
**Contemporary Issues in Triage and Inhospital
Assessment and Management of Women's Acute
Coronary Syndrome in Victorian Public Hospitals: A
Retrospective Study**

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for the degree of Doctor of Philosophy**

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The *Diagnose and Manage Early*: Women's Ischaemia and Infarction (*DaME II*) Study

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List of abbreviations used in this thesis

Abbreviation	Definition
ABS	Australian Bureau of Statistics
ACEM	Australasian College for Emergency Medicine
ACS	acute coronary syndrome
ACU	Australian Catholic University
AIHW	Australian Institute of Health and Welfare
AMI	acute myocardial infarction
ATS	Australasian Triage Scale
CABG(S)	coronary artery bypass graft (surgery)
CaRT	Classification and regression tree
CENA	College of Emergency Nursing Australasia
CHD	coronary heart disease
CI	confidence interval
CP	chest pain
CSANZ	Cardiac Society of Australia and New Zealand
CVD	cardiovascular disease
D2B	door-to-balloon
D2N	door-to-needle
D2T	door-to-treatment
DHS	Department of Human Services, Victoria
DoH	Department of Health, Victoria
ECG	Electrocardiogram; electrocardiograph
ED	emergency department
H ₀	null hypothesis

ICD 10-AM	International Classification of Diseases and Related Health Conditions, 10 th Revision, Australian Modification
IHD	ischaemic heart disease
KPI	key performance indicator
MI	myocardial infarction
n	number
NHF	National Heart Foundation (of Australia)
NHMRC	National Health and Medical Research Council
NSTEACS	non-ST-segment elevation acute coronary syndrome
NSTEMI	non-ST-segment elevation myocardial infarction
NTS	National Triage Scale
p	probability
PCI	percutaneous coronary intervention
PTCA	percutaneous transluminal coronary angioplasty
SAP	stable angina pectoris
SD	standard deviation
SPSS	Statistical Package for the Social Sciences
ST	ST segment on electrocardiograph
STEMI	ST-segment elevation myocardial infarction
TnI; TnT	cardiac troponin I; cardiac troponin T
UA(P)	unstable angina (pectoris)
US; USA	United States of America
VAED	Victorian Admitted Episodes Dataset
VEMD	Victorian Emergency Minimum Dataset
VHIRS	Victorian Health Information Repositories System
WHO	World Health Organization

Glossary of terms used in this thesis

Term	Definition
Atherosclerosis; atherosclerotic disease	The build-up of plaque from accumulated cholesterol, fatty acids, calcium and cellular debris in blood vessel walls that restrict the flow of blood. The plaques can split, erode or break off and lead to embolus.
Australasian Triage Scale	A ranking system from 1 – 5 used in Australasian EDs to indicate <i>urgency</i> of a patient's need for medical and nursing care. ²
Coronary angiography	The insertion of a catheter through the patient's skin ('percutaneously') and into the coronary arteries to diagnose disease causing coronary artery narrowing.
Coronary artery bypass graft	The process of bypassing a blockage in a coronary artery surgically via grafting of an artery or vein from another part of the body to return blood flow to affected heart muscle.
Equality <i>n., pl. –ties.</i>	The state of being equal; correspondence in quality, degree, value, rank, ability, etc. ³
Equity <i>n., pl. –ties.</i>	1. The quality of being fair or impartial; fairness; impartiality. 2. That which is fair and just. ³
Expected (or 'correct') triage decision	The decision made by ED triage nurses commensurate with the assessed patient's level of <i>urgency</i> as determined by objective clinical and physiological indicators. The decision optimises access time to medical and nursing attention in relation to other waiting patients who have more, less or similarly urgent their needs. ⁴
Gender	Refers to the social and psychological attributes used to categorise as masculine, feminine or androgynous. They are culturally-imposed behavioural and temperamental traits, not necessarily biologically determined, but culturally and socially defined. ⁵

Infarction (myocardial)	Commonly referred to as a 'heart attack'; it is permanent heart muscle cell damage due to absent or decreased blood flow to an area of the heart. There are numerous types of myocardial infarction, with the most common type and that which will be concentrated upon in this thesis being 'spontaneous' (acute) myocardial infarction (Type 1) (Appendix A). ⁶
Ischaemia (myocardial)	The reduction of oxygen supply to myocardial (heart) cells secondary to reduced blood flow, which usually leads to pain or pressure in the chest or other symptoms suggestive of ischaemia.
Necrosis	A response to ischaemia leading to cellular swelling, loss of intracellular organelles, membrane rupture and calcium overload resulting in an inflammatory response and permanent changes.
Over-triage	A type of 'incorrect triage' that occurs when a patient receives a triage score allocation higher than their level of urgency as determined by defined objective clinical and physiological indicators. Increased risk is due to the likelihood of their being treated ahead of patients with higher clinical urgency as a result. ⁴
Percutaneous coronary intervention	A method of reperfusion by which a catheter is inserted through the skin ('percutaneously') and angioplasty is undertaken whereby a balloon is inflated to push open a blocked coronary blood vessel. A <i>stent</i> may be inserted to maintain blood vessel patency.
Sex	Refers to the biological characteristics by which humans are categorised as male or female (or rarely hermaphrodite), man and woman, men and women, and boys and girls. ⁵

Socio-Economic Indexes for Areas	Assigned nationally, it is a numeric means of ranking a patient's socioeconomic status, based on their usual reported area of residence. ² It is based on a number of measures and is a means of summarising people from within an area and not a person or an individual dwelling from within that area. ¹
Stent	A scaffold-like device placed inside an artery to prevent closure.
Triage	A formal process of 'sorting' patients into level of clinical urgency to ensure optimal timing of care commensurate with clinical needs. Primary decisions pertain to establishment of a patient's chief complaint and allocation of an <i>urgency</i> rating. Secondary decisions are made at triage to expedite commencement of care and patient disposition. ⁴ 'Triage' in this thesis relates to primary decisions.
Triage nurse	In Australia, the <i>triage</i> role is undertaken by an ED nurse who has specialised knowledge and experience with a wide range of illnesses, injuries and healthcare processes. The triage nurse works in a complex environment in conditions limited by time and usually without prior medical diagnoses. ⁴
Triage system	The process by which a clinician, which in Australia is usually a <i>triage nurse</i> assesses a patient and allocates their level of clinical <i>urgency</i> . ⁴
Under-triage	A type of 'incorrect triage' that occurs when a patient receives a triage score allocation lower than their level of <i>urgency</i> as determined by defined objective clinical and physiological indicators. Risk is due to the likelihood of their receiving delayed management behind patients with lower levels of clinical <i>urgency</i> . ⁴
Urgency (triage)	The status defined by the patient's clinical condition, which is independent of illness or injury severity or complexity. ⁴

Abbreviations. Please refer to abbreviations listed in previous section

Glossary References

1. ABS (2006). 2039.0 – Information paper: An introduction to Socio-Economic Indexes for Areas (SEIFA), 2006. ABS, Canberra.
2. AIHW (2012). Australian hospital statistics 2011-12: emergency department care. Health services series no. 45. Cat. no. HSE 126. AIHW, Canberra.
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5. Jary D & Jary J. (1991). *Collins dictionary of sociology*. HarperCollinsPublishers, Glasgow, UK.
6. Thygesen K, et al. (2007). Universal Definition of Myocardial Infarction, *Circulation*; 116:2634-2653.

Candidate's statement of originality

This thesis contains no material published elsewhere, other than where stated, or extracted in whole or part from a thesis by which I have qualified for or been awarded another degree or diploma.

No other person or persons' work has been used without due acknowledgement in the text of the thesis.

This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

All research procedures reported in this thesis received the approval of the relevant Ethics/Safety Committees, where required.

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Abstract

Introduction

Coronary heart disease (CHD) is the world's leading killer of men and women. Mortality rates have improved over recent decades, however reductions in women's deaths have failed to keep pace with men's. *Heart attack* (acute myocardial infarction, *AMI*) fits within a continuum of CHD known as acute coronary syndrome (ACS). Under-assessment and under-treatment of women's AMI compared to men's have been blamed for some of the disparity. Death and disability due to AMI is preventable with timely access to reperfusion therapy, making it one of the most critical conditions managed in the emergency department (ED) and in-hospital systems. There is a paucity of literature available specific to women's ED and in-hospital care of ACS and AMI, particularly in Australia, however international research reveals women sometimes fail to receive equitable access to evidence based care compared to their male counterparts, potentially compromising health outcomes.

Aims

The overall aims of this research were to examine and describe ED triage score allocation and treatment onset patterns in relation to patient sex and other demographic factors, in addition to in-hospital access to reperfusion treatment and mortality for women with ACS and AMI in Victorian public hospitals.

Methods

A programme of research was completed to address the study aims and research objectives. After completing review of the literature, a series of discrete retrospective quantitative analyses were undertaken on data extracted from the State Government of Victoria's Victorian Emergency Minimum Dataset (VEMD) and the Victorian Admitted Episodes Dataset (VAED) for adult (18 – 85 year old) patients admitted to public hospitals for ACS and AMI. Statistical procedures used included descriptive and non-parametric tests, in addition to regression tree method. Key aspects of patient care were investigated from the point of ED

triage, via access to timely ED management, implementation of inhospital reperfusion treatment and discharge, with the primary measured outcome being inhospital death.

Results

The literature review identified women with AMI were often challenging for ED nurses to triage accurately due to their gender, older average age and tendency to experience more atypical symptoms. This was found to be consistent with triage practice for patients with AMI in Victoria using VEMD data ($p < 0.001$).

Regression tree analysis uncovered a number of connected variables including patient sex, arrival by ambulance, ability to speak English and patient regional or metropolitan address, which, in addition to assigned triage score, had significant impact upon time taken to commence treatment of patients with AMI in EDs.

Analysis of VAED data for management of AMI and equity of outcomes from the disease indicated younger and older women (age split at 65 years) received less evidence-based reperfusion treatment ($p < 0.001$) and had proportionately higher inhospital mortality rates than equivalently aged men ($p < 0.001$) admitted to Victorian public hospitals for ST-segment elevation myocardial infarction (STEMI).

Conclusion

This programme of research enhances knowledge of ED triage and inhospital practice around timeliness and access to treatment for ACS and AMI in an Australian population. Research identified sex-related differences in triage, treatment and outcomes, depicting important differences which may result in sex-based bias in assessment and management of women's heart disease. The identified disparities in women's timeliness to treatment onset and access to reperfusion treatment, with concurrent higher mortality rates are of concern and warrant further investigation. These variations in care can be improved, in particular through the use of interventional research. The findings will be incorporated into the Candidate's post-doctoral research, to be undertaken to reduce the identified practice gaps.

Key words

Acute coronary syndrome; emergency department; equity; hospital-care; ischaemia; myocardial infarction; reperfusion; STEMI; triage; women

Figure i. Flow chart of publication chapters, set between introductory and concluding chapters



Publications by the candidate Included in the thesis

Chapter 2: Literature review paper

Literature review: triage of women's heart disease

Kuhn L, Page K, Davidson P, Worrall-Carter L. (2011). Triageing women with acute coronary syndrome: A review of the literature. *Journal of Cardiovascular Nursing*, 26(5), 395-407; DOI: 10.1097/JCN.0b013e31820598f6.

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The Journal of Cardiovascular Nursing (JCN) has an Impact Factor (2012) of 1.473. It is a blind-peer reviewed journal that is published in 6 issues per year. It is ranked: Nursing 13/95, Cardiac and Cardiovascular Systems 75/117. JCN is the official journal of the Preventive Cardiovascular Nurses Association and the Australasian Cardiovascular Nursing College. It is affiliated with the Council on Cardiovascular Nursing of the American Heart Association.

Chapter 3: Research paper

Impact of patient sex on triage for ACS and MI and time to treatment onset

Kuhn L, Page K, Rolley J, Worrall-Carter L. (2013). Effect of patient sex on triage for acute myocardial infarction and treatment onset times: A retrospective analysis of Australian emergency department data. *International Emergency Nursing*; <http://dx.doi.org/10.1016/j.ienj.2013.08.002> [open access].

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The International Emergency Nursing (IEN) journal (formerly, *A&E Nursing*) does not yet have an Impact Factor, however, the UK-based Elsevier Inc. journal has recently been selected for coverage in Thomson Reuter's products and services and has announced an Impact Factor will be forthcoming. It has a long history of publishing interdisciplinary papers and is easily accessible through the various databases. Abstracting and Indexing: ASSIA, BDLIC, British Nursing Index, CINAHL, CIRRIE, CISTI, Current Contents/Social & Behavioral Sciences, ENB Health Care Database, Journal Citation Reports – Social Sciences Edition, PubMed, and SciSearch/Science Citation Index Expanded. IEN is an international, blind, peer-reviewed journal published 4 times a year. It is the official publication of the European Society for Emergency Nurses and the Faculty of Emergency Nursing (UK). It is officially recognised by the National Emergency Nurses Affiliation Inc. (Canada).

Chapter 4: i. Method discussion paper; ii. Research paper

i. **CaRT method: utility and limitations in nursing research**

Kuhn L, Page K, Ward J, Worrall-Carter L. (2013). The process and utility of classification and regression tree methodology in nursing research. *Journal of Advanced Nursing*; DOI: 10.1111/jan.12288 [*OnlineOpen*].

The Journal of Advanced Nursing (JAN) is a North American-based journal with an Impact Factor (2012) of 1.527. It has a high ranking (ISI Journal Citation Reports, 2012): 14/104 (Nursing (Social Science)); 16/106 (Nursing (Science)). It is said to be the most cited nursing journal in the world, with over 3 million articles downloaded online per year and is subscribed to by 10 000 libraries. JAN is an international Wolters Kluwer Health/Lippincott Williams & Wilkins journal, which is issued second-monthly. Manuscripts are subjected to a blind, peer review process.

[Please refer to Appendix L with proof of payment for Creative Commons Rights pending]

ii. Risk factors for delayed treatment onset for AMI in the ED

Kuhn L, Worrall-Carter L, Ward J, Page K. (2013). Factors associated with delayed treatment onset for acute myocardial infarction in Victorian emergency departments: A regression tree analysis. *Australasian Emergency Nursing Journal*, 16(4), 160-169; DOI: 10.1016/j.aenj.2013.08.002.

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The Australasian Emergency Nursing Journal (AENJ) does not yet have an Impact Factor. AENJ was chosen because it is the professional peer-reviewed journal of choice for Australasian emergency nurses. AENJ regularly includes multidisciplinary papers. It is an Elsevier Inc. journal and is circulated to the 1400 financial members of the College of Emergency Nursing Australasia four times a year. It is indexed in MEDLINE and had an ERA Ranking of 'A' in December, 2010. The manuscripts are subjected to a double-blind, external peer review process.

Chapter 5: Research paper

Influence of patient sex on treatment and mortality for patients admitted to Victorian hospitals with STEMI

Kuhn L, Page K, Rahman MA, Worrall-Carter L. (Under journal review). Influence of patient sex on treatment and mortality for patients admitted to Victorian hospitals with ST-segment elevation myocardial infarction: A retrospective database study. *Australian Critical Care*.

Published quarterly, the Australian Journal of Critical Care (AuCC) has an Impact Factor of 0.953 (JCR 2012) and manuscripts are subjected to a blind, peer-review process. AuCC is an Elsevier publication and is abstracted/indexed with EMBASE/Excerpta Medica, Exerpta Medica, ISI Alerting Services, MEDLINE, Reactions Weekly and Science Citation Index.

Presentations by the candidate

Included in the thesis

Published abstract

Kuhn L, Page K, Davidson P, Worrall-Carter L. (2010). A comparison of triage allocation for women and men for acute coronary syndrome across Victorian emergency departments. *Australasian Emergency Nursing Journal*, 13(4), 153.

Oral and poster presentations

Kuhn L. (2013). *Women's heart disease*. Lecture for Deakin University, Master of Nursing: Cardiac, Critical, Intensive and Emergency Care, 18th September; Melbourne, Australia.

Kuhn L. (2012). Student presenter at inaugural Higher Degree Research, Faculty of Health Sciences 1-day Seminar. Winner Student Prize for Concurrent Session Presentation, 10th December; Melbourne, Australia.

Kuhn L. (2012). Guest speaker at Heart Foundation (Victoria) forum: *What happens when people go to emergency with heart problems?* 5th December; Melbourne, Australia.

Kuhn L, Page K, Ward J, Worrall-Carter L. (2012). *Risk factors for increased time to treatment for acute myocardial infarction in Victorian emergency departments: A regression-tree analysis*. Peer reviewed oral presentation for the 10th International Conference for Emergency Nursing of the College of Emergency Nursing Australasia (CENA), 10th – 12th October; The Grand Chancellor Hotel, Hobart, Australia.

Kuhn L. (2012). *Women and heart disease in Victoria: Is there equity in care?* Invited speaker for Heart Foundation (Victoria) and Women's Health Victoria, Public Forum; "Women, Inequity and Heart Disease". Women's Health Victoria, Bourke Street, 27th June; Melbourne, Australia.

Kuhn L. (2012). *Women's heart disease*. Lecture for Deakin University Graduate Diplomas of Cardiac and General Critical Care Nursing, 23rd May; Melbourne, Australia.

Kuhn L. (2011). *Women's heart disease*. Lecture for Deakin University Graduate Diplomas of Cardiac, General Critical Care and Emergency, 7th September; Melbourne, Australia.

Kuhn L. (2011). *Staying the course*. Lecture for ACU Postgraduate Students' Association, ACU, 15th July; Melbourne, Australia.

Kuhn L, Page K, Rolley J, Worrall-Carter L. (2011). *Triage score allocation and subsequent time to treatment for men and women with acute myocardial infarction across Victorian emergency departments: A comparison*. Invited, peer reviewed oral presentation for the 2011 Australasian Cardiovascular Nursing College (ACNC) Scientific Meeting, 19th March; The Sebel, Albert Park, Melbourne, Australia.

Kuhn L, Page K, Davidson L, Worrall-Carter L. (2010). *A comparison of triage allocation for women and men for acute coronary syndrome across Victorian emergency departments*. Invited, peer reviewed oral presentation for the 8th International Conference for Emergency Nursing of the College of Emergency Nursing Australasia (CENA), 14th – 16th October; The National Convention Centre; Canberra, Australia.

Kuhn L. (2010). *Management of women and men for acute coronary syndrome across Victorian emergency departments: A comparison*. Invited speaker for ACU (Ballarat) and Ballarat Health, Allied Health Professionals, 21st October; Ballarat, Australia.

Kuhn L. (2010). *Women's heart disease*. Lecture for Deakin University Graduate Diploma of Cardiac Nursing, 7th September; Melbourne, Australia.

Kuhn L, Page K, Rolley J, Worrall-Carter L. (2010). *The impact of patient sex on triage of acute myocardial infarction in Victorian emergency departments and the effect on time to*

treatment. Moderated poster presentation for St Vincent's Hospital Research Week, 23rd – 25th August; Melbourne, Australia.

Kuhn L. (2010). *My PhD progress thus far*. Student oral presentation for SVCNR/CvRC Research Training Workshop, St Vincent's/ACU Centre for Nursing Research/Cardiovascular Research Centre, 16th June; Melbourne, Australia.

Riegel B, Dickson VV, **Kuhn L**, Page K, Worrall-Carter L. (2009). *Factors influencing heart failure self-care differ in men and women*. Abstract presented for American Heart Association Scientific Sessions, 14th – 18th November; Orlando, Florida.

Kuhn L, Page K, Davidson P, Worrall-Carter L. (2009). *Triage of men and women with acute coronary syndromes in Victorian emergency departments: Is there a difference?* Moderated poster presentation for St Vincent's Hospital Research Week, 24th - 26th August; Melbourne, Australia.

Kuhn L. (2009). Confirmation of Candidature, Oral and written presentations for Examination Panel, ACU National, 28th May; Melbourne, Australia.

Kuhn L. (2009). *Insights into ACS in women*. Invited speaker for National Institute of Clinical Studies (NICS), National Health and Medical Research Council (NHMRC), Emergency Care Community of Practice National Teleconference, Friday 27th March, 1:30 – 2:30 pm; Melbourne, Australia.

Kuhn L. (2009). *Starting the PhD journey*. Invited speaker for Collaborative Cardiovascular Doctoral and Postdoctoral Meeting, ACNC Doctoral Seminar, 25th – 26th February; Curtin University of Technology, Curtin House; Sydney, Australia.

Kuhn L, Cameron J. (2008). *Managing your PhD by publication*. Invited speaker for St Vincent's Centre for Nursing Research, 4th December; Melbourne, Australia.

Kuhn L. (2008). *Women's heart disease*. Invited speaker for the Sixth Annual Collaborative Cardiac Seminar, Australian College of Critical Care Nurses and Victorian Cardiac Nurses' Association, 28th November; Melbourne, Australia.

Kuhn L. (2008). *Work in progress presentation*, for ACU Panel, Staff and Students, ACU National, 11th November; Melbourne, Australia.

Kuhn L. (2008). *Women's heart disease*. Lecture for Deakin University Graduate Diploma of Cardiac Nursing, September; Melbourne, Australia.

Worrall-Carter L, Sabine C, **Kuhn L**, Page K. (2008). *Return to work issues following an acute cardiac event*. Poster presented for Cardiac Society of Australia and New Zealand, 57th Annual Scientific Meeting, August; Sydney, Australia.

Page K, Worrall-Carter L, **Kuhn L**, Allen RJ, Davidson P. (2008). *Prevalence and onset of depression in women after an acute cardiac event*. 2nd Australasian Cardiovascular Nursing College Scientific Meeting, Winner of scientific poster competition, February; Melbourne, Australia.

Page K, Worrall-Carter L, **Kuhn L**, Allen RJ, Davidson P. (2008). *Prevalence and onset of depression in women after an acute cardiac event*. Poster presented 7th – 10th August, Cardiac Society of Australia and New Zealand (CSANZ) Scientific Meeting; Adelaide, Australia.

Page K, Worrall-Carter L, **Kuhn L**, Allen RJ, Davidson P. (2008). *Prevalence and onset of depression in women after an acute cardiac event*. Poster presented St Vincent's Research Week, August; Melbourne, Australia.

Contribution to jointly published work

It is duly acknowledged that I collaborated within a research team and as such, have been mentored and supported by this team's members and others at Australian Catholic University for my research training and work.

The body of work for this programme of research was conceptualised by me and undertaken for my PhD, and is therefore my own intellectual property.

It is acknowledged that while a number of researchers contributed in part to the publications included in this thesis, the actual research undertaken and preparation of the manuscripts for publication were solely my own work.

It is acknowledged that all co-authors of jointly published papers included in this thesis provided their consent for the inclusion of each paper in this thesis and that the co-authors accept my contribution to the paper as so described in the *Statement of contribution to jointly-published work* by others. All other work included in this thesis, not part of published papers or those accepted for publication, are entirely my own work, except where duly acknowledged.

My contribution and the contribution of others to each of the published papers included in this thesis are outlined in the following statements.

Statement of contribution to jointly published work – Chapter 2

It is acknowledged that all co-authors of this jointly published paper included in Chapter 2 of this thesis provide their consent for the inclusion of this paper in this thesis and that the co-authors accept the contribution of Ms Kuhn to the paper as described in the *Statement of contribution to jointly published work* by others and their contributions, as set out below.

Kuhn L, Page K, Davidson P, Worrall-Carter L. (2011). Triaging women with acute coronary syndrome: A review of the literature. *Journal of Cardiovascular Nursing*, 26(5), 395-407.

Lisa Kuhn	Conception and design of the literature search and data extraction
	Analysis and interpretation of data
	Drafting the article and revising it for critically important intellectual content
	Approval of the final version for publication and submission of the article to the journal for publication
Karen Page	Made critical revisions to the draft versions for important intellectual content
Patricia Davidson	Made critical revisions to the draft versions for important intellectual content
Linda Worrall-Carter	Made critical revisions to the draft versions for important intellectual content

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Statement of contribution to jointly published work – Chapter 3

It is acknowledged that all co-authors of this jointly published paper included in Chapter 3 of this thesis provide their consent for the inclusion of this paper in this thesis and that the co-authors accept the contribution of Ms Kuhn to the paper as described in the *Statement of contribution to jointly published work* by others and their contributions, as set out below.

Kuhn L, Page K, Rolley J, Worrall-Carter L. (2013). Effect of patient sex on triage for ischaemic heart disease and treatment onset times: A retrospective analysis of Australian emergency department data. *International Emergency Nursing* [open access].

Lisa Kuhn	Conception and design of the literature search and data extraction
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	Drafting the article and revising it for critically important intellectual content
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Karen Page	Made critical revisions to the draft versions for important intellectual content
John Rolley	Made critical revisions to the draft versions for important intellectual content
Linda Worrall-Carter	Made critical revisions to the draft versions for important intellectual content

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Statement of contribution to jointly published work – Chapter 4

It is acknowledged that all co-authors of the jointly published papers included in Chapter 4 of this thesis provide their consent for the inclusion of this paper in this thesis and that the co-authors accept the contribution of Ms Kuhn to the papers as described in the *Statement of contribution to jointly published work* by others and their contributions, as set out below.

- i. Kuhn L, Page K, Ward J, Worrall-Carter L. (2013). The process and utility of classification and regression tree methodology in nursing research. *Journal of Advanced Nursing* [OnlineOpen].

Lisa Kuhn	Conception and design of the literature search and data extraction
	Analysis and interpretation of data
	Drafting the article and revising it for critically important intellectual content
	Approval of the final version for publication and submission of the article to the journal for publication
Karen Page	Made critical revisions to the draft versions for important intellectual content
John Ward	Made critical revisions to the draft versions for important intellectual content
Linda Worrall-Carter	Made critical revisions to the draft versions for important intellectual content

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Ms Lisa Kuhn

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Date: _____

Date: _____

- ii. Kuhn L, Worrall-Carter L, Ward J, Page K. (2013). Factors associated with delayed treatment onset for acute myocardial infarction in Victorian emergency departments: A regression tree analysis. *Australasian Emergency Nursing Journal*, 16(4), 160-169.

Lisa Kuhn	Conception and design of the literature search and data extraction
	Analysis and interpretation of data
	Drafting the article and revising it for critically important intellectual content
	Approval of the final version for publication and submission of the article to the journal for publication
Linda Worrall-Carter	Made critical revisions to the draft versions for important intellectual content
John Ward	Made critical revisions to the draft versions for important intellectual content
Karen Page	Made critical revisions to the draft versions for important intellectual content

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Ms Lisa Kuhn

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Statement of contribution to jointly authored work – Chapter 5

It is acknowledged that all co-authors of this jointly authored paper included in Chapter 5 of this thesis provide their consent for the inclusion of this paper in this thesis and that the co-authors accept the contribution of Ms Kuhn to the paper as described in the *Statement of contribution to jointly authored work* by others and their contributions, as set out below..

Kuhn L, Page K, Rahman MA, Worrall-Carter L. (Under journal review). Influence of patient sex on treatment and mortality for patients admitted to Victorian hospitals with ST-segment elevation myocardial infarction: A retrospective database study. *Australian Critical Care*.

Lisa Kuhn	Conception and design of the literature search and data extraction
	Analysis and interpretation of data
	Drafting the article and revising it for critically important intellectual content
	Approval of the final version for submission of the article to the journal for publication
Karen Page	Made critical revisions to the draft versions for important intellectual content
Muhammad Aziz Rahman	Made critical revisions to the draft versions for important intellectual content
Linda Worrall-Carter	Made critical revisions to the draft versions for important intellectual content

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Date: _____

Publications by the candidate

Relevant to the subject

The following published, peer-reviewed papers have been co-authored by the Candidate throughout the candidature period and portray scholarly writing and professional networking within the area of cardiac healthcare, but are not included within this thesis.

Worrall-Carter L, McEvedy S, **Kuhn L**, Rahman MA. (In progress). Why women with ACS are less likely to receive an angiogram than men: A systematic review investigating three hypotheses. Target journal: *PLoS One*. To be submitted, December 2013.

Dickson VV, Worrall-Carter L, **Kuhn L**, Riegel B. (2011). Whose job is it? Gender differences in perceived role in heart failure self-care. *Journal of Nursing and Healthcare of Chronic Illness*, 3(2), 99-108.

Kuhn L, Lee G. (2011). The need for increased vigilance in managing hyperglycaemia during acute coronary syndrome in the emergency department: An introduction to the evidence. *Australasian Emergency Nursing Journal*, 14(3), 202-207.

Riegel B, Dickson VV, **Kuhn L**, Page K, Worrall-Carter L. (2010). Gender-specific barriers and facilitators to heart failure self-care: A mixed methods study. *International Journal of Nursing Studies*, 47(4), 888-895. [IF 2.310]

Askham J, **Kuhn L**, Frederiksen K, Davidson P, Edwards K, Worrall-Carter L. (2010). The information and support needs of Faroese women hospitalised with an acute coronary syndrome. *Journal of Clinical Nursing*, 19(9-10), 1352-1361. [IF 1.430]

Rose L, **Kuhn L**. (2009). ECG Interpretation Part 2: Determination of bundle branch and fascicular blocks. *Journal of Emergency Nursing*, 35(2), 123-126. [IF 0.399]

Kuhn L, Rose L. (2008). ECG Interpretation Part 1: Understanding mean electrical axis. *Journal of Emergency Nursing*, 34(6), 530-534. [IF 0.399]

Presentations by the candidate

Relevant to the subject

The following abstracts and posters have been co-authored by the Candidate throughout the candidature period and portray scholarly writing, professional networking and development of academic presentation skills within the area of cardiac healthcare, but are not included within this thesis.

Published abstracts

Riegel B, Dickson VV, **Kuhn L**, Page K, Worrall-Carter L. (2009). Abstract 1590: Factors influencing heart failure self-care differ in men and women. American Heart Association Scientific Sessions, *Circulation* 120, S524.

Kuhn L, Lee G. (2009). Managing hyperglycaemia is an imperative during admission for cardiac disease: building the case. *Australasian Emergency Nursing Journal*, 12(4), 181.

Page K, Worrall-Carter L, **Kuhn L**, Allen J, Davidson P. (2008). Prevalence and Onset of Depression in Women after an Acute Cardiac Event. *Heart, Lung and Circulation* 17 (Supp 3), S77.

Submitted abstracts (under review)

Worrall-Carter L, McEvedy S, **Kuhn L**, MacIsaac A, Rahman MA. (Submitted, September 2013). A systematic review investigating whether the presence of severe co-morbidities explains lower rates of angiography among women compared to men with non-ST elevation acute coronary syndrome. World Congress of Cardiology Scientific Sessions 2014, Melbourne, Australia; under review, identifier WCC14-ABS-1872.

Worrall-Carter L, McEvedy S, **Kuhn L**, MacIsaac A, Rahman MA. (Submitted, September 2013). A systematic review investigating whether gender differences in risk stratification profile explain lower rates of angiography among women compared to men with non-ST elevation acute coronary syndrome. World Congress of Cardiology Scientific Sessions 2014, Melbourne, Australia; under review, identifier WCC14-ABS-1194.

Poster presentations

Worrall-Carter L, McEvedy S, **Kuhn L**, MacIsaac A, Rahman MA. (2013). *A systematic review investigating the impact of risk stratification on lesser angiogram among women compared to men with acute coronary syndromes*. Poster presented for Australasian Cochrane Symposium 2013, 20 – 21st November. Australasian Cochrane Centre, Monash University/Alfred Hospital, Melbourne, Australia.

Kuhn L, Lee G. (2009). *Managing hyperglycaemia is an imperative during admissions for cardiac disease: Building the case*. Poster abstract presented for 7th International Conference for Emergency Nursing (ICEN), 7 – 10th October – First prize winner of scientific poster competition; Gold Coast, Australia.

Chapter 1

Overview and introduction to the thesis



Chapter 1 Introduction

- Overview of and introduction to the thesis
 - Coronary heart disease and acute coronary syndromes; the right to equity, understanding the pathophysiology and symptomatology, and the importance of early treatment
 - Research rationale, aims, objectives and questions
 - Research methods overview and outline
-

1.1 Overview

The purpose of this chapter is to situate the programme of research within the context of what is understood about coronary heart disease, particularly the time-sensitive nature of the acute coronary syndrome (ACS) continuum of disease. It is used to provide an overview of the epidemiology and pathophysiology of ACS, differences in ACS related to patient sex, how research and our understanding of the syndrome has evolved, the role of the emergency department (ED) and the ED triage nurse, the application of evidence based treatment, and morbidity and mortality outcomes.

The first chapter will be used to introduce the layout and background of the thesis, opening with the basic human right to equity, before focusing on why it is vital to act on cardiac ischaemia and infarction with the greatest of urgency and why therefore, it is incumbent upon emergency nurses to ensure that through their expert assessment, the early diagnosis and management of women's heart disease is enabled. It will utilise knowledge of women's ACS management in other areas of healthcare to identify gaps in the literature on ED issues. The chapter will conclude with the research aims, objectives, overall design and methods, and an outline of the research programme.

