ORIGINAL RESEARCH

Sex disparities in the assessment and outcomes of chest pain presentations in emergency departments

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ABSTRACT

Objective To determine whether sex differences exist in the triage, management and outcomes associated with non-traumatic chest pain presentations in the emergency department (ED).

Methods All adults (≥ 18 years) with non-traumatic chest pain presentations to three EDs in Melbourne, Australia between 2009 and 2013 were retrospectively analysed. Data sources included routinely collected hospital databases. Triage scoring of the urgency of presentation, time to medical examination, cardiac troponin testing, admission to specialised care units, and in-ED and in-hospital mortality were each modelled using the generalised estimating equations approach.

Results Overall 54 138 patients (48.7% women) presented with chest pain, contributing to 76 216 presentations, of which 26 282 (34.5%) were cardiac. In multivariable analyses, compared with men, women were 18% less likely to be allocated an urgency of 'immediate review' or 'within 10 min review' (OR=0.82, 95% CI 0.79 to 0.85), 16% less likely to be examined within the first hour of arrival to the ED by an emergency physician (0.84, 0.81 to 0.87), 20% less likely to have a troponin test performed (0.80, 0.77 to 0.83), 36% less likely to be admitted to a specialised care unit (0.64, 0.61 to 0.68), and 35% ($p=0.039$) and 36% ($p=0.002$) more likely to die in the ED and in the hospital, respectively.

Conclusions In the ED, systemic sex bias, to the detriment of women, exists in the early management and treatment of non-traumatic chest pain. Future studies that identify the drivers explaining why women presenting with chest pain are disadvantaged in terms of care, relative to men, are warranted.

INTRODUCTION

Globally, coronary artery disease (CAD) is a leading cause of death and disability, responsible for 15% and 20% of all deaths in women and men, respectively.^{1–3} Moreover, there is accumulating evidence that, irrespective of age, women with CAD experience worse short-term and long-term outcomes relative to similarly affected men.^{4–7}

Sex differences in outcome in the clinical presentation for CAD, its early detection and clinical management have been previously reported.^{7–12} Women wait longer than men before seeking medical advice for coronary symptoms,⁶ which may be further exacerbated by a greater delay in the evaluation and treatment of their coronary symptoms.⁸ Further, women who present to the emergency department (ED) with chest pain are treated

less aggressively than men with similar conditions, are less likely than men to undergo an ECG or have their cardiac enzymes tested,⁹ and are less likely than men to undergo a percutaneous coronary intervention,¹⁰ or be admitted to a coronary care unit (CCU) or an intensive care unit (ICU).¹¹ Furthermore, in patients diagnosed with coronary heart disease (CHD), women are less likely than men to be prescribed with recommended medications.¹²

To date, the reported literature on sex differences in triage categorisation in those presenting with chest pain has been inconsistent,^{9–13} with most focusing on its late management.¹⁴ Further, it is uncertain whether, among individuals who present with chest pain, delay in time to medical examination is associated with increased in-hospital mortality, and if so if this differs by sex.

In this 5-year, population-based panel study, we investigated risk-adjusted sex differences between women and men presenting with non-traumatic chest pain for the following outcomes: urgency score allocation by triage nurses, time to examination by ED physicians, cardiac troponin testing, admission to a specialised care unit, and in-ED and in-hospital mortality.

METHODS**Study population and design**

All adults (≥ 18 years) who presented with non-traumatic chest pain presentations to three EDs in metropolitan Melbourne, Australia between January 2009 and December 2013 were included in this unbalanced panel analysis. Cases were identified using the International Classification of Diseases, 10th Revision (Australian Modification) (ICD-10-AM) codes R07.1, R07.2, R07.3 and R07.4. To be included, the patient needed to have presented with chest pain either as the main or secondary symptom. Patients presenting with chest pain due to trauma or other injury were excluded.

Study variables

Information on sociodemographics, symptoms, arrival mode, arrival time and day of week, nursing and medical management items, diagnoses, admission status, and hospital admitting ward on departure from the ED was collected from ED routinely collected data. The three EDs participating in this study used the same electronic database (Symphony V.2.29, Ascribe, Bolton, UK). In-ED and in-hospital mortality were ascertained from the hospital electronic administrative records. The classification of

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the acute myocardial infarction (AMI) to ST elevation myocardial infarction (STEMI) or non-ST elevation myocardial infarction (NSTEMI) was based on ICD-10 codes I20.0, I20.1, I20.2, I20.3, I20.4 and I20.9.

