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Authors

Hu, Xuchen
Fanous, Elias
Jackson, Nicholas J
et al.

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Impact of COVID-19 Pandemic on Sex and Racial Disparities in Chest Pain Presentation and Management Through the Emergency Department

Xuchen Hu[a], Elias Fanous[a], Nicholas J. Jackson[b], Gabrielle I. Daso[a], Icy Liang[a], Lynnell B. McCullough[c], Richelle J. Cooper[c], Tamara B. Horwich[a], Karol E. Watson[a], Janki B. Shah[a], Negeen Shahandeh[a], Marcella A. Calfon Press[a, d, e]

Abstract

Background: Sex and racial disparities in the presentation and management of chest pain persist, however, the impact of coronavirus disease 2019 (COVID-19) on these disparities have not been studied. We sought to determine whether the COVID-19 pandemic contributed to pre-existing sex and racial disparities in the presentation, management, and outcomes of patients presenting to the emergency department (ED) with chest pain.

Methods: We conducted an observational cohort study with retrospective data collection of patients between January 1, 2016, and May 1, 2022. This was a single study conducted at a quaternary academic medical center of all patients who presented to the ED with a complaint of chest pain or chest pain equivalent symptoms. Patient were further segregated into different groups based on sex (male, female), race, ethnicity (Asian, Black, Hispanic, White, and other), and age (18 - 40, 41 - 65, > 65). We compared diagnostic evaluations, treatment decisions, and outcomes during prespecified time points before, during, and after the COVID-19 pandemic.

Results: This study included 95,764 chest pain encounters. Total chest pain presentations to the ED fell about 38% during the early pandemic months. Females presented significantly less than males during initial COVID-19 (48% vs. 52%, $P < 0.001$) and Asian females were least likely to present. There was an increase in the total number of troponins and echocardiograms ordered during peak COVID-19 across both sexes, but females were still less likely to have these tests ordered across all timepoints. The number of coronary angiograms did not increase during peak COVID-19, and females were less likely to undergo coronary angiogram during all timepoints. Finally, females with chest pain were less likely to be diagnosed with acute myocardial infarction (AMI) during all timepoints, while in-hospital deaths were similar between males and females during all timepoints.

Conclusions: During COVID-19, females, especially Asian females, were less likely to present to the ED for chest pain. Non-White patients were less likely to present to the ED compared to White patients prior to and during the pandemic. Disparities in management and outcomes of chest pain encounters remained similar to pre-COVID-19, with females receiving less cardiac workup and AMI diagnoses than males, but in-hospital mortality remaining similar between groups and timepoints.

Keywords: COVID-19; Sex disparities; Chest pain; Emergency department; Acute myocardial infarction

Introduction

Ischemic heart disease has been the leading cause of death in the United States and the world for many years, and despite the coronavirus disease 2019 (COVID-19) pandemic, it continued to be the number one cause of death in the United States in 2020 and 2021 [1, 2]. Unfortunately, sex disparities in management of patients who present to the emergency department (ED) with possible acute myocardial infarction (AMI) persist [3-5]. Although females present in similar numbers as males to the ED, it has been well documented that females not only have delays to presentation to the ED, but they also receive less workup for their symptoms, fewer diagnoses of AMI, and fewer reperfusion therapies [3, 4, 6]. Not surprisingly, these differences have led to greater morbidity and mortality for females [7-11]. It has been speculated that the lack of knowledge of sex differences in chest pain presentation may partly explain disparities between males and females. Studies have documented that even though chest pain is the most frequent symptom of angina in both males and females, anginal symptoms in females are more often atypical (e.g., pain in

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[a]Department of Medicine - Cardiology, University of California, Los Angeles, CA 90095, USA
[b]Department of Medicine - Statistics, University of California, Los Angeles, CA 90095, USA
[c]Department of Emergency Medicine, University of California, Los Angeles, CA 90095, USA
[d]UCLA Cardiovascular Center, Los Angeles, CA 90095, USA
[e]Corresponding Author: Marcella A. Calfon Press, UCLA Cardiovascular Center, Los Angeles, CA 90095, USA. Email: MCalfonPress@mednet.ucla.edu

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the jaw, neck, or arms, nausea, fatigue, anxiety, and dyspnea) [4, 12-15]. Other studies have suggested that female anginal symptoms may frequently be attributed to anxiety, especially if they have a prior diagnosis of anxiety, take antidepressants or anxiolytics, or be of younger age [16]. When considering age, race, ethnicity, and socioeconomic status, this disparity is further amplified [15, 17-19]. Black adults are less likely to be diagnosed with AMI, undergo revascularization therapy, and have poorer outcomes after AMI than White adults [20-22]. A recent study showed that non-White adults had longer wait times before they were seen by a physician and were less likely to be prescribed antianginal medications [6]. Health care disparities were further exacerbated by the COVID-19 pandemic. Studies showed higher COVID-19 infection rates, hospitalization rates, and deaths in non-White individuals, marginalized communities, and those of lower socioeconomic status [23]. A study conducted by the Centers for Disease Control and Prevention (CDC) in 2020 showed that ED visits during the early months of the pandemic sharply declined by an average of 42%, with females presenting less often than males (45% vs. 37%) [23]. Previous studies showed that differences in care exist between males and females, including delayed transportation to the hospital, prehospital aspirin or analgesia administration, and 12-lead electrocardiogram administration. In this analysis, we asked if the COVID-19 pandemic impacted pre-existing sex and racial disparities in patients who presented to our ED with cardiac symptoms.

