7]. Early recognition of STEMI is imperative to rapidly initiate reperfusion therapy and limit ischemic damage and myocardial cell death [7–12]. In patients presenting with concerning symptoms for acute coronary syndrome, an electrocardiogram (EKG) should be obtained within 10 min of arrival to the emergency department (ED) [8–10]. When STEMI is identified, percutaneous coronary intervention (PCI) should be completed as soon as possible, with a goal door-to-balloon (DTB) time under 90 min in capable centers and up to 120 min when transferring is necessary [11–14]. Even modest delays are

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https://doi.org/10.1016/j.heliyon.2024.e32218
Received 6 February 2024; Received in revised form 28 May 2024; Accepted 29 May 2024
Available online 31 May 2024

associated with increased mortality [13–18].

Despite the critical and time sensitive nature of this pathology, disparities in diagnosis, treatment and outcomes are well described. Socioeconomic status, gender, age, race, and ethnicity are all factors that have all been independently associated with prolonged time to intervention and divergent clinical outcomes [19–34]. Disparities in race and/or ethnicity have been shown in various metrics, such as obtaining pre-hospital EKG, as well as in mortality differences [35]. While there is some evidence to suggest these gaps have narrowed over time with increased awareness, guideline driven care and attempts at national healthcare reform, many disparities have persisted [34–44].

During the early months of the coronavirus disease 2019 (COVID-19) in March and April 2020, there was a reported 42 % decline in visits to the emergency department compared to the prior year [45]. Despite changes in overall visits, the COVID-19 pandemic has forced healthcare systems to make significant adjustments to the accessibility and delivery of patient care due to shifts in clinical emergencies and their priorities (such as providing emergent and critical care to patients with COVID-19). There have been fewer presentations for acute myocardial infarction during the early phases of the pandemic [46]. When comparing the clinical characteristics of STEMI patients, it has been shown that a higher proportion of patients presented later in their disease process (time from symptom onset) during the pandemic than prior [47,48]. In studies focused on the early pandemic stages, patients received PCI less frequently than in years prior. Instead, many patients underwent coronary computed tomography and conservative management due to delays in their presentation [47,48]. Chew et al., found in their global systematic review and meta-analysis that the COVID-19 pandemic had worse metrics and outcomes for STEMI care, such as delay in PCI and increase in-hospital mortality, specifically in low- or middle-income countries [49]. Similar to other financial and health crises, we are aware that the COVID-19 pandemic has affected racial and ethnic disparities. Differences in all-cause mortality not only reflected pre-pandemic concerns, but worsened for various racial and ethnic groups during the COVID-19 pandemic [50]. As the pandemic lingers, hospital systems and public health officials continue to review disease presentation and outcomes to minimize excess morbidity and mortality, particularly with those already experiencing health disparities. To identify any potential health disparities for patients who presented with STEMI and the impact of the ongoing COVID-19 pandemic on our patient population, we reviewed electronic health record data for STEMI care from April to September 2019 (pre-pandemic) and April to September 2020 (during the pandemic).

2. Materials and methods

The original NorthShore University HealthSystem (NSUHS), currently a growing, multihospital system across greater Chicago, had four hospitals which were all included in this study. Three of these sites have cardiac catheterization capabilities serving urban and suburban patient populations, while the fourth is an orthopedic specialty hospital. ED patients at the specialized location must be transferred to any of the remaining three sites for PCI care. Among the three hospitals, one was designated to be the "COVID Hospital" early in the pandemic, focusing care primarily on COVID-19 patients, and with public declaration we found patients' decision making on which hospital to attend was significantly affected [51]. As such, two of our hospitals during the test period did not have cardiac catheterization capabilities, thus requiring patient transfer. Those requiring transfer were commonly, but not exclusively, transferred to our trauma one hospital, which is close in proximity to the orthopedic specialty hospital. Ethical approval for this study was exempted by the NorthShore University Health System institutional review board based on the quality improvement focus of this study. Therefore, patient consent was waived per exemption guidelines.

Data were drawn from Epic electronic health record system (Epic Systems Corporation, Verona, WI) for NSUHS patients who were identified using the previously validated International Classification of Diseases, Tenth Revision (ICD-10) diagnostic codes for acute coronary syndrome, acute myocardial infarction, and ST-segment elevation myocardial infarction [52–54]. These diagnoses were cross-referenced between Epic reports and the catheterization reporting system, which captures patients who had a "Code STEMI" activated, encapsulating all patients who required cardiology review for STEMI & possible PCI. Patients who were activated for a "Code STEMI" within 12 h of their presentation to the hospital, or pre-hospital, were included in this study to focus on outcomes related to emergency medicine care.