We constructed a relative index of inequality (RII)¹⁵ of socioeconomic disadvantage using the residential postcode-based Socio-Economic Indexes For Areas.¹⁶ The estimated index was further categorised into tertiles according to its distribution in the sample.

Patient-level management variables for each presentation included the following: (1) allocation of a time-based triage urgency score by the triage nurse, using the validated Australasian Triage Scale (ATS)¹⁷—the ATS defines the time to definitive medical review: ATS 1, immediate; ATS 2, within 10 min; ATS 3, within 30 min; ATS 4, within 60 min; or ATS 5, within 120 min; (2) the actual time from the patient's arrival to the ED to examination by a physician; (3) ordering cardiac troponin blood tests; and (4) discharge or admission to a medical ward, ICU or CCU.

Statistical analysis

Descriptive

Sex differences in patient characteristics were compared using Pearson's χ^2 tests for categorical variables, and t-tests compared the means. The comparisons were conducted by the median age of the study participants on their first presentation to the ED during the study period, as this age approximately differentiated between premenopausal and postmenopausal women in this sample.¹⁸

Multivariable analyses

The multivariable analyses were constructed across all 5-year chest pain presentations for the following study outcomes: (1) ATS urgency scoring for chest pain as demanding an 'immediate review' or 'within 10 min review'; (2) examination by a physician within the first hour of arrival to the ED; (3) ordering troponin blood test; (4) admission to ICU or CCU; and (5) in-ED mortality and (6) in-hospital mortality among admitted patients. A binomial regression modelled each outcome using the generalised estimating equations (GEE) approach.¹⁹ An exchangeable working covariance matrix was used to account for correlation and dependence between repeated measurements on the same individual over time across all presentations.

Covariates associated with study outcomes at $p < 0.2$ (in the univariate analyses) were introduced into the multivariable model, which compared women and men adjusting for age, RII, time of presentation, day of the week, urgency of presentation, time to medical examination, admission department, hospital bed size, known comorbidities and acute diagnoses associated with the chest pain presentation. The multivariable models were constructed separately for those aged 18–54 and ≥ 55 years. However, since mortality was an uncommon event in the younger age group, the mortality models were run on the whole sample including all age groups.

The goodness of fit of each multivariable GEE model was tested using the quasi-likelihood under independence model criterion (QIC), comparing models that adjusted for age with full models. Lower values of QIC indicated better model fit to the data.²⁰

Sensitivity analyses were conducted by hospital type. The forest plot was constructed using a random-effect model. All statistical analyses were performed using Stata V.15.

RESULTS

Descriptive characteristics of study subjects

A total of 54 138 individuals (48.7% women) presented with chest pain, of whom 42 676 (78.8%) presented once, 7296 (13.5%) presented twice, and the remaining 4166 (7.7%) presented ≥ 3 times within the three hospitals, altogether contributing to 76 216 chest pain presentations. Patient characteristics on first encounter varied by sex in the overall sample and when stratified by median age (table 1). In both age groups, chest pain was the primary symptom in both women (81.5% in those aged 18–54 years and 75.1% in those aged ≥ 55 years) and men (85.1% and 78.4%, respectively) across all 5-year presentations.

The length of stay in the ED was longer for women than for men. Irrespective of urgency of chest pain presentation, women were significantly more likely to stay longer in the ED compared with men (6.9 (SD 5.2) hours in women vs 6.7 (SD 5.3) hours in men; $p < 0.001$).

Of the 76 216 chest pain presentations, 26 282 (34.5%) had a cardiac cause. Of the 54 138 presenting men and women, 5011 (9.2%) were diagnosed with an AMI (32.5% women), of whom STEMI was diagnosed in 1253 (25.0%) patients, less commonly diagnosed in women (18.1%) than in men (28.3%) ($p < 0.001$).