1.2 Introduction to the thesis subject

Australian healthcare has a universally accessible system at its core. It provides free or significantly subsidised healthcare to all Australian citizens, most residents and, depending upon reciprocal agreements with other countries, some overseas visitors (Biggs, 2003). The system is called 'Medicare' and "all Australian" is the key phrase in Bigg's parliamentary briefing paper from 10 years ago. In providing free hospital services for public patients in public hospitals via Australian Health Care Agreements with the states and territories, the onus is on healthcare professionals and the systems within which they operate to ensure what they are providing is evidence-based care equally available to all. A central tenet of the Australian Government's National Health System Performance Framework for an effective healthcare system relates to equity of service access (Australian Institute of Health and Welfare (AIHW), 2012a).

The World Health Organization (WHO) defines health inequities as; "avoidable [WHO added emphasis] inequalities in health between groups of people within countries and between countries" (WHO, 2008: p. 1). At its most basic level, inequity in healthcare is described in WHO documentation as, just "unfair" (Whitehead & Dahlgren, 2006: p. 3). Equity within healthcare is an essential component of societal equity (Whitehead & Dahlgren, 2006; WHO, 2007). Health equity is a fundamental human right (WHO 1948, cited in Nygren-Krug, 2008), however, it has been repeatedly demonstrated that inequity does exist in Australian healthcare; negatively affecting groups such as Indigenous Australians, rural Australians and those from lower socioeconomic groups generally (AIHW, 2012a; Stratigos, 2010). Amongst many other groups listed as experiencing social disadvantage and marginalisation, the WHO report (2007) makes a special point of mentioning women and the effect health care inequity has on this group's health outcomes.

It is difficult to imagine health inequity which disadvantages women could exist in contemporary Australian healthcare, where Medicare has operated since 1975 (initially known as 'Medibank') (Biggs, 2003) and women have been allowed to vote for over a century (and for the past half-century for Australian Aboriginal women and men) (Australian Electoral Commission (AEC), 2011). Despite the perceived improbability, unequal access to in-hospital management for cardiovascular disease has been documented for Australian women (AIHW,

2010; Roe et al., 2013). Although any disparity is likely to be related to lack of awareness, rather than malice on behalf of the healthcare providers (Mosca et al., 2005), it is important to determine whether inequitable conditions related to patient sex exist at all points of cardiovascular care, which will enable them to be addressed to ensure care is provided with fairness and equity.

The cardiovascular diseases (CVDs) are the leading killers of both sexes worldwide (WHO, 2011), including in Australia (AIHW, 2012a). Together, the CVDs, which are predominantly ischaemic heart disease (IHD) and stroke, account for 31 percent of all deaths globally (WHO, 2011). To put this into perspective; combined communicable (including HIV/AIDS, malaria and tuberculosis), maternal, perinatal and nutritional conditions account for 27 percent of annual worldwide deaths (WHO, 2011).

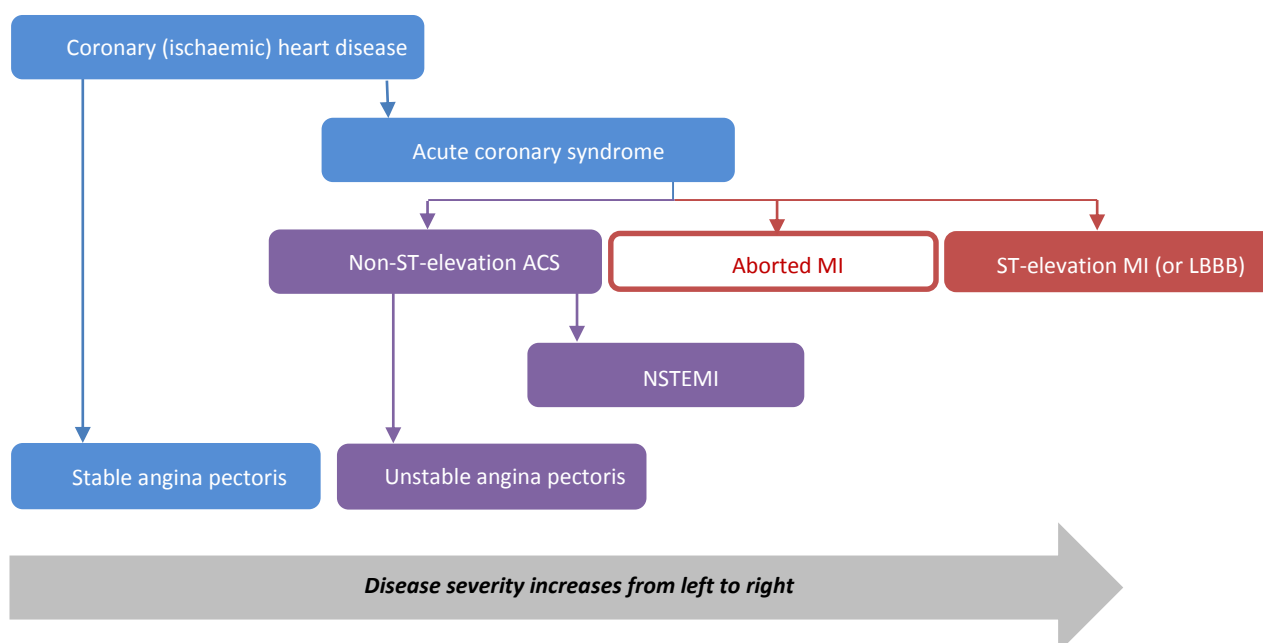
Approximately 80 percent of these deaths occur in low and middle-income countries (WHO, 2008), however, the figures in Australia also paint a bleak picture: CVD kills one Australian nearly every 10 minutes (AIHW, 2008); it affects more than 3.4 million Australians and claimed nearly 46,100 Australian lives in 2009 (AIHW, 2012a). This was 34 percent of all Australian deaths in the most current figures (AIHW, 2012a). CVD is much more common in the elderly (AIHW, 2012a), and was estimated to affect about 1.6 million males and 1.8 million females in Australia in 2007-08 (Australian Bureau of Statistics (ABS), 2009). The age-standardised CVD death rates were much higher for males than females however. In 2009, age-standardised death rates were calculated to be 215 per 100,000 for males compared to 156 per 100,000 for females (AIHW, 2012a). In terms of cost, more is spent on CVD in Australia than for any other disease. Records show that at \$7.9 billion in 2009, this was 11 percent of the \$74.2 billion allocated for recurrent annual health spending by the Australian government (AIHW, 2012a).

Coronary heart disease (CHD), which is synonymous with IHD, accounts for more than half of the annual CVD mortality rate, both in developed and developing countries alike (AIHW, 2012a; WHO, 2011). Of the 17.5 million annual worldwide deaths from CVD, CHD kills 7.6 million and stroke causes 5.7 million deaths, and approximately 9 million of the total CVD deaths are women (WHO, 2008). Despite the high numbers, improvement in mortality rates for CHD over the last three decades have been remarkable (WHO, 2011). Yet, it has been well documented that improved mortality rates have been inequitable in a number of respects;

women's rates of reduction have failed to keep pace with men's (Bailey Merz, 2006; Blomkalns et al., 2005; Gulati et al., 2012; Pepine, 2006; WHO, 2004).

CHD is a group of diseases that are classified together because of their common aetiology. The diseases are those where the coronary arteries are primarily affected, usually due to accumulated atherosclerotic plaques (atheroma) in the arterial walls (AIHW, 2010). CHD can broadly be divided into the chronic conditions including stable angina pectoris (SAP), which are generally managed on an outpatient basis, and acute coronary syndrome (ACS) (Figure 1.1), which constitute the acute and most urgent form of the disease.

Figure 1.1. Classificatory relationship of the coronary heart diseases



LBBB, left bundle branch block; MI, myocardial infarction; NSTEMI, non-ST-segment elevation myocardial infarction; Non-ST-elevation ACS, non-ST-segment elevation acute coronary syndrome; ST-elevation MI, ST-segment elevation myocardial infarction

When compared to men with CHD, women have been shown to experience inequity in provision of treatment at multiple points in their trajectories of healthcare (Gulati et al., 2012; Pepine, 2006). Research has shown that in contrast to men, women with CHD tend to be: Prescribed less medications (Jneid et al., 2008; Johnston et al., 2011; Redberg, 2006; Ridker et

al., 2005; Rosenfeld, 2006); admitted to hospital less often (AIHW, 2012a); receive less diagnostic tests and procedures (Bailey Merz et al., 2006; Wilson & Raveendran, 2008); discharged from hospital earlier (Kaul et al., 2007); and, referred to cardiac rehabilitation programmes less often (Allen et al., 2004; Cottin et al., 2004). Examples of inequities have been reported in European (Alfredsson et al., 2007; Crilly & Bundred, 2005), North American (Blomkalns et al., 2005), Asian (Srichaiveth et al., 2007) and Australian (AIHW, 2010; Walters et al., 2008) literature. There is also evidence of gender-based inequity within ED healthcare provided to patients with CHD in Asia (Srichaiveth et al., 2007), the UK (Capewell et al., 2006), the USA (Chang et al., 2007) and Canada (Atzema et al., 2009, 2010). Most of the international research to date has concentrated on ED care provided by physicians or resulting from ED processes (Khot et al., 2007; Phelan et al., 2009; Takakuwa et al., 2009). With the exception of several studies from North America (Arslanian-Engoren, 2004, 2005, 2009; Atzema et al., 2009, 2010), there seems to have been minimal investigation of emergency nursing care of women with CHD, particularly from the point of patient arrival at triage.

Most patient admissions to hospitals for management of time-sensitive CHD occur via entry through EDs, making the early assessment and management received in these departments critical. The first health professionals who patients meet on arrival at EDs are highly skilled triage nurses, whose role is to sort them into levels of acuity according to defined triage processes and guidelines. As the first health professionals to evaluate patients with CHD, triage nurses may influence the speed at which patients with time-critical conditions are able to access reperfusion therapy.

This doctoral study provides an empirically-based programme of analysis and critique of early ED assessment and management of the time-sensitive CHDs known collectively as acute coronary syndrome (ACS). The purpose is to add to the knowledge around issues of access and timeliness to evidence-based care at the point of entry to public hospitals ED and subsequent in-hospital management and outcomes of ACS in women in Australia's second most populous state. It revolves around the understanding that it is critical to ensure women's ischaemia and infarction are diagnosed and managed early to optimise patient outcomes. It provides research-based analytic insight into the triage score allocation and subsequent treatment onset times for patients with ACS, exploring a number of other sociodemographic variables' influence on time to treatment, whilst concentrating on gender-

related treatment and mortality patterns in Victoria, Australia. The full title of this thesis is 'Contemporary Issues in Triage and Inhospital Assessment and Management of Women's Acute Coronary Syndrome in Victorian Public Hospitals: A Retrospective Study', and the research programme is known as; 'The **D**iagnose **a**nd **M**anage **E**arly: Women's **I**schaemia and **I**nfarction study' or '*DaME II*.'

1.2.1 Global and national importance of cardiovascular and coronary heart disease

CVD is the group of diseases responsible for the greatest number of deaths of all disease groups annually, for both men and women, in developed and developing countries (WHO, 2011). In Australia, the CVDs make up a substantial number of the top five causes of death annually for men and women. As shown in Table 1.1, CHD occupies first place for men and women, and stroke, another type of CVD, occupies second place for women and third place for men for causing death in Australia (AIHW, 2012a).

Table 1.1. Australia's five leading causes of death

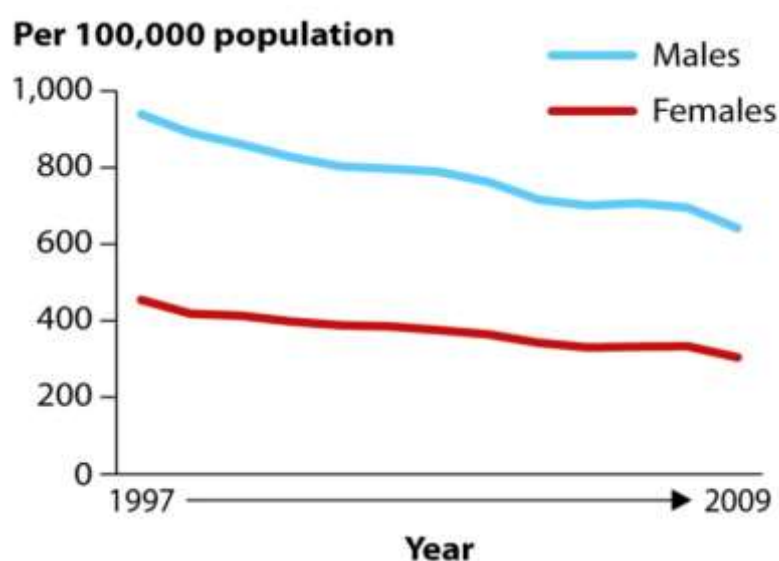
Men			Women		
Disease	Total	%	Disease	Total	%
Coronary heart disease	12 047	16.7	Coronary heart disease	10 476	15.3
Lung cancer	4 761	6.6	Stroke	6 706	9.8
Stroke	4 514	6.2	Dementia and Alzheimer's disease	5 491	8.0
Chronic lower respiratory diseases	3 209	4.8	Lung cancer	3 025	4.4
Prostate cancer	3 111	4.3	Breast cancer	2 772	4.1
Total all causes	72 320			68 440	

Source: AIHW, 2012a

The figures listed in Table 1.1 are the most recently available Australian number of deaths and percentages for each sex for the first five diseases. Whilst these are important data, comparison of crude rates of death between the sexes can be problematic due to average life expectancy differences. CHD mortality rates are closely associated with increased patient age. This means that if more people live longer, a greater number of them will eventually die of more heart disease (AIHW, 2012a). Australian women live longer on average than do Australian men (ABS, 2012).

Crude death rates from CHD have decreased markedly over the last decade in Australia (AIHW, 2012a). At the same time, patient survival has increased. Government data show that for people aged 40–90 who had heart attacks in 2009, 63 percent survived, compared with 47 percent in 1997 (AIHW, 2012a). Part of this trend, however, may be due to the increased diagnosis of milder heart attacks. CHD is more easily diagnosed now than it was historically, partly due to the increased availability and sensitivity of blood tests such as cardiac troponin levels (AIHW, 2012a; White & Chew, 2008). The blood assays work equally well in men and women however, so it is worthwhile looking at the trends of CHD incidence rates over time. Figure 1.2 illustrates the number of major coronary events among people aged from 40 – 90 years over 12 years.

Figure 1.2. Coronary heart disease incidence rates



Source: AIHW, 2012a

The graph presents an age-standardised number of incidences per 100 000 Australian people, which includes the number of deaths from CHD and the number of non-fatal hospitalisations for the disease over time for both sexes (Figure 1.2). It shows the incidence rates for CHD have reduced for men and women over this timeframe, although the gradient of reduction appears to have been less pronounced in women.

1.2.2 Pathophysiology of acute coronary syndrome (ACS)

ACS is an umbrella term for a collection of diseases resulting in myocardial injury from atherosclerotic processes (Leeper et al., 2011) (Figure 1.1). The diseases are spread along a continuum of myocardial damage due to insufficient oxygen supply ('hypoxia') to the epicardium, which, depending upon the duration of hypoxia, results in ischaemia, infarction and eventually, irreversible necrosis (Leeper et al., 2011). The grey arrow at the base of Figure 1.1 illustrates the increased extent of myocardial damage and therefore, severity of disease as the continuum moves from unstable angina to ST-segment elevation myocardial infarction (STEMI) or new left bundle branch block (LBBB). Myocardial ischaemia can lead to myocardial cell injury after as little as 20 – 30 minutes, but it takes several hours for full thickness myocardial ('transmural') necrosis to develop (Bates & Jacobs, 2013). Transmural necrosis involves all heart muscle layers. Hence, the earlier the myocardium can be reperfused, the less necrosis develops and the more positive the patients' prognoses are likely to be (Gibson et al., 2008). This is what is meant by the phrase; "time is muscle" (Bates & Jacobs, 2013; Gibson et al., 2004; Scott, 2010) and the reason so much effort has been expended in reducing time to reperfusion treatment. The umbrella term is known as a syndrome of disease and includes unstable angina pectoris (UAP) and acute myocardial infarction (AMI) (Leeper et al., 2011; Siebens et al., 2007).

The currently accepted universal definition of myocardial infarction (MI) was developed by an international taskforce led by Thygesen and colleagues in 2007. There are a number of clinical types of MI caused by diseases not related to atherosclerosis included in the accepted definition (Appendix A). Type 2 MI may be caused by ischaemia due to conditions that lead to increased oxygen demand (e.g. rapid arrhythmias or hyperthyroidism) or reduced oxygen supply (e.g. circulatory shock, coronary embolism or anaemia) (Thygesen et al., 2007). Others

may occur during procedures such as coronary artery bypass graft (CABG) surgery (Type 5) or percutaneous coronary intervention (PCI) (Type 4a), or when stents previously inserted to maintain patency of coronary arteries become blocked with clots ('thromboses'), which are classed as Type 4b MIs (Thygesen et al., 2007). Another form of MI commonly caused by atherosclerosis is sudden unexpected cardiac death (Type 3). This occurs when a person goes into cardiac arrest with symptoms suggestive of myocardial ischaemia or electrocardiographic (ECG) abnormalities are noted, but death often occurs before blood samples can be obtained or biomarkers change (Thygesen et al., 2007). Cause is likely to be determined at autopsy.

The MI classified as 'Type 1' (Thygesen et al., 2007), which is a spontaneous acute coronary syndrome (Chew et al., 2011), is the category of ACS investigated in this thesis. It is the classification of 'acute' MI, resulting from atherosclerotic processes and progression can potentially be averted or reduced through early intervention. It accounts for over 70 percent of MIs and is caused by partial or complete obstruction of an epicardial coronary artery from plaques vulnerable to erosion or rupture (White & Chew, 2008). Atherosclerosis leads to inflammation and damages the internal walls of the coronary arteries ('lumens'), enabling the accumulation of material such as cholesterol, lipids and calcium over a prolonged period of time (Leeper et al., 2011). The coronary arteries may remain patent under resting conditions and ischaemia might only occur when the myocardium receives insufficient oxygen, such as during exertion, stress or fever. If a plaque is stable and does not rupture, it can expand into the lumen until it eventually obstructs flow at rest and leads to unstable angina (Leeper et al., 2011). Rupture of an unstable plaque activates the intrinsic clotting cascade and a thrombosis occurs at the site of the plaque, which may lead to fixed or intermittent coronary artery occlusion (Leeper et al., 2011). When the blockage prevents the oxygen supply from meeting myocardial metabolic demands, ischaemia occurs in the myocardial cells ('myocytes'), unless the thrombosis can be reduced or removed and coronary patency regained.

Removal or reduction of offending thromboses and regaining patency of affected coronary arteries can be achieved through early fibrinolysis or PCI with or without stent insertion, or balloon angioplasty, and maintained with pharmacotherapy. Early reperfusion can prevent detectable myocardial cell death ('myonecrosis'), which is known as "aborted myocardial infarction" (White & Chew, 2008) (Figure 1.1).

A description of the ECG changes is beyond the scope of this discussion and the reader is referred to the universally accepted criteria for AMI provided in Appendix B (Thygesen et al., 2007).

1.2.3 Sex-related differences in pathophysiology of ACS

The accepted generic pathophysiological understanding of ACS is founded on extensive basic science (White & Chew, 2008), however, it is increasingly argued that women are biologically different to men and this leads to variations in pathophysiology and outcomes (Bailey Merz et al., 2006; Gulati et al., 2012; Shaw et al., 2009). There is growing experimental and clinical data supporting that sex has an important influence on cardiovascular pathogenesis (Bellasi et al., 2007), detection of the syndromes (Michos et al., 2006; Vaccarino et al., 2011), and short and long-term outcomes. Biological differences between men and women are believed to be responsible for many epidemiological differences between the sexes and need to be acknowledged in order to build the case as to why women and men cannot be assessed and treated generically for heart disease (Vaccarino et al., 2013). Data from the National Heart, Lung, and Blood Institute (USA) instigated Women's Ischemia Syndrome Evaluation (WISE) studies have helped propel researcher interest in this area (Pepine, 2006).

Although a thorough discussion of the pathophysiological basis of CHD in women is beyond the limits of this review, key differences in women's heart disease from the generic understanding need to be considered. They can broadly be broken down into the following biological sub-categories: a) Women's hormones; b) coronary vasculature; c) response to chemicals; d) comorbid disease clusters; and e) risk factor variations. All of these factors are inextricably intertwined and are inseparable from how women experience their heart disease in a behavioural (gender-related) sense, with frequent reports of anxiety and depression, and limitations to women's abilities to perform activities of daily living acknowledged (Olson et al., 2003; Phillips et al., 2003; Worrall-Carter et al., 2005). Psychosocial factors are thought to play a large part in the course of CHD (Rozanski et al., 2005; Sinning et al., 2010), with the phenomenon of apical ballooning known as 'Tako-Tsubo cardiomyopathy' linked to stress and anxiety, and occurring most frequently in older women (Prasad et al., 2008; Summers et al., 2010). Women's societal and familial roles play a considerable role in how they react to the

disease before, during and after the diagnosis of heart disease. Health related quality of life measures indicate that women are more likely to live with more heart disease related disability than their male counterparts (Pilote et al., 2007) and this is both physical and emotional.

Women's hormones. Until menopause, women appear to be largely protected from CHD development by endogenous oestrogen levels (Pepine et al., 2006). Part of the problem is the false sense of safety promulgated amongst women, the wider community and health care professionals as a result (Papadopoulou & Kaski, 2013; Stramba-Badiale et al., 2006). Women tend not to consider their risk high enough to warrant risk factor management until it is too late and their likelihood of developing CHD rapidly equalises after reaching menopause; the community as a whole does not see this as a significant issue and comparatively little time and energy is spent raising awareness and helping to manage risks; and health care professionals are lulled into a false sense of women's safety and too often send women away after they have sought appropriate treatment. A group of women interviewed by McSweeney et al. (2005) described their anger at not having been assessed to be at risk of heart disease despite numerous visits to clinicians with symptoms until they eventually suffered ACSs, and therefore, sustained significant myocardial damage and the morbidities associated with them.

A number of diseases such as hypertension in pregnancy, gestational diabetes and polycystic ovarian syndrome are purely women's conditions related to sex hormones and increase the subsequent occurrence of hypertension, diabetes mellitus type 2 (DM2) and obesity in women (Pepine, 2006). Some inflammatory conditions occur more frequently in women such as migraines, systemic lupus erythematosus, vasculitis, coronary spasm and Raynaud's phenomenon (Pepine et al., 2006; Shaw et al., 2009). These disorders tend to precede traditional risk factor development for CHD such as hypertension, diabetes, obesity and inactivity in women.

Some authors postulate a number of mechanisms for the development of ischaemic diseases in women are related to hormones (Bailey Merz et al., 2006; Shaw et al., 2009). They contend there are unknown factors responsible for the much higher mortality rate in pre-menopausal women than in men of the same age (Bailey Merz et al., 2006). Pre-menopausal women have

lower rates of AMI (Gulati et al., 2012), however when they do experience it, they have much higher mortality rates than men of equivalent age (Gulati et al., 2012; Rosenfeld, 2006; Vaccarino et al., 1999; Vaccarino et al., 2001). Hypo-oestrogenaemia and dysmetabolic states have been implicated in the differences (Gulati et al., 2009; Reynolds et al., 2011).

Coronary vasculature. There are a number of important differences in coronary vasculature between the sexes. Women tend to have better preserved left ventricular function than men, but develop a more severe and different form of vascular disease than men (Bailey Merz et al., 2006; Pepine et al., 2006; Shaw et al., 2006; Shaw et al., 2009; Smilowitz et al., 2011). Structurally, women's vessels are smaller than men's in internal diameter (Dodge et al., 1992; Lee et al., 2013; Mikhail, 2006), making obstruction with smaller lesions more likely and locating culprit lesions with coronary angiography more difficult due to issues with instrument access (Schampaert et al., 2004). Smaller coronary arteries also make women more susceptible to developing ischaemia during angiography (Lau et al., 1999).

It is hypothesised that prolonged high levels of endothelial inflammation, coupled with sudden loss of oestrogen and other changes during menopause may be associated with endothelial dysfunction, loss of arterial compliance and dysfunction of coronary microvasculature (Bailey Merz et al., 2006; Bugiardini et al., 2004). The changes may lead to remodelling which enables greater atherosclerotic storage along the arteries, leading to reduced intrusion from isolated plaque lesions (Bailey Merz et al., 2006), but more generalised narrowing. Remodelling and fibrosis may also lead to stiffer aortas in women (Pepine et al., 2006). The result of these changes is inability to respond to altered oxygen demands within myocardial cells distal to affected coronary blood vessels, and promotion of higher blood pressures.

Considerable research has been undertaken in recent years examining the phenomenon of non-obstructive CHD in women (Bugiardini et al., 2007; Gulati et al., 2009; Sharaf et al., 2013; Vaccarino et al., 2011). Women can have near normal coronary arteries and have high risk of death from ACS (Sharaf et al., 2013), even when compared to similarly aged men (Bugiardini et al., 2007; El-Menayar et al., 2013; Shaw et al., 2009). It is not unusual for women with ACS to have 'normal' or 'non-obstructive' coronary artery disease found on angiograms (Bugiardini

et al., 2007; Gulati et al., 2012; Humphries et al., 2008), with false negatives during investigations implicated in under-treatment of women's ACS (Bugiardini et al., 2010; Daly et al., 2006; Dey et al., 2009; Shaw et al., 2009). In their paper, Shaw et al. (2009) argue that current ACS guidelines focus on improving outcomes in obstructive disease, rather than reducing risk and easing symptom burden in women. They propose more needs to be done to identify non-obstructive atheroma in women in order to stratify them more accurately for risk and improve therapy targeting (Shaw et al., 2009).

Response to chemicals. Women's responses to a number of chemicals such as nicotine, the oral contraceptive pill and high blood glucose are known to heighten risk for heart disease, more so than in men (Bolego et al., 2002; Richey Sharrett et al., 2004; Steinberg et al., 2000). A number of chemicals used to treat breast cancer have also been found to be associated with increased CHD risk in women (Jones et al., 2007). Women are at high risk of chronic hyperglycaemia during and after gestational diabetes, with increased incidence of DM2, obesity and metabolic syndrome. It is purported the chronic hyperglycaemic state leads to reduced endothelium-dependent and endothelium-independent coronary vasodilatory response (Di Carli et al., 2003) and an inability to adjust to altered oxygen requirements. Overall, women experience higher rates of DM2 than men (Gulati et al., 2012). Diabetes leads to endothelial dysfunction in both sexes, but loss of vasodilation is more significant in women (Sowers, 1997). Women with DM2 have a three-fold higher risk of CHD than non-diabetic women (Spencer et al., 2008). DM2 completely abrogates any protection afforded to pre-menopausal women (Steinberg et al., 2000) and is a significant additional co-morbidity post-menopausally. Control of acute hyperglycaemia upon ED presentation for ACS is strongly recommended for all patients with or without known DM2 (Kuhn & Lee, 2011).

Comorbid disease clusters. A number of behavioural and biologic factors conspire to produce clusters of risk factors favourable to the development of heart disease in women, more often than they do in men. Combined risk factors for CHD such as obesity, dyslipidaemia, hyperinsulinaemia and hypertension are also known as metabolic syndrome, and impact upon many more women than men (Gami et al., 2007; Mitrakou, 2006; Regitz-Zagrosek et al., 2007). Even when men have metabolic syndrome, women with the same combinations of

comorbidities are at higher risk of developing CHD than them (Gulati et al., 2012). Regular exercise has been shown to have favourable effects on many of these risk factors. It maintains glucose control, blood pressure regulation, serum lipid profiles, weight control and general fitness levels (Boule et al., 2001; Mitrakou, 2006; Vidal, 2002; Wallace, 2003), but 76 percent of Australian women are classified as 'physically inactive' (AIHW, 2010). Women often underestimate their personal risk for CHD, so do not understand the benefit of exercise as it relates to them (Hart, 2005). They are therefore, less likely to be motivated to remedy sedentary behaviour. Women are known to have a number of competing social demands (Schoenberg et al., 2003), which effect their ability to exercise and also may cause them to delay seeking treatment for heart disease. Women for example, cite a number of factors including the presence of children in the home for an inability to exercise (Chen & Millar, 1999; King et al., 2000). This is a significant issue in Australia where obesity is increasing alarmingly; 54 percent of Australian women are overweight or obese (AIHW, 2011). The greatest cause for concern in relation to clusters of risk however, is Australia's rapidly ageing population. Older people generally accumulate more comorbid disease (AIHW, 2012a) and women have greater longevity than men (ABS, 2012).

Risk factors. Ageing is the greatest risk factor for CHD. The ageing Australian population is likely to exacerbate the prevalence of ACS for women in the future because of the associated increase in prevalence of obesity, diabetes, hypertension, sedentary lifestyle and dyslipidaemia (AIHW, 2010; Fulcher et al., 2003). Other risk factors remain important; even though the epidemiology of ACS is widely understood, approximately 15 percent of Australian women continue to smoke daily (AIHW, 2010). Reduction in smoking has played a large part in the reduced death toll from CHD over recent decades, but as this risk factor has decreased, other risk factors have increased markedly (AIHW, 2012a). More than 90 percent of the female population has at least one modifiable risk factor for heart disease (AIHW, 2010). All risk factors are significant risk factors for ACS in women, particularly when they are clustered together (Pepine, 2006). Mortality increases exponentially with the addition of each extra risk factor for heart disease, a pattern more profound in women than men (Gerber et al., 2006; Oda et al., 2006). The increasing prevalence of risk factors is likely to continue to increase the burden of heart disease in Australian women.

1.2.4 Gender- and sex-related symptom differences in ACS

In tandem with variations in the biological and pathophysiological basis for CHD, there seem to be notable differences in symptoms experienced with the diseases between the sexes. An important means of identifying patients with potential CHD are patterns of symptoms. The problem is that ‘typical’ symptom patterns of CHD have historically been defined from largely and sometimes all male populations (Douglas & Ginsberg, 1996; Pilote et al., 2007).

Numerous researchers have investigated symptom differences experienced by men and women in an effort to identify and differentiate these patterns (Albarran et al., 2007; Bosner et al., 2009; Canto et al., 2007; DeVon et al., 2008; Dey et al., 2009; McSweeney et al., 2004). Cardiac events in women are often heralded by non-specific symptoms (‘prodromes’), making differentiation from other physiologic and functional aetiologies for the women themselves and healthcare personnel problematic (Shaw et al., 2006). In a qualitative study by McSweeney and Crane (2000), 37 out of 40 participants revealed prodromal symptoms occurred from 3 weeks to 2 years prior to their ACS events. In another study, McSweeney and colleagues described a set of prodromal symptoms for ACS specific to women including unusual fatigue, sleep disturbance, shortness of breath, weakness, anxiety and chest discomfort (McSweeney et al., 2003). Acutely, women are more likely to present with complaints of unusual or profound fatigue (Shaw et al., 2009), with complaints of dyspnoea, dizziness, cold sweats (McSweeney et al., 2003), nausea (Arslanian-Engoren et al., 2006), weakness, indigestion (DeVon et al., 2008), and throat, neck and jaw pain (Philpott et al., 2001) all having been reported. A significant proportion of women have right-sided chest and arm pain (Albarran et al., 2002). Others report no pain at all (Shlipak et al., 2001). Bosner et al. (2009) found women tended to experience longer periods of pain, but men experienced shorter pain durations when positive for ACS. Women have been reported to regularly experience chest pain several times a week (Mieres et al., 2011), which is consistent with a large meta-analysis indicating ongoing signs of ischaemia are more common in women than men (Hemingway et al., 2006). The more persistent ischaemic symptoms are blamed for more frequent hospitalisations and repeat procedures in women (Shaw et al., 2006).

Despite differences in the degree and description of chest pain experienced by women compared to men, most women nevertheless, do experience some form of chest pain (Canto

et al., 2007). Chest pain is an important symptom when examined in the context of early ACS assessment because it is considered the hallmark of the syndrome's presentation. The proliferation of Chest Pain Units around the world for the management of patients deemed to be at low-to-moderate risk for ACS (Siebens et al., 2007) supports that patients with ACS generally present with complaints of chest pain. Indeed, a number of decision algorithms for predicting ACS rely on chest pain as a major predictor of the syndrome (Boufous & Kelleher, 2003; Fesmire et al., 2002; Selker et al., 1998). It has been reported that patients who arrive at emergency departments (EDs) with what are deemed to be 'atypical' presentations receive delayed management for ACS (Washington & Bird, 2002). Brieger et al. (2004), found that patients who failed to present with the requisite chest pain with ACS had delayed treatment and worse outcomes; they found such presentations were associated with the administration of fewer evidence based therapies such as revascularisation, anticoagulation, β -blockade, statins and antiplatelet agents, which they espoused, led to greater hospital morbidity and higher mortality in this patient group (Brieger et al., 2004).