The ED admissions during the COVID-19 pandemic spanned April through September 2020 and we used ED admissions from the same months in 2019 as our control group. To assess the quality of care provided to STEMI patients, two metrics were evaluated: (1) time elapsed from ED arrival to the completion of an EKG and (2) time elapsed from ED arrival to the completion of cardiac catheterization. We categorized patients according to age (younger or older than 70 years old), gender (male or female), and race/ethnicity (Caucasian, non-Caucasian or Unknown). Given our already small sample size, we combined those identifying as Asian, Hispanic, African-American and Black patients together as non-Caucasian; patients who did not have any race/ethnicity data reported were combined into the Unknown group. The intervention metrics, time to EKG and time to cardiac catheterization, were compared across age groups, gender, and race/ethnicity categories.

A power calculation was performed to assess whether our study had sufficient sampling. In order to detect a difference of 5, 10, or 15 % between any two groups at 80 % power and a 95 % significance level, we would need about 1562, 385 or 167 patients respectively. If we were to extend our study period, this may increase our sample size to be closer to the size needed for a 10–15 % difference. In doing so, however, we would no longer be restricted to assessing the first wave of the COVID-19 pandemic adding complexity to our analysis.

We counted the number of patients who received care in a timely manner, setting the target threshold to 10 min for EKG completion and 90 min for cardiac catheterization.

Patients were grouped into intervals based on their turnaround times for EKG (<10 min, 10–15 min, 16–20 min, 21–60 and > 60 min) or catheterization (<90 min, 91–120 min, >120 min) These time intervals measured how many patients met the target, were a few minutes past the target or took much longer than the set target. We allowed up to 120 min for PCI to account for patient transfers, due to shifts in resources from having a dedicated COVID hospital. The relevant subgroups (e.g., male and female for the gender categories) were compared using a Chi-squared or Fisher's exact test as appropriate. Multiple comparisons were made, and thus we applied a Bonferroni correction for determining statistical significance.

3. Results

At NSUHS, there was a total of 65,988 ED admissions from April through September 2019, compared to 47,016 visits during the same months in 2020, an approximate 30 % decrease in patient volume from the same time a year prior. At our COVID hospital, the ED patient volume dropped by about 40 %, while the orthopedic specialty hospital ED experienced a 45 % decrease in volume in 2020 compared to 2019. The change was not as drastic at our tertiary center and trauma hospital, as well as our community hospital where the volumes decreased by 14 % and 18 % respectively. While ED patient volumes during the pandemic were lower overall, the proportion of patients meeting STEMI criteria and needing cardiac catheterization actually increased from 2019 to 2020.

Our patient population for each of the interventions (EKG and cardiac catheterization) is described in Table 1, where patients who needed PCI are a subset of the EKG population. A total of 241 patients satisfied STEMI criteria with consideration for PCI during both study periods: 133 patients included in the control group from April 1 to September 30, 2019, and 108 patients during the April 1 to September 30, 2020 test period. Out of the 133 patients, 101 (75.9 %) were activated for Code STEMI and went for catheterization in the control period. Similarly, in the test period, 88 out of the 108 (81.5 %) patients were activated for a Code STEMI and underwent cardiac catheterization. There were fewer female patients than male for both periods (36.8 % and 32.4 % for control and test periods, respectively) and patients were typically Caucasian (65.4 % in the control period and 69.4 % in the test period.) About half of the patients were younger than 70 years old in both periods (55.6 % and 49.1 % for control and test periods.) Despite having a COVID-designated hospital and expecting a greater number of system transfers during the test period, we saw a decrease in the percentage of catheterized patients requiring transfer for that procedure (44.6 % during the control and 34.1 % for the test early pandemic period).

We evaluated the timeliness of EKG turnaround between subgroups (e.g. comparing male and female turnaround times for gender) during each time period (Table 2.) Ideally, patients would have an EKG in 10 min or less, and turnaround times that exceeded 10 min were included to gauge the distribution. No statistically significant differences in EKG turnaround were found for all patients in both study periods. In other words, the distributions in turnaround times were independent of patient gender, age grouping or race/ethnicity during the control as well as the test periods. A similar comparison was performed for evaluating turnaround times for cardiac catheterization (Table 3.) The differences in turnaround times were not statistically significant between all patient subgroups, even when a patient transfer between pavilions was necessary ($p = 0.6655$ for the control period and $p = 0.2619$ for the test period.) For completeness, we also did a comparison of each subgroup across the two time periods (e.g. female patients during the control period compared to female patients in the test period) and also did not find any statistically significant differences (Supplementary Table 1.)