Triage urgency allocation score

ATS urgency scoring for chest pain varied by sex irrespective of age or subsequent diagnosis of AMI. Among the 18–54 years age group, triage nurses rated chest pain presentation in women significantly less urgent than in men, with 37.2% of women allocated an urgency of 'immediate review' or 'within 10 min review' compared with 45.3% in men ($p < 0.001$). This difference was largest in patients subsequently diagnosed with AMI (65.8% in women vs 76.1% in men; $p < 0.001$). Similar findings were observed in patients aged ≥ 55 years, being 47.4% in women compared with 52.6% in men ($p < 0.001$). The latter differences were largest in patients subsequently diagnosed with AMI (51.5% in women vs 64.2% in men; $p < 0.001$).

Sex differences in the triage urgency scoring were also observed when chest pain presentations were stratified by troponin testing, with the largest differences observed in patients subsequently diagnosed with AMI (table 2).

A similar pattern was observed in the multivariate analyses. Women aged 18–54 years were approximately 20% less likely than men to be allocated an 'immediate' or 'within 10 min' time to definite medical review (OR=0.79, 95% CI 0.76 to 0.83; $p < 0.001$). The corresponding sex difference in those aged ≥ 55 years was 10% (0.90, 0.86 to 0.95; $p < 0.001$) (table 3A).

Time to clinical examination

Women waited longer than men to be examined by an ED physician, irrespective of age, urgency of presentation or subsequent diagnosis of AMI. In all presentations, 55.8% and 61.4% of women and men ($p < 0.001$), respectively, were examined by a physician within 1 hour of arrival to the ED. This difference was largest in patients subsequently diagnosed with AMI irrespective of age group: in patients aged 18–54 years old, the corresponding estimates were 75.0% vs 85.3% in women and men, respectively ($p < 0.001$); and in patients aged ≥ 55 years, the estimates were 63.5% vs 72.2%, respectively ($p < 0.001$).

The overall sex mean difference (MD) in time to medical examination in minutes, comparing women with men, was 0.15 (95% CI 0.13 to 0.17; $p < 0.001$). Sex differences were also observed after stratifying by urgency of chest pain presentation

Table 1 Patient covariates by sex and median* age on first chest pain presentation

Covariate	Ages 18–54 years			Ages 55+ years		
	Women n=13 452 (47.4%)	Men n=14 932 (52.6%)	P value	Women n=12 918 (50.2%)	Men n=12 836 (49.8%)	P value
Age, mean (SD)	38.5 (10.3)	39.2 (10.1)	<0.001	71.0 (10.5)	69.4 (9.8)	<0.001
SES by tertiles of RII, %			0.051			0.441
Low SES (first tertile)	38.4	39.5		39.0	38.8	
Middle SES (second tertile)	29.6	28.3		26.2	26.9	
High SES (third tertile)	32.1	32.2		34.8	34.3	
Main presenting sign or symptom, %			<0.001			<0.001
Chest pain	82.2	85.9		75.1	77.2	
Arrhythmia/altered consciousness	13.0	10.4		19.4	17.3	
Shortness of breath	1.8	1.2		2.2	2.5	
Musculoskeletal pain	3.0	2.5		3.4	2.9	
Arrived to ED by ambulance, %	29.0	29.4	0.384	60.6	58.3	<0.001
Triage urgency score of chest pain presentation, %			<0.001			<0.001
Review immediately (ATS 1) or within 10 min of arrival to ED (ATS 2)	35.5	44.2		46.4	52.8	
Review within 30–120 min of arrival to ED (ATS 3–5)	64.5	55.8		53.6	47.2	
Time from arrival to the ED until examination by physician, %			<0.001			<0.001
Up to 15 min	23.0	29.3		27.6	34.2	
16–30 min	13.3	14.4		13.6	13.3	
31–45 min	9.7	9.0		9.4	9.2	
46–60 min	7.6	7.1		7.0	7.0	
More than 1 hour	46.3	40.2		42.5	36.2	
Diagnosed with AMI, %			<0.001			<0.001
No	98.2	94.0		91.0	83.6	
Yes, non-ST segment elevation AMI	1.4	4.1		7.4	11.9	
Yes, ST segment elevation AMI	0.4	1.9		1.6	4.5	
Admission to hospital, %			<0.001			<0.001
No, patient discharged home from the ED	88.9	81.2		61.8	49.6	
Yes, admitted to a medical ward	7.0	8.4		24.2	25.0	
Yes, admitted to CCU or ICU	4.1	10.4		14.0	25.4	

*The median age of study participants on their first encounter was chosen as it approximately differentiated between premenopausal and postmenopausal women in the study sample.