Symptom recognition in the emergency department. Using chest pain as a key descriptor for assessing ACS in the ED is problematic for a variety of reasons. First, it is difficult to gauge how many women actually present with complaints of chest pain and second, if they do not present with chest pain and this is the symptom most likely to rouse suspicion for ACS in the minds of the emergency clinicians, it needs to be asked: How many ACS episodes have been missed? The figures presented by researchers on experiences of chest pain in women with ACS are widely disparate. Brieger et al. (2004) for instance, found only 8.4 percent of patients positive for ACS presented to EDs with no chest pain, but these patients were more likely to be women. In another study, researchers combined all descriptors that could have been described as pain or discomfort and found 43 percent of women presented without chest pain (McSweeney et al., 2003). Others found women were less likely to experience chest pain than men in their studies (Gupta et al., 2002), but reported differences between sexes to have been insignificant when controlled for factors such as age (Arslanian-Engoren et al., 2006). A recent prospective cohort study examined prodromal symptoms experienced by younger men and women using the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey during hospitalisation to evaluate, amongst other things, the absence of chest pain in

young patients with ACS, and the association of chest pain (or not) with markers of disease severity (Khan et al., 2013). Khan et al. found younger women patients (mean age 49 for both sexes) were more likely to present without chest pain than men and chest pain presence was not correlated with severity of ACS, as demonstrated by cardiac troponin levels or coronary stenosis. Another problem may be that the description of chest pain can differ markedly between men and women; there may be a gender-based difference in the expression of pain. One research group argued men and women both experienced chest pain equally, but on finding that perceptions of chest pain were very different between the sexes, proposed a framework based on psychosocial, biological, physiological and anatomical differences to explain how symptoms manifested (DeVon et al., 2008).

Hence, it is difficult to say with certainty that chest pain is the chief complaint for all patients with ACS, but it can be said that by applying current understandings of ‘typical’ chest pain, ACSs are more easily differentiated in men (Pepine et al., 2006), making diagnosis of ACS in this sex more straightforward. This may be partly due to the male bias in clinical trials, where, despite efforts to balance the equation, women remain under-represented (Maas et al., 2011; Redberg, 2006; Washington & Bird, 2002). Symptoms reported to occur generically are therefore, more likely to reflect the male pattern for disease (Clancy, 2002; Stramba-Badiale et al., 2006), as are treatments based on the evidence from these findings. This has led to what has been described as a “gender neutral” understanding of heart disease and calls for health professionals to develop a clearer understanding of the nature of women’s ACS and the evidence base that underpins the disease and its management, as it is experienced by them (Lockyer, 2008, p. 161). Criticism has also been levelled at ACS management guidelines because of their “gender neutral” nature (Blomkalns et al., 2005). Blomkalns hypothesised that treatment guidelines’ failure to take the female pattern of disease into account would likely result in continued disparities in outcomes for women.

1.2.5 Diagnosis and early treatment of ACS in the emergency department (ED)

Diagnosis of ACS in an ED is generally undertaken using the patient history of presenting complaint, cardiac troponin analysis (repeated to evaluate for increase and change) (Chew et al., 2011) and serial electrocardiograms (ECGs) to evaluate for change over time. Goodacre et al. (2005) however found serial ECGs added little diagnostic or prognostic value in patients with normal or non-diagnostic initial ECGs. The severity of the ACS and the benefit of earliest revascularisation depends on the type of AMI. This is determined by analysis of the ECG focusing on the section of the electrical complex known as the 'ST-segment'. Using the ECG findings, patients are ascribed the diagnosis of STEMI, NSTEMI, UAP or NSTEMI. Some patients will also be diagnosed with AMI based on changes recorded as new left bundle branch block (Rose & Kuhn, 2009) (Appendix B). Patients with new left bundle branch block are assigned to the STEMI ACS group for treatment (White & Chew, 2008).

In order to abort the process of myonecrosis, patients with ACS need to arrive at an ED soon after onset of ACS, be diagnosed expeditiously and managed using evidence based therapies such as pharmacotherapy and revascularisation techniques. In the case of the most serious and time-critical of the AMIs, the STEMI, prompt treatment through reperfusion therapy salvages oxygen-depleted myocardial cells. According to current Australian (Aroney et al., 2006, Chew et al., 2011), European (Steg et al., 2012) and USA (O'Gara et al., 2013) ACS guidelines, revascularisation techniques for STEMI are ideally completed in less than 90 minutes from the point of symptom onset for STEMI. STEMI are more common in men than women (Berger et al., 2009) and account for approximately a quarter of all ACS presentations (Briege & Redfern, 2013). For patients experiencing NSTEMI or unstable angina, early angiographic evaluation of the lesion(s) and implementation of an appropriate revascularisation strategy is considered to confer the greatest benefit (Fox et al., 2010; Mehta et al., 2009). Timely reperfusion of hypoxic myocardial cells can result in positive effects on patient morbidity and mortality associated with the syndromes (Berger et al., 1999; Briege & Redfern, 2013) and therefore, require the earliest possible diagnoses.

The benefits achieved by early revascularisation and negative outcomes potentially avoided, make ACS one of the most important and time-critical conditions managed in the ED. The

ability to provide effective treatment depends on a number of factors, with early recognition of the syndrome and presentation to an ED vital. Presentation to an ED for management depends first, on patients with ACS recognising and acting upon their symptoms of disease without delay. However, there continues to be widespread misconception about the prevalence of and risks associated with women's ACS and heart disease risk generally within the lay community (Mosca et al., 2006; WHO, 2007), as well as by health professionals (Clancy, 2002; Mosca et al., 2005).

1.2.6 Timeframes and the triage role for ACS

If coronary reperfusion is achieved in the first 1 – 2 hours after STEMI onset, the death rate may be halved (Gersh et al., 2005; Scott, 2010). Delays in administering definitive treatment need to be minimised, with rapid restoration of epicardial blood flow understood to be of critical importance (White & Chew, 2008; Wu et al., 2011). In the context of ACS, this is generically known as “door-to-treatment” (D2T) time. Depending upon treatment method, these are called “door-to-balloon” (D2B) or “door-to-needle” (D2N) time. When percutaneous coronary intervention (PCI) facilities are available, PCI is the preferred option for patients with STEMI (Aroney et al., 2006; Chew et al., 2013), and the timeframe is known as the ‘D2B’ time (Finn et al., 2007). If PCI is unavailable where the patient with STEMI has presented for treatment, or transfer delays to appropriately equipped and staffed facilities are likely to preclude early PCI, the patient should instead be administered fibrinolytic or fibrin (i.e. clot) dissolving medication (Aroney et al., 2006; Chew et al., 2011; White & Chew, 2008). This timeframe is known as D2N time (Finn et al., 2007). Although there is a preference to use PCI where possible (Aroney et al., 2006; Boersma, 2006), the key emphasis should be on opening coronary arteries “quicker” (Gibson et al., 2004; Huynh et al., 2010). It has been demonstrated that the goal of a 90-minute D2T time should be reduced even further if possible (Rathore et al., 2009). Every minute of delay has been shown to count in terms of clinical outcomes (De Luca et al., 2004; Gibson et al., 2004). A recent Australian paper asserted mean treatment times were well beyond the timeframes in which irreversible myocardial necrosis occur, pointing out the median delay to D2B in Australia was in excess of 3 hours, and over 2 hours for D2N (Brieger & Redfern, 2013). Both are unacceptable.

Timeframe calculations for D2T time are the combination of numerous stages in the interval between arrival at an ED and implementation of definitive treatment. Each of these needs to be understood and optimised to decrease the delays to revascularisation. In their research involving monitoring physician performance for D2B time for AMI, Shry et al. (2003), argue that focus on D2B time is important because it is the only period of time that can be readily changed in hospital practice. EDs are the entrance points for most patients with ACS in Australia and for almost all patients with STEMI. As newly presenting patients will first be evaluated and prioritised by triage nurses according to perceived levels of urgency, it is critical that this phase of the D2T time is investigated. Due to the evolutionary nature of myocardial damage, it is one of the most time-critical conditions requiring ED management (Brieger & Redfern, 2013; Jacobs et al., 2007) and thus, triage evaluation of patients with ACS lead to one of the most important triage decisions reached by a triage nurse.

Applying timely and evidence based therapy for ACS requires complex and rapid decisions which are evident throughout the patient's trajectory of ED care. Triage is a patient's first point of contact with healthcare personnel inside an ED and the role requires the significantly advanced clinical decision making ability by a nurse, without the benefit of prior diagnoses or technology to assist. The Australasian Triage Scale (ATS) is a 5-tiered scale designed to enable the 'sorting' of patients with equity and efficiency (Richardson, 2004), according to level of acuity (Australasian College for Emergency Medicine (ACEM), 1993; DHS, 2001). It is a formalised process in all Australian government funded hospital EDs (ACEM, 1993), whereby patients are prioritised by experienced, educated and specialty-qualified emergency nurses according to their level of clinical need. Emergency triage staff apply the following question to all patients upon presentation to an ED: "This patient should wait for medical assessment no longer than... [minutes]" (DHS, 2001) and rank them according to their perceived clinical urgency (ACEM, 2000). Patients who are assigned ATS Category 1 are assessed to be in immediately life threatening danger if treatment is not commenced immediately, so their treatment is instantaneous with arrival. Patients who are assessed to have imminently life-threatening or important time-critical conditions or who are in severe pain, are allocated ATS Category 2; not to wait longer for medical or nurse practitioner assessment and treatment than 10 minutes. Those patients who are deemed by the triage nurse to have potentially life-threatening conditions, situational urgency, severe discomfort or distress are allocated ATS

Category 3; not to wait longer than 30 minutes. Those with potentially life-serious, situational urgency or with conditions of significant complexity and severity, severe distress or discomfort are allocated ATS Category 4; to wait no longer than 60 minutes. Patients who are evaluated by the triage nurse to have less urgent (not life-threatening) or clinico-administrative problems are allocated ATS Category 5; with treatment to be commenced in less than 120 minutes (DHS, 2001). The ATS table, as described, is provided in Chapter 2 of this thesis (Table 2.1).

Ideally, patients who are allocated the highest priority should always be assessed and managed before others allocated lower triage scores regardless of arrival time. The reality of EDs in Australia is that many patients will not be treated by ED medical or nursing staff within the timeframe deemed to be warranted by the triage nurse through triage score allocation (AIHW, 2012b). Australian EDs regularly experience what is known as ‘access block’, which results in overcrowding of EDs because patients who have already been assessed and stabilised for admission are not able to be moved out of EDs due to lack of beds ‘upstream’ in the in-hospital areas (Richardson & Mountain, 2009). Even without access block, uncapped patient numbers arriving for treatment simultaneously can result in long queues at the triage desk and more patients requiring care for conditions triaged as ATS Category 1 and 2 than staff and cubicle resources can accommodate. Patients who are allocated ATS Category 3 may wait a great deal longer than the 20 minutes extra deemed to be safe between ATS Categories 2 and 3. Similarly, patients allocated ATS Category 4 may wait much longer than 50 minutes extra than the timeframe deemed satisfactory for ATS Category 2. Unless patients presenting with ACS are assessed at triage to be in immediately life-threatening danger requiring immediate resuscitation (in which case they are allocated ATS Category 1), patients with ACS should be allocated ATS Category 2. This is because they are in imminently life-threatening danger with important time-critical conditions, and often with very severe pain, there is a high probability their time to onset of treatment will be well in excess of the 10-minute recommendation if given a lower acuity triage score.

Delays in D2T times have not, to the best of the Candidate’s knowledge, been found to occur because of incorrect triage score allocation for ACS. The important role of the triage nurse and their triage decision for ACS appears to have been overlooked, which represents a significant gap in the literature given the importance of ACS in society because of the sheer

number of incidences, associated burden of disease and mortality. The triage nurse role and the provision of triage score allocation for ACS have not been studied for men or women in either international or Australian ED systems, making the evaluation and quantification of this early stage of ACS management imperative. In the context of the broader healthcare systems both within Australia and overseas, it has however been shown that women tend to be under-evaluated and under-treated for ACS during many other points in their healthcare delivery.

Research from the USA shows that application of prompt reperfusion therapy does not always occur equally for both sexes. Interrogating data from more than 78,000 patients with AMI across the USA, Jneid and colleagues (2008) ascertained women presenting to EDs were older, had more co-morbidities, presented less often with STEMI and had higher unadjusted inhospital death (8.2% versus 5.7%, $P<0.0001$) than men. After multivariate adjustment, these sex-related differences were no longer observed, apart from in the STEMI cohort. Jneid et al. (2008) found it was significant women received less early aspirin, β -blockade, reperfusion therapy and timely reperfusion than men. They also received less cardiac catheterisation and revascularisation procedures after AMI (Jneid et al., 2008). Similar patterns have also been observed in many other studies around the world (Barron et al., 1998; Jneid & Thacker, 2001; Milcent et al., 2007; Vaccarino et al., 2005), including for some treatments in Australia (Roe et al., 2013; Walters et al., 2008). Researchers believe the answer to reducing the significant disparities between the sexes is to correct the underuse of evidence-based treatments and avoid delayed reperfusion (Jneid et al., 2008).

International research has shown that compared to men, women are more likely to be discharged prematurely from EDs with ACS (Kaul et al., 2007), and are less likely to undergo revascularisation procedures (Jneid et al., 2008; Kaul et al., 2007; Radovanovic et al., 2007; Rosenfeld, 2006). Jneid and colleagues (2008) believe such less aggressive therapy administration is likely part of the reason women suffer greater very early death than men when admitted with STEMI (Jneid et al., 2008). Contemporary research has shown this also to be the case in Australia, where, although knowledge amongst physicians is good, application of evidence to practice is inconsistent or poor (Chew et al., 2007; Chew et al., 2013; Huynh et al., 2009). To date, the role emergency nurses play in the timely commencement of treatment for ACS, and whether there is practice variation related to patient sex, have not been explored in the Australian context.

The early assessment and management of all patients with ACS is critical to the effectiveness of myocardial reperfusion. Early access to reperfusion therapy for STEMI prevents or limits myocardial injury and death, improving clinical outcomes such as re-infarction and mortality (Shaw et al., 2009). In an Australian study (Huynh et al., 2010), timely reperfusion of STEMI in patients was associated with a 78 percent reduction in mortality (hazard ratio, 0.22; $p = 0.04$). For patients experiencing NSTEMI/ACS, early access to medical care enables stratification of the patients' conditions into levels of risk. Early medical evaluation allows appropriate management decisions to be made in a way that balances the need to reduce ischaemia and possible infarction with risk factors associated with PCI and pharmacotherapy, such as bleeding (Maas et al., 2011). Women have been noted to have proportionately more bleeding complications with reperfusion therapy than men (Chew et al., 2011). Bleeding risk is more pronounced in younger women (Argulian et al., 2006). Not all patients with ACS require immediate therapy, but all patients with ACS have an acute and dangerous disease in need of early, evidence-based therapy. The recently published Australian and New Zealand SNAPSHOT ACS Study (Chew et al., 2013) demonstrated considerable variation in management of ACS in a two-week snapshot of care in a number of hospitals ($n = 286$) in Australia and New Zealand. Up to 40 percent of patients did not receive any reperfusion therapy and evidence-practice gaps were uncovered during pre-, in-, and post-hospital ACS management (Chew et al., 2013). The comprehensive study provided new insights into challenges associated with provision of timely and effective ACS care (Chew et al., 2013), although variation due to ED or in-hospital management and patient sex specifically have not yet been reported.

1.3 Research rationale

Using the alias 'Richard Saunders', Benjamin Franklin penned the following aphorism in his 'Poor Richard's Almanac':

You may delay, but time will not.

(Franklin in Kofoia, 1914: p. 62)

Franklin could have been writing about the overarching importance of acting with expedience when patients arrive at EDs with ACS. Failure to rapidly manage patients with ACS, for whatever reason, equates to increased myocardial damage and potentially avoidable increased risk of morbidity and mortality. Failure to provide eligible patients with equal access to timely management in such a way that they are not equally able to avoid increased risk equates to inequity.

The extraordinary reduction in incidences of death from CHD over the last 30 years have largely been due to reduction in prevalence of smoking and other lifestyle modifications reducing primary disease (AIHW, 2012a). Substantial reductions in death rates from ACS have also been attributed to revascularisation and pharmacological interventions (White & Chew, 2008), although it has been suggested there is currently a levelling off of these gains (Chew & Scott, 2013). Gains are based on treatments being given according to guidelines, which in many cases, is as early as possible (Brieger & Redfern, 2013; Shaw et al., 2009; White & Chew, 2008). Findings from the ACACIA registry demonstrate it is not the mode of reperfusion, but the use of any reperfusion therapy and the timeliness of its provision that are most associated with outcome benefits (Huynh et al., 2010). Surprisingly, in spite of all of the novel therapies under development and testing, White and Chew (2008) did not foresee as much benefit to be gained by introducing new therapies for AMI, compared to better applying what was already available. They argued it was the systems that needed to be improved. They cited some impressive calculations for potential lives saved by implementing what was already known and available into practice better; estimating that increasing the proportion of patients receiving therapy for STEMI could potentially save 270 lives per 10 000 patients; and, by

reducing time to fibrinolysis or changing from fibrinolysis to PCI, 154 lives per 10 000 patients with STEMI could be saved (White & Chew, 2008, p. 580).

Despite what is understood about the potential lives saved from improving access to and timeliness of reperfusion, the influence the triage role has on door-to-reperfusion time has not been adequately evaluated. Little is known about patient evaluation of ACS at triage and the multitude of factors which may influence the effectiveness of this role. Several studies have examined triage nurse ability to effectively triage women for ACS in the ED and most have described difficulties with this (Arslanian-Engoren, 2004, 2005, 2009), but there has been minimal investigation (Atzema et al., 2009, 2010) of triage nurse influence on time to treatment onset for ACS, and none reported in Australia. Atzema and colleagues investigate triage-to-electrocardiogram (ECG) time. The only other patient factors found to negatively influence triage accuracy for ACS were found to be patient age; older age in years was found to be associated with lower acuity triage assessment in one study (Arslanian-Engoren, 2001), and younger patient age was found to cause lower acuity triage evaluation for ACS in another (Arslanian-Engoren, 1999). No studies were uncovered seeking to examine other non-clinical variables leading to difficulty triaging patients with suspected ACS population to appropriate levels of acuity.

The rationale for undertaking this PhD is to undertake an empirically-based programme of exploration and analysis of the earliest point of ED assessment and management of ACS. It will provide new, research-based insight into the triage score allocation and subsequent treatment onset times for patients with ACS, exploring other sociodemographic variables' influence on time to treatment from triage, and examine gender-related treatment and mortality patterns across Victoria using several years of contemporary data. It will also examine the equity with which men and women patients are treated for ACS in Victorian public hospitals and whether or not there are any observable patterns of disparity within this population.

1.4 Research aims and objectives

The intentions of undertaking this programme of research are to: First, add to emergency healthcare knowledge around ED triage assessment for patients with different demographic patterns, particularly sex for ACS, where there is an identified knowledge gap; and second, examine reperfusion management patterns and outcomes of ACS in women and men to enable identification of any disparity and guide future research and practice towards reducing any avoidable differences. Central to the research is the understanding that timing and access are critical factors in effective treatment of ACS, and hospital system delays must be identified and minimised to ensure women's ischaemia and infarction are diagnosed and managed expeditiously to optimise patient outcomes. Hence, 'The **Diagnose and Manage Early: Women's Ischaemia and Infarction (DaME II)** study'.

The overall aims of the DaME II study are to:

1. Examine and describe the early triage score allocation patterns and patterns in times to treatment onset for ACS in women and men; and
2. Describe and compare the management and outcomes for ACS in women and men in Victorian hospitals.

The following research objectives are used to guide the programme of research. They are to:

1. Appraise existing evidence to ascertain a research-based understanding of the effect of patient sex on ED triage for ACS;
2. Explore current practice of triage score allocation for ACS and AMI and subsequent treatment onset times in relation to patient sex;
3. Examine if non-clinical demographic factors influence the time to treatment onset for ACS in EDs; and
4. Determine whether patient sex influences access to evidence based treatment for ACS in Victorian public hospitals, and whether mortality rates from ACS are influenced by patient sex.

1.5 Research questions

Through literature review and a series of discrete analyses of two statewide datasets, the research programme explores a selection of separate, but related questions around triage, treatment onset time, and inpatient management and mortality of patients with ACS in Victoria.

The research questions for Chapters 2 – 5 (Figure 1.3), from which publications arise are as follows:

Chapter 2.

Research question: What is understood from review of the literature about clinical decision making by ED triage nurses for women with ACS, including how triage nurses formulate decisions and which factors influence these?

Chapter 3 [research paper].

Research question: Does patient sex influence triage score allocation for ACS and AMI in EDs and if there is disparity, does this impact upon treatment onset times in Victorian EDs?

H₀. Patient sex has no influence on triage score allocation for ACS and AMI in EDs and patient sex has no effect on treatment onset times for the coronary heart diseases in Victorian EDs.

Chapter 4 [research paper].

Research question: Which patient and non-patient factors are associated with increased risk of delayed treatment onset for AMI in Victorian EDs?

H₀: Other than for reasons of perceived clinical urgency, patient and non-patient demographic factors do not affect the speed at which patients are treated for AMI in EDs from triage?

Chapter 5 [research paper].

Research questions:

1. Is interventional reperfusion therapy equally provided to younger and older men and women patients admitted to Victorian public hospitals with STEMI?

H_0 : Patient sex and age are not associated with interventional reperfusion therapy provided for patients admitted to Victorian public hospitals with STEMI.

2. Are patterns of inhospital mortality different between younger and older men and women patients admitted to Victorian public hospitals with STEMI?

H_0 : Patient demographic factors of sex and age are not associated with patterns of mortality for patients admitted to Victorian public hospitals with STEMI.

1.6 Research design and methods overview

The research design for the DaME II programme is a compilation of individual studies which were retrospective, non-interventional descriptive, observational database research.

Two Victorian Health Information Repositories System (VHIRS) databases were analysed when undertaking the DaME II study:

- i) Victorian Emergency Minimum Dataset (VEMD); and
- ii) Victorian Admitted Episodes Dataset (VAED).

Non-identifiable aggregated data were provided in compressed, password protected digital files in Statistical Package for Social Sciences (SPSS) format. Statistical programmes used included SPSS versions 18, 19 and 21, Microsoft Excel and R packages, with full details of data preparation, statistical analysis and software used are provided in each of the research publications. Data were saved to different programmes for analysis using the comma separated values (CSV) format.

Variables were selected using the VAED and VEMD manuals and lists of data fields available online at the Department of Health (DoH) through <http://www.health.vic.gov.au/>. Patient age was provided in years as a continuous variable initially and transformed to 5-year and dichotomous groupings as necessary in both datasets. Data for length of stay variables were also continuous, but all other variables were categorical. String variables were allocated numerical codes, and data were examined for missing values, outliers and accuracy of data entry. Distributions were checked for normality using the Lilliefors test. Frequency tables provided descriptive statistics for variables necessary to answer the research questions. Continuous variables were compared using the Wilcoxon rank-sum test, Student's *t*-test and one-way ANOVA. Categorical variables were compared using chi-squared test (χ^2). Continuous non-parametric statistics were presented as medians with first and third interquartile ranges unless otherwise specified in the publications, and categorical variables were presented as percentages with binomial confidence intervals. All statistical tests were two-tailed and *p*-values of less than 0.05 were considered to indicate statistical significance. Data were validated according to the Australian Coding Standards, which applied to

International Classification of Diseases and Related Health Problems, tenth revision Australian Modification (ICD-10-AM) and Australian Classification of Health Interventions (ACHI), which are used in all Australian public and private hospitals (National Centre for Classification in Health (NCCH), 2008).

Using these parameters, the DaME II study used research of administrative data to provide insight into triage score allocation and other variables affecting treatment onset times, in addition to proportional reperfusion therapy provision and mortality for patients of each sex with ACS treated in the Victorian public hospital system. The study determined the impact, efficacy and equity in public hospital ED triage of heart disease in women and in-hospital treatment and outcomes, compared to their male cohort. In the format of a PhD by Publication, the thesis incorporated a number of different methodologies appropriate to meet the needs of each publication's research aim(s) and question(s) listed in Section 1.5 in publications incorporated into chapters, and outlined below. Chapters 2 and 4i incorporated literature review methodology to ensure all available literature meeting the inclusion criteria were appraised at the outset for review and critique. The methodologies for each are incorporated into the opening sections of the associated publications.

Chapter 3 was undertaken to compare equity of triage score allocation and associated times to treatment onset for ACS and AMI between two groups (men and women). To do this, a large contemporary administrative dataset (VEMD) was retrospectively analysed using mostly Student's *t*-tests and ANOVA (one-way and two-way between groups) for all Victorian adults ($n = 261,628$) admitted to EDs from 2005-10 with possible and actual heart attacks. Included were all patients, aged 18 to 85 years who were alive on arrival, and admitted to any of Victoria's general public hospital EDs ($n = 34$) over a period of five years (2005 – 2010) with selected diagnoses of acute myocardial infarction, unstable angina pectoris, stable angina pectoris, and the common symptom for admission when diagnosis has not been established, chest pain, using ICD-10-AM codes. The data were analysed in two separate samples to enable:

- a. Evaluation of triage score allocation and mean subsequent times to treatment onset for men and women who may have reasonably been suspected of experiencing a time-sensitive ACS at ED triage; and

- b. Evaluation of triage score allocation and mean subsequent treatment onset times for patients who were formally diagnosed with the principal diagnosis of AMI.

Chapter 4ii employed regression tree analysis to determine risk factors for increased time to treatment for all patients aged 18 – 85 years, with AMI (n = 21,080), who presented to any of the 34 general Victorian public hospital EDs over five consecutive years (2005 – 2010). VEMD data were partitioned into three randomly selected sub-sets using a method described by Williams (2011), with a complexity parameter set at 0.0005.

Descriptive statistics were used to analyse data from the VAED dataset to evaluate distributions and describe the characteristics of men and women admitted to Victorian public hospitals from 2005 – 2010 with STEMI (n = 13 744) for Chapter 5. Categorical data were analysed using chi-squared test and larger contingency tables. Normally distributed data were analysed using independent *t*-tests and for non-normally distributed data, Mann-Whitney U tests were used.

1.7 Research outline

This thesis comprises six chapters, an abstract, a bibliography list and appendices. Figure 1.3 illustrates the position of each chapter in relation to the others. The thesis contains five manuscripts; three of which are research papers (two are accepted and available in peer reviewed, scientific journals, and a third is under journal review). A literature review and a methodology paper have also been published in peer-reviewed, highly regarded scientific nursing journals.

The overall structure commences with the current chapter's introduction to a broad range of literature and examination of evidence important to the subject of early assessment and management of heart disease, before focusing on differences according to patient sex. It leads into important background information necessary to understand the severity of CHD and ACS, the aetiology, epidemiology, pathophysiology, symptomatology, management and outcomes for the diseases. It situates the need for equity in healthcare within the global and local healthcare arenas. This review of the literature is in addition to the published literature review provided in Chapter 2.

The literature review published in Chapter 2 provides an examination of the issues related to clinical decision making and triage allocation for women with ACS in the context of busy and often chaotic ED environments. Where there is little information related to ED triage assessment of women with ACS, it uses research published from other healthcare areas to guide exploration of the subject and further discussion.

Chapter 3 incorporates a publication examining the equity of triage score allocation for men and women with ACS and AMI, and associated onset to treatment times. In this manuscript, inequities in ED triage are raised as cause for concern and further investigation.

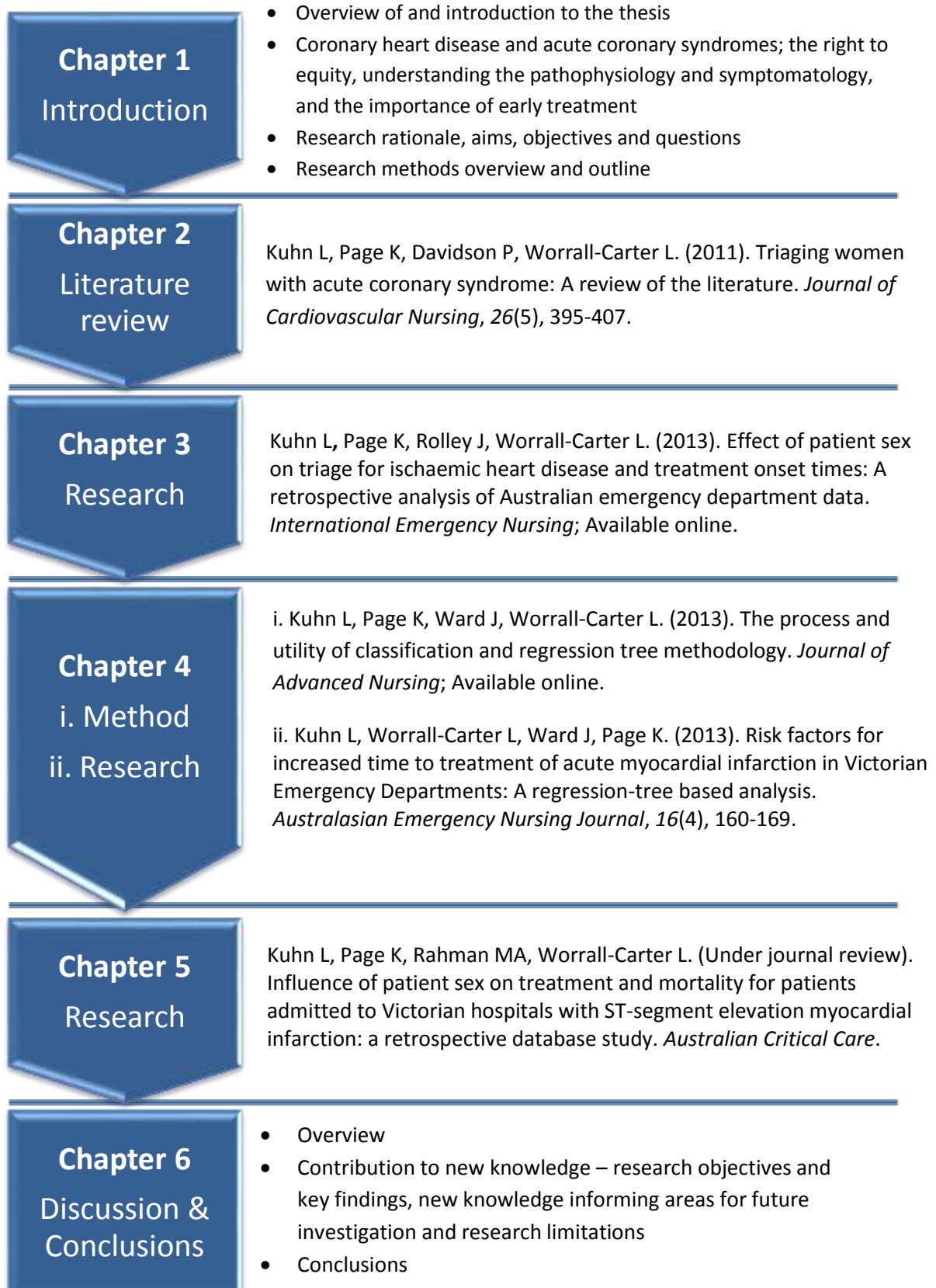
Chapter 4 introduces and utilises a novel quantitative approach to research in nursing. It includes two publications: The first is an introductory discussion of classification and regression tree method, which has the potential to prove valuable and provide alternative an method of analysis in the near future; the second article included in this chapter is the research paper which identifies and explores relationships between variables not previously known to interact with each other or impact upon the time to treatment onset for AMI in the

ED. It uncovers variables which, when combined with other specific patient variables, lead patients with AMI to be vulnerable to undertriage and delayed treatment onset.

Chapter 5 incorporates a research publication developed with state-wide admitted patient data. It explores the treatment and inhospital mortality for patients with STEMI across one Australian state over a number of years, focusing on variations possibly equating to bias and certainly finding disparity related to patient sex.

Chapter 6 provides an overview of the DaME II study findings. It details the study's contribution to new knowledge important to the future provision of equitable care of women with ACS in the ED. Through examining two extensive, non-identifiable datasets detailing patient demographic features and clinical variables on a large population, the healthcare provided to patients for the disease responsible for more deaths than any other, has been assessed for efficacy and equity as much as possible. A number of limitations are associated with all database research however, and these separate research endeavours were no exception. Important limitations are discussed and recommendations for future research are made.