Materials and Methods

Study design

This is a single-center, observational cohort study with retrospective data collection of patients who presented with chest pain or chest pain equivalent symptoms to the Ronald Reagan UCLA Medical Center (RR UCLA) Emergency Department. RR UCLA is a quaternary care medical center and a ST-segment elevation myocardial infarction (STEMI) receiving center with an annual ED census of approximately 55,000 patients. The UCLA Institutional Review Board (IRB) approved this study. We collected data through the electronic health record (UCLA EPIC/CareConnect database), which comprises all patients presenting to the RR UCLA ED. We identified cases between January 2016 to May 2022 using the chief complaint of "chest pain", "shortness of breath", "nausea/vomiting", "weakness", "jaw pain", "arm pain", and "abdominal pain". We excluded patients who had immediate imaging or other diagnostic results indicating non-cardiac etiology of chest pain (e.g., pulmonary embolism, pneumonia, tension pneumothorax) from the study. Cases were separated based on time periods: pre-COVID (January 1, 2016 - March 19, 2020); begin lockdown (March 20, 2020 - November 1, 2020); alpha surge (November 2, 2020 - January 31, 2021); end lockdown (February 1, 2021 - June 15, 2021); delta surge (June 16, 2021 - December 1, 2021); omicron surge (December 2, 2021 - February 28, 2022); and current state (March 1, 2022 - May 1, 2022). These time periods correspond to three of the Los Angeles County COVID-19 surges and the Los Angeles County "stay-at-home" order between March 20, 2020 and June 15, 2021. We further segregated the collected data into different groups based on sex (male, female), race (White, Black, Asian, Hispanic, other), and age (18 - 40, 41 - 65, > 65). The combined primary endpoints of this study are AMI and in-hospital death. Secondary endpoints include: 1) initial troponin orders; 2) diagnostic interventions including echocardiograms, stress tests, and coronary angiograms; and 3) admission to inpatient or cardiology service.

This study was conducted in compliance with the ethical standards of the UCLA IRB.

Statistical analysis

Descriptive statistics (means with standard deviation, relative frequency) are provided for variables at each time period. Between time periods, differences were assessed using Welch's *t*-test and Chi-square analysis. Our primary analysis examined the sex distribution over the course of the COVID-19 pandemic, referent to the pre-COVID period. Differences in the sex distribution between time periods were assessed using logistic regression models with sex as the outcome and time period as a fixed effect categorical predictor. This model was additionally adjusted for the month of encounter to account for secular trends. Subsequent models examined separate interaction in terms of race-by-time period and age group-by-time period to examine if changes in the sex distribution over time differed by age or race. For our secondary outcomes examining cardiac workup, we examined the probability of inpatient admission, being admitted to cardiology service, as well as the probability of having various diagnostic evaluations and treatments (e.g., troponin, echocardiogram, catheterization) over time for males and females through the use of logistic regression models. These models contained main effects for month of encounter, sex, time period, and sex-by-time period interaction term to determine if changes in these outcomes relative to the pre-COVID era were different between the sexes. Finally, AMI and death outcomes were examined through similar logistics regression models with fixed effects for month of encounter, sex, time period, and sex-by-time period interaction terms. Marginal estimates from the models are shown in figures. All analyses were conducted in Stata Version 16.1, StataCorp LLC (College Station, Texas).

Results

Study population

Between January 2016 and May 2022, we analyzed a total of 95,764 chest pain presentations, and all patients presented to RR UCLA with chest pain or equivalent symptoms. Of those presentations, 47,993 (50%) were males and 47,754 (50%) were female. Of the patients, 30,747 (32%) were aged 18 - 40, 30,252 (32%) were aged 41 - 65, and 34,765 (36%) were aged > 65, with a mean age of 54 years old. Within races, 44,455

Table 1. Demographics

	Pre-COVID-19	Begin lockdown	Alpha surge	End lockdown	Delta surge	Omicron surge	Current state	Overall
	Jan. 2016 - Mar. 2020	Mar. 2020 - Nov. 2020	Nov. 2020 - Jan. 2021	Feb. 2021 - Jun. 2021	Jun. 2021 - Dec. 2021	Dec. 2021 - Feb. 2022	Mar. 2022 - May 2022	
Total encounters	62,523	8,154	3,370	4,850	8,312	4,213	4,342	95,764
Sex								
Male	31,056	4,196	1,840	2,503	4,129	2,130	2,139	47,993 (50%)
Female	31,471	3,956	1,529	2,346	4,179	2,080	2,193	47,754 (50%)
Age								
18 - 40	20,311	2,706	1,018	1,509	2,564	1,233	1,406	30,747 (32%)
41 - 65	19,687	2,689	1,131	1,493	2,547	1,362	1,343	30,252 (32%)
> 65	22,525	2,759	1,221	1,848	3,201	1,618	1,593	34,765 (36%)
Race and ethnicity								
Asian	4,973	554	269	418	650	313	365	7,542 8%)
Black	8,180	1,180	444	663	1,119	573	596	12,755 (13%)
Hispanic	10,210	1,539	755	945	1,562	880	835	16,726 (17%)
Other	8,480	1,308	522	756	1,501	754	970	14,291 (15%)
White	30,685	3,573	1,380	2,068	3,480	1,693	1,576	44,455 (46%)