AMI, acute myocardial infarction; ATS, Australasian Triage Scale; CCU, coronary care unit; ED, emergency department; ICU, intensive care unit; RII, relative index of inequality; SES, socioeconomic status.

(0.07, 0.05 to 0.10, $p<0.001$, in less urgent presentations; and MD=0.093, 95% CI 0.07 to 0.11, $p<0.001$, in presentations demanding immediate or within 10 min review). On average it

took between 5 and 10 min longer for women to be examined by a physician compared with men ($p<0.001$ in both younger and older age groups).

Table 2 Triage urgency scoring of chest pain presentation and time to examination by a physician from arrival to ED by sex: all presentations and presentations subsequently diagnosed with an AMI

	Troponin test ordered (all presentations) n=53 277 chest pain presentations			Troponin test not ordered (all presentations) n=22 939 chest pain presentations		
	Women	Men	P value	Women	Men	P value
Chest pain presentations allocated an ATS score of 1 'demanding immediate review' or ATS score of 2 'demanding review within 10 min', %	49.6	54.8	<0.001	28.3	33.4	<0.001
Medical examination by a physician within one hour from arrival to the ED, %	57.7	62.8	<0.001	52.0	57.7	<0.001
	Troponin test ordered (presentations subsequently diagnosed with AMI) n=4682 chest pain presentations			Troponin test not ordered (presentations subsequently diagnosed with AMI) n=780 chest pain presentations		
	Women	Men	P value	Women	Men	P value
Chest pain presentations allocated an ATS score of 1 'demanding immediate review' or ATS score of 2 'demanding review within 10 min', %	50.8	64.9	<0.001	73.8	83.9	0.001
Medical examination by a physician within one from arrival to the ED, %	62.0	72.9	<0.001	87.6	93.6	0.005

AMI, acute myocardial infarction; ATS, Australasian Triage Scale; ED, emergency department.

Table 3 Urgency allocation of a chest pain presentation as ATS 1 'immediate review' or ATS 2 'within 10 min review' by median age* (A) and examination by physician within the first hour of arrival to the emergency department by median age* (B) multivariable binomial regression† using the GEE approach

Covariates	(A) Urgency score allocation models				(B) Examination by physician models			
	Ages 18–54 n=37 307 presentations		Ages 55+ n=38 909 presentations		Ages 18–54 n=37 307 presentations		Ages 55+ n=38 909 presentations	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Age categories								
First tertile (youngest category) (reference)	1.00		1.00		1.00		1.00	
Second tertile	2.21 (2.09 to 2.34)	<0.001	0.90 (0.85 to 0.95)	<0.001	0.99 (0.94 to 1.06)	0.861	0.96 (0.91 to 1.02)	0.226
Third tertile (oldest category)	3.00 (2.81 to 3.18)	<0.001	0.77 (0.72 to 0.81)	<0.001	0.98 (0.92 to 1.04)	0.534	0.91 (0.85 to 0.97)	0.003
Female sex	0.79 (0.75 to 0.83)	<0.001	0.90 (0.86 to 0.95)	<0.001	0.85 (0.81 to 0.89)	<0.001	0.83 (0.79 to 0.87)	<0.001
Socioeconomic disadvantage score	–	–						
Low SES (first tertile) (reference)			1.00		1.00		1.00	
Middle SES (second tertile)			0.97 (0.91 to 1.03)	0.278	1.02 (0.96 to 1.08)	0.677	1.06 (0.99 to 1.13)	0.055
High SES (third tertile)			0.89 (0.84 to 0.94)	<0.001	1.07 (1.00 to 1.14)	0.039	1.06 (0.99 to 1.13)	0.068
Arrival by ambulance	0.73 (0.70 to 0.77)	<0.001	0.58 (0.55 to 0.61)	<0.001	1.19 (1.13 to 1.26)	<0.001	1.35 (1.28 to 1.42)	<0.001
Main presenting sign or symptom								
Musculoskeletal pain (reference)	1.00		1.00		1.00		1.00	
Chest pain	6.36 (5.20 to 7.76)	<0.001	8.55 (7.13 to 10.3)	<0.001	0.01 (0.87 to 1.16)	0.918	1.12 (0.97 to 1.29)	0.121
Arrhythmia/altered consciousness	3.25 (2.60 to 4.06)	<0.001	4.81 (3.96 to 5.85)	<0.001	1.17 (0.98 to 1.39)	0.084	1.44 (1.22 to 1.69)	<0.001
Shortness of breath	1.89 (1.41 to 2.55)	<0.001	2.11 (1.66 to 2.68)	<0.001	0.84 (0.66 to 1.07)	0.162	1.16 (0.94 to 1.32)	0.157
Urgency ATS score allocation of 1 'immediate review' or 2 'review within 10 min'	–	–	–	–	9.65 (5.90 to 15.78)	<0.001	9.13 (8.64 to 9.64)	<0.001
AMI								
No (reference)	1.00		1.00		1.00		1.00	
Yes, non-ST segment elevation AMI	2.49 (2.16 to 2.87)	<0.001	1.57 (1.44 to 1.70)	<0.001	2.23 (1.86 to 2.66)	<0.001	1.36 (1.24 to 1.49)	<0.001
Yes, ST segment elevation AMI	8.63 (6.39 to 11.6)	<0.001	9.27 (7.49 to 11.5)	<0.001	9.65 (5.90 to 15.78)	<0.001	9.24 (6.81 to 12.55)	<0.001
QIC for model adjusting for age	48 660.4		53 692.1		50 500.1		51 366.0	
QIC for full model	38 939.6		41 009.2		29 601.5		32 222.3	