Figure 1.3. Flow chart of PhD thesis by publication outline



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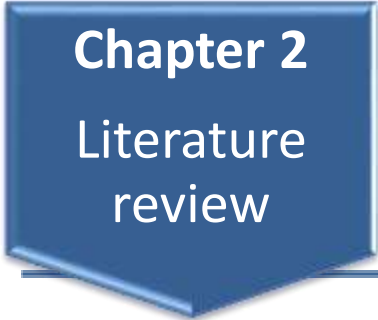
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Chapter 2

Review of the literature: triage of women's heart disease



Chapter 2 Literature review

Kuhn L, Page K, Davidson P, Worrall-Carter L. (2011). Triage of women with acute coronary syndrome: A review of the literature. *Journal of Cardiovascular Nursing*, 26(5), 395-407.

2.1 Background

Coronary heart disease (CHD) remains the leading cause of death of men and women internationally (WHO, 2008), as well as in Australia (AIHW, 2012). While the total number of deaths from CHD has fallen (AIHW, 2012; WHO, 2008), this has not translated into an equivalent reduction in the mortality rates from heart disease for many subsets of women, when compared to their male cohorts (Ashley et al., 2013). CHD is a leading cause of disease burden in Australian women over 65 years of age (ABS, 2006; AIHW, 2012). Some groups of women have worse outcomes secondary to the acute coronary syndromes (ACSs), the types of CHD that include acute myocardial infarction (AMI) and unstable angina pectoris (UAP), than do their male counterparts (Bassand et al., 2007; Pilote et al., 2007). The reasons for the inequities in outcome are multifaceted and partly related to how women with heart disease (WHO, 2007) and those within the health care community (Clancy, 2002; Mosca et al., 2005) perceive and react to their disease.

For maximal benefit in terms of reduced myocardial muscle damage and improving outcomes in mortality and morbidity, delay in seeking and receiving definitive treatment must both be understood and minimised. Significant work has been done identifying reasons for patient delays in seeking treatment (Moser et al., 2007; Perkins-Porras et al., 2009) however, less research has been undertaken around the factors affecting how long it takes for patients to receive recommended therapies after they present at hospitals with ACS. The usual point of

entry into Australian hospitals for ACS is via emergency departments (EDs). Australian research has identified that hospital medical staff generally have good knowledge of Australian ACS treatment recommendations, yet implementation is often poor (Chew et al., 2007; Walters et al., 2008). Women have been found for instance, to be referred less often to angiography than men (Walters et al., 2008). The Australian studies did not focus on medical staff in the ED environment. Emergency nursing knowledge and practice of women's heart disease is largely unknown.

Patients arriving at Australian EDs with ACS, like all illnesses, are first evaluated at triage by an experienced and educated triage nurse (ACEM, 2000). The triage nurse role is central to the running and efficacy of care in an ED because triage nurses are responsible for sorting all newly arrived patients to expedite care where necessary within limits of available resources. The role of the triage nurse is one of the most important in the ED because of the requirement the nurse is able to consistently differentiate between many possible diseases, usually without diagnoses or test results, and in chaotic and often overcrowded environments. An improved understanding of the ED nurse triage role, factors influencing the accuracy of triage for ACS and the effectiveness in differentiating ACS from other disease entities is therefore pivotal to optimal ACS management.

Chapter 2 provides a discussion about the management of ACS in the context of the ED, examining the role of the triage nurse. Identifying key tenets of the triage nurse role at the beginning of this thesis acknowledges the fundamental role these nurses have in emergency departments and the likely importance their decisions have in relation to ACS outcomes. A published literature review is incorporated into this chapter, focusing on how triage nurses assess patients with ACS and what is known about *triaging* (the act of undertaking formal triage) women with ACS. All of the studies discussed in the literature review have been undertaken overseas. While the international literature is valuable, it clearly demonstrates that Australian research in this area is warranted. In particular, the understanding of ACS presentation and management by ED nurses has not been explored in the Australian context.

2.1.1 Australian emergency management of acute coronary syndromes

Approximately 49 500 major cardiac events were estimated to have occurred in Australia in 2007 in the 40 – 90 year old group and nearly 40 percent of these were fatal (Australian Institute of Health and Welfare (AIHW), 2011). Cardiac death due to ACS is largely preventable. It has been suggested if coronary reperfusion is achieved in the first 1 – 2 hours after ACS onset, the death rate could be halved (Gersh et al., 2005). Due to the evolutionary nature of myocardial damage, it is one of the most time-critical conditions requiring ED management (Jacobs et al., 2007). Delays in receiving definitive treatment are broadly divided into several phases. Pre-hospital delay is divided into two phases; first, the time taken by the patient to seek professional help; and second, transport time, or time elapsed between seeking help and arrival at an ED. The hospital delay is the interval between arrival at an ED and implementation of definitive treatment. In the context of ACS, this is also known as “door-to-needle” time, which is arrival to administration of fibrinolytic or fibrin (i.e. clot) dissolving medication, and “door-to-balloon time”, which is time taken from arrival to percutaneous coronary intervention (PCI) (Finn et al., 2007).

Applying timely and evidence based therapy for ACS requires complex and rapid decisions which are evident throughout the patient’s trajectory of ED care. Triage is a patient’s first point of contact with an ED and discharge of the role usually requires significantly advanced clinical decision making ability by a nurse, without the benefit of prior diagnoses or technology to assist. The Australasian Triage Scale (ATS) is a 5-tiered scale designed to enable the “sorting” of patients with equity and efficiency (Richardson, 2004) according to level of acuity (Australasian College for Emergency Medicine (ACEM), 2000; Department of Human Services (DHS), 2001). It is a formalised process in all Australian government funded (and most private) hospital EDs (ACEM, 2000), whereby patients are prioritised by experienced, educated and specialty-qualified emergency nurses according to their level of need. Emergency staff apply the following question to all patients upon presentation to an ED: “This patient should wait for medical assessment no longer than... [minutes]” (DHS, 2001) and rank them according to the following scale (Table 2.1):

Table 2.1. Australasian Triage Scale guidelines for triage category allocation

ATS	Time frame	Description of category
1	Immediate	Immediately life-threatening
2	Assessment and treatment start within 10 minutes	Imminently life-threatening or important time-critical treatment or very severe pain
3	Assessment and treatment start within 30 minutes	Potentially life-threatening or situational urgency or humane practice mandates relief of severe comfort or distress within 30 minutes
4	Assessment and treatment start within 60 minutes	Potentially life-serious or situational urgency or significant complexity or severity or human practice mandates the relief of severe discomfort or distress within 60 minutes
5	Assessment and treatment start within 120 minutes	Less urgent or clinic-administrative problems

ATS, Australasian Triage Scale

Source: DHS, Guidelines for Triage Education and Practice, 2001, p. 11

Patients with potential ACS fit into ATS Category 2 for at least two reasons described: First, the syndromes are severe enough to cause death – a patient with ACS may have circulatory compromise on arrival or may deteriorate rapidly without warning. Second, ACS is considered a time critical condition – myonecrosis is likely to be exacerbated without the application of suitable intervention within a rapid timeframe, as is the likelihood of myocardial electrical rhythm disturbances (dysrhythmias) (Moser et al., 2005). The majority of patients with ACS will also have pain, and therefore should usually fit into ATS Category 2 for assessment and management of this symptom as well.

Formalised triage requires nurses learn to integrate a complex array of objective data which consists of primary survey (whether a patient's airway, breathing circulation or central

neurological status are compromised), pain and neurovascular status, and subjective data supplied by the patient or significant other to come to an initial *working or provisional* diagnosis. The latter requires the triage nurse consider the patient's chief complaint, precipitation of symptom onset, mechanism of injury, time of onset and relevant history (including medical, familial and drugs) (DHS, 2001). All of this is done within a matter of minutes in the setting of a busy ED with various patient and family exigencies and institutional interruptions complicating the process. The final decision relies on the triage nurse formulating judgements (or inferences) that can include "probability judgements" and the assigning of a specific Category (Cioffi, 1998, p. 184).

If a triage nurse decides it is likely a patient has ACS based on assessment and clinical findings, the patient is taken through to the monitored cubicle area within the main section of the ED, ideally within the 10-minute timeframe. If they do not come to this initial provisional judgement, a patient may be assigned a lower ATS category that leaves them either waiting for longer for treatment in the ED, discharging themselves against the triage nurse's advice, or seeking medical assistance elsewhere. Treatment delay is likely to increase mortality and morbidity in ACS. Hence, "initiation of emergency care primarily depends on the decisions made by the triage nurse" (Considine, 2000, p. 201).

If a patient is recognised to have possible ACS by the triage nurse, the nurse will generally write brief comments indicating the objective and subjective assessment, and, depending on the expectations and culture within an ED, will have recorded a plan for the patient to have an ECG as a matter of urgency, with aspirin given concomitantly. Documentation by the triage nurse is an important determinant of whether or not patients with ACS receive adequate care. In a recent study, it was found that 10 percent of all patients had no documented symptoms of AMI when they presented to EDs for treatment. The researchers concluded these patients were less likely to receive aspirin and β -blockade within 24 hours, reperfusion therapy for STEMI or to survive their hospitalisation (Schelbert et al., 2008).

Performance of an ECG soon after a patient is judged to have possible ACS is critical for diagnosis of ACS and timely implementation of evidence-based care. Some studies have advocated procuring the ECGs in technologically equipped ambulances and forwarding them to the receiving institution to reduce delay to reperfusion in STEMI on arrival at the hospitals

with good results (Clemmensen et al., 2005; Herlitz et al., 2002; Terkelson et al., 2002). An early ECG is important for diagnosis and risk stratification and, depending on its interpretation may result in the patient proceeding directly to a cardiac catheter laboratory for reperfusion therapy, bypassing that hospital's ED, or going to another hospital with these facilities. It has recently been reported that ventricular repolarisation abnormalities on ECG are important predictors for ACS complications and mortality in postmenopausal women (Rautaharju et al., 2006), but this has been shown in women more broadly also (Triola, 2005). It must be noted however, that the ECG taken soon after onset of ACS has low sensitivity for ACS and injury cannot be safely ruled out (Aroney et al., 2006). Having said this, an ECG with the required ST-segment changes, or new left bundle branch block (Rose & Kuhn, 2009), can "be the sole test required to select patients for emergency reperfusion" (Aroney et al., 2006).

Another important test likely to be instigated soon after a patient with suspected ACS arrives for treatment is blood assay for a chemical biomarker of myonecrosis (Collinson, 2000; Wilcox et al., 2001). Cardiac biomarkers are recognised as important and sensitive for the diagnosis of myocardial injury, however, like the ECG, they do not change immediately. Cardiac serum troponin levels are the favoured biochemical tests for ACS, although they may not rise after myonecrosis for 4 – 6 hours after the event (Aroney et al., 2006). The new high-sensitivity troponin tests; Troponin I or Troponin T, are repeated at 6 hours after onset of pain to rule out AMI if a negative initial assay does not capture myonecrosis (Aroney et al., 2006; Chew et al., 2011). However, this is problematic because reperfusion therapy for STEMI or high risk NSTEMI (AMI with serum troponin rise) (Aroney et al., 2006) should have been implemented within 30 minutes for fibrinolysis and 90 minutes for percutaneous coronary intervention (PCI) of the patient's arrival at the ED (Chew et al., 2012).

Due to the potential delays described in these quantifiable measures of ACS, great importance rests on the ability of the triage nurse to accurately triage a patient for ACS and assign an appropriate level of acuity. Even if the triage nurse does suspect ACS and documents and categorises the patient's level of acuity accordingly, time may be lost waiting for ECG and CTn changes to occur, or for medical staff to review the patient. Accurate evaluation of potential ACS is a problem in both sexes; it has been estimated EDs turn away between 2 – 8% of patients who are positive for the disease (Collinson, 2000; Pope, 2000), but a substantial number of these are misdiagnosed (Collinson et al., 2006). Gauging an accurate proportion of

women being misdiagnosed is difficult however; as health care professionals often fail to recognise the signs and symptoms unique to women's heart disease (Clancy, 2002), it is likely the number being turned away is even higher.

2.1.2 Current understanding of triage nurse evaluation of women with ACS: the need for review of the literature

Given the importance of expedient, but accurate triage of ACS and that it has been reported that when compared to men, women are disadvantaged within ED systems and hospitals generally due to under-assessment and under-treatment of the disease, appraisal of existing evidence for triage of women with heart disease is essential.

The following article, published in the United States' Journal of Cardiovascular Nursing, is a literature review undertaken to explore and critique current evidence in relation to:

- a. How triage nurses evaluate and prioritise management of women patients with ACS; and,
- b. Challenges associated with triaging women for ACS in the ED.

In the journal article, Kuhn et al. (2011) present a number of themes arising from the literature which lead to difficulties in reaching accurate triage assessment of women for ACS. Recommendations are made for future research to better understand and ameliorate problems in assessment of women's ACS and describes implications for ED nursing practice.

2.2 Publication

Kuhn L, Page K, Davidson P, Worrall-Carter L. (2011). Triageing women with acute coronary syndrome: A review of the literature. *Journal of Cardiovascular Nursing*, 26(5), 395-407.

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Triaging Women With Acute Coronary Syndrome A Review of the Literature

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Aims and Objectives: This article analyzes the literature describing factors affecting nurses' triage of emergency department (ED) patients with potential acute coronary syndrome (ACS), with particular attention paid to gender-based differences. **Introduction:** Acute coronary syndrome is one of the most time-critical conditions requiring ED nurse triage. This literature review will provide examination of how triage nurses prioritize patients with possible ACS, reflecting on challenges specifically associated with evaluating women for ACS in the ED. The article presents a description of the research findings that may help improve the timely revascularization of ACS in women. **Methods:** An electronic search of EBSCOhost CINAHL, Health Source Nursing Academic Edition, MEDLINE, Psychology and Behavioral Sciences Collection databases, online theses, the Cochrane Library, the Joanna Briggs Institute, and National Guideline Clearinghouse resources were used to identify all relevant scientific articles published between 1990 and 2010. Google and Google Scholar search engines were used to undertake a broader search of the World Wide Web to improve completeness of the search. This search technique was augmented by hand searching these articles' reference lists for publications missed during the primary search. **Results:** Review of the literature suggests factors such as patient age, sex, and symptoms at ED presentation affect the accuracy of nurses' triage of ACS, particularly for women. However, research examining delays due to ED triage is scant and has predominantly been undertaken by one researcher. Little research has examined triage of ACS specifically in women. **Conclusions:** The literature search revealed a small number of articles describing challenges associated with nurse triage of women with ACS. Although most of this published research is North American, the themes uncovered are well supported by broader international research on acute assessment and management of women's ACS. These include the following: gender-based differences in the presentation of ACS can preclude early identification of ACS, advanced patient age often correlates with missed or delayed diagnosis of ACS, and there appears to be a general bias against managing women for ACS in parity with men's disease. **Relevance to Practice:** Early reperfusion therapy is critical for optimal health outcomes in ACS. Triage nurses are ideally placed to minimize time to treatment for ACS. An understanding of the issues related to clinical decision making and triage allocation of women with ACS at triage is necessary to ensure appropriate treatment.

KEY WORDS: acute coronary syndrome, clinical decision making, emergency department nurse triage, women

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Emergency department (ED) triage nurses are the first health professionals to evaluate patients within many acute health systems and therefore are in a strong position to influence health outcomes.¹ These nurses are ideally placed to enhance outcomes for patients with time-sensitive conditions because of their responsibility for assessing acuity or urgency of illness and assigning the order in which patients receive ED care.^{2,3} For the management of acute coronary syndrome (ACS), ED nurses are integral to determining the time to revascularization.^{4,5}

As the entry point for patients coming into hospital systems via the ED, the triage role is central to the efficient delivery of emergency care^{6,7} and paramount to patient safety.^{2,6,8,9} However, this role is often undertaken in crisis-driven³ and chaotic¹⁰ settings. Decisions are made in the context of significant time constraints, crowded waiting rooms, and high patient anxiety.

Arrival at a triage decision is recognized to be a dynamic process.¹¹ It is formulated based on patients' chief complaints, clinical histories, general states of well-being, and signs and symptoms.⁷ Vital and other physiological signs may not be used as often to inform decisions as some recommend.⁷ Competing demands on ED nurses have been found to cause them to rely on "pattern recognition" to reach triage acuity decisions.¹² Because assigning lower triage scores than required for ACS risks unnecessarily delaying treatment and increasing cardiac muscle damage, examination of issues affecting triage of these conditions is essential to all reliant on or involved in cardiovascular nursing.

Little is known about how ED triage nurses formulate decisions related to possible ACS and the factors that influence these. This article reviews issues arising from the literature involving clinical decision making at ED triage for assessment and management of women for ACS.

Literature Search Methodology

An advanced search using the EBSCOhost interface was undertaken for CINAHL, Health Source Nursing Academic Edition, MEDLINE, and Psychology and Behavioral Sciences Collection databases using the following terms in Boolean Phrase search modes: triage (*triag**), women (*female** or *wom** or *gender** or *sex*) and heart disease (*heart* or *coronary* or *myocardial* or *cardi**). This was supplemented with electronic searching of online thesis listings, Cochrane Library Systematic Reviews, Joanna Briggs Institute databases, and the National Guideline Clearinghouse to identify other relevant articles not published in professional journals. Articles selected included adult population samples, which were peer reviewed and published in English. Google and Google Scholar

search engines were also used to undertake a broader search of the World Wide Web to improve completeness of the search. The search technique was augmented by hand searching reference lists for publications missed during the primary search.

The review was focused on articles involving ED nursing triage of women's ACS from 1990 to March 2010. Articles were included if they pertained to ED nurse triage of women's heart disease or clinical decision making related to ACS of either sex at the time of nursing triage.

When searching subject headings in CINAHL EBSCOhost, 308 results were returned. All citations were reviewed to ascertain those relevant to the current literature review. Seventeen of these records were retrieved in full, having ruled out all others because they failed to relate sufficiently to the topic of nurse triage for ACS or examined other conditions such as respiratory disease and traumatic injuries. Many also described nonprimary ED decision-making processes and were excluded. Six articles were found to be relevant.¹³⁻¹⁸ An electronic search was then undertaken using the same terms in the Ovid MEDLINE (MeSH) database. This was narrowed in the same manner as described for EBSCOhost and uncovered 4 additional articles. One of these met the requirements for this review.¹⁹ Searches of the National Guideline Clearinghouse, Cochrane Systematic Reviews and Joanna Briggs Institute databases, and Google and Google Scholar search engines failed to locate additional articles. A review of online theses identified one further article meeting the review requirements.²⁰ Retrieved article reference lists searched for articles missed in the electronic searches failed to yield any more suitable references.

The search strategy identified 8 articles meeting the search criteria (Table). The search included articles that were prospective randomized controlled trials, observational studies, literature reviews, meta-analyses, theses, and published conference abstracts.

Literature Search Results

The articles highlighted through the search that met the inclusion criteria are listed in the Table. All but one were written by the same lead author (Arslanian-Engoren) and emanated from the United States, including the thesis. The other study was conducted across multiple sites in Canada.

Literature Review Findings

Research articles are grouped by similar methods in the current section to enable description and synthesis of their findings and explication of themes. The earliest record relevant to triage of women's heart disease by

TABLE Literature Review Findings for Primary Emergency Department Triage Decision Making in Women's Heart Disease

Author(s) and Year	Abstract Outline	Summary
Arslanian-Engoren (1999) [thesis] ²⁰	Purpose of study	To derive an improved understanding of the phenomenon of triaging men and women for CHD by exploring relationships between HCP inferences, knowledge and experience, patient sex, patient cues, and triage decisions
	Sample/design/ method(s)/ instrument(s)	A nonexperimental, descriptive design, and methodological triangulation were used. Clinical vignettes were used to answer research questions, and focus groups were used to elucidate ED nurses' decision-making processes in a "cross-sectional quantitative approach" with qualitative interviews (n = 260, 52% response rate)
	Findings and conclusion	ED nurses were unable to associate cues by middle-aged women identical to cues of middle-aged men, to heart disease. Older patients were more likely to be allocated high-acuity triage categories for presentations suggestive of CHD. Women were more likely to have cues associated with respiratory and gallbladder disease than heart disease, than their male counterparts
Arslanian-Engoren (2000) ¹³	Purpose of study	To examine triage decisions made by ED nurses for patients with possible AMI. The theoretical frameworks for this investigation were Hammond's lens model for clinical inference and Evan's 2-stage reasoning model
	Sample/design/ method(s)/ instrument(s)	This was a qualitative study with 4 focus group sessions conducted. The participants' oral descriptions were tape recorded, transcribed verbatim, and analyzed using the thematic content method of Krueger
	Findings and conclusion	Several important issues influencing triage decisions were identified: patient presentation, nursing knowledge and experience, practice environment, intuition, fear of liability, and sex-specific behaviors. ED nurses held different perceptions regarding the significance and likelihood of AMI for male and female patients seeking evaluation and treatment. AMI was not the first diagnosis considered in middle-aged women. The analysis concluded the inability of ED nurses to associate middle-aged women's presenting symptoms with MI may contribute to the increased morbidity and mortality
Arslanian-Engoren (2001) ¹⁴	Purpose of study	To examine whether ED nurses' triage decisions were different when the nurse was presented with similar cues for AMI, but different patient sex
	Sample/design/ method(s)/ instrument(s)	A non-experimental, descriptive study was conducted; 500 ED nurses were randomly selected to receive a mailed clinical vignette questionnaire. Data analysis included descriptive, bivariate, and multivariate analyses
	Findings and conclusion	ED nurses perceived the middle-aged male vignette patient to be in need of more urgent triage ($t_{207} = 2.58$; $P = .01$) and an admission to an ICU bed ($\chi^2_1 = 10.43$; $P = .001$) and were more likely to consider a cardiac diagnosis in the male than the age-matched female ($\chi^2_1 = 37.49$; $P < .0001$) with identical presentation. No differences were noted in elderly vignette patients. Findings suggested sex bias and ageism may account for disparities in triage decisions for middle-aged women with possible CHD
Arslanian-Engoren (2004) ¹⁵	Purpose of study	To examine the role of emergency nurses' triage decisions on recent research findings that women are less likely to receive aggressive treatment for ACS, and are more likely to die after them
	Sample/design/ method(s)/ instrument(s)	108 Triage decisions made by 13 nurses were examined in this prospective study to determine if nurses' initial triage decisions could predict admission or discharge diagnoses for ACS
	Findings and conclusion	There were no differences in nurses' triage decisions based on patient sex, race, or age. By multivariate analysis, chest pain, history of CHD or AMI, and smoking were predictive of an ACS decision. Overall, accuracy for predicting admission diagnosis was poor. Sensitivity and specificity were 57% and 59%, respectively, with a positive predictive value of 68% and a negative predictive value of 56%. Predictions were also poor for discharge diagnosis. Sensitivity and specificity for discharge diagnosis were 55% and 69%, respectively, with a positive predictive value of 17% and a negative predictive value of 93%. Findings indicated limitations in nurses' triage decisions to predict admission and discharge diagnoses for ACS
Arslanian-Engoren (2005) ¹⁶	Purpose of study	To determine patient cues used by ED nurses triaging male and female patients with complaints suggestive of ACS and to determine if cues used to formulate clinical inferences varied by patient sex or nurse demographic characteristics
	Sample/design/ method(s)/ instrument(s)	Using clinical vignette questionnaires with different patient characteristics, ED nurses' triage decisions were evaluated to determine patient cues used to predict ACS
	Findings and conclusion	Men and women were equally likely to be given an ACS triage decision, which was not affected by nurses' demographic characteristics. However, nurses used different cues to triage both sexes with complaints suggestive of ACS. Female vignette patients were more likely than males to be assigned a suspected cause of cholecystitis for their presentation in a small subset of 13 (11:2; OR, 1.653; 95% CI, 1.115–24.47; $P = .036$)

(continues)

TABLE Literature Review Findings for Primary Emergency Department Triage Decision Making in Women's Heart Disease, continued

Author(s) and Year	Abstract Outline	Summary
Arslanian-Engoren and Engoren (2007) ¹⁷	Purpose of study	To determine if GAs can be used to decipher the prediction rules used by ED nurses to triage patients suspected of having ACS and to determine whether these rules differ according to patient sex
	Sample/design/method(s)/instrument(s)	3000 ED nurses were selected randomly to receive a mailed clinical vignette questionnaire, and 840 questionnaires were returned in this nonexperimental, descriptive study. Data analysis included BLR, development of a GA, sensitivity, specificity, ROC curves, and Monte Carlo simulations
	Findings and conclusion	Nurses used different prediction rules for triaging male and female vignette patients with possible ACS. Accuracies were similar between BLR and GA. Both had reduced loss of predictive accuracy when algorithms or equations developed on one sex were tested on the other. Monte Carlo simulations showed similar cues were used in triaging both men and women, but were combined differently in producing GA. Using GA was found to yield as accurate results as those attained by BLR, and it can be used to predict nurses' triage decisions for ACS
Arslanian-Engoren (2009) ¹⁸	Purpose of study	To explicate decision-making processes of ED nurses who triage men and women for AMI
	Sample/design/method(s)/instrument(s)	A qualitative, descriptive study was conducted using focus group methodology. A synthesized conceptual model was used to guide focus group discussions and begin developing a conceptually based, quantifiable measure of ED nurses' cardiac triage decisions. The 12 participants' oral descriptions were audiotaped, transcribed verbatim, and analyzed using the Krueger content analysis method
Atzema et al (2009) ¹⁹	Findings and conclusion	When making triage decisions for AMI and assigning urgency status, ED nurses determine underlying causes of patients' chief complaints based on clinical presentation, patient demographics, medical history, as well as their own attitudes, perceptions and beliefs, nursing knowledge, and ED experience. Important patient cues include general appearance, vital signs, cardiac history, chest pain, and mode of transportation. Nurses are knowledgeable of age and sex differences in AMI presentation. However, some hold cultural biases and stereotypes that may interfere with triage decision making
	Purpose of study	To examine triage of AMI (STEMI and NSTEMI) to determine if it is associated with subsequent delays in processes of AMI management
	Sample/design/method(s)/instrument(s)	A retrospective cohort analysis of a population-based cohort of AMI patients admitted to 102 acute hospitals in Ontario, Canada, from July 2000 to March 2001. Main outcome measures were rate of low-acuity triage (CTAS III, IV, or V) among AMI patients and its association with delays in D2ECG and D2N time
	Findings and conclusion	50% of AMI patients were given low triage scores, which was independently associated with substantial delays in D2ECG and D2N. Statistically significant regression parameters leading to delayed D2ECG time were being male, with chest pain, in arrest or shock, positive history of CHD, arrival by ambulance, between midnight and 4:00 AM. The quality of ED triage may be an important factor-limiting performance on key measures of AMI care

Abbreviations: ACS, acute coronary syndrome; AMI, acute myocardial infarction; BLR, binary logistic regression; CABG, coronary artery bypass graft; CCU, coronary care unit; CHD, coronary heart disease; CI, confidence interval; CTAS, Canadian Triage and Acuity Scale; D2ECG, time of arrival ("door") to first electrocardiography; D2N, time of arrival ("door") to fibrinolysis administration ("needle"); ECG, electrocardiography; ED, emergency department; GA, genetic algorithm; HCP, healthcare provider; ICU, intensive care unit; n, number of cases in sample; NSTEMI, non ST-elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; ROC, receiver operating characteristic; STEMI, ST-elevation myocardial infarction; t, t statistic.

Arslanian-Engoren²⁰ highlighted in this search was her doctoral dissertation. Her work covers a 10-year period and incorporates a number of different techniques. For her thesis, the author used a cross-sectional quantitative approach augmented with qualitative interviews to examine relationships between ED triage staff, knowledge, and experience, as well as patient sex, patient cues, and triage decisions. Using identical clinical vignettes in which only patient sex was changed, Arslanian-Engoren found older patients more likely to be allocated higher triage acuity scores for presentations suggestive of heart disease. She found acute myocardial

infarction (AMI) was more easily differentiated in men, with women more often being assigned triage acuity scores for perceived respiratory and gallbladder diseases.²⁰

Two of the studies by Arslanian-Engoren were qualitative.^{13,18} The researcher used focus group methodology to explore triage decision-making processes of ED nurses for men and women with cardiac illness. Both studies analyzed data from 12 participants, and although they did not state where or when the sessions were conducted, there was variation in sex balance, suggesting that some aspects of the studied groups had changed. Similar methodology allowed

some comparison of how the triage nurses' knowledge and decisions related to ACS changed over time.

The earlier study found ED nurses were knowledgeable of the differences in sex-specific presentations, but were unable to apply this knowledge to middle-aged women's presentations with ACS.¹³ The ED nurse participants held differing perceptions of significance and likelihood of women seeking care for AMI than they did men.¹³ In the more recent study, Arslanian-Engoren¹⁸ reported the nurse participants who took part in another focus group study remained knowledgeable about differences in ACS presentation related to age and sex, but prone to hold cultural biases and stereotypes that interfered with clinical decision making at triage. Assessment of urgency status and subsequent triage categorization was assigned to patients according to their chief complaints, demographic features, and history, in addition to the participants' own attitudes, perceptions, beliefs, knowledge, and clinical experience. Triage decisions were formulated using a number of important patient cues including general appearance, vital signs, cardiac history, chest pain, and mode of transportation to the ED. Hence, issues remained similar over an extended period for these sample groups.

Other research reported by Arslanian-Engoren¹⁴⁻¹⁷ used clinical vignette questionnaires to expose patient cues used by triage nurses to predict ACS in women and men. The first of the studies using surveys involved a mailed questionnaire with 3 clinical vignettes, sent to 500 emergency nurses (response rate, 52%; 260 respondents). The vignettes were 3 identical scenarios, which were developed in pairs, male or female.¹⁴ Participants ranked up to 5 cues from the information provided on a visual analog scale from least (0 mm) to most (100 mm) for relevance in the triage decision. They were then asked to rate how urgently the vignette patients should be evaluated (0, nonurgent; 100, urgent) on a 100-mm visual analog scale and whether patients should be admitted (and if so, to a general ward, electrocardiograph [ECG]-monitored bed, or intensive care unit) or discharged home. Multiple regression analysis was used to determine if cue relevancy scores could predict triage urgency. The researcher concluded ED triage nurse sex bias and ageism could account for disparities uncovered in triage decisions for middle-aged women with vignettes suggestive of heart disease.¹⁴ This was at odds with the contribution from the author's dissertation already described; that increased patient age resulted in higher triage score allocation.²⁰

In another study reported several years later, the same researcher evaluated 108 triage decisions, which were determined as necessary for medium effect size using a power calculation for 8 predictor variables ($\alpha = .05$, power = 0.80) to evaluate triage nurse accuracy of prediction for admission for ACS.¹⁵ Analysis

of these data found no differences based on patient sex, race, or age, but found that the overall accuracy for admission prediction for ACS was poor.¹⁵

Findings published in the following article contradicted the absence of sex bias in ACS triage.¹⁶ Using a power calculation for 15 predictor variables, it was determined that 952 subjects were required (small effect size, $\alpha = .05$, power = 0.80). A total of 840 usable questionnaires were returned, meaning the study was underpowered according to the stated power analysis. The researcher asserted that different cues were used by ED nurses to determine clinical inferences for complaints suggestive of ACS based on patient sex. Female clinical vignette patients with ACS were more likely than male vignettes to be assigned suspected diagnoses of cholecystitis than ACS, despite identical symptoms.¹⁶

The researcher's subsequent article, copublished with a colleague, reported a 28% response rate to the mailed questionnaires.¹⁷ The researchers developed a genetic algorithm to predict nurses' triage decisions for ACS with reported success. They described a genetic algorithm as a form of computing, which "establishes simple heuristic rules for making a prediction of outcome, evaluates the correctness of these rules, changes or evolves these rules, and evaluates the correctness of the new rules."^{17(p83)} They used this to determine if triage nurses applied different reasoning and rules to formulate triage decisions for men and women with suspected ACS. The results of this study showed that triage nurses did use different prediction rules when triaging male and female clinical vignette patients for ACS. The cues they used for both sexes were similar, but were combined differently to formulate their decisions.

The final article listed in the Table describes a retrospective analysis of a population-based cohort of 3088 patients with AMI admitted to 102 Ontario acute care hospitals for 9 months to March 2001.¹⁹ Outcome measures were low-acuity triage scores using the Canadian Triage and Acuity Scale for these patients and its association with delays in arrival to treatment time (door to ECG and door to administration of fibrinolysis). The researchers found half of the patients with AMI were given inappropriately low Canadian Triage and Acuity Scale scores, and this was associated with significant delays in acquisition of ECGs and administration of fibrinolysis. They reported that being male had a positive and independent effect on patient median door-to-ECG time for ACS, in comparison to being female ($P = .05$). The researchers reinforced that ED triage was an important factor limiting performance on key measures of quality for AMI.¹⁹

Discussion

A number of themes have emerged from the literature search. First, presentation differences between men

and women with ACS, such as chest pain and symptoms generally, may affect the quality of nursing assessment. Second, advanced patient age can be associated with inconsistency when triaging patients with possible ACS, and finally, there appears to be a pervasive sex bias when decision making for women with ACS in the ED. The thematic contributions from the literature search are placed in the context of broader literature relating to assessment and management of women's ACS, where it fits with the highlighted themes.