Jan.: January; Mar.: March; Nov.: November; Feb.: February; Jun.: June; Dec.: December; COVID-19: coronavirus disease 2019.

(46%) were White, 16,726 (17%) were Hispanic, 12,744 (13%) were Black, 7,542 (8%) were Asian, and 14,291 (15%) were identified as Other. We analyzed a total of 62,523 patients before COVID-19 and 33,241 patients after the start of the pandemic. Detailed demographics are shown in Table 1.

ED visits for chest pain decreased during the COVID-19 pandemic

Prior to the COVID-19 pandemic, females and males presented in similar numbers to the ED with a primary complaint of chest pain or chest pain equivalent symptoms. From 2016 until early 2020, chest pain encounters to the RR UCLA ED slowly trended up in both females and males in similar rates, with an approximately 32% absolute increase in total encounters (Fig. 1a). Before COVID-19, there were similar proportions of chest pain visits between females and males (50.6% vs. 49.4% respectively; mean difference (d) = 1.2%, 95% confidence interval (CI): 0-1.0%, P < 0.001) (Fig. 1b). With COVID-19 and the LA county "stay-at-home" order, RR UCLA ED saw a drastic decrease in chest pain encounters, with approximately 38% absolute decrease in ED visits compared to the month prior to the lockdown, and 33% fewer compared to March 2019 (Fig. 1a). ED visits for chest pain or equivalent symptoms decreased significantly more in females than males (48% vs. 52%, d = 4%, CI: 2.4-5.4%, P < 0.001) (Fig. 1b). When the lockdown was lifted, ED visits returned to pre-COVID-19 numbers, and the proportion of females and males encounters returned to baseline (Fig. 1a, b).

When the data were examined by race and ethnicity (White, Black, Hispanic, Asian, and other), we found that prior to COVID-19, White patients presented the most to the ED with chest pain (49%) and Asian patients presented the least (8%) (Fig. 2a). However, when we examine sex and race together, we found that Asian, White, and Black females had a significant decrease in chest pain presentation compared to males of the same race and ethnicity during the alpha surge compared to pre-COVID-19 (Fig. 2b). Asian females had the most significant decrease in proportional presentation (47.3% vs. 56.5%, d = 9.2%, CI: 3.1-15.3%, P < 0.05). Black females (44.7% vs. 51.9%, d = 7.2%, CI: 2.5-12.0%, P < 0.005) and White females (42.0% vs. 48.1%, d = 6.0%, CI: 3.3-8.7%, P < 0.001) also showed a significant decrease in presentation. Proportions returned to pre-COVID-19 values after the pandemic (Fig. 2b).

Females were less likely to receive cardiac workup for their chest pain than males

Before the COVID-19 pandemic, females consistently had fewer proportions of troponin orders (32.8% vs. 39.2%, d = 6.4%, CI: 5.7-7.2%, P < 0.001) (Fig. 3a), echocardiograms (12.9% vs. 17.4%, d = 4.5%, CI: 3.9-5.1%, P < 0.001) (Fig. 3b), and cardiac catheterizations (2.1% vs. 4.5%, d = 2.4%, CI: 2.1-2.7%, P < 0.001) (Fig. 3c) than males. Females were less likely than males to receive intravenous (IV) heparin (14.7% vs. 19.7%, d = 5.0%, CI: 4.4-5.6%, P < 0.001) or aspirin (15% vs. 23.4%, d = 8.4%, CI: 7.7-9.1%, P < 0.001) (Supplementary Material 1, www.cardiologyres.org). Females were also less likely to be admitted to an inpatient service (29% vs. 36.7%, d = 7.7%, CI: 7.0-8.4%, P < 0.001), including a primary cardiology team (6.2% vs. 10.1%, d =