*The median age of study participants on their first encounter was chosen as it approximately differentiated between premenopausal and postmenopausal women in the study sample.

†Models were also adjusted for comorbidities: angina pectoris, chronic heart disease and chronic respiratory disease; acute conditions associated with chest pain: cardiopulmonary arrest, acute respiratory and neurological conditions, and emotional and mental disorders; hospital; and day during week and hour of presentation.

AMI, acute myocardial infarction; ATS, Australasian Triage; GEE, generalised estimating equations; QIC, quasi-likelihood under independence model criterion; SES, socioeconomic status.

Similar findings were observed when the presentations were stratified by cardiac troponin testing, with the largest difference observed in those who were subsequently diagnosed with AMI (table 2).

In multivariable analyses, women aged 18–54 years were 15% less likely than men to be examined by a physician within the first hour of arrival to the ED (OR=0.85, 95% CI 0.81 to 0.89; $p<0.001$). The corresponding sex difference in those aged ≥ 55

years was 17% (OR=0.83, 95% CI 0.79 to 0.87; $p<0.001$) (table 3B).

Cardiac troponin testing and admission to a specialised unit

In individuals aged 18–54 years, women were significantly less likely to have a cardiac troponin test compared with men (54.8% vs 64.8%; $p<0.001$) and so too in those aged ≥ 55 years (77.9%

Table 4 Cardiac troponin blood assay by median age*: multivariable binomial regression† using the GEE approach

Covariates	Ages 18–54 n=37 307 presentations		Ages 55+ n=38 909 presentations	
	OR (95% CI)	P value	OR (95% CI)	P value
Age categories				
First tertile (youngest category) (reference)	1.00		1.00	
Second tertile	2.41 (2.28 to 2.54)	<0.001	1.15 (1.08 to 1.23)	<0.001
Third tertile (oldest category)	3.07 (2.88 to 3.26)	<0.001	1.23 (1.15 to 1.32)	<0.001
Female sex				
Arrival by ambulance	0.73 (0.70 to 0.77)	<0.001	0.91 (0.87 to 0.97)	0.001
Main presenting sign or symptom				
Musculoskeletal pain (reference)	1.00		1.00	
Chest pain	1.22 (1.05 to 1.39)	0.008	1.30 (1.12 to 1.50)	<0.001
Arrhythmia/altered consciousness	0.56 (0.48 to 0.66)	<0.001	0.41 (0.35 to 0.48)	<0.001
Shortness of breath	1.14 (0.91 to 1.43)	0.263	1.32 (1.04 to 1.66)	0.020
Urgency ATS score allocation of 1 'immediate review' or 2 'review within 10 min'	2.49 (2.37 to 2.62)	<0.001	1.60 (1.51 to 1.69)	<0.001
AMI				
No (reference)	1.00		1.00	
Yes, non-ST segment elevation AMI	2.46 (2.02 to 3.01)	<0.001	2.30 (2.03 to 2.60)	<0.001
Yes, ST segment elevation AMI	0.73 (0.57 to 0.92)	0.009	0.54 (0.46 to 0.63)	<0.001
QIC for model adjusting for age	50678.7		39921.1	
QIC for full model	37879.9		26712.3	

*The median age of study participants on their first encounter was chosen as it approximately differentiated between premenopausal and postmenopausal women in the study sample.