Table 1
Summary of patient population. The number of patients who received an electrocardiogram (EKG) or cardiac catheterization are shown here. These populations are further subdivided into groups for gender, age and race/ethnicity, and the percent composition of each of these groups is shown. Cardiac catheterization patients are a subset of those who received EKGs.

Electrocardiogram	Control period		Test period	
	Number of Patients	Percent of Population	Number of Patients	Percent of Population
Total number of EKG patients	133		108	
Female	49	36.8 %	35	32.4 %
Male	84	63.2 %	73	67.6 %
Patients age less than 70	74	55.6 %	53	49.1 %
Patients aged 70 or older	59	44.4 %	55	50.9 %
Caucasian Patients	87	65.4 %	75	69.4 %
Non-Caucasian Patients	26	19.5 %	17	15.7 %
Unknown Race/Ethnicity	20	15.0 %	16	14.8 %
Cardiac Catheterization	Control period		Test period	
	Number of Patients	Percent of Population	Number of Patients	Percent of Population
Total number of EKG patients	101		88	
Female	35	34.7 %	29	33.0 %
Male	66	65.3 %	59	67.0 %
Patients age less than 70	65	64.4 %	49	55.7 %
Patients aged 70 or older	36	35.6 %	39	44.3 %
Caucasian Patients	64	63.4 %	62	70.5 %
Non-Caucasian Patients	22	21.8 %	12	13.6 %
Unknown Race/Ethnicity	15	14.9 %	14	15.9 %
No Transfer	56	55.4 %	58	65.9 %
Transfer	45	44.6 %	30	34.1 %

Table 2
Electrocardiogram turnaround times. The target turnaround time for an electrocardiogram is 10 min, and the number of patients who were seen within this timeframe or at a longer time interval are shown here. The p-values reflect the results from Chi-squared or Fisher's exact test to compare the relevant patient groups.

	Number of Patients	≤10 min (target)	10–15 min	16–20 min	21–60 min	>60 min	p-value
Control Period							
Female	49	28	5	2	5	9	0.8404
Male	84	48	13	5	7	11	
Age under 70	74	43	12	3	5	11	0.6902
Age 70 and older	59	33	6	4	7	9	
Caucasian	87	50	12	5	8	12	0.5005
Non-Caucasian	26	16	4	2	0	4	
Unknown	20	10	2	0	4	4	
Test Period							
Female	35	18	4	4	8	1	0.2332
Male	73	43	7	2	13	8	
Age under 70	53	31	6	3	10	3	0.9009
Age 70 and older	55	30	5	3	11	6	
Caucasian	75	41	10	3	15	6	
Non-Caucasian	17	12	0	0	2	3	
Unknown	16	8	1	3	4	0	0.1473

Table 3
Cardiac catheterization turnaround times. Patients should receive a cardiac catheterization within 90 min upon ED arrival. The number of patients who satisfy this target are shown below, and additional time intervals were added to account for patients who had longer turnaround times. The p-values reflect the results from performing Chi-squared or Fisher's exact test to compare relevant groups to each other.

	Number of Patients	<90 min	91–120 min	>120 min	p-value
Control Period					
Female	35	18	5	12	0.3921
Male	66	43	6	17	
Age under 70	65	38	7	20	0.8660
Age 70 and older	36	23	4	9	
Caucasian	64	39	8	17	0.9663
Non-Caucasian	22	13	2	7	
Unknown	15	9	1	5	
No Transfer	56	36	5	15	0.6655
Transfer	45	25	6	14	
Test period					
Female	29	20	2	7	0.7513
Male	59	43	6	10	
Age under 70	49	39	4	6	0.1302
Age 70 and older	39	24	4	11	
Caucasian	62	43	4	15	
Non-Caucasian	12	7	3	2	
Unknown	14	13	1	0	0.05059
No Transfer	58	43	3	12	
Transfer	30	20	5	5	0.2619

4. Discussion

Patient volumes decreased overall at NSUHS, similar to other healthcare systems, during various pandemic phases, particularly in early 2020. The accessibility and availability of the cardiac catheterization team and other emergent cardiac resources may have differed due to fewer patient visits and other system-wide precautions taken during the pandemic. Despite the evolving clinical landscape, there were no statistically significant differences in time to EKG or DTB times between the pre-pandemic and pandemic study populations when stratified by race, age, and gender.