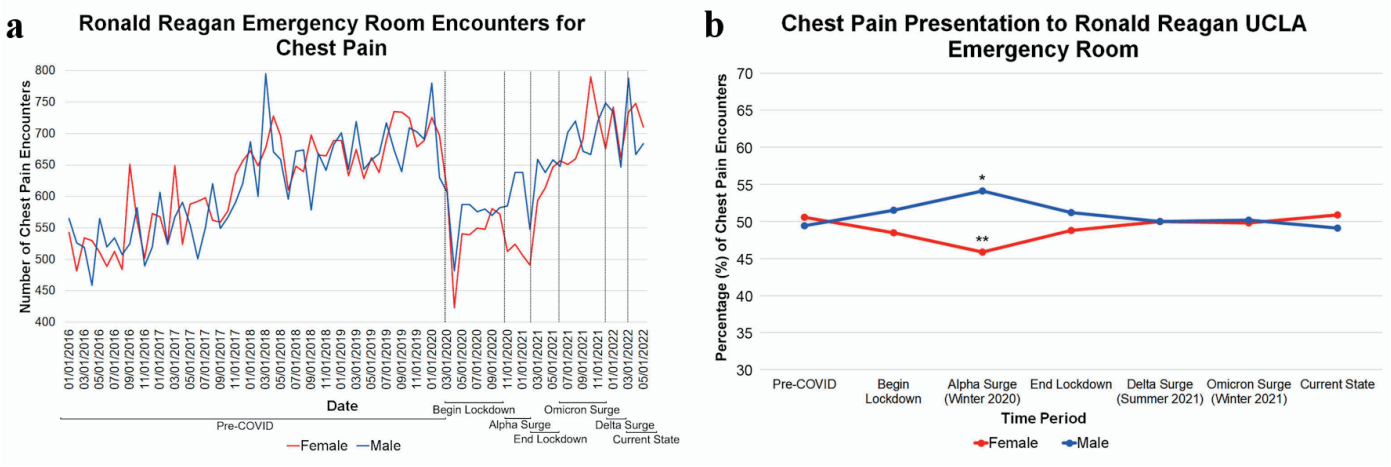

Figure 1. (a) Total chest pain encounters to the UCLA Emergency Department (ED) over time between females (red) and males (blue). Vertical dotted lines denote COVID-19 time periods (pre-COVID (before March 2020), begin lockdown (March 2020 to November 2020), alpha surge (November 2020 to January 2021), end lockdown (February 2021 to June 2021), delta surge (June 2021 to December 2021), omicron surge (December 2021 to February 2022), current state (March 2022 to May 2022)). ED visits for chest pain fell 38% at the start of lockdown. (b) Percentage of total chest pain encounters that are females and males. Females and males presented in similar proportions prior to COVID-19 (50.6% vs. 49.4% respectively, mean difference (d) = 1.2%, confidence interval (CI): 0-1.0%, P < 0.001). Females had a significant decrease (48% vs. 52%, d = 4%, CI: 2.4-5.4%, P < 0.00) in presentation compared to males during the lockdown period. Proportions returned to pre-COVID-19 numbers after the lockdown was lifted. **Statistical significance between male and female. *Statistical significance between pre-COVID and alpha surge. COVID-19: coronavirus disease 2019.

3.9%, CI: 3.5-4.3%, P < 0.001) (Fig. 3d). During the early pandemic (lockdown and alpha surge), we found an increase proportion of troponin orders and echocardiograms for both males and females when compared with pre-COVID-19. Despite increase in total troponin orders and echocardiograms, females still continued to receive less troponin orders (42.8% vs. 49.4%, d = 6.6%, CI: 5.1-8.1%, P < 0.001) and echocardiograms (17.8% vs. 21.9%, d = 4.1%, CI: 1.4-6.8%, P = 0.003) than males. However, in the current state (post-COVID-19 surges), we found no significant difference in troponin orders or echocardiograms between males and females (troponin: 39.9% vs. 41.9%, d = 2.0%, CI: -0.5% - 0.9%, P = 0.172; echocardiogram: 18.5% vs. 20.2%, d = 1.6%, CI: -3.5% - 0.2%, P = 0.08) (Fig. 3a, b). The use of IV heparin and aspirin did not change significantly during the pandemic compared to pre-pandemic (Supplementary Material 1, www.cardiolo-