†Models were also adjusted for comorbidities: angina pectoris, chronic heart disease and chronic respiratory disease; acute conditions associated with chest pain: cardiopulmonary arrest, acute respiratory, gastrointestinal and neurological conditions, and emotional and mental disorders; hospital; and day during week and hour of presentation.

AMI, acute myocardial infarction; ATS, Australasian Triage; GEE, generalised estimating equations; QIC, quasi-likelihood under independence model criterion.

vs 80.7%; $p<0.001$). These sex differences remained in the multivariable models (table 4).

Of the 76 216 presentations, 22 880 (30.0%) were admissions to hospital, with women significantly less likely than men to be admitted to an ICU or CCU. This effect was observed across the different age groups and irrespective of type of AMI (figure 1). In the multivariable analysis, sex was an independent factor associated with admission to such specialised units, with women being

approximately a third less likely than men to be admitted to ICU or CCU (OR=0.69, 95% CI 0.62 to 0.77, $p<0.001$, in those aged 18–54 years; OR=0.66, 95% CI 0.62 to 0.71, $p<0.001$, in those aged ≥ 55 years).

Sex differences in in-ED and in-hospital mortality

Of the 54 138 individuals presenting with chest pain to the ED, 858 (1.6%) died. Of these, 242 (45.5% women) died in the ED and the remaining 616 (43.8% women) died during hospital admission. The overall unadjusted in-hospital mortality was lower in women than in men (1.4% in women vs 1.7% in men; $p=0.009$).

Among patients who died, compared with men, the proportions of women triaged to lower urgency scores (27.1% in women vs 17.8% in men; $p=0.001$), or examined after 1 hour of arrival to ED (19.5% in women vs 12.6% in men; $p=0.006$), or admitted to medical wards (64.5% in women vs 53.8% in men; $p=0.002$) were significantly higher, as shown in online supplementary appendix 1.

Risk-adjusted multivariable analyses showed that women were more likely than men to die in the ED (OR=1.35, 95% CI 1.02 to 1.79; $p=0.039$) (table 5, model A), and among admitted patients women were 36% more likely than men to die in the hospital following admission (OR=1.36, 95% CI 1.12 to 1.66; $p=0.002$) (table 5, model B). Among the 5011 patients admitted for an AMI, women were 48% more likely than men to die in the hospital (OR=1.48, 95% CI 1.07 to 2.06; $p=0.018$). In patients diagnosed with AMI, in-hospital mortality was higher in women with NSTEMI (4.3% in women vs 2.0% in men; $p<0.001$) and with STEMI (7.6% in women vs 4.0% in men; $p=0.009$).

In all multivariable models, no interactions between variables were found.

Figure 1 Admission to ICU or CCU by median age and emergency department diagnosis of acute myocardial infarction: OR (95% CI), comparing women with men. AMI, acute myocardial infarction; CCU, coronary care unit; ICU, intensive care unit; NSTEMI, non-ST elevation myocardial infarction; STEMI, ST elevation myocardial infarction.

Table 5 In-ED mortality (model A) and in-hospital mortality (model B) following a non-traumatic chest pain presentation in the ED using the GEE approach