Because of the small number of articles and different methodologies used in their development, it is not feasible to provide in-depth analysis of themes from this literature alone. Other scientific articles are used to build on themes arising from the reviewed literature and inform the issue of triage of women's ACS on arrival at EDs in the current section. Exploration and synthesis of uncovered themes will be provided here, which will lead into Summary and Recommendations for Future Research, informing avenues of further research aimed at improving women's access to timely management for ACS in the ED.

Presentation Differences Between Women and Men With ACS

Two articles uncovered in this review reveal difficulties associated with recognition of symptoms of ACS in women by triage nurses.^{13,20} This is consistent with much of the literature published regarding symptoms of women's ACS, which has reported significantly different presentations between the sexes.²¹ Although there is some discord,²² literature generally supports the presence of differences in symptoms²³⁻²⁶ or in the proportion of symptoms experienced.²⁷

A significant proportion of women have right-sided chest and arm pain.²⁸ Others report no pain at all.²⁹ Cardiovascular events in women are often heralded by nonspecific symptoms, making differentiation from other physiological and functional etiologies for them and ED personnel problematic.²⁶ In a qualitative study by McSweeney and Crane,³⁰ 37 of 40 participants revealed prodromal symptoms occurred from 3 weeks to 2 years prior to their ACS events. McSweeney and colleagues³¹ examined women's symptoms both prodromally (before onset) and acutely (concurrent with onset) for ACS. They described a set of prodromal symptoms for ACS specific to women including unusual fatigue, sleep disturbance, shortness of breath, weakness, anxiety, and chest discomfort.³¹ Acutely, women are more likely to present with complaints of unusual fatigue, dyspnea, dizziness, cold sweats,³¹ nausea,²³ weakness, and indigestion.^{32,33} Prominent throat, neck, and jaw pains have also been reported acutely.³⁴

Atypical Nature of Women's Symptoms for ACS

Time from arrival to assessment and management for women with ACS in the ED setting tends to be delayed, compared with men's according to numerous studies.³⁵⁻³⁷ Women's tendency to experience "atypical" symptoms and signs for ACS is believed to account for much of the time delays.³⁸ Typical chest pain in ACS has been historically defined by men's experiences of ACS.³⁹ Some claim this has resulted from past overrepresentation of men in studies related to heart disease.⁴⁰⁻⁴² Symptoms reported to occur are more likely to reflect the male pattern for ACS,⁴³⁻⁴⁵ as are treatments based on evidence from these findings.⁴⁶

Chest Pain Is Central to Early ACS Assessment

Chest pain is an important symptom examined in the context of early ACS assessment because it is considered the "hallmark" characteristic of the syndrome's presentation.²¹ A number of decision algorithms for predicting ACS in EDs rely on chest pain as a major predictor of the syndrome.⁴⁷⁻⁴⁹

Using chest pain as the key descriptor for assessing women's ACS in the ED is problematic for a variety of reasons. First, a proportion of women do not present with complaints of chest pain when experiencing ACS, and this may be higher than in men. A recent meta-analysis, for instance, calculated that 37% of women and 27% of men diagnosed with AMI fail to present with chest pain.²¹ Hence, chest pain should not be the only chief complaint considered when assessing patients for ACS, particularly women. Second, if patients do not present with chest pain and this is the symptom most likely to "trigger" suspicion for ACS in the minds of triage nurses and other emergency clinicians, it is difficult to gauge how many ACS episodes have been missed. Emergency department triage nurses have been found to rely on pattern recognition when formulating clinical decisions,¹² and if the patient presentations do not fit the pattern, serious disease may be overlooked altogether, increasing the time to initiation of any treatment and quantity of permanent myocardial damage.

Another challenge for triage nurses may be that even when the symptom is present, descriptors of chest pain can differ markedly between sexes.⁵⁰ One research group argued men and women both experienced chest pain equally, but, on finding perceptions of chest pain differed between the sexes, proposed a framework based on psychosocial, biological, physiological, and anatomical differences to explain how symptoms manifest.³² This is problematic when applying current understandings of "typical" chest pain because ACSs are more easily differentiated in men.⁵¹

When it is described as triage personnel anticipate it to be, chest pain provides useful diagnostic cues for the time-sensitive ACSs.^{16,17}

Triage Inconsistencies in ACS Related to Advanced Patient Age

Triage score allocation for ACS has been found to be inconsistent in articles highlighted in this review because of patient age.^{14,20} Advanced age may lead to both higher and lower triage score allocation for ACS than required for optimal patient outcome. In her thesis, Arslanian-Engoren²⁰ reported that older patients were more often allocated higher acuity triage scores than younger patients. This contradicts other research, however, which report triage acuity levels negatively correlate with increased patient age.^{14,52–55} Hence, older age tends to attract lower triage allocation for ACS presentations, which can be detrimental to early revascularization and prevention of cardiac damage.

Possible bias against patients of advanced age has been examined for its potentially negative ramifications in ACS in other studies. A recent study by Han et al⁵³ found that clinical practice for ACS in the ED did not reflect best available evidence for the elderly. They found that older patients suffered significantly higher 30-day mortality risk for ACS, but received less testing, reflecting an age bias.⁵³ Magid et al⁵⁴ argue that it is plausible the lower application of evidence-based treatment is partially responsible for the poorer outcomes in older-age patients with AMI. As women tend to present with their first ACS event 8 to 10 years older than their male counterparts,⁵⁶ the likelihood of undertriage (assigning lower than expected triage acuity score) for this patient population is potentially greater. Some researchers have noted particularly high ACS mortality rates in women 65 years or older.^{52,57} Shaw and colleagues⁵⁸ described patients with heart disease who had combined old age and female sex as becoming victims of inequality.

Advanced age brings with it an increased range of comorbidities such as type 2 diabetes mellitus, hypertension, and chronic arthritic diseases.⁵⁹ As women are more likely to experience ACS after menopause, they are likely to have accrued more comorbid illnesses than men by the time the syndrome manifests.^{60,61} Increased comorbidities have previously been used to explain differences in ACS management provided to men and women patients.⁶²

Interestingly, recent studies have shown advancing age in women and men leads to diminished perception of chest pain in ACS.^{23,25} This may be pertinent to the identification of ACS in newly presenting older patients of either sex, when assessed by ED triage personnel. They showed that such presentations

were associated with the administration of fewer evidence-based treatments such as revascularization and pharmacotherapy. This, they proposed, led to greater hospital morbidity and higher mortality in this patient group, which included older women and men.^{23,25} Similar results were found in a large study ($n = 10\,783$) across 10 hospital EDs in the United States.⁶³ Coronado et al⁶³ concluded that heart failure, age, female sex, and diabetes were most often associated with painless ACS. They found that patients who did not experience chest pain with ischemia were less likely to be admitted to coronary care units, but suffered increased hospital mortality.⁶³

Sex-Related Influences From ED Triage to Ongoing Assessment and Management

Literature featured during the current review purports that women are assessed and managed differently than men for ACS during ED triage.^{13,16,19,20,64} Available research supports evidence of an ongoing and pervasive international bias against women's ACS management from the time of triage, which negatively affects their treatment through the remaining ED trajectory of care.

In a North American study, Lehmann et al⁶⁵ found a bias against women presenting to EDs with new-onset chest pain, even when their symptoms were similar to their male counterparts'. The timeliness to treatment and outcomes for women were also reported to be poor in Ireland with women experiencing longer in-hospital treatment delays than men for ACS in Dublin EDs.⁶⁶ The interval from time of triage to physician review for women was 30 minutes, compared with 20 minutes for men. This delay may have induced delays to intervention in subsequent intervals; median door-to-needle time was 70 minutes for women and 52 minutes for men ($P = .02$). Women also waited longer to receive aspirin and were transferred to the coronary care unit an average of 1 hour later than men ($P \leq .0001$). It has been shown that women are more likely to be discharged prematurely from EDs with ACS.⁶⁷ A number of researchers have closely examined time to treatment for patients with ACS in the ED.^{19,65,66,68} All have found issues of inequity of ACS management, which have constituted quantifiable bias against women's treatment for ACS.

Literature indicates that there are significant differences in assessment and management of women throughout the care pathway in acute hospital settings, beyond EDs.^{60,66,67,69} The problem is not new; the phrase "Yentl syndrome" was coined almost 20 years ago in a *New England Journal of Medicine* article outlining sex bias in treatment for women's heart disease.⁷⁰ It has since been invoked to illustrate finding that even when clinical and nonclinical predictors

of admission were controlled for, women were significantly less likely to be admitted to hospital for chest pain or to have diagnostic tests than men.⁷¹

Research continues to show women are less likely to undergo revascularization procedures than men.^{36,67,72-74} Women also receive less evidence-based pharmacotherapy than men, including anticoagulation, β -blockade, statins, and antiplatelet drugs.^{36,75,76} Swedish researchers compared outcomes for women and men with chest pain or other symptoms suggestive of AMI who had normal ECGs.⁷⁷ Men were admitted to coronary care units more readily than women, and although women developed less AMIs, they had equivalent in-hospital mortality as men and during their first year subsequent to this presentation.⁷⁷

Jneid and colleagues³⁶ believe less aggressive administration of therapy is likely part of the reason women are more prone to experience premature death when admitted with ST-elevation myocardial infarction than men. Contemporary research has shown that inadequate use of evidence-based management for women's ACS also occurs in Australia,⁷⁴ where although knowledge among physicians is good, application of evidence to practice is inconsistent or poor.⁷⁸

Summary and Recommendations for Future Research

The current literature review describes the triage of women patients with ACS in the ED. All but 1 of the 8 articles revealed challenges. The article that differed most from the others¹⁵ was itself, contradicted a year later in a similar but larger study by the same researcher.¹⁶ Since the early publication of the longitudinal Framingham study acknowledging that heart disease is in fact an important cause of mortality and morbidity in women,⁷⁹ research has continued to show the global heart disease burden for them is not diminishing at the same rate as men's.⁸⁰ It remains the greatest killer of women worldwide.⁸¹

Literature uncovered through this review indicates the urgency of women's ACS is neither always recognized nor managed with parity to that of men.^{67,69,82} The importance of women's heart disease remains underestimated by health professionals.^{43,83,84} This underestimation is said to be partly responsible for the underrecognition and undertreatment of heart disease in women in hospitals.⁶²

Underestimation of Prevalence of Women's ACS

Emergency department clinicians have been shown to underestimate women's ACS risk,^{13,36,64} which can have dire consequences at the stage when most can be done to prevent myocardial cell damage. Timely re-

perfusion for ACS has positive effects on patient mortality and morbidity.⁸⁵ Yet, in a recent large study in the United States ($n = 78\ 000$), it was found that women with AMI presenting to EDs received less early aspirin, β -blockade, reperfusion, and timely reperfusion than men.³⁶ They also received less cardiac catheterization and revascularization procedures after AMI.^{36,86} Similar disparities against women are identified in numerous studies internationally.^{67,72-74,87-89}

Despite acknowledging that time to treatment is a critical factor in ACS,^{85,90} there is very little research addressing time delay from the time affected patients present to the triage desk. Triage is a developing concept⁹¹ in a relatively new specialty.⁹² Research of the role has intensified in the last decade in recognition of the effect triage nurse decisions have on subsequent ED care.⁹ The primary aims of triage are to ensure patients with life-threatening conditions are assessed accurately and managed expeditiously.⁹³

Themes arising from the literature reveal sex-related differences for ACS treatment at ED triage, most likely due to underestimation of the prevalence of the syndromes in women.^{20,13} Extensive evidence supports women are treated differently for ACS during ED and inpatient trajectories of care. Some researchers have labeled this "gender bias"^{94,95} and believe it is responsible for many disparities experienced by women.⁴⁰ Themes from this literature review suggest a number of reasons women may be undertreated for ACS in the ED, likely related to differences in symptoms, age, comorbid illness, and an unwillingness to accept ACS to be so prevalent in women. The themes suggest women's sex may influence their triage and subsequent assessment and management for ACS, but they do not portray an intentional bias against women. In fact, it has been shown if either a man or woman presents to an ED with ACS, time to treatment may be delayed if he/she does not fit the "pattern" expected for a patient with ACS.⁹⁶ Chest pain, for instance, is seen to be central to accurate assessment of ACS; Brieger and colleagues⁷⁵ found that patients who failed to present with the requisite chest pain with ACS had delayed treatment and worse outcomes, regardless of their sex.

Assessment of ACS Is Based on Men's Experiences

Literature illustrates that women's ACS is often not anticipated by many ED triage nurses.^{20,13} Even if the nurses are knowledgeable about the syndrome's symptoms in women,¹⁶ they are less likely to triage according to expected category for ACS if the pattern of presentation is different than men's. This is not surprising, given that most research has historically involved male participants.⁹⁷ Despite concerted efforts by investigators, particularly in the United

States,⁴¹ to include more women in cardiovascular trials, some continue to argue that women's cardiovascular health remains underresearched.^{40,41,69} This has led to what has been called a "gender-neutral" understanding of heart disease.⁹⁸ Women are assumed to present with the same symptoms as men and the same therapeutic needs. Lockyer⁹⁸ calls for health professionals to "develop a clearer understanding of the nature of CHD [coronary heart disease] as it affects women and develop an evidence base that underpins..." it.^{98(p162)} There is much scope for research to understand how to convert knowledge of differences in ACS presentation in women into consistent evidence-based practice. Research needs to be undertaken to determine if it is possible to improve access to timely management for women with ACS through further increasing awareness of the syndrome among ED triage nurses and their colleagues, or if behavior is better modified in a different way. Research has previously shown that changes on 12-lead ECGs are predictive of increased cardiovascular events and mortality in women who are asymptomatic,⁹⁹ so it may be useful to promote performing more ECGs in women who present to EDs with a broader range of complaints.

Pattern Recognition for ACS

Emergency department triage nurses operate under conditions of ongoing time constraint and often in rapidly changing settings. To enable them to function in their role and assess all patients as they present to the ED, they need to be able to formulate decisions promptly. One of the methods they use to do this is by pattern recognition.¹² Arslanian-Engoren¹⁷ labeled these *prediction rules*. She argued that triage nurses use "cues" to enable them to formulate clinical inferences to predict likelihood of patients presenting with ACS.¹⁶ Patients whose complaints, physical attributes, age, sex, and comorbid conditions fit certain patterns for illnesses are assigned a triage category based on the probability they are experiencing a particular condition. Cioffi² calls this a *probability judgment*. A patient who is experiencing an ACS should be given a high triage score to enable early revascularization and reperfusion of ischemic myocardium. However, for a triage nurse to judge it probable the patient is having this condition, he/she needs to recognize a pattern or series of cues to enable the formulation of the triage judgment or inference. Symptoms including chest pain and demographic features such as patient sex, age, and comorbid illness all trigger probability judgments necessary to come to an appropriate triage decision, only if they are anticipated as possible cues for ACS. If the triage nurse does not arrive at this judgment, identification of ACS may be overlooked or delayed.

Regardless of a triage nurse's knowledge or intention to expedite all patients with ACS appropriately, preconceived notions such as expected prevalence of ACS in women affect triage nurse decisions. This was evident in several of the studies located in the literature review.^{13,16,20} Despite being knowledgeable of women's ACS experiences, triage nurses were unable to associate ACS with middle-aged women.¹³ Identical presentations elicited different responses from triage nurses based on patient sex.²⁰

Future research is required to ascertain if it is possible to increase ED triage nurse awareness of the range of cues for ACS and when it is necessary to delve further into a patient's presentation to avoid missed or delayed recognition of time-sensitive conditions. The use of pattern recognition is an important adjunct to the triage nurse's advanced assessment skills because it enables rapid categorization for commonly presenting illnesses, such as ACS. While it is important to retain the ability to triage large numbers of patient arrivals in a shift, the evidence that not all ACS presentations are the same needs to be built into clinical assessment. Research needs to show how triage nursing can be undertaken with expedience, while reducing the risk of overlooking what does not fit the usual mold for ACS.

Limitations

An extensive search of multiple resources revealed a small number of scientific articles seeking to better understand primary ED triage decisions for women presenting to EDs with possible ACS, making meaningful comparison difficult. The prime limitation of the literature review was that most of the research and therefore discussion were provided by 1 lead author (Arslanian-Engoren). Although this work is valuable and examination of the subject would be limited without it, this may portray a singular view of the subject. This researcher has, however, used various methods that have been well explicated and arrived at similar conclusions. Hence, her research in this area is of great value.

A second limitation is that investigation was limited to North American EDs. Issues affecting these EDs may differ from others internationally. Each was done using 5-tier triage scales (0, lowest urgency, to 5, highest urgency). Such triage scales have been described as the most valid and reliable methods for stratifying patients for clinical urgency.^{100,101} Similar 5-tier scales are also used in the United Kingdom, Australia, and New Zealand,¹⁰² which may increase the comparability and relevance of these findings in these countries also.

Although some objectives were similar, there was no consistency across study designs, which meant comparable conclusions could not be reached. Multiple

Clinical Pearls

- Emergency nurses play an important role in enabling early reperfusion therapy in acute coronary syndrome (ACS) for women and men through accurate and timely triage.
- Issues including female gender and advanced age may preclude accurate triage of ACS.
- An understanding of the issues related to clinical decision making at triage in women and aged patients with potential ACS may improve timeliness to management and therefore, outcomes for these patients.

methodologies were used; hence, meta-analysis could not be undertaken. A number of studies were qualitative in nature, and results were not generalizable beyond the participant groups described. Sample sizes in the focus group studies were small,^{13,18} which is suitable for this methodology.¹⁰³

Implications for Practice

A number of research projects have addressed delays to reperfusion for patients with ACS in EDs.^{104–107} These have included studies to measure and/or improve door-to-reperfusion times for patients managed in EDs with potential ACS.¹⁰⁸ Considering the primary role triage nurses play in expediting management for all ED patients, particularly those with time-sensitive conditions such as ACS, studies specifically examining cardiac triage decisions in women and men are surprisingly rare. Canadian researchers recently determined that more than half of all patients with ACS failed to reach benchmark times for reperfusion.¹⁹ The situation may be deteriorating, with only 40% of patients reportedly undertriaged in the early 1990s.¹⁰⁹

The implication is that there is a great deal to be done in terms of ACS management for women at the time of ED triage internationally. Evidence is not being applied satisfactorily to practice.¹¹⁰ Despite increasing research efforts aimed at redressing shortages of evidence for women's heart disease,⁹³ there appear to be a number of gaps in the literature related to this issue. There are no recent reports evaluating triage category allocation and patient outcomes for ACS. Little is known about current ED nursing knowledge of women's ACS, or how nurses make decisions at ED triage for patients of either sex with possible ACS outside North America.

Strategies need to be devised, tested, and evaluated to ensure that women's presentations for ACS, even when atypical, are evaluated and expedited appropriately. To do this, the authors recommend a systematic suite of studies to examine current knowledge base requirements, assessment practice, and process-related constraints to accurate assessment of ACS in women at various management time points. This would

include studies using various designs such as case study, staff survey, and medical record audit with mixed quantitative and qualitative methodologies to ensure not only breadth but also depth to this important area of research. With the benefit of thorough understanding and stakeholder input, evidence would be more readily implemented into ED practice.

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2.3 Summary

ACS has been established as one of the most serious and time-critical diseases managed in the ED setting. It is well recognised that morbidity and mortality rates can be improved markedly if effective evidence based therapies are administered before myocardial ischaemia and infarction become necrosis. ACS, particularly the ST-elevation myocardial infarctions (STEMIs), are time-sensitive diseases. Numerous studies have been conducted with the intention to measure and reduce time to percutaneous coronary intervention (door-to-balloon time) in the cardiac catheter laboratory, but surprisingly few of these have focused on management provided in emergency departments (EDs). Time to commence treatment in EDs can be broken down into smaller parts or stages and each evaluated and optimised for reduction of delay in treatment provision for ACSs, particularly STEMIs.

Most of the ED-based studies have failed to examine the important function of triage evaluation and assignment of priority based on perceived clinical urgency. Unfortunately there has been little systematic data collected around the ED nursing management of AMI, which means many of those involved in the care of these patients have not had input into the decision-making on research undertaken in this area. This literature review provides an important examination of the role of the ED triage nurse in relation to patients with suspected ACS. This role is unique for a number of reasons already discussed; the extensively educated and experienced ED triage nurse specialists work in a chaotic, busy, noisy environments and evaluate an unlimited number of patients in a shift. The patients arrive without appointments in a wide array of cognitive, emotional and physical states, often without any diagnoses. The triage nurse then sifts through information available to them, including what they observe, are told, and what they 'know' are common patterns of presentation for particular diseases.

This literature review has provided insight into the role of the triage nurse and therefore, the role of the professional responsible for assigning hierarchical order to each patient's level of acuity upon presentation at ED triage, the usual entrance point to acute care hospitals. It has located, critiqued and synthesized available published literature involving clinical decision making at ED triage for assessment and management of women for ACS. It provides important information regarding the first of the ED stages that should be measured and

where necessary, manipulated to ensure the most is being done to reduce delayed implementation of evidence based treatment, thereby optimising outcomes from this important and time-sensitive condition. A number of issues have been described which have been found to influence the application of evidence based practice, particularly in women, who continue to be the most disadvantaged sex for management and outcome from heart disease. The literature review identified women with AMI were often challenging for ED nurses to triage accurately due to gender, older average age and tendency to experience atypical symptoms.

All of the research reviewed was conducted in North America and none investigated whether findings from these studies are relevant in contemporary triage nurse practice in Australian EDs, where the validated 5-tiered Australasian Triage Scale (ATS) is employed. It is unknown if patients presenting to EDs in Australia are triaged with equity based on sex and whether or not time to treatment onset for suspected ACS is actually affected by triage score allocation, thus providing the impetus for the database research presented in Chapter 3.

2.4 References

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Chapter 3

The influence of patient sex on triage score allocation and treatment onset time for women with heart disease



Chapter 3 Research

Kuhn L, Page K, Rolley J, Worrall-Carter L. (2013). The impact of patient sex on triage score allocation for acute myocardial infarction in Victorian public emergency departments and effect on times to treatment. *International Emergency Nursing*; open access.

3.1 Background

Coronary heart disease (CHD) is the number one killer of women worldwide (World Health Organization (WHO), 2008). A number of factors continue to thwart efforts to reduce the impact of the CHDs; acute myocardial infarction (AMI) and unstable angina pectoris, known collectively as acute coronary syndrome (ACS), on women including under-evaluation and under-treatment (Jneid et al., 2008; Kaul et al., 2007; Radovanovic et al., 2007; Rosenfeld, 2006). Mortality rates and morbidity occurrence in ACS is proportional to myocardial damage resulting from prolonged blockage of coronary arteries. Delayed reperfusion of occluded coronary arteries in ACS is thus, an important factor that needs to be minimised at initial stages of acute care from the moment symptoms occur.

A patient's early presentation to an emergency department (ED) for ACS enables instigation of prompt revascularisation, potentially aborting or minimising significant myocardial damage and reducing mortality and morbidity. When patients arrive at Australian EDs, they first present to the triage nurse for evaluation and assignment of level of acuity. The level of acuity, ranked 1 – 5 on the Australasian Triage Scale (ATS) denotes priority given to their

clinical urgency (Table 2.1), as assessed by the triage nurse. The number assigned guides the maximum timeframe in which a patient should have treatment commenced by an ED doctor or nurse (Department of Human Services (DHS), 2001). The hierarchical ranking of patients for order of priority is a process central to the proper functioning of all Australian EDs and is primarily dictated by the triage nurse's evaluation of each patient's clinical urgency.

The review of the literature provided in Chapter 2 has demonstrated a number of patient variables other than clinical urgency confounding accurate ED triage of women experiencing ACS from the USA and Canada. Women with AMI were reported to be more challenging for ED nurses to triage accurately due to gender, older average age and tendency to experience atypical symptoms. It cannot be assumed that the same issues concerning inaccuracies in triage of ACS occur in Australia however, due to notable differences in the healthcare system, the triage system and general patient profiles to those in North America. It is not known if patients presenting to Australian EDs with suspected ACS are triaged with equity based on sex and whether or not time to treatment onset for ACS is actually affected by triage score allocation, thus providing the impetus for the database research presented in Chapter 3.

An improved understanding of triage patterns for ACS according to patient demographic characteristics at Australian EDs is integral to ensuring benefit from early treatment of the time-sensitive disease is maximised in Australia. The focus of this component of the *DaME II* research programme relates to what happens when patients present to EDs in Victoria, Australia with possible ACS from the perspective of triage priority allocation in the ED system. As has been discussed, international research investigating other aspects of ED management for ACS have shown women are more likely to be discharged prematurely from EDs with ACS (Kaul et al., 2007), and are less likely to undergo revascularisation procedures (Jneid et al., 2008; Kaul et al., 2007; Radovanovic et al., 2007; Rosenfeld, 2006), but little is known about patterns of triage and presence of any avoidable delays from arrival at triage to treatment onset in Australia. This poor understanding of the efficacy by which women and men are triaged in Australian EDs for ACS, leads to the aims of this project:

1. To describe and compare the allocation of ATS scores for women and men for ACS across Victorian public hospital EDs; and
2. To examine the impact triage score allocation for ACS has on treatment times.

3.1.1 Effect of patient sex on triage for suspected ACS and associated treatment onset times: the need for analysis of ED data

A central tenet of the Australian Government's National Health System Performance (Australian Institute of Health and Welfare (AIHW), 2012) framework revolves around equity within the health system. Given that women have been shown to have been treated with inequity compared to their male counterparts in other areas of primary and secondary healthcare (Anderson & Pepine, 2007; Redberg, 2006), it is essential that gaps in ED care are identified so they may be ameliorated. Research undertaken in North American EDs has indicated that accurate triage of women with ACS is more difficult than for men for a number of reasons. The triage role is unique in the hospital system and an integral component of ED care delivery. It is unknown if triage is provided with equity to both sexes with suspected ACS and whether evidence based, time-sensitive therapy is available to men and women equally with ACS in the Australian context.

The following article, published in the United Kingdom's International Emergency Nursing journal (formerly, 'Accident and Emergency Nursing'), is original research undertaken to evaluate triage equity between the sexes and the effect on treatment onset times for ACS and AMI. It has arisen from the premise of this DaME II study; that diagnosing and managing ischaemia and infarction early is central to ensuring equity in healthcare and optimising patient outcomes from ACS in women.

The manuscript presents analyses from retrospective audit of triage score allocation and time to treatment onset for patients presenting to Victorian (Australian) EDs with diagnoses or symptoms that could perceivably have been triaged as suspected ACS (AMI; unstable angina pectoris, *UAP*; stable angina pectoris, *SAP*; and chest pain), and then separately for those who were eventually diagnosed with AMI. Recommendations are made for future research, which will require improved linking between datasets held by public agencies to better understand disparities in ED triage practice.

3.2 Publication

Kuhn L, Page K, Rolley J, Worrall-Carter L. (2013). Effect of patient sex on triage for ischaemic heart disease and treatment onset times: A retrospective analysis of Australian emergency department data. *International Emergency Nursing*; open access.



Effect of patient sex on triage for ischaemic heart disease and treatment onset times: A retrospective analysis of Australian emergency department data [☆]

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ABSTRACT

Time between emergency department (ED) presentation and treatment onset is an important, but little-researched phase within the revascularization process for ischaemic heart disease (IHD).
Objective: To determine if sex influences triage score allocation and treatment onset for patients with IHD in the ED.
Methods: Retrospective data for patients 18–85 years presenting to EDs from 2005 to 2010 for acute myocardial infarction (AMI), unstable and stable angina, and chest pain were analysed collectively and separately for AMI.
Results: Proportionately more men (61% of males) were triaged correctly for AMI than women (51.4% of females; $P < 0.001$). Across all triage categories, average treatment time was faster for men than women with AMI ($P < 0.001$). When incorrectly triaged for AMI, treatment time for men was faster than for women ($P = 0.04$). When correctly triaged for AMI, there was no difference in mean treatment time between men and women ($P = 0.538$).
Conclusions: Substantial undertriage of AMI occurred for both sexes, but was worse in women. Incorrect triage led to prolonged treatment times for AMI, with women's treatment delays longer than men's. When triaged correctly, both sexes were treated early for AMI, emphasising the need for all patients to be accurately triaged for this time-sensitive disease.

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Introduction

Mortality rates from acute myocardial infarction (AMI) have improved considerably in Australia and most other westernized countries over recent decades (Mackay and Mensah, 2004; AIHW, 2013). Slower improvements in outcomes associated with women's AMI, when compared to men's have previously been attributed to under-assessment, under-diagnosis and under-treatment

of women for AMI in the emergency department (ED) (Arslanian-Engoren, 2000; Jneid et al., 2008). No research regarding the effect of ED nurse triage on treatment times for ischaemic heart disease (IHD), including AMI, stable and unstable angina and chest pain likely to be of cardiac origin was located, prompting us to test our hypotheses that women are more often undertriaged than men for IHD and undifferentiated chest pain, resulting in delays in women's treatment.

Published Australian research for triage of women's heart disease is lacking however a recent literature review has identified pervasive sex related influences working against women from triage through to early ED treatment in North American EDs (Kuhn et al., 2011). This may be partly attributable to differences in symptoms reported by women experiencing AMIs (Arslanian-Engoren et al., 2006; DeVon et al., 2008; Canto et al., 2012). However, other research has shown women with new onset of chest pain received different treatment to men in EDs, even

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when their symptoms were similar (Lehmann et al., 1996). Triage nurse biases and use of stereotypes have been found to negatively influence triage of women with AMI in North America (Arslanian-Engoren, 2009). One study concluded nurses' inability to "associate middle-aged women's presenting symptoms with MI (myocardial infarction) may contribute to the increased morbidity and mortality experienced by this population" (Arslanian-Engoren, 2000: p. 117).

One of the most important developments in AMI therapy over recent decades has been the early revascularisation of affected coronary arteries by pharmacologic or mechanical means. There has been considerable interest in establishing the superiority of one method over the other, yet time delay between symptom onset to commencement of treatment is considered an important obstacle to positive results (Boersma, 2006; Gibson et al., 2008; Rathore et al., 2009). According to current Australian and New Zealand guidelines, revascularisation therapy for AMI is ideally undertaken in less than 90 min from the point of contact with health carers (Aroney et al., 2006). These narrow time-frames are consistent with the latest American Heart Association (O'Gara et al., 2013) and European Society of Cardiology (Steg et al., 2012) guidelines. They are generally more important for patients with ST segment elevation myocardial infarction (STEMI) than non-ST segment elevation myocardial infarction (NSTEMI) (Aroney et al., 2006; O'Gara et al., 2013). Differentiation of STEMI from NSTEMI is not possible at the point of triage unless the patient presents with an ECG with confirmed changes, so all suspected patients with AMI should be treated with haste until the provisional diagnosis is determined and the patient stabilised. The time-dependent nature of AMI requires expeditious patient triage upon arrival and immediate transfer through to the ED treatment area for rapid application of evidence-based therapy. Australian EDs employ the Australasian Triage Scale (ATS) to assess all presenting patients on arrival.

The ATS is a 5-tiered scale designed to enable the "sorting" of patients arriving at EDs according to level of physiologic urgency (Australasian College for Emergency Medicine, ACEM, 1993; Department of Human Services, DHS, 2001). Urgency is defined as the need for time-critical intervention, rather than disease severity or likelihood of patient admission (ACEM, 2000). Patients with STEMI represent a time-critical cohort where delay of even a few minutes may be clinically consequential (De Luca et al., 2004; Rathore et al., 2009). All patients with AMI require early treatment until stable. Unless in cardiopulmonary arrest or shocked (such affected patients require ATS Category 1), patients with AMI, ongoing angina or chest pain likely to be of cardiac origin should receive ATS Category 2 on the basis of the illness potentially being a life-threatening, time-critical and generally a painful condition (DHS, 2001; ACEM, 2006). Patients allocated ATS Category 2 should have treatment commenced within 10 min (ACEM, 2006). 'Treatment' within this context includes procuring and evaluating an ECG.

Patients with AMI or other conditions not readily differentiated from AMI triaged to lower acuity than ATS Category 2 (3, 4 or 5) are considered to be 'undertriaged', whereas those who receive the recommended triage category for AMI receive 'expected' or 'correct' triage (Hollis and Sprivilis, 1996). Undertriage may lead to longer waiting times and increased risk of adverse patient outcomes (Considine et al., 2001).

This paper will present findings from a retrospective audit of five consecutive years of contemporary State Government of Victoria, Australia administrative health data to establish if patients with AMI, unstable or stable angina or undifferentiated chest pain are triaged differently according to their sex and if so, whether this influences time to treatment.