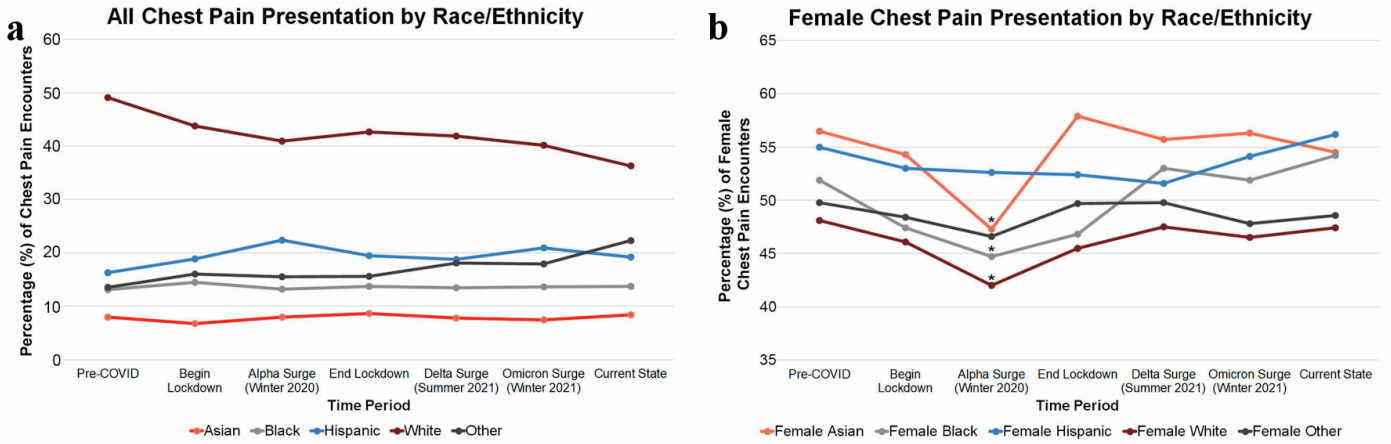

Figure 2. (a) Percentage of all chest pain presentation by race and ethnicity. White patients presented the most with chest pain prior to and during the pandemic. White patients had a decrease in proportion of chest pain presentations during the pandemic. Asian patients consistently were least likely to present with chest pain. (b) Percentage of female chest pain presentation by race and ethnicity. The proportion of Asian females significantly dropped between alpha surge and pre-COVID-19 (47.3% vs. 56.5%, mean difference (d) = 9.2%, confidence interval (CI): 3.1-15.3%, P < 0.05). Black females (44.7% vs. 51.9%, d = 7.2%, CI: 2.5-12.0%, P < 0.005) and White females (42.0% vs. 48.1%, d = 6.0%, CI: 3.3-8.7%, P < 0.001) also has significant decrease in proportions during this time. Proportions returned to baselines after lockdown was lifted. *Statistical significance between time periods compared to pre-COVID-19. COVID-19: coronavirus disease 2019.