	Model A: in-ED mortality n=76 216 presentations			Model B: in-hospital mortality n=22 880 hospital admissions		
	OR	95% CI	P value	OR	95% CI	P value
Age quintiles (years)						
18–44 (reference)	1.00			1.00		
45–54	1.05	0.55 to 2.01	0.883	0.81	0.51 to 1.27	0.352
55–64	1.19	0.65 to 2.16	0.577	1.02	0.68 to 1.54	0.909
65–74	2.08	1.21 to 3.57	0.008	1.54	1.05 to 2.26	0.028
75+	4.30	2.63 to 7.06	<0.001	2.42	1.69 to 3.47	<0.001
Female sex	1.35	1.02 to 1.79	0.039	1.36	1.12 to 1.66	0.002
Socioeconomic disadvantage score tertiles	–	–	–			
Low SES (first tertile) (reference)				1.00		
Middle SES (second tertile)				0.93	0.74 to 1.18	0.551
High SES (third tertile)				0.79	0.63 to 0.99	0.050
Arrival by ambulance	2.16	1.36 to 3.44	0.001	2.49	1.81 to 3.43	<0.001
Main presenting sign or symptom						
Musculoskeletal pain (reference)	1.00			1.00		
Chest pain	0.10	0.05 to 0.20	<0.001	0.31	0.18 to 0.55	<0.001
Arrhythmia/altered consciousness	0.87	0.43 to 1.74	0.693	1.05	0.58 to 1.91	
Shortness of breath	1.04	0.48 to 2.26	0.924	1.12	0.57 to 2.20	0.877 0.736
Urgency ATS score allocation of 1 'immediate review' or 2 'review within 10 min'	3.36	2.05 to 5.49	<0.001	1.86	1.43 to 2.44	<0.001
Examined by physician within 1 hour from arrival to ED	2.66	1.46 to 4.85	0.001	1.38	1.04 to 1.84	0.025
AMI						
No (reference)	1.00			1.00		
Yes, non-ST segment elevation AMI	2.13	1.27 to 3.59	0.004	0.47	0.33 to 0.67	<0.001
Yes, ST segment elevation AMI	3.47	1.78 to 6.77	<0.001	0.62	0.41 to 0.95	0.028
Cardiorespiratory arrest on arrival to ED	25.0	15.71 to 39.93	<0.001	4.35	3.03 to 6.25	<0.001
Chronic angina pectoris	–	–	–	0.08	0.05 to 0.15	<0.001
Chronic ischaemic heart disease or failure	0.83	0.34 to 1.99	0.669	0.20	0.12 to 0.33	<0.001
Chronic respiratory disease	–	–	–	0.71	0.48 to 1.05	0.084
Acute gastrointestinal illness	–	–	–	0.58	0.28 to 1.17	0.130
Acute neurological conditions including stroke	–	–	–	2.52	1.40 to 4.52	0.002
Chest pain without a differential diagnosis	–	–	–	0.20	0.12 to 0.33	<0.001
Admission to ICU/CCU	–	–	–	1.61	1.28 to 2.02	<0.001
Hospital						
A	1.00			1.00		
B	1.07	0.63 to 1.83	0.806	2.48	1.53 to 4.02	<0.001
C	0.98	0.58 to 1.66	0.933	2.70	1.68 to 4.35	<0.001
QIC for model adjusting for age	5683.1			9678.8		
QIC for full model	3410.0			4501.3		

AMI, acute myocardial infarction; ATS, Australasian Triage Scale; CCU, coronary care unit; ED, emergency department; GEE, generalised estimating equations; ICU, intensive care unit; QIC, quasi-likelihood under independence model criterion; SES, socioeconomic status.

Comparing initial models that only included age with full models as presented in [tables 3–5](#), model fit improved in all analyses.

Sensitivity analyses

The three participating hospitals serve uniquely different metropolitan subpopulations in Victoria, Australia.²¹ To test for consistency, we further separately tested all study outcome measures by each hospital, with results consistently supporting the evidence for sex bias in the assessment and management of chest pain in the ED (online supplementary appendix 2).

DISCUSSION

This large population-based study provides evidence that sex disparities, to the detriment of women, exist in the early stages of

assessment and management of non-traumatic chest pain presentations in the ED. These disparities, which could not be explained by known confounders, were present in both older and younger age groups and were particularly pronounced among individuals subsequently diagnosed with an AMI. On presentation, men were consistently prioritised over women: compared with men, women were less likely overall to be allocated an urgency score warranting an 'immediate review' or 'within 10 min review', less likely to be examined by an ED physician within the first hour of arrival to the ED and less likely to have a cardiac troponin blood test. Women were also less likely to be admitted to an ICU or CCU, and when admitted to the hospital women were more likely to die in the hospital than men. Sex differences in

mortality were not explained by patients' age, known comorbidities, severity of illness and treating hospital.