Methods

Design and setting

A retrospective analysis of non-identifiable Victorian Emergency Minimum Dataset (VEMD) data on adult patient presentations for the diagnoses; AMI, unstable angina pectoris (UAP), stable angina pectoris (SAP) and chest pain (CP) reporting to Victorian public hospital EDs between 1 July 2005 and 30 June 2010 was conducted. We sought to establish the number and proportion of men and women receiving correct triage for these diagnoses, to compare equity in triage score allocation and evaluate mean times to onset of ED treatment for patients grouped by triage score and sex.

Selection criteria

In Victoria, the State Government Department of Health (DoH) routinely collects data for all ED patient presentations regarding patient sex, triage score allocation, time to treatment and principal diagnosis in the VEMD. Data for patient presentations to all non-specialist regional and metropolitan Victorian public hospital EDs ($n = 34$) were collected for five years (2005–2010). Specialty hospital EDs, whose staff do not routinely triage patients for AMI were excluded from data collection. Private hospital ED presentations were excluded because not all were reporting complete data to DoH for the entire study period.

Presentations classified as alive on arrival, and aged between 18 and 85 years were obtained using the International Classification of Diseases, 10th Revision Australian Modifications (ICD-10 AM) for the principal diagnoses: AMI (I21.9); UAP (I20.0); SAP (I20.9); and with complaint of chest pain (R07.4). All were selected to obtain an overview of triage patterns for presentations which may have prompted triage nurses to consider patients potentially experiencing AMI at the time of triage. The data were then filtered for I21.9 specifically to evaluate equity in triage score allocation for patients diagnosed with AMI. The VEMD does not differentiate between STEMI and NSTEMI, which would have been our preferred option, had it been available.

Data collection

Data were requested from the custodians of the VEMD for variables including age, time to treatment, ICD-10 AM code (hereafter, ICD), patient sex and ATS score allocation, and provided to the researchers in non-identifiable digital datasets.

Statistical analysis

All data were transferred to SPSS Statistics Version 18.0 (SPSS Inc., an IBM Company, Chicago, Ill, USA) software, where string data fields were allocated numerical codes, examined for missing values, outliers and accuracy of data entry. Distributions were checked for normality with the Lilliefors test.

Frequency tables were used to provide descriptive statistics for independent variables (patient sex and triage score allocation) and dependent variables (triage score allocation and time to treatment), for all diagnoses combined, followed by selection for AMI separately. Independent-samples *t*-tests were conducted to compare times to treatment for men and women for all selected diagnoses and also for AMI singly. AMI, as the most time-critical of the identifiable cardiac event presentations, was analysed and reported separately.

To determine interaction effects when patient sex and triage score allocation were added to the investigation, we applied one-

way analysis of variance (ANOVA) and two-way between-groups ANOVA, allowing the examination of individual and joint effects of the two independent variables on the dependent variable.

Main outcome measures were triage score allocation proportions and mean times to reported onset of treatment for males and females. All tests of statistical significance were 2-tailed, with a P value < 0.05 considered to be statistically significant.

Ethics approval

The Australian Catholic University Human Research Ethics Committee approved the study (HREC V2009 83). The Victorian Department of Human Services 'Conditions of Release of Patient Level Data Sets' were also met.

Results

Demographic and diagnostic characteristics

A total of 261,628 patients presented to Victorian EDs between 1 July 2005 and 30 June 2010 with AMI, UAP, SAP or CP (Table 1). The mean age for all male ($n = 146,603$) presentations was 53.29 years (SD 16.04) and 57.63 years (SD 16.69) for females ($n = 115,025$). As shown in Table 1, chest pain was the most common principal diagnosis assigned to women and men.

A total of 21,080 patient presentations were assigned a principal diagnosis of AMI, accounting for 5.8% ($n = 6,638$) of extracted women's presentations and 9.9% of men's presentations ($n = 14,442$). Women with AMI were an older average age (mean = 68.97 years; SD 12.25) than men (mean = 62.84 years; SD 13.07, $t(21,078)$, $P < 0.001$).

Table 1

Baseline characteristics of patient presentations to Victorian public EDs from July 1st 2005 to June 30th 2010 with AMI, UAP, SAP and CP diagnoses.

Variable	Total n (%)	Women n (%)	Men n (%)
AMI	21,080 (8.1)	6638 (5.8)	14,442 (9.9)
UAP	25,319 (9.7)	9677 (8.4)	15,642 (10.7)
SAP	9648 (3.7)	4199 (3.7)	5449 (3.7)
CP	205,581 (78.6)	94,511 (82.2)	111,070 (75.8)
Extracted total	261,628 (100)	115,025 (100)	146,603 (100)

AMI, acute myocardial infarction; CP, chest pain; EDs, emergency departments; SAP, stable angina pectoris; UAP, unstable angina pectoris.

Table 2

Mean times to treatment for all principal diagnoses and AMI only, allocated ATS Categories 1–5.

ATS category	Total (both sexes)		Women		Men		P
	n (%)	Mean TT (SD)	n (%)	Mean TT (SD)	n (%)	Mean TT (SD)	
All principal diagnoses (AMI, UAP, SAP, CP)							
1	1697 (0.6)	0.08 (0.28)	413 (0.4)	0.09 (0.29)	1284 (0.9)	0.08 (0.27)	0.321
2	133,326 (51.0)	7.74 (10.94)	55,480 (48.2)	8.00 (11.17)	77,846 (53.1)	7.55 (10.72)	<0.001
3	100,540 (38.4)	24.64 (36.51)	46,665 (40.6)	25.68 (37.91)	53,875 (36.7)	23.73 (35.22)	<0.001
4	24,380 (9.3)	57.25 (68.65)	11,754 (10.2)	59.03 (70.45)	12,626 (8.6)	55.59 (66.90)	<0.001
5	1685 (0.6)	50.51 (62.79)	713 (0.6)	48.67 (57.78)	972 (0.7)	51.86 (66.23)	0.009
Total	261,628 (100)	19.07 (35.49)	115,025 (100)	20.61 (37.63)	146,603 (100)	17.86 (33.68)	<0.001
AMI only							
1	1250 (5.9)	0.09 (0.28)	294 (4.4)	0.09 (0.29)	956 (6.6)	0.08 (0.28)	0.45
2	12,161 (57.7)	6.07 (9.54)	3412 (51.4)	6.1 (9.28)	8749 (60.6)	6.06 (9.64)	0.538
3	6404 (30.4)	21.15 (33.09)	2392 (36.0)	21.67 (33.97)	4012 (27.8)	20.83 (32.56)	0.242
4	1178 (5.6)	48.16 (66.13)	511 (7.7)	50.21 (69.17)	667 (4.6)	46.60 (63.71)	0.268
5	87 (0.4)	31.05 (50.80)	29 (0.4)	21.14 (31.94)	58 (0.4)	36.00 (57.60)	0.054
Total	21,080 (100)	12.75 (27.71)	6638 (100)	14.91 (31.53)	14,442 (100)	11.76 (25.71)	<0.001

AMI, acute myocardial infarction; ATS, Australasian Triage Scale; CP, chest pain; ED, emergency department; Mean TT, Mean Time to Treatment (minutes); P , significance value for mean time for patient sex; SAP, stable angina pectoris; SD, standard deviation; UAP, unstable angina pectoris.

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Triage categories

As shown in Table 2, a narrow majority (133,626; 51%) of the total presentations ($n = 261,628$) were allocated ATS Category 2. A greater proportion of men ($n = 77,846$; 53.1% of all males) were allocated Category 2 compared to women ($n = 55,480$; 48.23% of all females; $P < 0.001$). More women were allocated both ATS Categories 3 ($P < 0.001$) and 4 proportionately ($P < 0.001$) than men.

A larger proportion of male patient presentations with AMI were allocated ATS Category 2 than were females with the same diagnosis (Table 2). The difference in probability of a male with AMI being allocated Category 2, as opposed to a female was statistically significant (OR 1.45; 95% CI 1.37–1.55; $P < 0.001$).

Time to treatment onset

The mean reported time to onset of treatment for all patient presentations across all triage categories for all diagnoses ($n = 261,628$) was 19.07 min (SD 35.49). For males, the mean treatment time was 17.86 min (SD 33.68) and for females, 20.61 min (SD 37.63, $t(261,626) = -19.678$, $P < 0.001$). For all diagnostic groups combined, and then filtered for AMI separately, there were no differences in mean treatment times if patients were given ATS Category 1; patients were treated immediately with mean treatment times recorded as less than 1 min for both sexes (Table 2).

Men had shorter times to treatment than women in ATS Categories 2, 3 and 4 for the combined diagnostic groups, however women had shorter times to treatment than men when they were allocated ATS Category 5 [$t(4,261,618) = 17.07$; $P < 0.001$]. When testing differences in treatment times for patients given ATS Category 2, men were treated statistically significantly faster than women (men, mean = 7.55 min, SD 10.77; women, mean = 8 min, SD 11.17, $t(133,324) = -7.37$, $P < 0.001$). When women were allocated ATS Categories 3 or 4, they had longer mean treatment times (mean = 32.39 min, SD = 48.22) than men in the equivalent two ATS Categories (mean = 29.78 min, SD 44.84; $t(124,918) = -9.916$, $P < 0.001$).

A two-way univariate ANOVA test revealed a significant interaction effect between patient sex and diagnosis; male times to treatment were significantly shorter across all diagnoses than were the female mean times for equivalent diagnoses [$F(3,261,628) = 4.143$; $P = 0.006$].

The mean overall treatment times for patients with principal diagnosis of AMI were significantly shorter for men (mean = 11.76 min; SD 25.71) than women (mean = 14.91 min;

SD 31.53; $t(21,078) = -7.671$, $P < 0.001$). When given any of the possible triage categories lower than expected (i.e. Cats 3, 4 and 5), as a composite group, mean treatment times for men (mean = 24.65 min; SD 39.88) were significantly shorter than they were for women (mean = 26.64 min; SD 43.6; $t(7667) = -2.054$, $P = 0.04$). However, when patients with AMI were assigned the expected ATS Category 2, there was no statistical difference observed in mean treatment times between males (mean = 6.06 min; SD 9.64) and females (mean = 6.10 min; SD 9.28; $t(12,159) = -2.25$, $P = 0.538$). This was the case for all treatment time comparisons between men and women for all individual ATS scores, analysed for AMI separately. There were no statistical differences observed between men's and women's treatment times for any of the ATS Categories (1–5) for this group diagnosed with AMI (Table 2).

Discussion

We have evaluated triage score allocation proportions and times to recorded treatment onset to establish whether women were more often undertriaged than men for AMI, and whether any triage disparity was associated with delays in women's treatment for AMI, UAP and SAP and CP potentially of cardiac origin in Victorian EDs. Analysis of the complete dataset demonstrated an association between sex and triage score allocation; women were less likely to receive correct triage score allocation for AMI, UAP, SAP and undifferentiated chest pain than men, and this was associated with prolonged times to treatment. Although limited to one Australian state, analysis of triage practice for ischaemic heart disease on this dataset is likely to enlighten other health jurisdictions about ED practice performance measures and outcomes in their own systems.

Numerous researchers have demonstrated women receive less evidence based management during hospitalisation for AMI than do their male counterparts (Milcent et al., 2007; Radovanovic et al., 2007; Jneid et al., 2008). Our data revealed that for this state-wide population of patients who presented to ED triage nurses with either potential or actual AMI, a smaller proportion of women received the expected triage score than did men over the period investigated. We found the comparative triage differences between the sexes to have been even greater for patients with the principal diagnosis of AMI; women were even less likely to receive an adequate triage score when experiencing AMI than men. Triage score allocation was poor for both sexes however; it was incorrect for almost 50% of women and 40% of men and is worthy of further research to clarify the issue and improve performance.

We then aimed to investigate whether triage score allocation made a difference to mean treatment times for patients from the aggregate diagnoses (AMI, UAP, SAP and CP), and then specifically for those diagnosed with AMI. Our findings suggest that for these five years, triage score was likely an important determinant of treatment onset times for both sexes, if they were undertriaged (given ATS Categories 3, 4 or 5). For all diagnostic groups combined, and then filtered for AMI separately, there were no differences in mean treatment onset times if they were given ATS Category 1; both sexes' mean waiting times were a matter of seconds.

Disparities in treatment times for the sexes varied statistically between the aggregate and AMI-only groups when allocated ATS Category 2. For women from the aggregate group, allocation of the correct Category 2 meant their mean treatment times were statistically significantly longer than men from the equivalent sample group. We do not believe this would have been clinically significant however as many of these patients' conditions could not have justifiably been allocated ATS Category 2 on clinical grounds. This was not the case for patients selected with the principal diagnosis of AMI; men and women with AMI had statistically equivalent

treatment times when given the expected ATS Category 2. Both men and women with AMI allocated ATS Category 2 were treated in less than 10 min, although proportions of each sex triaged to this expected Category were disappointing.

When allocated ATS Categories 3 or 4, men from the aggregate group were treated faster than women from the same group; this inequity reached statistical significance. This was not the case when the sample was limited to the principal diagnosis of AMI; mean treatment onset times for women were observably slower than men's with AMI when allocated ATS Categories 3 or 4. Whilst this may have had clinical ramifications, it did not reach statistical significance. The result of being undertriaged with AMI was poor for both sexes, with mean waiting times well in excess of the 10 min recommended for treatment of patients who should have received ATS Category 2 (ACEM, 2000).

Interpretation of analyses for patients of both the aggregate group, as well as those filtered for AMI by sex were intriguing; men were treated more slowly than women when allocated ATS Category 5. This reached statistical significance when the aggregate group was analysed, but narrowly failed to reach statistical significance for patient presentations filtered for the principal diagnosis of AMI. Men allocated ATS Category 5 with AMI waited almost 15 min longer on average to commence treatment than their equivalent cohort of women, but the sample sizes were small compared to those in the other triage categories. Reasons for this capricious result are unclear. We recommend further prospective research to identify whether this pattern of triage score allocation continues and determine the basis of the divergence of the decision making at triage.

Also of interest was the fact that patients of both sexes tended to be treated faster when given ATS Category 5 than 4. This finding was unexpected, and may have been due to unequal sample sizes, but we wonder whether it was due in part to the fast track systems operating in Victorian EDs for patients triaged to lower levels of acuity (O'Brien et al., 2006; Considine et al., 2008). Without the fast track systems, these patients could wait protracted periods of time if their treatment was repeatedly deferred due to arrival of other patients with more urgent conditions. Hence, patients of either sex were more fortunate in terms of times to treatment when allocated the least acute ATS Category 5, than they generally were when given ATS Category 4.

Limitations

This research has a number of limitations requiring elaboration. Even though the database is likely to contain all patient presentations to Victorian public hospital EDs with the principal diagnoses researched, it fails to provide detail regarding outcomes such as classification of AMI, AMI resolution and morbidity. It is an administrative dataset.

Lack of available data linkage at the time of data extraction means we are unable to gauge if the same patients have returned on multiple occasions and have been counted numerous times. Comprehensive linkage of datasets may enable the determination of patients who have represented to EDs or presented with escalating disease and the impact on their outcomes. In such a large dataset, knowledge of repeated presentations and establishment of patterns of subsequent major adverse cardiac events or death may be feasible with improved data linkage and are likely to be useful epidemiologically. It is hoped the Australasian Cardiac Outcomes Registry anticipated to have been launched nationally in 2012 (CSANZ, 2011) will address a number of these issues when it becomes fully operational.

Limited detail in available data at the time of extraction has meant we do not know how long patients had symptoms prior to seeking medical assistance or whether they had been seen by local

medical practitioners prior to their ED presentations. It is also unknown how long patients waited for ambulances or whether they were subjected to *ramping* prior to commencement of ED triage, thus artificially reducing real waiting times. The practice of *ramping* occurs at some Victorian EDs and involves leaving patients on ambulance trolleys for longer to be attended to by paramedics due to resource limitation issues within the EDs (VEPA, 2011). We do not have data reflecting whether usual practice dictates triage evaluation as the ambulances arrive, or whether this first ED assessment is delayed.

Despite the acknowledged shortcomings inherent in this type of research, the application of the ATS throughout Victoria, coupled with the collection of ICD-10 coded data has enabled important inferences regarding equity between patient sexes to be drawn on the accuracy of triage score allocation and the influence of triage on a large population of patients with suspected and actual AMI. Until further prospective studies are undertaken, these findings can be viewed as correlations rather than causes.

Conclusions

Key findings emanating from our analyses of five years of contemporary public hospital ED data include:

1. Incorrect triage score allocation for patients with AMI of either sex is common. However, analysis revealed women were more disadvantaged than their male counterparts. A statistically significant smaller proportion of women diagnosed with AMI were given the correct triage score than the proportion of men with AMI.
2. Incorrect triage score allocation was associated with prolonged treatment times for Victorian patients with AMI. When allocated lower triage acuity than Category 2, treatment delays were prolonged for both sexes.
3. Correct allocation of triage score for AMI was and is important; when patients of either sex were given ATS Category 2, there was no significant difference in treatment times, which were under 10 min.

Hence, when triage nurses allocate correct ATS scores for heart disease, the triage system is working well and generally enables early implementation of time-sensitive therapies, when indicated. However, this research is exploratory and more detailed analysis needs to be done as comprehensive datasets and improved linkage between datasets become available. Ideally, future health management will be based on evidence ascertained nationally, which may be feasible due to the nationwide use of the disease classification and triage systems. In addition to this, further research needs to address whether inequities in triage score allocation and subsequent delays do affect patient outcomes for heart disease and if so, how they can best be overcome. At this stage, we have shown an association, but this needs further validation and evaluation of relevant patient outcomes. Future work may include incorporation of sex-specific heart disease assessment and management into ED triage educational processes and a promotional campaign to increase awareness of issues which continue to confound opportunities to minimise myocardial damage.

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3.3 Summary

Synthesis and review of the literature provided in Chapter 2 concluded that in a number of North American EDs, triage assessment of women with ACS was more difficult than it was for men for a number of reasons. Other than the Canadian studies by Atzema et al. (2009, 2010), these studies did not examine whether difficulties found evaluating women at triage were actually associated with disparity in triage practice for ACS and AMI. The research reported in the current chapter provides an answer to this question.

Analysis provided new information essential to understanding and improving the management of AMI for women and men across Victoria, Australia. Proportionally, there was statistically significant undertriage of women with AMI across Victoria compared to men. Incorrect triage score allocation for suspected ACS and AMI led to prolonged treatment times for both men and women patients with AMI. When not allocated ATS Category 2, women's treatment delays were significantly worse than they were for men. Correct allocation of triage for AMI was important; when patients of either sex were given ATS Category 2, there was no significant difference in treatment times, which were both less on average than the recommended 10-minute maximum for patients allocated to ATS Category 2. Triage score allocation did correspond with time to onset of treatment for AMI.

It is not known to what extent triage patterns for ACS and AMI vary between Australian states and territories, but close examination of one of Australia's most populous state's ED data over a five-year period provides new and important insight into triage management of ACS in the Australian context. Extrapolation to other states and territories cannot be done without analysis of each jurisdiction's separate datasets, but it is possible because the ATS is used in all Australian EDs and ACS and AMI are reported to all states and territories using the International Classification of Diseases and Related Health Conditions, 10th Edition (ICD-10) system (World Health Organization (WHO), 2011). Ideally, all state and territory health datasets will be linked to each other in the near future and to other datasets such as registries of death, Medicare and health insurance, enabling more detailed analysis and benchmarking of patterns of presentation, readmission and death and comparison between the jurisdictions. Numerous other countries use structured triage systems (Gerdtz et al., 2009) and most use the ICD-10 disease classification system as published by the World Health Organization (WHO,

2011). It is therefore, likely that a methodology similar to the one outlined in this chapter's research publication could be used to evaluate triage equity and efficacy for ACS and AMI in other countries where similar datasets are maintained.

By highlighting and quantifying existing inequities in healthcare, this research provides a step forward. It can be used to help guide future strategies to increase equity in healthcare and improve outcomes from ACS and AMI for patients presenting to EDs with the heart diseases. Demonstrating that there is in fact a difference in terms of how men and women are assessed at triage is important. It will encourage further research and the uptake by EDs of triage practice processes that will further enhance cardiac care for all patients, but particularly for the group identified as more vulnerable to under-assessment and under-treatment; women.

This research provides an important contribution to knowledge regarding triage equity in relation to patient sex and the influence triage allocation has on treatment onset times for ACS and AMI. This is a phase identified in the *DaME II* study as a critically important, but previously overlooked stage in the quest to improving door-to-treatment times for AMI. This phase in ED care has been measured to enable quantification and improvement in triage and other ED processes to facilitate the earliest possible implementation of reperfusion therapy. Triage inequality related to patient sex has been demonstrated in this database research, prompted in part by the research uncovered in the published literature review (Chapter 2). Triage for ACS and onset to treatment times may also be influenced by other non-clinical factors not yet identified however, and Chapter 4 will be used to further research and examine these.

3.4 References

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Chapter 4

Factors influencing the timeliness of management onset for AMI in the ED

Chapter 4

i. Method

ii. Research

i. Kuhn L, Page K, Ward J, Worrall-Carter L. (2013). The process and utility of classification and regression tree methodology. *Journal of Advanced Nursing*; open access.

ii. Kuhn L, Worrall-Carter L, Ward J, Page K. (2013). Risk factors for increased time to treatment of acute myocardial infarction in Victorian Emergency Departments: A regression-tree based analysis. *Australasian Emergency Nursing Journal*, 16(4), 160-169.

4.1 Background

Research presented in Chapter 3 demonstrated inequity in the allocation of triage acuity rating associated with patient sex. It found a significantly smaller proportion of women were correctly assigned Australasian Triage Score (ATS) Category 2 for acute myocardial infarction (AMI) than men with the same diagnosis. It concluded triage score allocation was associated with time to onset of treatment; the lower the allocated level of acuity, the longer the delays and perceivably, the longer it would take to initiate revascularisation therapy. Therefore, more women were *undertriaged* than their male cohort for AMI and were proportionately more likely to have been disadvantaged.

The findings of the published literature search discussed in Chapter 2 prompted this analysis of data extracted from the Victorian Emergency Minimum Dataset (VEMD) to gauge ATS Category allocation equity between men and women, and the effect on times to treatment onset. With the exception of advanced patient age which resulted inconsistent triage decision making for ACS in one study (Arslanian-Engoren, 1999) and had no effect in others by the

same lead-author (Arslanian-Engoren, 2001, 2004), no other demographic factors were found during the literature search to influence triage accuracy for ACS (Kuhn et al., 2011). As they had not been studied before, it was also felt to be important to test if other patient characteristics influenced time to onset of treatment for ACS in EDs; the point of patient entry to public hospitals for acute disease. Any variables found to impact upon ED triage score allocation for ACS other than clinical factors related to patient urgency need to be identified in order to correct any inequities.

The aim of the current chapter is to determine if other demographic factors affect the speed at which treatment is commenced for patients with AMI in EDs using a novel data mining methodology.

4.1.2 Identifying a novel method for harnessing the potential of VEMD data

Large datasets that were previously prohibitive to analyse due to their size have become increasingly available through new methods of quantitative analysis.

The paradigm of 'big data' provides a novel means of analysing datasets such as the VEMD for patterns amongst variables not previously observed. It has been enthusiastically claimed the paradigm is about to revolutionise the way healthcare is measured and managed (Mayer-Schönberger & Cukier, 2013). Big data is an evolving concept which is growing rapidly in popularity and perceived legitimacy in healthcare. It has long been used in areas such as meteorology, statistics and ecology, but has recently come to the fore in health sciences, where it is seen as an important means of advancing translational research (Ackerman, 2012). Big data is increasingly being recognised a means of discovery that is done retrospectively on whole populations, providing new understanding of patterns of events, behaviours and treatments which first came to the PhD Candidate's attention at the time she was contemplating how to find important, previously hidden patterns for early patient care amongst the large VEMD dataset.

The VEMD dataset contains information regarding patient variables such as age, sex, location of residence, mode of arrival, preferred language and whether or not treatment was provided

at a metropolitan or regional public hospital. Extracted from a government-collected administrative dataset, the VEMD data also provided information for triage score allocation and time to commencement of treatment after triage in minutes. Both variables are integral to the concept of DaME II study which seeks to examine the phase in treatment that occurs when a patient first arrives at an ED with ACS in order to optimise care. With newly available techniques for analysis, the dataset was ideal for discovering or 'mining' patterns between ED patient variables.

Data mining is an analysis method that fits into the big data framework and is used for uncovering new patterns from large datasets, with a focus on modelling, knowledge discovery and prediction (Ohlhorst, 2012). Classification and regression tree (CaRT) analysis is central to data mining (Williams, 2011) and it was felt it would be an ideal method for uncovering patterns in patient management in the ED. For this reason, a literature search was conducted to ascertain if CaRT had been used to evaluate patient care in this way previously and as it had not, to find an exemplar to guide the method's implementation on the VEMD dataset. Literature search for prior CaRT use in healthcare showed that although the method was becoming increasingly used in medicine (Mann et al., 2008; Quintana et al., 2010) and public health (Protopopoff et al., 2009), its utility as a method of research had largely gone unnoticed within nursing, with only a few nursing publications describing it (Bonner, 2001; Dowding & Thompson 2004; Su et al., 2011), with no studies located outlining its use in triage or the ED. This was a particularly exciting innovation and for this reason, the case for CaRT was made, and then utilised the method in the research process to determine patterns of patient vulnerability to delayed treatment onset. This led to two publications, both of which provide important new knowledge to the nursing profession and the ED specialty:

- i) The first presents a discussion around the utility, application, criticisms and limitations of CaRT in nursing research; and,
- ii) The second presents research undertaken with regression tree analysis to determine risk factors for increased time to treatment for patients with AMI arriving at Victorian EDs over 5 years.

4.2 Publication – method paper

i. Classification and regression tree (CaRT) method

Kuhn L, Page K, Ward J, Worrall-Carter L. (2013). The process and utility of classification and regression tree methodology in nursing research. *Journal of Advanced Nursing*; open online.



Why is this research or review needed?

- Classification and regression tree analysis is a relatively new tool of research available to nursing.
- An understanding of classification and regression tree method will empower clinicians and scholars privy to the nuances of their profession to interrogate large data sets for attributes meaningful to nursing practice.
- Like all research methods, researchers need to be cognizant of classification and regression tree analyses' strengths as well as weaknesses.

What are the three key findings?

- Classification and regression tree software can handle large volumes of data, explicating previously concealed links among important patient, management and outcome variables.
- Classification and regression tree method is a useful exploratory form of research capable of providing insights into what is happening across whole populations from large databases and may be used to develop models to evaluate and improve care, stratify risk and determine prognoses.
- As with all research methods, there are several limitations in classification and regression tree analysis; it will not replace other quantitative methods, but will complement these and enhance our nursing knowledge base.

How should the findings be used to influence policy/practice/research/education?

- Classification and regression tree analysis allows the researcher to question practice and outcomes on large data sets collected on whole populations. It may be used to improve research questions and inform future research agendas to improve evidence-based practice.
- Classification and regression tree analysis should be used to more fully use available data sets to inform targeted research towards fulfilling national research priorities.
- Database research is an important means for nurse researchers, clinicians and managers to evaluate what is working for patients across healthcare systems in terms of processes and equity of care, enabling them to advocate, educate and rectify any management gaps through refining models of contemporary care.

Introduction

New databases are regularly developed with existing ones expanding at an exponential rate in this data-rich society. Healthcare databases are numerous, extensive and growing prodigiously. They provide rich, relatively untapped sources of important quantitative information about patient popula-

tions, patterns of care and outcomes. To overlook them in nursing research would be a missed opportunity to add to existing nursing knowledge, generate new knowledge empirically and improve patient care and outcomes.

There are numerous methods for analysing quantitative data; each requires careful selection to suit the unique aims of each project of research. The aim of this paper is to describe classification and regression tree (CaRT) analysis and to highlight the benefits and limitations of this method for nursing research.

Background

Healthcare databases are large repositories of information that include a variety of clinical and administrative information and, although not specifically designed for the purpose, may be useful for secondary data analysis (Magee *et al.* 2006). Data sets, the collections of data in the databases, can be analysed to determine the influences on, and differences between, selected variables (Williams 2011) answering many questions. Patterns uncovered can inform health care and build knowledge, providing that research questions are well formulated and the extraction well planned and executed. Like all research methods, a conceptual fit is necessary between the data set and data analysis.

Fitting within the burgeoning framework of 'big data' (Mayer-Schönberger & Cukier 2013), CaRT analysis is an important component of data mining (Williams 2011), a means of exploring and analysing large data sets in search of meaningful patterns (Hurwitz *et al.* 2013). CaRT has become increasingly prevalent internationally since the sentinel work by Breiman *et al.* (1984). To date, the method has been used infrequently by nurse researchers (Bonner 2001, Dowding & Thompson 2004); however, we believe that, as the utility of the CaRT method becomes better known and research using large data sets gains momentum, its implementation will become commonplace in nursing research. It will provide new insights into community-wide healthcare systems in relation to patterns of care delivery and outcomes, including prognoses in any country in which health data are maintained.

CaRT method has been lauded because of its ability to overcome missing data by use of surrogate measures (Lamborn *et al.* 2004). Missing data are a common occurrence in many data sets, even those developed prospectively for the purpose of specific investigations (Speybroeck 2012); however, it is particularly a problem when working with large administrative and clinical data sets, such as those used in secondary data analysis (Lange & Jacox 1993, Speybroeck 2012).

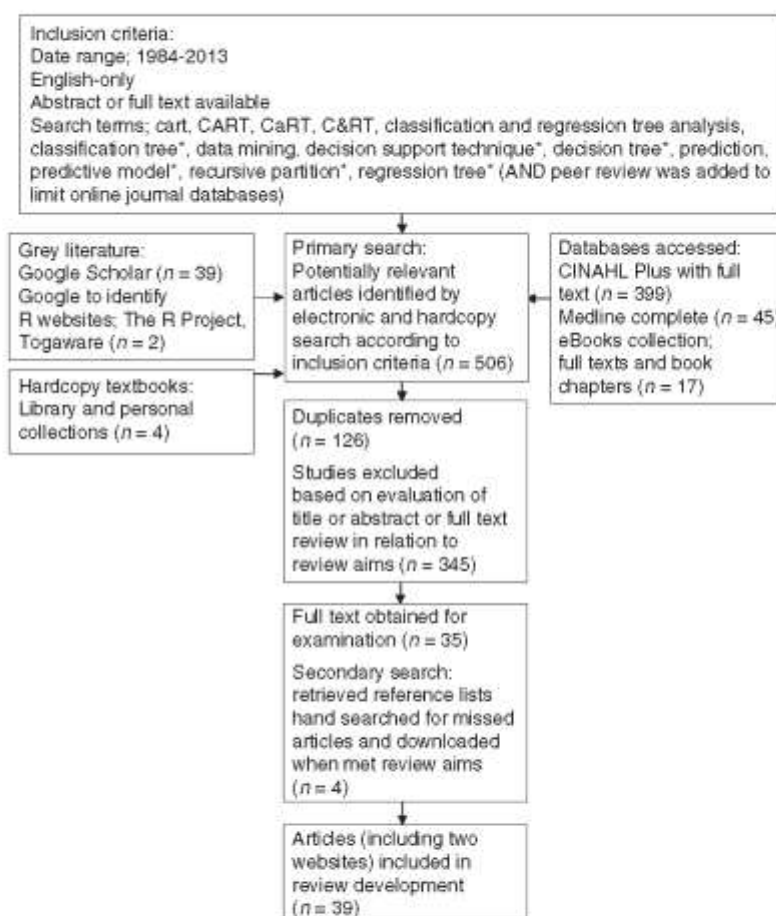


Figure 1 Flow chart of search method and results.

CaRT is an exploratory method of research used to uncover relationships and produce clearly illustrated associations between variables not amenable to traditional linear regression analysis (Crichton *et al.* 1997). The method has a long history in market research and has more recently become increasingly used in medicine to stratify risk (Karolis *et al.* 2010) and determine prognoses (Lamborn *et al.* 2004). In addition to quantification of risk, CaRT is an important means for uncovering new knowledge. The method of analysis is ideal for exploratory nursing research, as it may be used to uncover gaps in nursing knowledge and current practice. Through analysis of large data sets, we believe CaRT is capable of providing direction for further healthcare research regarding outcomes of health care, such as cost, quality and equity.

Data sources

This paper was informed by literature on classification and regression tree analysis from 1984, the year Breiman *et al.* (1984) published the sentinel classification and regression

trees text until the time of writing this article in January 2013. Data sources included the online journal databases; MEDLINE Complete, CINAHL Plus full text and the eBooks databases; in addition to hardcopy research reference texts. The online facilities Google Scholar and Google were searched and reference lists of articles and books found to be pertinent to understanding the method or its use in the context of health care were also searched manually. A full list of search terms, the strategy used and the final number of articles incorporated into the development of this review are included in Figure 1. The search was restricted to English language articles and books.