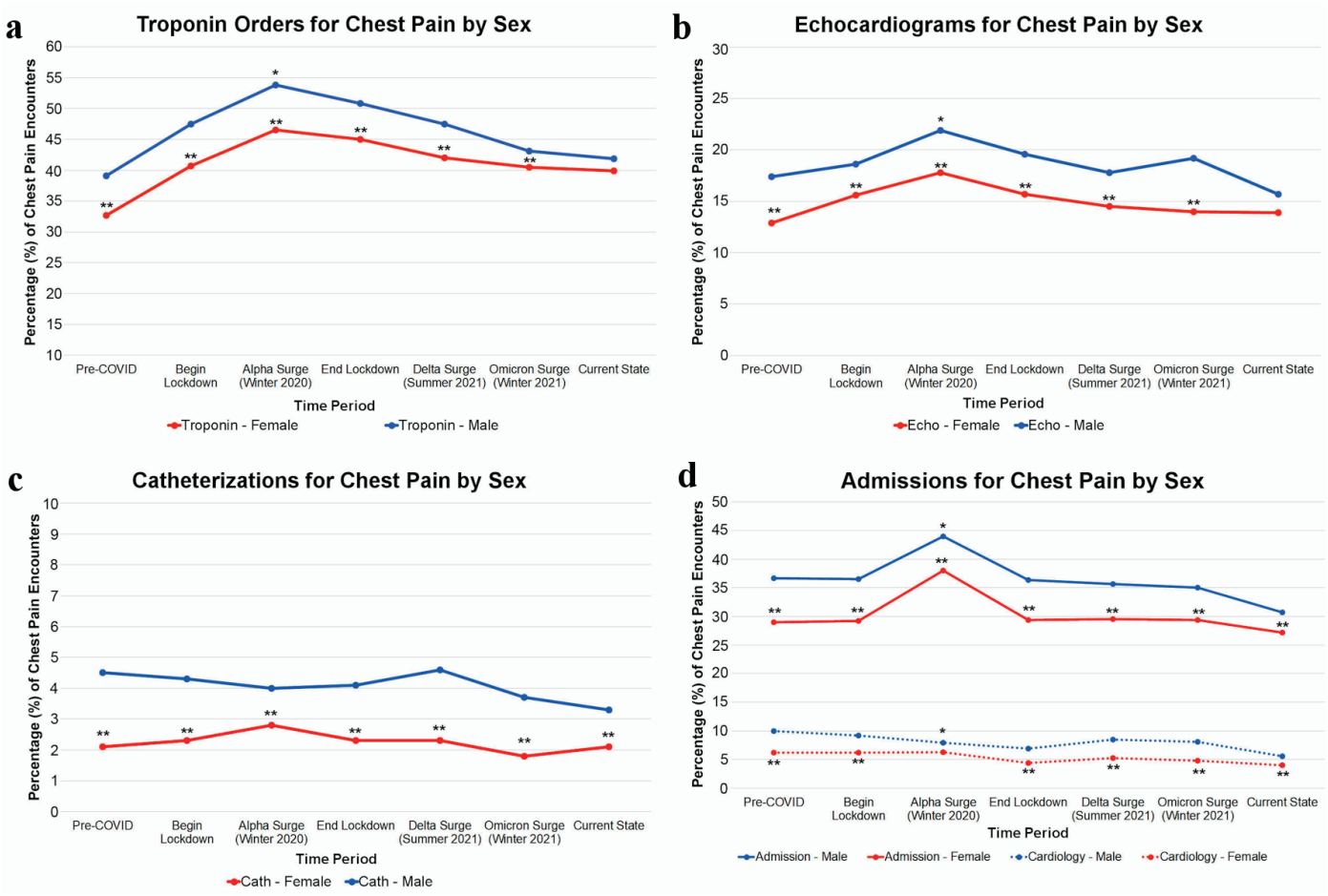

Figure 3. (a) Percentage of chest pain encounters where initial troponins were ordered. Females consistently received a lower percentage of troponin orders compared to males prior to COVID-19 (32.8% vs. 39.2%, mean difference (d) = 6.4%, confidence interval (CI): 5.7-7.2%, P < 0.001). Troponin orders increased for both sexes during the initial COVID-19 lockdown period (P < 0.001), however females continued to receive fewer troponin orders (42.8% vs. 49.4%, d = 6.6%, CI: 5.1-8.1%, P < 0.001). (b) Percentage of chest pain encounters where echocardiograms were obtained. Females received fewer echocardiogram orders compared to male before (12.9% vs. 17.4%, d = 4.5%, CI: 3.9-5.1%, P < 0.001) and during COVID-19 (17.8% vs. 21.9%, d = 4.1%, CI: 1.4-6.8%, P = 0.003). Echocardiogram orders significantly increased for both sexes during the COVID lockdown (P < 0.001). (c) Catheterizations for chest pain. Females had considerably lower proportion of coronary artery catheterizations compared to males before COVID-19 (2.1% vs. 4.5%, d = 2.4%, CI: 2.1-2.7%, P < 0.001). Catheterizations did not significantly change for males and females during the pandemic (P > 0.05). (d) Inpatient total admissions (solid line) and cardiology admissions (dotted line) for chest pain. Before COVID-19, females were less likely to be admitted than males (29% vs. 36.7%, d = 7.7%, CI: 7.0-8.4%, P < 0.001). This pattern continued during COVID-19 (31.5% vs. 39.4%, d = 7.0%; CI: 5.4-8.4%; P < 0.001). In terms of admission to a primary cardiology team, females were less likely than males before (6.2% vs. 10.1%, d = 3.9%, CI: 3.5-4.3%, P < 0.001) and during the pandemic (5.7% vs. 8.2%, d = 2.5%, CI: 1.8-3.3%, P < 0.001) to be admitted to cardiology. **Statistical significance between males and females. *Statistical significance between time periods. COVID-19: coronavirus disease 2019.

gyres.org). Proportions for cardiac catheterizations did not significantly change during the pandemic when compared to pre-pandemic. The difference in proportions between males and females receiving cardiac catheterizations also remained the same (Fig. 3c). For inpatient admissions, males and females were both more likely to be admitted for the chest pain during the first COVID-19 surge compared to pre-COVID-19, though again, the difference in proportion between sexes remained comparable such that males were admitted at higher rates than females. There was no significant change in admissions to a primary cardiology service during COVID-19 (Fig. 3d).

Females were less likely to be diagnosed with AMI, though in-hospital death rates are similar between females and males

AMI diagnoses were fewer in females than males before the pandemic (2.6% vs. 4.8%, d = 2.2%; CI: 1.9-2.5%, P < 0.001). AMI diagnoses had a small but significant increase during the alpha surge compared to pre-COVID-19 (3.6% vs. 2.6%, d =