Interestingly, despite having a COVID-designated hospital where we would have expected increased system transfers during the early pandemic for acute cardiac care, we saw a decrease in the percentage of catheterized patients requiring transfer for PCI. In another review, we did find patient self-selection of hospital choice for those arriving by private vehicle which may help explain this phenomenon. Similar to other systems, we experienced evolving patient care guidelines for procedures and surgical operations in the early pandemic while learning more about COVID-19.

From our analysis, we found that there were no statistically significant differences between the three race/ethnicity groups. We want to encourage others to consider this variable (race/ethnicity) in their own study as sampling may be different. For approximately 15 % of our population, the race and ethnicity data were classified as Unknown based on EMR documentation, making it difficult to draw meaningful conclusions for this group. Our study was a retrospective analysis looking at how the early phase of the pandemic may have affected emergent cardiac care with consideration of health disparities, and it was our goal to prompt further discussion and review to provide equitable care if any differences were found. The pandemic comes at a time of increased attention into the identification and consideration of health disparities. While there have been ongoing efforts by our quality and Epic utilization committees in improving the capture of demographics data, at our hospital system, this study may aid in the prioritization of this type of work. More recently, patients have the capability to self-assign or change their identifiers in the electronic patient portal, and there have been efforts to promote patient self-identification, with special consideration for personal autonomy allowing for better tracking of health equity.

5. Limitations

There are some limitations to our study due to the patient population and generally low number of STEMI occurrences. The health system studied, is predominantly Caucasian population, although patient populations for the different hospital sites have some variation. This restricts the generalizability of our results to other health care organizations with more diverse populations. Additionally, most patients at NSUHS have well-established primary care providers, insurance, and overall increased access to resources when compared with the general population. This means that patients may have more opportunities to receive cardiac risk stratification, imaging, and cardiac care prior to the development of an emergent condition such as a STEMI.

As reflected, not all patients activated under Code STEMI underwent cardiac catheterization. We did not specifically review the reasons patients did not undergo PCI as this was not one of the goals of our study, and extracting these unstructured data elements would have presented different challenges. Some potential reasons for refusing PCI may include patients or families opting out of aggressive treatment (as in the case of cardiac catheterization), patients having conditions or co-morbidities that require more urgent medical treatment (such as in septic shock), or patients not qualifying for reasons determined in consultation with cardiology.

This study was primarily completed to check for potential disparities in care for our specific region with consideration of the COVID-19 pandemic, and to address them if found. Given the small differences between cohorts, a larger patient population may have allowed for more robust statistical conclusions. As noted, we were underpowered and under sampled due to the nature of the time frame and evaluating the effect of the COVID-19 pandemic on emergent cardiac care. Even though the differences found were not statistically significant, this study provides awareness of our current practices and serves as an essential first step to evaluating the impact of any future measures aimed at promoting equitable care.

Using EMR data to identify patients for inclusion also carries the risk of coding errors. We opted to focus on ED presentations of STEMI and, as such, did not include patients with abnormal stress imaging or other outpatient factors which may have prompted cardiac catheterization. Furthermore, limited data on patient race and ethnicity often due to incomplete documentation, necessitated patient cohorts to be defined as Caucasian, non-Caucasian and Unknown, where the Unknown could include some Caucasian and non-Caucasian patients as well as patients who opted not to report their race/ethnicity, which may have affected our conclusions.

6. Conclusion

There were no statistically significant differences in time to EKG or cardiac catheterization between the study periods for STEMI patients when stratified by race/ethnicity, age, or gender for the hospital system we evaluated. However, due to the exploratory nature of this study with the infrequency of STEMI presentations it is possible our findings reflect insufficient power to detect differences. Regardless, this study establishes a baseline, which will aid in the continued to monitoring of our clinical workflows, allowing us to identify and intervene on any potential disparities in health equity sooner and with greater efficiency.

Funding statement

There is no funding to disclose by the authors.

Data availability statement

Data can be made available on request with privatized health information.

CRediT authorship contribution statement

Jessica Folk: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Conceptualization. **Kevin McGurk:** Writing – original draft, Investigation, Conceptualization. **Loretta Au:** Writing – review & editing, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Polina Imas:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Sarah Dhake:** Writing – review & editing, Writing – original draft, Conceptualization. **Adam Haag:** Writing – review & editing, Methodology, Investigation, Conceptualization.

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.

Acknowledgements

This evaluation of potential health disparities in acute cardiac care and intervention highlights the vital role of our interventional and interprofessional cardiac team. We would like to recognize the assistance of matching data with Dr. Jonathan Rosenberg and Johnny Driscoll, RN-BC, BSN Johnny Driscoll RN-BC, BSN.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e32218.

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