Discussion

Classification and regression trees

CaRT is a computationally intensive (Crawley 2007) exploratory, non-parametric (Breiman *et al.* 1984) procedure that makes no distributional assumptions of any kind (Frisman *et al.* 2008). It does not require a pre-defined

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underlying relationship between the dependent variable (referred to in CaRT terminology as 'target' variable) and the independent variables ('predictors'). It does not imply cause-and-effect relationships between variables, but rather statistical associations between them (Leclerc *et al.* 2009).

CaRT-generating programs are available in several well-recognized commercial statistical computing packages such as SPSS, SAS and STATA, often as add-on modules. A statistical program familiar to the authors is R (R Development core Team 2010). This open-source program is freely downloaded from <http://www.r-project.org> and comes with the 'rpart' command package, enabling the generation of classification and regression trees. Rpart treats a variable preselected by the researcher as the target variable and the others selected as predictors.

Classification and regression tree analysis methodology

Classification and regression trees are labelled according to the dependent variable or variable of interest. Classification trees are used when the target variables are categorical, such as race, patient sex or gender and marital status. Regression trees assume that the outcome or dependent variable is continuous, for instance, age, height and time. Classification trees build classificatory models by asking categorical questions, for instance: 'Is it going to be hot today?' The answers are usually binary ('yes' or 'no'), but not always (Williams 2011). They can have more categories such as 'too hot', 'just right' or 'too cold', all of which are classificatory. Regression tree models produce a numeric set of outcomes calculated mathematically by examining relationships between target and predictor variables to determine their mathematical relationship. This formula is then applied to new observations in an attempt to predict likely outcome. Using the same analogy, the outcomes for the day's comfort level would be expressed in Celsius or Fahrenheit scales. Williams (2011) calls this 'predictive analytics' (p. 175) and explains that it is carried out to produce both classification and regression tree models. The computer algorithms, therefore, learn (or are 'trained') from other related or historical data and their influence on target outcomes and then applies what is learnt to predict subsequent outcomes in new data. This is called 'machine learning'.

CaRT analysis is often called 'recursive partitioning' (Lemon *et al.* 2003, Fonarow *et al.* 2005, Strobl *et al.* 2009) because it forces data to split by algorithm into increasingly smaller and homogenous subsets according to researcher-specified criteria (Crichton *et al.* 1997). Williams (2011) describes this partitioning as dividing and conquering.

All predictor variables are checked at each level for the split that will result in the most pure split nodes (Prasad *et al.* 2006) according to the algorithm learnt by the machine. The machines are modern computers with increased power to handle large volumes of data. The learnt or trained algorithms of CaRT are repeated and are fitted to data in each partitioned subset by testing all variables in search of the one that results in the cleanest split (Frisman *et al.* 2008). This separates it from traditional statistical procedures, such as linear regression, which are global models with single predictive formulae (Lemon *et al.* 2003). With CaRT analysis, each question asked at each step is based on the answer to the previous question (Williams 2011).

Successive variable data, which may be mixed categorical or continuous independent variables, are split into increasingly mutually exclusive or homogenous subgroups in relation to the target variable (Lemon *et al.* 2003). The algorithm is designed to split and provide the best balance between sensitivity and specificity for predicting the target variable and continues until perfect homogeneity is reached or the researcher-defined limits are reached (Frisman *et al.* 2008). The final node along each branch contains all of the decisions (Williams 2011). Each corresponds with a specific pathway or set of decisions made by algorithm to navigate through the tree. Hence, the overarching name often given to the structures is 'decision trees' (Quintana *et al.* 2009, Gardino *et al.* 2010, Williams 2011).

There are several ways purity (which is carried out by calculating impurity) in each node is determined. These are statistical techniques to estimate 'impurity' in all predictor variables at each level to predict the largest difference between impurity of the parent node and weighted average of the impurity of the child nodes (Lemon *et al.* 2003, p. 174). These are the Gini, entropy and minimum error functions (Zhang & Singer 2010). The choice of impurity function and implementation of each are internal to the different statistical programs. Their calculations are beyond the scope of the current paper and interested readers are referred to Breiman *et al.* (1984) original text or those developed since, including Crichton *et al.* (1997), Lemon *et al.* (2003) and Williams (2011) for further explanation. Whichever impurity function is employed, the independent variable whose split has the greatest value is selected for splitting at each step by statistical algorithm (Lemon *et al.* 2003).

Using the fictitious tree illustrated in Figure 2 as an example, the researcher uses data for 1000 patients who were admitted to Hospital X in 2013 with acute myocardial infarction (AMI) to determine which patient characteristics

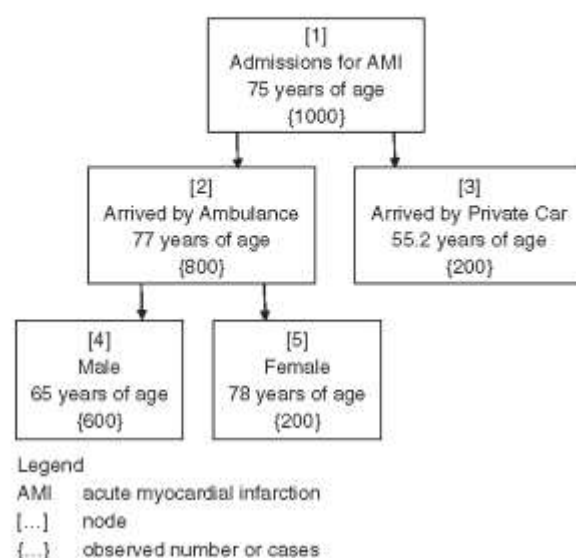


Figure 2 Fictional illustration of a regression tree indicating relationships of variables associated with age at hospitalization for acute myocardial infarction.

(predictor variable(s)) are associated with patient age in years (the target variable) at the time of admission. The model is a regression tree because the target variable is continuous. Predictor variables available to build the regression tree are residing distance from Hospital X, patient sex, patient marital status, arrival at hospital by ambulance or private car and health insurance status. When the target variable and predictor variables are selected in the CaRT program, the computer algorithm chooses the variable that offers the most improvement in purity in the node (therefore has the most impurity with the greatest scope for correction by splitting). In this instance, *the patient arrival at hospital by ambulance or private car variable* provides the greatest splitting value, hence is chosen. There are no more splits fitting the criteria for patients who arrived by private car, hence this becomes a terminal node. For those who arrive by ambulance, the variable that provides the greatest value in splitting is patient sex. The exemplar constitutes an unusually simple and unrealistic tree model, however, the reader can see at a glance that younger patients with AMI tend to arrive by private car. Those patients who are older more often come by ambulance and the majority of those are men, who are much younger, generally, than women. The illustration presents a tree that provides minimal information and seems to have stopped splitting too early to provide much more explanation than simple grouping. The tree appears to be limited to too few splits and to only three levels, but still may uncover new information. It may

indicate, for instance, that the message that patients with AMI should call an ambulance for transportation to hospital is not heeded by younger patients, which may guide future spending on media campaigns for AMI.

The example provided in Figure 2 lacks depth and complexity, yielding less information than may have been uncovered with broadened parameters. The overall level of complexity in CaRT models is determined by the complexity parameter (CP), which controls the number of splits in a tree by defining the minimum benefit that must be gained at each split to make that split worthwhile (Williams 2011). The CP eliminates splits that add little or no value to the tree and, in so doing, provides a stopping rule (Lemon *et al.* 2003). Set by the researcher, the CP assists the process of pruning a tree by controlling its size (Williams 2011). The parameter is reached using trial and error; the investigator observes trees at different CP levels and decides when no real information gain is made with greater levels of complexity. This is a form of pruning internal to the statistical program involving an iterative process employed by the researcher (Rokach & Maimon 2007).

Pruning is an essential function of CaRT analysis. It is the process of controlling, limiting or reducing a tree's size. Pruning removes sub-branches from overfitted trees to ensure that the tree's remaining components are contributing to the generalization accuracy and ease of interpretability of the final structures (Rokach & Maimon 2007).

This is an important function because reaching absolute homogeneity would result in a huge tree with almost as many nodes as observations and provide no meaningful information for interpretation beyond the initial data set. Large trees are unhelpful and are the result of 'overfitting', thereby providing no explanatory power (Crawley 2007). As the intention is to build a useful model, it is important that the components of the tree are able to be matched to new and different data. The more complex model will have good explanatory power for the data set on which it is trained, but will not be useful as a model applied to different data (Williams 2011).

Some researchers describe building a large tree and then employing 'pruning' techniques to the structure (Lemon *et al.* 2003, Fan *et al.* 2006, Williams 2011, Chang *et al.* 2012). Several investigators advocate a three-staged procedure: (1) Growing a large tree; (2) Pruning back the tree; and (3) Selecting the best-sized tree (Lemon *et al.* 2003, Fan *et al.* 2006, Williams 2011, Chang *et al.* 2012). The process of adjustment by the researcher ensures that important relationships between predictor variables and the target variable are not missed by growing too small a tree. Researcher involvement in the model built in the final tree

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is ideal as they are able to observe variables important to the process, but pruned to increase generalizability of the final model. The point at which to prune trees becomes visually evident and the researcher will see at which point the trees become overgrown and erratic. If they are not replicated past a certain point, they are stopped to maintain usefulness of the tree model. Any researcher bias is avoided in the selection process because future analysis would demonstrate a tree without any predictive ability on other data or a tree so overcomplicated, it would be of no use applied to other data and would fail the validation procedure.

To ensure that maximum tree interpretability is accompanied by utility, several other restrictions or stopping criteria are imposed on CaRT construction (Hess *et al.* 1999, Williams 2011). The stopping criteria are set by the researcher after repeated testing to balance the needs for accuracy of the model with simplicity. These include setting the maximum tree depth, minimum number of cases in terminal nodes, minimum number of cases in child nodes and splitting criteria level, which is set not be higher than a certain threshold (Rokach & Maimon 2007). These are used to control how large a tree is grown and determine the minimal degree of statistical difference between groups considered meaningful (Lemon *et al.* 2003). Deviance in CaRT models increases if there are too many nodes (Crawley 2007). Important outcomes from the CaRT modelling process are the rules associated with membership to each terminal node data class. All of these rules and settings help determine the components of the model and the final shape of the tree.

Components of the classification and regression tree

At the top of the multilevel inverted tree is the 'root' (Figure 3). This is often labelled 'node 1' and is generally

known as the 'parent node' because it contains the entire set of observations to be analysed (Williams 2011). The parent node then splits into 'child nodes' that are as pure as possible to the dependent variable (Crichton *et al.* 1997). If the predictor variable is categorical, then the algorithm will apply either 'yes' or 'no' ('if then') responses. If the predictor variable is continuous, the split will be determined by an algorithm-derived separation point (Crichton *et al.* 1997). These splits are sometimes called 'edges' (Rokach & Maimon 2007) or 'branches' (Williams 2011). The branches bifurcate into non-terminal (interior) or child nodes if they have not reached a homogenous outcome or selected stopping point. The ultimate aim of CaRT analysis is to reach terminal nodes within-node variance statistics. These are also known as 'leaf' nodes (Williams 2011) and occur when no new information will be gained through further splitting. Every node in the tree represents a distinct, homogenous data class enabling exploration. All of the nodes are numbered. These are used to illuminate associations otherwise indiscernible by conventional statistical inference and are specific to each portioned variable.

Criticisms of classification and regression tree methodology

An important criticism aimed at CaRT analysis is its inherent instability (Rokach & Maimon 2007, Protopopoff *et al.* 2009, Su *et al.* 2011). Small changes in data can alter a tree's appearance drastically and thereby alter the interpretation of the tree if not managed with caution. This is because, if a split changes, all splits subsequent to the affected node are changed as well. Each optimal partition depends on the path already taken through the tree (Crichton *et al.* 1997). Rokach and Maimon (2007) describe this oversensitivity in classification and regression trees as a

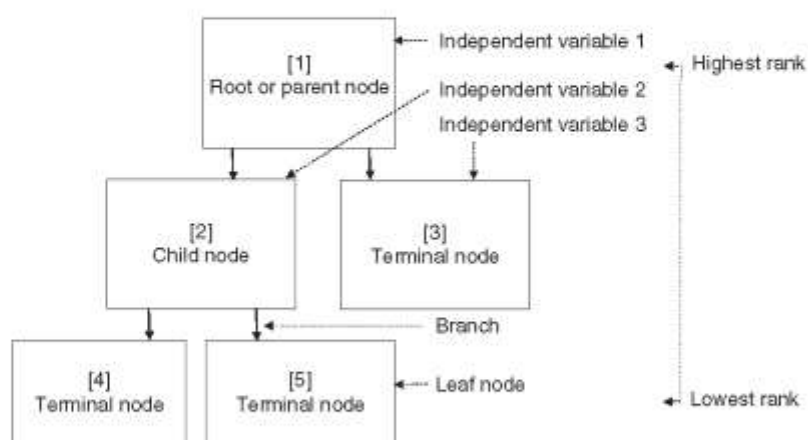


Figure 3 Generic illustration of a regression tree indicating relationship of child and terminal nodes to the root node with branches and level of hierarchy.

'greedy characteristic' (p. 75) and caution against irrelevant attributes and noise affecting training data sets. Crawley (2007) cites 'over-elaboration' as a problem with the trees because of their ability to respond to random features in data (p. 690). For this reason, the process of CaRT tree building is not as fast as it appears on the computer-generated outputs. Although the time taken to compute the algorithm for thousands of observations cited below the tree may be less than a second, it is a thoughtfully planned and executed process conducted by the researcher with numerous models developed through a process of comparison, adjustment and repetition. When the researcher has reached the point where the variables selected for splitting by the algorithm are reasonably consistent and spurious ones have been removed, a process of validation is undertaken to determine the final model.

CaRT methodology could be criticized because it does not provide a statistical output such as a confidence interval by which to quantify or support the validity of the findings. This lack of statistical assumption has been seen to be one of the method's strengths and also its weaknesses (Breiman *et al.* 1984). Decision-making is algorithmic rather than statistical; there are no distributions, likelihood ratios or design matrices common in traditional statistical modelling methods (Lemon *et al.* 2003). Few statistical inference procedures are available to the researcher seeking validation of the method (Crichton *et al.* 1997), which may be a source of stress for researchers hoping to quantify findings in these ways.

For this reason, and because CaRT analysis is relatively new to nursing research, we have sought to temper this discussion with a sample of the validation methodologies described by various healthcare researchers. Validation in CaRT methodology can involve partitioning out and withholding data from larger data sets or testing small subsets of smaller data sets multiple times. Ideally, a CaRT model will be validated on independent data before it can be deemed generalizable.

Validation in classification and regression tree analysis

In their CaRT survival analysis of 1000 consecutive patients with carcinoma of unknown primary origin, Hess *et al.* (1999) outlined important findings using their model, which they built using three different trees for estimating length of survival in months emanating from different root nodes for each of the trees. They used variables identified previously as prognostically significant (liver involvement, histology and lymph node involvement) as their root nodes in separate analyses and followed the algorithm-derived splits through to the terminal nodes for each. They then

compared the attributes of each tree built and found that, although similar variables remained important, new prognostic groups and covariate structures were also identified. The researchers argued that the fact that the different approaches used similar variables to stratify patient survival confirmed the importance of these variables and supported the validity of their CaRT analysis. Hess *et al.* also noted that the variables found to be important using the CaRT methodology were concordant with those they had identified in previous research using the Cox univariate and multivariate techniques to stratify patients into survival groups. The previous findings were more generic and reportedly difficult to implement into clinical practice, hence Hess *et al.* believed that the new structures and prognostic groups would be useful. When describing the shortcomings of their CaRT analysis, the researchers pointed out that their model could not be accepted without validation performed on an independent data set (Hess *et al.* 1999).

The most commonly used validation technique for CaRT method in medical research is to train the computer algorithm with a subset of the data and then validate it on another. Models may be validated internally or externally.

In a departure from this, Chang *et al.* (2012) used a 50:50 split for their survival analysis of patients with adenocarcinoma ($n = 10,494$). They randomly assigned 50% of their sample to a software training sample for regression tree model building and the other half became the test sample by which to build the model. Chang *et al.* described several other statistical techniques such as Kaplan Meier plot and log-rank test to compare survival differences amongst the groups identified in their regression tree analysis and found good discriminating capability for survival. Validation in this case was largely dependent on other statistical techniques and not on an independent set of observations.

Other researchers describe using a 10-fold cross-validation methodology for their medical research (Fan *et al.* 2006, Frisman *et al.* 2008, Protopopoff *et al.* 2009, Sayyad *et al.* 2011), thus also avoiding the use of an independent data set. For these studies, usually conducted with smaller sample sizes, rather than lose a portion of the sample to training and testing, randomly selected samples of the same data set were retested several times to observe for consistency of the tree models. Sayyad *et al.* (2011), for instance, performed cross-validation with 10 randomly selected subsets (called 'sample folds'), providing a measure of the final tree's predictive accuracy for risk of progression of diabetic nephropathy. This type of validation technique is open to criticism for not testing the model on observations quarantined from the model during its development.

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The methodology for CaRT validation described by Williams (2011) is likely to provide a more robust option for validation, but is best suited to application to moderate-to-large data sets. The R program readily lends itself to this three-way testing procedure.

Williams (2011) describes models built using three entirely separate, randomly selected subsets of the whole sample in R. Rpart provides an automatic partition function the researcher can easily select out of or change. The default partition is set at 70/15/15 of the total sample. Another common separation is 40/30/30 (Williams 2011), which provides more balanced proportions among the three samples. Random selection in the program provides three representative samples of the data, independent of researcher influence. The final decision of the partition ratio configuration rests with the researcher, who will seek to build the most stable tree model. In a recent study using regression tree analysis to determine factors influencing treatment onset times for patients with myocardial infarctions arriving at hospitals, the authors used 35/35/30 per cent divisions to enable more balanced proportions for tree development (Kuhn *et al.* 2013). As CaRT methods are novel in nursing research, the researchers chose to undertake their own randomized selection using Microsoft Excel (2010). This enabled reader comparison of sample characteristics across the three validation subsets with each other and with the whole data set (Kuhn *et al.* 2013).

The first randomly selected partitioned subset is the training data set, which is used to provide an estimate of the model's unbiased performance (Williams 2011). The observations used in this first data set are used for algorithm training, rather than model building, and remain segregated. The second data set is called the validation data set and is used to test various iterations to fine-tune the model (Williams 2011). Labelling this set 'validation' may lead to some confusion, however, as it does not provide a means of evaluating the performance of the derived model (Williams 2011). Williams says that this can also be called a 'design dataset' (p. 60) because it is manipulated by the researcher to design the model, which is less confusing. Model parameters such as the minimum observations in node size, complexity parameter and number of variables or nodes will be adjusted to improve performance of the developing model in this second data set (Williams 2011). This is a critical part of the researcher's role and tends to be developed slowly through an iterative process. The final portion of the original sample, the testing data set, is also called the 'hold-out' or 'out-of-sample' data set (Williams 2011, p. 60). This third data set will have been randomly selected and holds no observations previously used in the other two data sets.

It provides an 'unbiased estimate of the true performance of the model on new, previously unseen observations' (Williams 2011, p. 60). This provides the CaRT method with a technique for internal validation.

Whilst some researchers have used a variety of techniques that have continued to incorporate sample data used to develop as well as test the model, validation of CaRT analysis is ideally performed using an independent, external data set (Blumenstein 2005). In his editorial, Blumenstein (2005) says that it is still internal validation unless the trees are tested on data collected from other settings. External validation is not always possible, however, and CaRT researchers argue that their tree analyses are exploratory and need to be further tested in larger, prospective trials at any rate (Hess *et al.* 1999). They use trees derived by internal validation to make known previously undescribed associations between variables to enable further, targeted research. Discovering these new, otherwise indistinguishable relationships amongst data is their intention.

Implications for nursing

The aim of this paper was to provide a non-technical introduction and methodological overview of CaRT analysis to enable the method's effectual uptake into nursing research.

CaRT analysis is a useful means of identifying previously unknown patterns amongst data. Complex interactions are elucidated clearly between covariates and the variable of interest in an easy-to-understand tree diagram. Without researcher bias in selection of predictor variables, the CaRT analysis creates subgroups by testing all possible variable splits and illustrates previously unseen interplay amongst variables, enabling the researcher to hypothesize and further test the variables against each other in an informed way. Through careful application of algorithms at each step, the computer algorithms examine for patterns and disparities between all variables. The process is not necessarily an easy or fast one applied by the researcher. As with many other methods of database analyses, it can be tedious, with many attempts and adjustments made to select the right stopping rules and the best tree size to provide the most predictive model, without showing every observation in a leaf or terminal node.

Despite the encumbrances in uncovering the relationships between variables, CaRT offers meaningful insight into interactions between variables, which are not revealed by linear, traditional quantitative research because such research methods seek to observe global patterns amongst data. If research is restricted to these global paradigms, meaningful

interactions between separate variables, and therefore reasons things occur the way they do, may not manifest.

An increasing number of large databases are becoming available in what has been popularly labelled 'big data' (Mayer-Schönberger & Cukier 2013) and more of these are likely to be linked, dramatically increasing their usefulness in research in the future. As yet, there are few effective methodological approaches available for nurses and other health researchers to meaningfully engage with the exponentially increasing volumes of available data. CaRT has a potentially valuable role as part of mixed method research as it highlights potential relationships, which can be investigated either quantitatively or qualitatively. For example, outcomes in health systems can be analysed, risk models developed and those factors influencing poorer outcomes may be identified and rectified.

Whilst there are several reasons to embrace this method as a means of exploratory research, it is not the panacea for all types of model development. Like all database research, issues related to institutional Research Ethics Committee approval, as well as access to, and quality of, data collected and the feasibility and usefulness of the outcome, need to be considered.

Conclusion

Classification and regression tree analysis presents an exciting opportunity for nursing and other healthcare research. The approach is an easily interpreted, computationally driven and practicable method for modelling interactions between health-related variables, the significance of which would otherwise remain concealed. The importance of this cannot be overstated, as frequently, in healthcare research, there are unidentified factors influencing patient outcomes. The opportunity to identify and test the relevance of these factors is the beauty of this method. Independent of researcher preconceptions regarding fit between variables, knowledge is presented in a way that removes the need for prohibitive statistical procedures or mathematics, to provide insightful understanding of complex and hierarchical relationships.

Classification and regression tree analysis is a quantitative research tool, which has previously received little attention from nurse researchers, but is likely to become a common method for exploring large data sets in the push to integrate evidence in nursing practice in the future. Due to the ability, rapidly, to discern patterns amongst variables, CaRT will become a valuable means by which to guide nurses to reduce gaps in the application of evidence to practice. With the ever-expanding availability of data at our fingertips, it

is important that nurses understand the utility and limitations of this research method.

Future nursing research should engage CaRT for its exploratory and explanatory value when access to large data sets is available to evaluate what is working for patients across healthcare systems in terms of processes and equity of care, enabling nurses to advocate, educate and rectify any clinical management gaps through refining models of contemporary care.

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Author contributions

All authors have agreed on the final version and meet at least one of the following criteria [recommended by the ICMJE (http://www.icmje.org/ethical_1author.html)]:

- substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data;
- drafting the article or revising it critically for important intellectual content.

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4.3 Publication – research paper

ii. Risk factors for delayed treatment onset for AMI in the ED

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RESEARCH PAPER

Factors associated with delayed treatment onset for acute myocardial infarction in Victorian emergency departments: A regression tree analysis



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Summary

Background: Minimising time to treatment onset for acute myocardial infarction (AMI) in the emergency department (ED) is essential, yet little is understood about the interactions between variables affecting it. The aim of this study was to develop a regression tree model explicating the influence of patient and non-patient factors on the time taken to commence treatment for patients with AMI in Victorian EDs.

Methods: A regression tree model for variables impacting time to treatment was developed on retrospective data for patients aged 18–85 years with AMI treated in Victorian EDs from 2005 to 2010 ($n = 21,080$). Data were partitioned into three subsets, with a complexity parameter set at 0.0005.

Results: Four variables emerged in the final regression tree model; triage score; mode of arrival; area of residence; and patient sex. The variable most influencing time to treatment onset for AMI was triage category. For undertriaged patients, treatment time patterns were affected by

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arrival mode, residential location and their sex, significantly extending delays to treatment onset. **Conclusions:** Interactions between specific variables influenced whether patients with AMI were treated with equity in Victorian EDs, resulting in previously unidentified evidence–practice gaps and an improved understanding of which patient groups were vulnerable to delayed treatment for AMI.

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What is known?

Patients with AMI should be assessed and managed rapidly to enable maximal coronary reperfusion and minimise myocardial damage. Triage decisions should be based on clinical indications and not patient demographic or other non-clinical factors.

What this paper adds?

Our study explores equity of care onset for AMI in Victorian EDs over a 5 year timeframe. It demonstrates time to treatment onset is unduly affected by a number of variables in Victorian public hospital EDs. Non-clinical influences on utilisation of evidence based therapies can be minimised now that these factors have been explicated and relationships between them defined.

Introduction

Coronary heart disease (CHD) is Australia's leading killer of women and men.¹ Acute myocardial infarction (AMI) is one of the most frequent and time-critical of the CHDs managed in emergency departments (EDs). Damage from AMI is amenable to treatment and clinical outcomes can be further improved by closing current gaps between evidence and practice.²

A dictum commonly used in relation to management of AMI is "time is muscle"³ emphasising the importance of reducing delays to treatment onset. System delay has been described as the only risk factor that can be modified in the acute phase of AMI treatment.^{4,5} It has been suggested if coronary reperfusion is achieved in the first 1–2 h after AMI onset, the death rate could be halved.⁶ According to Australian⁷ and USA⁸ AMI management guidelines, revascularisation is ideally administered in less than 90 min of onset for many AMIs, particularly the ST-segment elevation myocardial infarctions (STEMIs). Researchers have shown even greater gains if door-to-treatment times are reduced further, particularly for the STEMIs.^{9,10}

As the gateway to EDs in Australia is via the triage process, it is likely triage is integral to the process of timeliness to treatment of AMI. The Australasian Triage Scale (ATS) is the five-point scoring system used in Australasian EDs by which nurses, who have received specialist education and training in emergency care and the triage role, establish a chief complaint and designate clinical urgency according to their answer to the following question: "This patient should wait for medical assessment and treatment no longer than...".^{11(p13)}

Triage decision-making is recognised to be a complex and dynamic process,¹² with most patients arriving

for assessment without differential or provisional diagnoses. Numerous patients may present for triage assessment simultaneously.¹¹ Important decisions are made "in the context of significant time constraints, crowded waiting rooms, and high patient anxiety".^{13(p396)} Triage nurses rely on what they find during objective and subjective assessments, and come to decisions partly based on pattern recognition¹⁴ in the context of the systems within in which they are working.

Whilst the role of triage is a difficult one, its evaluation is important because patient outcomes¹⁵ and measurement of resource consumption¹¹ are contingent upon it. Decisions are evaluated according to three commonly used outcomes; "expected" or "correct"; "overtriage"; and "undertriage".^{12,15,16} These outcomes are determined by whether or not patients are allocated a triage score at, above or below their true level of urgency, as determined by objective clinical and physiological indicators.¹²

Expected or correct triage^{16,17} for patients with suspected AMI in Australian EDs is normally Australasian Triage Score Category 2 (hereafter, ATS 2) according to the ATS objective clinical and physiological indicators.^{11,18} Category descriptors for ATS 2 include evaluation of conditions to be; imminently life threatening or important time-critical treatment or very severe pain.^{11,18} Clinical descriptors include chest pain of likely cardiac origin.^{11,18} Allocation of ATS 2 confers the expectation patients will be managed by a doctor or nurse within 10-min of arrival at the ED.¹² It denotes a high level of clinical urgency due to the time-sensitive nature of AMI, the pain often involved and potential for death. Patients found to be physiologically compromised during primary survey are correctly allocated ATS 1 for immediate treatment. The difficulty for triage nurses is that patients with AMI may not present with any of these descriptors and if AMI is not suspected because of unanticipated patterns of symptoms or for any other reason, affected patients may not be allocated ATS 2.

AMI is a diagnosis and not usually a presenting complaint at triage assessment, making the evaluation of triage decisions problematic. It is therefore, only after diagnosis is assigned and not usually at the time of decision-making at triage that it is obvious these patients fit into ATS 2 based on the described descriptors. Without the benefit of observing presenting complaints individually, it is difficult to judge an individual nurse's triage decision to be incorrect. Instead, we are able to retrospectively assess that as an aggregated group, patients with AMI best fit the descriptors for ATS 2 and are therefore, "undertriaged" if given a lower acuity score than this. Those patients with AMI given ATS 3, 4 or 5 are designated in the current study to be "undertriaged" as a group. Undertriaged patients are at increased risk of mortality because of the delayed onset of their management.¹⁷

Evidence based therapies for AMI are intended to be implemented according to clinical need, but decisions regarding their administration may be subject to non-clinical

influences both because of the system, as well as triage nurses' decisions. Such non-clinical influences can be difficult to identify and may lead to disparities in treatment amongst patients. Little research has been conducted examining the factors that may influence time to treatment for AMI from the time patients arrive at the ED.

Due to the lack of evidence in the ED environment, we have explored research literature from other acute hospital areas. A number of clinical and non-clinical factors have been reported to negatively impact upon treatment decisions and reduce the application of evidence based treatments for numerous patient groups with AMI. These include disparities related to race and ethnicity,¹⁹ distance to catheter laboratories,²⁰ patient sex and gender,^{21,22} age,^{23,24} urban or non-urban patient address²⁵ and sociodemographic factors generally.²⁶

We believe it is possible many of these variables also affect decisions regarding management for patients with AMI in the ED. It has recently been identified that patient sex influences time to treatment onset for AMI,²⁷ but it is likely a number of complex, non-linear interactions amongst patient variables, in addition to sex, influence treatment commencement and result in inequitable distribution of timely interventions for patients experiencing AMI. If better understood, these may be amenable to improvement and patients may be treated with increased equity. A key question in the Australian Government's National Health Performance Committee's framework in relation to Health System Performance is: 'Is it the same for everyone?'²⁸ We have undertaken to answer this of the Victorian triage system for patients with AMI. The aim of this study was to explore the influence of demographic and clinical variables on the time taken to commence treatment for patients with AMI in public Victorian EDs.

Materials and methods

We performed a retrospective analysis on non-identifiable Victorian Emergency Minimum Dataset (VEMD) data collected by the State Government of Victoria Department of Health (DoH) on all patient presentations classified as 'alive on arrival' with a principal ED diagnosis of AMI from July 1st 2005 to June 30th 2010 ($n = 21,080$). Patients were aged from 18 to 85 years and included all of those who presented to all 34 non-specialist Victorian public hospital EDs. Private hospital EDs were excluded due to incomplete data reporting to DoH over part of the investigated period.

Descriptive statistics, including number and percentage of patient deaths, mean age and treatment times with standard deviations were calculated using SPSS Statistics Version 18.0 (SPSS Inc, an IBM Company, Chicago, IL, USA) frequency and descriptive tables.

The 18 metropolitan and 16 regional hospitals were defined according to State Government Department of Human Services regional and metropolitan boundaries based on the Australian Standard Geographical Classification 2005.^{29,30} We converted local government area (LGA) data for patient residence to numerical data based on Socio-Economic Indexes for Areas (SEIFA) for Victoria, from 1 (lowest socioeconomic status) to 80 (highest socioeconomic

status) to test for sociodemographic influence in treatment onset times for AMI.³¹

The VEMD dataset provides information on all patients' exit diagnoses from EDs, which are coded according to the International Classification of Diseases, 10th Revision Australian Modification. We used data for AMI, coded as *Acute Myocardial Infarction, Unspecified* (I21.9). It was not possible to differentiate according to international acute coronary syndrome nomenclature for AMI; STEMI and NSTEMI using the VEMD dataset.

Time to treatment onset was the dependent variable. It was a continuous variable, recorded in minutes and was defined according to Australian Institute of Health and Welfare (AIHW) as elapsed time between patient presentation in the ED and time to commencement of the ED non-admitted clinical care.³² Commencement time was used as a proxy measure of time to treatment onset. Times to electrocardiography, other tests and treatments were not available. Apart from patient age (18–84 years, inclusive), which was initially analysed as a continuous measurement, all other variables were categorical: triage was trinominal to enable separate analyses for ATS 1 and 2 as correct for AMI, and ATS 3–5 were grouped as undertriaged for AMI; and all other categories were analysed as binomial data.