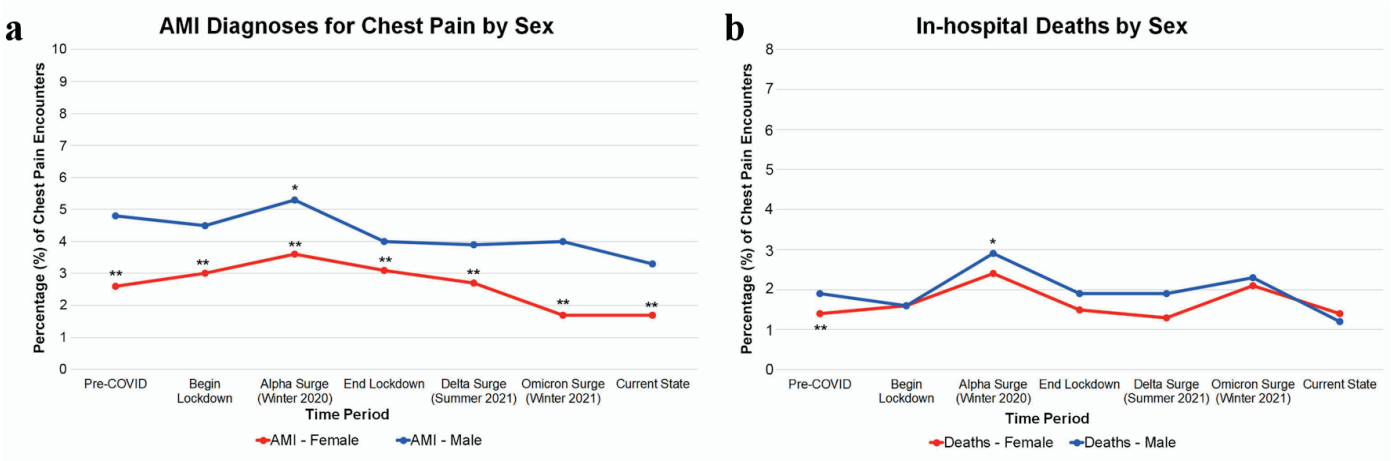

Figure 4. (a) Percentage of chest pain encounters where an AMI diagnosis was made. Prior to COVID-19, females were diagnosed in lower proportions than males with AMI (2.6% vs. 4.8%, mean difference (d) = 2.2%, confidence interval (CI): 1.9-2.5%, P < 0.001). AMI diagnosis had a small increase during the alpha surge compared to pre-COVID (3.6% vs. 2.6%, d = 1.0%, CI: 0.0-2.0%; P < 0.05). Females consistently had fewer AMI diagnosis than males (3.6% vs. 5.2%, d = 1.3%, CI: 0.7-1.9%, P < 0.001). (b) In-hospital deaths for chest pain. Prior to COVID-19, females had fewer hospital deaths than males who presented with chest pain (1.4% vs. 1.9%, d = 0.5%, CI: 0.3-0.7%, P < 0.001). During the COVID-19 winter 2020 surge, deaths from those who presented with chest pain slightly increased (males: 2.4% vs. 1.9%, d = 1.1%, CI: 0.3-1.9%, P < 0.001; females: 2.4% vs. 1.4%, d = 1.0%, CI: 0.2-1.9%, P < 0.01). There was no significant difference in percentage of deaths between males and females during this time (2.9% vs. 2.4%, P > 0.05). **Statistical significance between males and females. *Statistical significance between time periods. AMI: acute myocardial infarction; COVID-19: coronavirus disease 2019.

1.0%, CI: 0.0-2.0%, P < 0.05). However, females continued to have fewer AMI diagnoses than males (3.6% vs. 5.2%, d = 1.3%, CI: 0.7-1.9%, P < 0.001) (Fig. 4a). Prior to COVID-19, females had fewer in-hospital deaths than males who presented with chest pain (1.4% vs. 1.9%, d = 0.5%, CI: 0.3-0.7%, P < 0.001). During the COVID-19 alpha surge, deaths from those who presented with chest pain slightly increased compared to pre-COVDI-19 (males: 2.4% vs. 1.9%, d = 1.1%, CI: 0.3-1.9%, P < 0.001; females: 2.4% vs. 1.4%, d = 1.0%, CI: 0.2-1.9%, P < 0.01). There was no significant difference in proportions of deaths between males and females during the pandemic. Mortality rates returned back to pre-COVID-19 levels after the lockdown was lifted (Fig. 4b).

Discussion

Ischemic heart disease continues to remain the leading cause of morbidity and mortality in both males and females. Some progress has been made to improve health care disparities in females, but females continue to receive fewer diagnoses, delay in diagnosis and treatment, and overall suboptimal care. Our results demonstrated that during the pandemic, females, especially Asian female, presented in fewer numbers to the ED with chest pain or chest pain equivalent symptoms compared to the pre-pandemic time point. We also discovered that disparities in management of chest pain and diagnosis of AMI persisted throughout COVID-19 and remained similar when compared to pre-COVID-19. Both males and females were more likely to be diagnosed with AMI and die during index hospitalization of the initial alpha surge.

In this study, we found that the COVID-19 pandemic considerably decreased the number of chest pain presentations to the RR UCLA ED. This is consistent with prior studies showing a decrease in the number of total ED encounters by an average of 42%. The CDC also reported in 2020 that ED visits for chest pain and AMI decreased from January 2019 to May 2020 [23]. A study in Brazil also showed that ED visits for chest pain dropped substantially during COVID-19 with women presenting less than men, although they did not compare management of chest pain between men and women during this time [24]. We also re-demonstrated the finding that females were receiving less cardiac workup and AMI diagnoses than males before the COVID-19 pandemic. This was similar to several studies performed before the COVID-19 pandemic, including by Mnatzaganian et al in Australia, who showed that women were less likely to have troponins performed or admitted to a specialized unit for their chest pain [25]. Other groups including Preciado et al [5], Shin et al [3], and Banco et al [6], all showed similar findings of females receiving less cardiac workup for their chest pain when compared to males. However, these studies were all done in the era before the COVID-19 pandemic. We further showed that during the pandemic, females were less likely than males to present to the ED with chest pain or chest pain-related symptoms. It is unclear why females presented less than males during the initial months of the pandemic. Possible reasons include that females were more adherent to the "stay-at-home" order and only presented to the ED when absolutely necessary. Another reason could be that females were reluctant to go to the ED because they have been told in the past their symptoms are due to anxiety or stress. Other possibilities include females were providing childcare since children were now staying at home, or that more females are in the healthcare industry, working long hours and in difficult conditions during the early COVID-19

months. Further studies are needed to address the reasons why females were more impacted during the most recent pandemic. Furthermore, Asian females were least likely to present to the ED during the COVID-19 pandemic. It is unclear why Asians females were most affected during the pandemic. It is possible that Asians females were more fearful of contracting COVID-19 and willing to endure their anginal symptoms rather than going to the hospital. It is also conceivable that Asian females were unwilling to present to the ED due to the initial stigma surrounding the COVID-19 virus. It is also unknown whether the management and outcomes of Asian females were affected by the pandemic when compared to pre-COVID-19. In addition, we acknowledge that the Asian race is very broad and encompasses many different ethnic groups which have different prevalence and presentation of angina. Future studies will look into the management and outcomes of chest pain encounters between different races and ethnicities.