The clinical management of non-traumatic chest pain is considered a medical emergency until all life-threatening causes have been ruled out.²² In the ED, the nurse triaging the patient is the first clinical contact for a presenting patient and is the first to assess the urgency and seriousness of such presentations.²³ Investigating whether sex bias exists at this early critical phase of clinical priority allocation is important to ensure equality of care and optimisation of outcomes in both women and men. This is the first population-based study to demonstrate the existence of significant sex bias in the early phases of assessment of chest pain. This bias was consistently observed across different patient age groups, presentation urgency levels and diagnosis of AMI. As more than 90% of nurses in the ED in Australia are women,²⁴ the sex bias is unlikely to be due to discordance in the sex of the patient and the triage nurse. The detected sex bias may have its origins in the well-documented biological, physiological and psychosociological sex differences in the presentation, diagnosis and subsequent management of CHD. Compared with men, women typically have smaller conduit arteries with less compliance,²⁵ and in women CHD occurs more frequently as a result of spasm and endothelial microvascular dysfunction than that seen in men. This biological sex difference may lead to a poorer prognosis in women, but it does not justify poorer assessment of such women presenting with a suspected CHD. Another major difference between the sexes relates to the cardioprotective properties of oestrogen and its immunomodulation of the inflammatory response in arteriosclerosis seen in younger women, with risk of ischaemic heart disease in women considerably rising following menopause.²⁶ These, together with the more atypical gastrointestinal and musculoskeletal symptoms⁸ that are more observed in women (especially those <55 years of age),²⁷ may lead to suboptimal management, misdiagnosis or later diagnosis that all contribute to worse health outcomes, including higher mortality in women suffering with CHD. These sex differences are clinically important. Undertriaging of chest pain leads to delays in treatment and escalation of care to interventions such as angiography, which may cause larger infarct size and are associated with higher long-term mortality rates.²⁸

Strengths of this study include the longitudinal design and its population-based provenance, which improves the generalisability of the findings to the general population presenting to the ED with non-traumatic chest pain.

Limitations

Limitations of the study primarily relate to the available data, which restricted the ability to adjust for other than study available medical conditions. Medical management following hospital admission was not known to us. Information on mortality in the community following discharge was unknown, and therefore we could not comment whether this mortality varied by sex. The diagnoses used in this analysis were based on what was reported in the ED records and we had no access to inpatient records to further validate them against the diagnoses reached on hospital discharge. As with all observational studies, the potential for residual confounding remains.

CONCLUSIONS

From initial presentation to the ED with chest pain through to admission to a specialist ward, women were suboptimally managed relative to men. Integrating sex differences in health practice would be a crucial step in redressing this sex disparity.²⁹

Greater awareness of the presence of a sex bias in the management of individuals presenting to the ED with chest pain as well as strategies to mitigate this bias are warranted to optimise care for all patients treated in the ED, especially for women.

PATIENT INVOLVEMENT

All authors declare that, in this retrospective panel design that used routinely collected hospital data, patients/lay people/services users were not involved in the design or study objectives. The development of the research questions and the outcome measures were not informed by patients' priorities, experience or preferences. Dissemination of the results to study participants and/or patient organisations is not possible.

Key messages

What is already known on this subject?

- ▶ Sex bias in the evaluation of chest pain in the emergency department (ED) has been reported.
- ▶ Compared with men, women presenting to an ED with chest pain are less likely to undergo diagnostic and therapeutic invasive and non-invasive procedures.
- ▶ To date, studies that have evaluated sex differences in the assessment of chest pain in the ED have primarily focused on its late management.
- ▶ It remains unknown whether, on initial presentation with chest pain, sex differences exist in urgency score allocation by triage nurses or in time to medical examination by a physician.

What might this study add?

- ▶ This is the first population-based study to show that women presenting with chest pain are more likely to receive lower urgency scores compared with similarly affected men.
- ▶ Compared with men, women presenting with chest pain were 18% less likely to be allocated an urgency of 'immediate review' or 'within 10 minutes review'.
- ▶ Compared with men, women were 16% less likely to be examined by a physician within the first hour of arrival to the ED by an emergency physician and 20% less likely to have a troponin test performed.
- ▶ Compared with men, women were approximately one-third less likely to be admitted to a specialised care unit, one-third more likely to die in the ED, and when admitted to the hospital one-third more likely to die in the hospital.

How might this impact on clinical practice?

- ▶ This study provides evidence of significant sex bias in the early stages of chest pain assessment through to admission to a specialist ward.
- ▶ The integration of sex differences in health practice is crucial to redress sex disparities in the assessment and management of chest pain in the ED.

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