During the initial pandemic lockdown and surge, we found that providers were more likely to order cardiac testing in patients who presented with chest pain including troponin orders and echocardiograms. However, females consistently were less likely to undergo cardiac testing during all time points. Both males and females were more likely to be admitted to the hospital during the initial surge and lockdown, but females consistently were less likely to be admitted to the hospital across all time points. Interestingly, despite increased cardiac testing during initial surge, the proportion of cardiac catheterizations performed remained comparable throughout all time points, likely a reflection of reduced overall cardiac procedures for non-emergent presentations from the RR UCLA procedural services during the initial surge. Not surprisingly, the proportion of patients diagnosed with AMI increased for both sexes at the time, most likely given the increase in cardiac testing. Despite increase in cardiac testing during lockdown and surge, females still were less likely to be diagnosed with AMI compared to males, yet in-hospital mortality was similar between males and females. Unfortunately, exact cause of death during index hospitalization is unknown and a limitation of this study.

Our study has several other limitations. First, this was a retrospective study with reliance on the International Classification of Disease, 10th Revision (ICD-10) and Current Procedural Terminology (CPT) codes. Thus, there is a possibility that cases and cardiac workup were inadvertently excluded if the physician did not document the appropriate diagnosis, if there was inaccurate coding, or if patients died prior to a diagnosis being made. In addition, we are unable to control the provider's variability in clinical judgement and desire to perform testing, or a patient's willingness to undergo workup and management. However, we hope that given the large number of patients in our study, this particular bias would be spread equally between the different sexes and races. Future prospective studies controlling for specific providers would be helpful to mitigate this limitation. We did not collect data on the level of troponins or results of echocardiography which may influence subsequent testing and management. We also did not collect data on out-of-hospital deaths, and it is possible that patients who were discharged from the ED without a cardiac diagnosis for their chest pain, died at home or a different hospital from AMI. Due to the large and retrospective nature of our study, we did not utilize major adverse cardiac event (MACE) as a primary outcome, and future prospective studies would need to be done to obtain accurate data on MACE. Our study was a single-center analysis and therefore we are unable to generalize or extrapolate our findings to other hospitals or nationwide. Although UCLA Health accepts most medical insurances, including Medicare and Medi-Cal (California's Medicaid program), it still needs to navigate in- and out-of-network insurances, and therefore stable patients may require transfer to an in-network center rather than be admitted for their chest pain. This could potentially affect our admissions data. However, it should not affect our results of chest pain encounters and initial cardiac workup, as these would be completed in the ED prior to a potential transfer. In addition, those who are diagnosed with AMI would likely be deemed unstable for transfer and also would be included in our admissions data. Finally, UCLA Ronald Reagan Medical Center is situated in Westwood, Los Angeles and local demographics may impact trends in presentation and therefore may not be applicable on a national level. Further studies looking at different hospitals and national databases would be helpful.

Looking into the future, we are encouraged to see that health care disparities between males and females seem to be improving regarding AMI workup. A study in 2016 by Ruane et al [26] in Australia showed similarities in management and outcomes between male and female chest pain patients, suggesting improvement in sex disparities. In our study, in the most current state (post-COVID-19 surges), not only are females presenting again in similar proportions as males to the ED, the differences in some cardiac testing (troponins and echocardiograms) between males and females are no longer significant. More long-term follow-up is needed to confirm this finding. Although females are still less likely than males to receive care for their cardiac symptoms, this recent trend towards equality is a promising first step and likely a reflection of increased public awareness and education.

Supplementary Material

Suppl 1. Percentage of chest pain encounters where IV heparin (A) or aspirin (B) was given.

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Conflict of Interest

None to declare.

Informed Consent

Informed consent was waived for this retrospective cohort study.

Author Contributions

XH contributed to study design, engaged in data collection, analyzed and interpreted the data, and drafted the manuscript. EF contributed to study design, engaged in data collection, analyzed and interpreted the data, and contributed to drafts the manuscript. NJJ engaged in data collection, analyzed and interpreted the data, and contributed to drafts of the manuscript. GD and IL analyzed and interpreted the data and contributed to drafts of the manuscript. LBM, RJC, TBH, KEW, and JBS interpreted the data and provided critical reviews of the manuscript. NS and MCP designed the study, analyzed and interpreted data, and provided critical review of the manuscript.

Data Availability

Any inquiries regarding supporting data availability of this study should be directed to the corresponding author.

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