Statistical analysis for regression tree modelling was undertaken using classification and regression tree (CaRT) methodology³³ with the R statistical package.³⁴ A chronological summary of the methodological process is provided in Table 1. A CaRT model was used to explore the influence of specified independent variables on the time taken to treat patients from arrival with AMI in Victorian EDs. Because the target variable (time to treatment onset) was continuous, rpart with Rattle (Version 2.6.17, Togaware, 2012), was used to investigate relationships of a large number of possible independent variables on commencement time to determine which factors have the greatest influence on it.²⁷

Rpart was applied to non-identifiable patient presentation data extracted from the VEMD for all patients with AMI over these five years. Independent variables were identified using an iterative approach. A series of 'test' trees were built by recursive partitioning and a model developed based on recurring clinical and demographic variables.

The number of splits in a model defines the model's level of complexity and is controlled by the complexity parameter,³⁵ which was set at 0.0005 after appraising trees at several different complexity levels and deciding that no real information gain was achieved with greater levels of complexity. Any less than the 0.0005 threshold resulted in unstable, large trees with no perceivable new knowledge uncovered.

We used the 'information gain' measure³⁵ internal to the programme to decide between alternative splits.

The minimum number of observations that could be in a split (child or terminal) node was set at 20 and the maximum depth at four levels of splits, hence, controlling the tree size. The minimum split result that could be accepted in a new node was 10.

Variables that did not recur during this process or made the trees too complicated and nonsensical were either redefined and retested or withdrawn from the final model's development during the early 'pruning' process.³⁶ Patient age as a continuous variable was removed from

Table 1 Summary of major stages of the current regression tree model development process.**1. Data preparation**

Presentation data for all patients meeting inclusion criteria with AMI from Victorian public hospitals extracted from VEMD and cleaned to create full AMI dataset ($n = 21,080$) String variables recoded to numeric and where possible, changed to binomial (trinomial for triage score) variables using SPSS (V 18.0) for regression tree analysis

2. Data description, variable selection and testing

Descriptive statistics were completed for full AMI dataset with SPSS

The dataset was converted to comma separated values

(CSV) format for transfer into R (2010) for analysis using downloaded rpart and Rattle packages (2012)

The default partition in rpart (70/15/15) was accepted for testing with a random seed selected to ensure repeatability of results when retesting trees with different variables or researcher-set parameters (such as minimal number of observations in nodes which can be divided) Time to treatment onset (minutes) was designated the dependent variable

All other numeric variables were tested in rpart and Rattle for prominence and recurrence at various complexity parameters. Variables unheralded through repeated testing were withdrawn or redefined and retested if they appeared during testing, but were inconsistent or made the regression trees too complicated and uninterpretable After removal of variables that failed to recur, remaining variables were retested and resulted in similar shaped trees with common variables repeatedly selected by rpart and Rattle at different complexity parameter levels

3. Developing the final tree for interpretation

To enable visual inspection and comparison of the characteristics of partitioned subsets in a table (Table 2), data were moved to and randomised in Microsoft Excel (2010)

The complete AMI dataset was randomly partitioned into three subsets (35/35/30) to enable regression tree analysis validation of three groups of similar sizes without contamination from cross-over between groups and review of each sample. These became the training, validation and holdout (final) samples for regression tree building, integral to the validation process

Descriptive statistics were completed for all subsets (Table 2) in SPSS

Data were moved back into R separately from each of the three subsets via CSV. Three separate trees were built with all variables identified as important in Stage 2 included for possible selection by statistical algorithm in rpart and Rattle

Regression trees developed were consistent in order of variable selection and stable in their shape. Only one variable, most distal to the top of the trees exhibited any variation in selection by the rpart algorithm (Fig. 1, Nodes 30 and 31)

The results are illustrated in Fig. 1 and explored in the "Results" and "Discussion" sections

analysis at this point. It was recoded and analysed in five-year groupings, but again failed to appear in branch or terminal nodes during testing. The variable was then split at 51 years, the average age for women experiencing menopause in Australia³⁷ in recognition that post-menopausal women experience higher incidence rates of AMI.³⁸ SEIFA was another problematic variable within the trees and tended to make them overcomplicated and unstable. This was rectified by swapping SEIFA for the metropolitan versus regional binomial variable, which was felt to be reasonable because SEIFA's delineation into ranks incorporates the metropolitan/non-metropolitan variable into the calculation.³⁹

Validation

The method of validation we applied has recently been described in a methodological review of regression tree analysis in nursing research.²⁷ Briefly, we used three sub-samples, as outlined by Williams,³⁵ which suited analysis of a dataset this size. The first set was the *training dataset* which provided an estimate of the model's performance. The second set was called the *validation dataset* and was used to further fine-tune the model. The third and final sub-set was called the *holdout* or *out-of-sample dataset* and provided "an unbiased estimate of the true performance of the model".^{35(p60)} The default partition in rpart is set at 70/15/15 proportions of the whole sample.³⁵ This can be altered to test different proportions or deselected if wanting to develop a model on the whole dataset, which may be necessary when using smaller samples. If it is decided the dataset needs to be split for validation, the preferred partition proportions are selected and rpart undertakes random selection internally to ensure the same observations are not included in the different subsets. All randomised observations remain segregated in three separate groups to avoid introducing bias across subsets. The decision to select a seed number for randomisation is made by the researcher. To ensure results were repeatable, we set a random seed of 42 and reset it to this each time we ran rpart on testing samples.

When we reached the stage for development of the final regression tree, we made two adjustments to the model-building process described for preliminary testing to maximise the interpretability and clinical usefulness of the model. First, we wanted to display the demographic characteristics of each of the subsets in a table next to each other so we could visually inspect and compare the subsets with the whole dataset for patients with AMI and each other (Table 2). To do this, we randomised the data using Microsoft Excel (2010). Second, we chose to randomly assign the dataset into three subsets roughly equating to 35/35/30 percent divisions, believing that a maximum 5%point difference in proportions provided well-balanced and suitably large dataset sizes to enable each of the three models to develop. The sample size in each varied slightly from the absolute percentage due to random selection (Table 2).

Ethics approval

This paper reports the findings of a research study that conformed to the National Statement on the Conduct of

Table 2 Demographic characteristics for all patient presentations and randomised subsets with AMI.

Variable	Whole dataset Total (%)	Training dataset Total (%)	Validation dataset Total (%)	Holdout dataset Total (%)
Patient sex, male	14,442 (68.5)	5062 (67.8)	5025 (68.5)	4355 (69.3)
Patient sex, female	6638 (31.5)	2400 (32.2)	2309 (31.5)	1929 (30.7)
Age < 52	3785 (18.0)	1379 (18.5)	1297 (17.7)	1109 (17.6)
Age ≥ 52	17,295 (82.0)	6083 (81.5)	6037 (82.3)	5175 (82.4)
ATS 1	1250 (5.9)	439 (5.9)	453 (6.2)	358 (5.7)
ATS 2	12,161 (57.7)	4317 (57.9)	4219 (57.5)	3625 (57.7)
ATS 3–5	7669 (36.4)	2706 (36.3)	2662 (36.3)	2301 (36.6)
Metropolitan	14,168 (67.2)	5004 (67.1)	4931 (67.2)	4233 (67.4)
Regional	6912 (32.8)	2458 (32.9)	2403 (32.8)	2051 (9.7)
Arrival by ambulance	13,371 (63.4)	4690 (62.9)	4638 (63.2)	4043 (64.3)
Arrival by other	7709 (36.6)	2772 (37.1)	2696 (36.8)	2238 (35.6)
English-speaking	19,104 (90.6)	6754 (90.5)	6651 (90.7)	5699 (90.7)
NES preferred	1976 (9.4)	706 (9.5)	683 (9.3)	584 (9.3)
Indigenous status; yes	125 (0.6)	54 (0.7)	42 (0.6)	29 (0.5)
Death	145 (0.7)	44 (0.6)	53 (0.7)	48 (0.8)
Variable	Whole dataset Mean [SD]	Training dataset Mean [SD]	Validation dataset Mean [SD]	Holdout dataset Mean [SD]
Age in yrs, all	64.77 [13.13]	64.66 [13.19]	64.77 [13.1]	64.9 [13.1]
Age in yrs, male	62.84 [13.07]	62.78 yrs [13.16]	62.79 [13.01]	62.96 yrs [13.03]
Age in yrs, female	68.97 [12.25]	68.62 yrs [12.36]	69.06 [12.22]	69.30 yrs [12.13]
Treatment time min, all	12.75 [27.71]	13.37 [30.29]	12.58 [26.51]	12.22 [25.81]
Treatment time mins, male	11.76 [25.71]	12.25 [27.42]	11.70 [25.02]	11.26 [24.41]
Treatment time mins, female	14.91 [31.53]	15.73 [35.48]	14.49 [29.41]	14.38 [28.63]
Total	21,080 (100)	7462 (35)	7334 (35)	6284 (30)

AMI, acute myocardial infarction; ATS, Australasian Triage Scale; mins, minutes; NES, non-English speaking; pts, patients; SD, standard deviation; and yrs, years of age at presentation.

Human Research by the Australian National Health and Medical Research Council. The Australian Catholic University Human Research Ethics Committee approved the study (HREC V2009 83). The Victorian Department of Human Services "Conditions of Release of Patient Level Data Sets" were also met.

Results

Complete data were available for 21,080 patient presentations with AMI. Six independent variables were identified using these methods for inserting into R for regression tree analysis including: triage, mode of arrival (ambulance or non-ambulance), residential location (metropolitan or regional), patient sex (male or female), preferred language (English or non-English), and age (18–51 years or 52–84 years, inclusive). Prior reports have suggested inequities in healthcare related to Aboriginal and Torres Strait Islander descent,^{40,41} thus indigenous status was included as the seventh variable in the final model development, although it failed to appear as a node in earlier testing. Seven variables were included for possible selection by statistical algorithm in the final model (Table 2).

The demographic characteristics of the three subsets, as well as those of the whole sample are shown in Table 2. Patient death, age and mean treatment onset time for each

of the samples have been included for comparative purposes, including between the sexes and do not constitute components of the regression tree model.

Patient demographic characteristics were observably similar across the four groups, as were mean ages, times to treatment and proportions of deaths across the groups (Table 2). The mean age difference between men and women was approximately six years, with women presenting at EDs with AMI at a more advanced age generally. Women also waited several minutes longer overall to have their treatment commenced than their male counterparts across all samples. There were a small percentage of patients presenting to EDs who stated they were of Aboriginal or Torres Strait Islander origin (Table 2). Indigenous-identifying patients did not feature in any nodes identified by CaRT algorithm.

The final regression tree model is depicted in Fig. 1. The left side of the tree includes those patients with AMI who were allocated either ATS 1 or 2. Treatment onset time for patients on the right side of the tree was dependent on a number of consistently expressed variables, the first of which was undertriage (ATS 3, 4 or 5). The three regression tree models developed from the three subsets were remarkably similar in appearance, with only the positions in the trees occupied by Nodes 30 and 31 (English speaking or Non-English speaking preferred) changing variables intermittently between Male or Female and Age, split

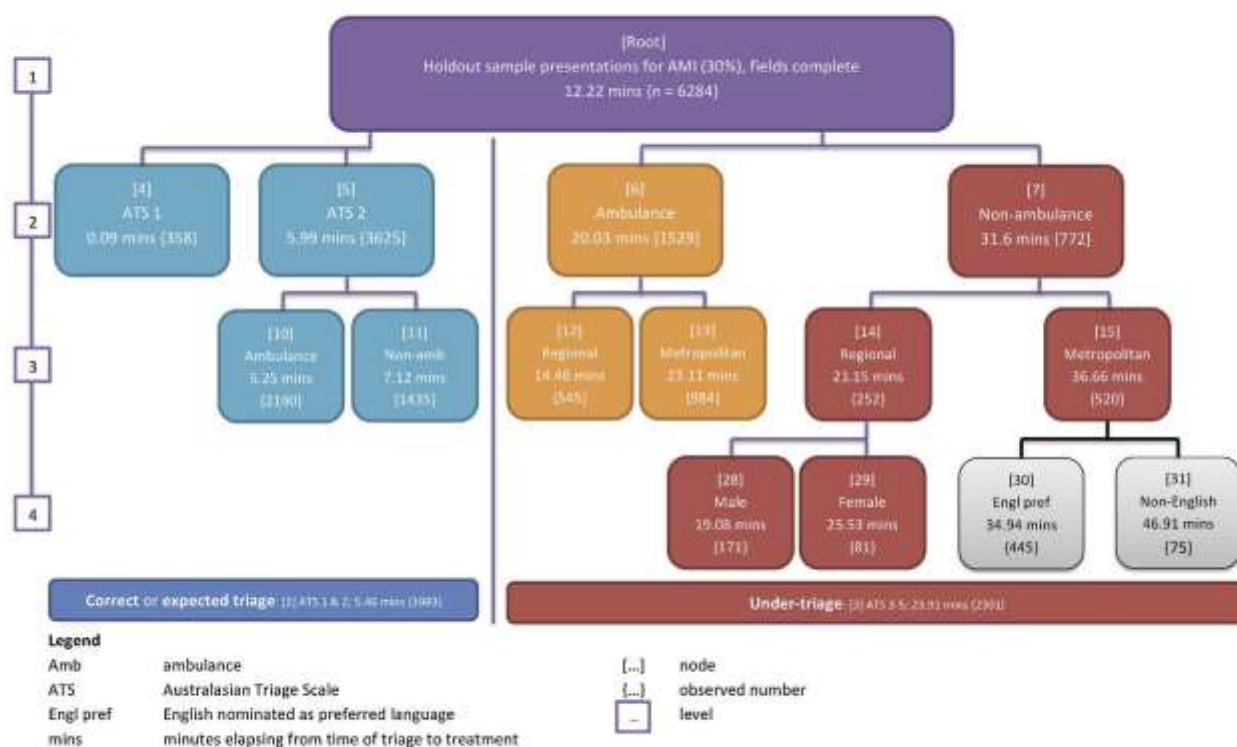


Figure 1 Regression tree for VEMD variables affecting time to treatment for holdout sample of patients presenting to Victorian EDs 2005–2010 with AMI.

before and after 51 years. The observations in each of the coloured nodes were similar in volume, as were the mean times to treatment onset in minutes for each of the variable pathways throughout the trees. Some variation in the outcomes in regression tree analysis is expected,⁴² but the conformity between the nodes and pathways demonstrated throughout the various regression trees implies development of a good model. Only the final (holdout) tree model developed with the benefit of the training and validation datasets is presented here (Fig. 1). The grey nodes denote the variable found to be the least stable. It might be reasonable to prune these nodes from the model and avoid mentioning the interchange of patient sex and age in their place however we found their occurrence so common in the multiple test trees, we believe they warrant a place in our discussion.

The greatest impact upon time to treatment was the triage category to which patients were assigned. When the triage nurse allocated ATS 1 or 2, the patients with AMI experienced minimum delays and were *seen on time*, which is defined as when clinical care is commenced within the time specified in the definition of triage category.³² When patients were assigned ATS 3, 4 or 5, treatment time onset for AMI depended upon a series of demographic factors within their profiles. The most influential variable affecting treatment time onset after allocation of ATS Category was arrival by ambulance. Patients were seen faster on average if they arrived by ambulance than if they did not, which usually meant they arrived by private car, walked, came with police or via public transport. This was the case for patients

allocated ATS 2, as well as those undertriaged (ATS 3–5). Patients who were assigned ATS 2 and presented by ambulance were still seen in less than the expected 10 min on average.

For those patients who did not arrive by ambulance and were undertriaged, treatment onset times depended upon whether they were from regional or metropolitan LGAs. Patients from non-metropolitan areas had faster time to treatment onset than those from metropolitan areas, and men were seen faster than women from this group by more than 5 min in the final model (Fig. 1). Women waited longer than men for treatment onset for AMI if they were undertriaged, did not arrive by ambulance and lived in a regional area.

There was a difference in treatment onset time observed in a number of regression trees, including the final model for the subset of patients who were undertriaged, did not arrive by ambulance and were from metropolitan LGAs, according to their preferred language status (Fig. 1). Patients of either sex fitting this profile waited around 35 min for treatment to be started if they preferred to speak English. For those who did not prefer (or were unable) to speak English, there was a time difference of approximately 12 min to treatment onset. These patients experienced the longest waits for treatment of AMI.

Discussion

We undertook this study to characterise the time to treatment onset patterns for 18–85 year old patients with AMI

with a variety of demographic features from Victorian public hospital EDs over a period of 5 years. In answering this, we have gained insight into where there are disparities in the triage system for AMI and which factors impede patient access to equitable, early care. We have identified combinations of demographic factors which are associated with the variations in delay. Essential to improving access to timely management for AMI for all patients is identification of factors subverting efficacy of care delivery and remedying any deficits for all patient groups, starting with the most vulnerable ones.

Presently, more than one in three Victorian patients with AMI is vulnerable to undertriage. Regression tree analysis has been used to delineate patients into groups based on demographic factors making them more or less exposed to delayed treatment onset than other groups with AMI. The vulnerability may be caused by differences in presentation patterns amongst groups, such as women or elderly patients who have been reported to exhibit atypical symptomatology more often than other groups;^{43–45} triage nurses may believe some groups are generally less likely to experience AMI and fail to suspect it;⁴⁶ or alternatively, they may realise a patient could be experiencing an AMI, but have come to the decision they would not benefit from early the implementation of evidence based therapy. Women for instance, have been shown to delay presentation to hospitals after onset of AMI considerably,⁴⁷ which may cause triage nurses to conclude their benefit from early intervention is reduced compared to other patients who have presented within the timeframe when treatment is most effective. We are not able to explicate cause here, but are able to identify which patient groups are most likely to experience delays in receiving evidence based therapy and are therefore, susceptible to poorer outcomes associated with delayed coronary reperfusion in AMI.

The regression tree model shows that after triage score allocation, not arriving by ambulance is the next most important factor inhibiting the speed of care delivery for AMI. If patients with AMI do not arrive by ambulance, treatment onset times are substantially delayed, particularly if they have been undertriaged. Approximately two-thirds of patients with AMI arrived at EDs in Victoria via ambulance throughout the study period. For those who did not, the onus was on ED triage staff and the systems within which they practiced to ensure their evaluation and treatment was at the highest possible standard and the non-ambulance arriving patients did not languish in triage queues or waiting rooms.

Patients arriving by ambulance are advantaged, not only because they are transported more safely and often with the benefit of assessment and treatment initiated en route, but because part of the process seems to procure their treatment commencement in the ED earlier than those who have arrived by other means. This is consistent with previous ED research.^{48,49}

There appears to be a pro-ambulance treatment time advantage, although it differs between regional and metropolitan areas. Patients from metropolitan and regional areas arriving by ambulance are seen faster on average than patients with AMI arriving by other means, although the difference is minimal when triaged correctly. Undertriaged patients from regional areas [Node 12], arriving at

EDs are seen on average 8 min faster than their metropolitan counterparts [Node 13], also arriving via ambulance. Undertriaged metropolitan patients who do not arrive at EDs by ambulance [Node 13] wait over 13 min longer on average for treatment to commence than do those presenting to their EDs by ambulance [Node 15], and over 15 min longer on average than their regional counterparts [Node 12]. Regional patients arriving by ambulance for AMI [Node 12] are seen 22 min faster on average than metropolitan patients who have not used ambulance transport to their treating EDs [Node 15].

Treatment onset times are delayed for metropolitan patients with AMI attending EDs compared to their regional counterparts, particularly if they are undertriaged. This is not a surprise, given the differences in volumes of patients seen between regional and metropolitan EDs,⁵⁰ but it is a positive finding for regional patients. Comparison of time differences for regional and metropolitan patients to travel to EDs after symptom onset or whether more regional patients waited for transfer to other facilities for interventional cardiac procedures is beyond the scope of this research. Likely differences in geographical distance from ED facilities and placement of most interventional cardiology centres in metropolitan areas may mean any time advantage in the treatment onset for AMI in regional EDs is negated by these factors.

Regression tree analysis also uncovered further sex-related disadvantage for regional patients who did not arrive by ambulance to EDs. Men received treatment almost 7 min faster on average [Node 28], than did women [Node 29] for AMI. This is consistent with ED research on triage for AMI, which has found women are disadvantaged at triage compared to men.⁴⁶ This has been found to be the case throughout the trajectory of hospital care where women tend to be discharged prematurely from EDs with AMI compared to men,⁷² undergo less revascularisation procedures^{22,44,51–53} and are given fewer drugs recognised to reduce risk.^{52,54}

Recent Australian research has shown patients who are undertriaged for AMI receive delayed treatment, and women are significantly more likely to be undertriaged for AMI than men.²⁷ Hence, it is taking longer to commence treatment for women with AMI overall. Other, mostly North American studies have found an association between gender and incorrect triage for AMI.^{46,55} With the exception of gender and sex however, the only other variable noted to influence ED triage decisions for AMI was found in a recent literature review to be a patient's age.¹³ In contrast to this, a recent report from research set in one large ED in the USA found no association between race, age and sex on the time it took to do the first ECG for AMI,⁵⁶ begging further investigation.

The least stable variables identified in our model were at the position of Nodes 30 and 31 in Fig. 1. These intermittently varied between English and non-English speaking preferences, age split at 51 years, and patient sex. These variables are, strictly speaking outside of the developed model, but the regularity of each variable's appearance throughout repeated testing means they cannot be totally ignored at this exploratory stage. The time to treatment onset was twice as long on average for metropolitan patients who arrived by ambulance, than those who were metropolitan patients who did not arrive by ambulance and were

non-English speaking. Patients from metropolitan areas who were undertriaged for AMI and failed to present by ambulance to EDs, who were either; non-English speaking, 52 years of age or older, and female waited an average of 45 min or longer for treatment to be commenced.

All three of the alternating variables feature prominently in literature; disparities have been reported in management of chest pain and CHD related to patient race and ethnicity, even though both race and ethnicity have been associated with greater baseline risk for CHD.^{19,57} Older patients have often been found to be undertreated, with advanced age being described as an "artificial barrier" to receiving evidence based therapy.^{24,58,59} Australian researchers have also uncovered disproportionately high mortality rates for AMI in older patients, which they claim could be improved if optimal AMI treatment were offered.⁶⁰ Patients who were both older and female have been shown to receive significantly less evidence based therapy than those not fitting this demographic profile.^{61,62} Although none of these studies were specific to triage, findings in these other large studies, supported by the findings in the current ED study invite further investigation in this area.

Analysis of this statewide dataset with regression tree methodology has enabled us to elucidate previously hidden interplay amongst variables influencing triage practice. These variables, signposted by research submitted for publication²⁷ around factors influencing assessment and treatment for AMI in Australia and internationally have now been tested and shown to impact the implementation of timely treatment for AMI in EDs in Victoria, Australia. Regression tree analysis is a relatively new method to health sciences research with few relevant examples of its use located within current nursing⁴² and medical^{63–65} scientific literature. For the current investigation in which we were able to utilise a large database, regression tree analysis has allowed us to hypothesise and further test the variables against and with each other in a guided way. It has enabled us to develop an easily interpreted display of system delay risk for AMI at ED triage. The regression tree is a model of patient risk of system delay in the ED.

Limitations

Like all database research, regression tree analysis is not without its limitations. Criticisms levelled at regression tree method include tree instability,³⁶ where small changes in data can alter the tree's appearance and therefore, its interpretation. These problems were avoided by careful adherence to recognised model growing and pruning procedures^{35,63–65} and developing the final tree structure with the three-way testing procedure described by Williams.³⁵

The data we have used were collected for administrative purposes and do not provide clinical information such as how long patients experienced symptoms before arriving at EDs, whether reported exit diagnoses constituted first AMIs or which AMIs were STEMI or NSTEMI events. It is a novel methodology within nursing research and has provided an easily interpreted exploratory approach to identifying

patterns within the dataset representing all patient presentations meeting inclusion criteria over five years.

Conclusion

Patients with AMI benefit from early application of evidence based care. Identification of evidence–practice gaps is integral to improved patient care and outcomes. This research has provided an enhanced understanding of which patient groups are vulnerable to treatment delays for AMI.

One of the most important outcomes and findings from this research is the confirmation that if triage nurses assign expected ATS 2 (or ATS 1 as required) for AMI, the system of triage in Victorian EDs is working well for affected patients. Regardless of other clinical and demographic factors, patients with AMI given expected triage scores are seen within the maximum time mandated by the ATS. The problem is that for whatever reason, a significant proportion of patients with AMI are not receiving an adequate triage score for AMI and the associated delayed treatment onset may affect cardiovascular outcomes for affected patients. Further research is necessary to determine whether this delay does in fact lead to negative clinical outcomes for these patients. Quantifying any change in mortality and other major adverse cardiac events will require linked datasets in order to follow these patients through to the conclusion of their health care.

This newly illustrated profile of risk for delayed treatment onset for AMI provides ED clinicians and educators with an understanding of patient groups who, for specific reasons, are prone to receiving suboptimal ED care for AMI. Directions for future research and remedial education and interventions to reduce inequities and minimise the evidence–practice gaps identified are possible only after this information has come to light.

Authors' contributions

L.K., L.W.C., K.P. and J.W. conceived and designed the study. L.K. conducted the literature review. L.K., K.P. and L.W.C. collected the data. L.K. and J.W. analysed the data. L.K. prepared the manuscript. L.K. and J.W. revised and edited the materials and methods section. L.K., L.W.C., K.P. revised and edited the manuscript draft in its entirety for submission. L.K., L.W.C., J.W. and K.P. approved the final manuscript. L.K. submitted the manuscript.

Human research ethics approval

Approval to conduct this research was granted by the Australian Catholic University Human Research Ethics Committee. The research was conducted in accordance with the approved protocol.

Provenance and conflicts of interest

Lisa Kuhn is a reviewer for the Australasian Emergency Nursing Journal, but had no part in the review process of this paper. There are no conflicts of interest. This paper was not commissioned.

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4.4 Summary

This chapter has included two peer-reviewed publications related to a relatively new area of research in order to: First, bring new knowledge to nursing about the scope, utility and limitations of classification and regression tree (CaRT) analysis as a means of enriching knowledge related to whole populations; and second, utilise CaRT method to uncover patterns and identify patients most at risk of delayed treatment onset for AMI, the most time-sensitive of the acute coronary syndromes.

The first paper was important because CaRT provides an accessible, easily interpreted method for making sense and finding correlations amongst large volumes of important information, which are all around us in healthcare. It is essential to systematically look at how we can collate large sets of information; patient hospital records, radiology scans and reports, pathology results, serial observations and electrocardiographs and even heart and lung sounds through digital stethoscopes are already or are about to be, digitalised and stored (Ackerman, 2012). Linkage of enormous amounts of patient data in the form of government and hospital records, life and health insurance, pharmacy prescriptions and death is now possible. In spite of concerns about privacy, each of our lives are already highly digitalised. Even access to sites on web search engines are recorded and past browsing patterns are used for future predictions of our spending and these are often passed on to other organisations for a fee. Using records of millions of computer searches during previous influenza outbreaks meant that Google was able to predict outbreaks of the deadly H1N1 virus two weeks before the US Centre for Disease Control was able to using data collected from patients treated by physicians in 2009 (Ackerman, 2012; Mayer-Schönberger & Cukier 2013), raising interest in the paradigm considerably in bureaucratic and healthcare communities.

An understanding of the potential of CaRT methodology is important for nursing. CaRT may be used on its own or as part of mixed methods research to highlight patterns and predict relationships between phenomena which can then be further investigated quantitatively or qualitatively. Nurse clinicians, administrators and academics are able to interrogate large datasets meaningful to practice, providing they know the method is available. Enabling nurses to analyse whole patient population data to uncover previously concealed patterns amongst patient, management and outcome variables, and to question processes and equities in care,

allowing them to advocate, educate and ameliorate gaps in practice or service availability through refining models of contemporary care (Kuhn et al., 2013a).

Equity in patient care is at the heart of the Australian healthcare system. Triage score allocation has been shown to effect early access to treatment for AMI in Victorian patients (Kuhn et al., 2013b). Equal accessibility to healthcare is a core value in the domain of Performance Framework (AIHW, 2012a). The Framework for an effective healthcare system stipulates: “People can obtain health care at the right place and right time irrespective of income, physical location and cultural background” (AIHW, 2012b, p. 25).

The aim of the research reported in the second published article in the current chapter was to develop a regression tree model explicating the influence of patient and non-patient factors on the time taken to commence treatment for patients with AMI measured from arrival at triage, in Victorian EDs. To do this, regression tree analysis was applied to data from all 18-85 year old patients presenting to Victorian public hospital EDs over a period of 5 years with AMI. Methodology for this research incorporated information uncovered in literature review and published in the Journal of Advanced Nursing method paper (Kuhn et al., 2013c), and the randomised partitioning of data into three separated subsets for regression tree development and analysis, as advocated by Williams (2011).

Analysis of the VEMD data with CaRT methodology was able to uncover and explicate previously unknown interactions between patient variables influencing the time it took to commence treatment for time-sensitive AMI. The final published regression tree (Kuhn et al., 2013a) illustrates specific combinations of demographic factors found to be associated with delay for treatment onset for patients with AMI. These illustrate that although the evidence-based ideal is that all patients with AMI should be treated as rapidly as possible to reduce morbidity and mortality from AMI, this is not achieved equally amongst all patients. Some patients are particularly vulnerable to delays and are therefore, possibly exposed to increased risk of these negative outcomes. The research has uncovered important biases in the system, which are likely to affect patients with certain non-clinical attributes more than others and result in disadvantage.

Accurate triage decision making is important to the timeliness of management for ACS, particularly the most critical of the AMIs, ST-segment elevation myocardial infarctions

(STEMIs). Timeliness in ACS-evaluation is important because it enables access to reperfusion therapy most likely to reduce patient morbidity and mortality. The next chapter will move away from CaRT methodology and will use descriptive statistics to analyse in-hospital data to determine if women are afforded equal access to reperfusion therapy and then, whether women in Victorian hospitals actually suffer worse outcomes in terms of mortality with STEMI than do their male counterparts.

4.5 References

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Chapter 5

Influence of patient sex on treatment and mortality for patients admitted with STEMI



Chapter 5 Research

Kuhn L, Page K, Rahman MA, Worrall-Carter L. (Under journal review). Influence of patient sex on treatment and mortality for patients admitted to Victorian hospitals with ST-segment elevation myocardial infarction: a retrospective database study. *Australian Critical Care*.

5.1 Background

The two most important factors affecting patient outcome after an ACS event are: First, the timeliness with which oxygenated blood can be returned to myocardial cells, reducing myocardial ischaemia and infarction; and the second is access to the reperfusion treatment. The previous chapter was used to further investigate factors contributing to delayed onset in implementing reperfusion therapy from the time a patient first presents to an emergency department (ED) triage nurse for assessment. Research findings presented in previous chapters have indicated women may have been more vulnerable than men to delayed treatment onset for ACS. They were not treated with the same timeliness as men for acute coronary syndrome (ACS).

In the current chapter, attention has turned to access to reperfusion treatment.

Retrospective database analyses were undertaken on data from the Victorian Admitted Episodes Dataset (VAED) to answer two questions. The first involved access to treatment:

1. Is interventional reperfusion therapy equally provided to younger and older men and women patients admitted to Victorian public hospitals with STEMI?

H_0 : Patient sex and age are not associated with interventional reperfusion therapy provided for patients admitted to Victorian public hospitals with STEMI.

Further research was then undertaken to compare patterns of inhospital mortality for younger and older men and women. A number of researchers have reported significant differences in the proportions of men and women who die inhospital with ACS (Blomkalns et al., 2005; Bugiardini et al., 2011; Gan et al., 2000; Radovanovic et al., 2007), but others argue there are no differences in mortality between the sexes when age and comorbidities that increase with age are taken into account (Berger et al., 2009; Wijnbergen et al., 2013). The second research question and accompanying null hypothesis involved patient mortality. It was:

2. Are patterns of inhospital mortality different between younger and older men and women patients admitted to Victorian public hospitals with STEMI?

H₀: Patient demographic factors of sex and age are not associated with mortality patterns for patients admitted to Victorian public hospitals with STEMI.

The questions were both important as answers to them were not found through literature review of research published in the Australian context for STEMI. As a leading killer of men and women in this country, any failure to implement reperfusion treatment for STEMI for either sex is a missed opportunity to reduce the devastating impact of the disease on the individuals affected and the greater community.

Personal cost to women with STEMI and their families is great due to the high rates of morbidity and mortality with the disease (Gulati et al., 2012). There is evidence to suggest women have significant social and psychological morbidity due to heart disease, with women reported to have more persistent lifestyle limiting symptoms (Daly et al., 2006), depression (Davidson et al., 2003; Page et al., 2010) and significantly lower satisfaction with their general health (Norekval et al., 2007).

The cost to the community in financial terms is also an important issue: A paper presented by Chew for Access Economics in Australia estimated that AMI would cost around \$15.5 billion in 2009 (Access Economics, 2009). This included direct costs including those for admission to hospital and medications (\$1.8 billion) and indirect costs due to lost productivity (\$3.8 billion). Chew found the greatest cost came from loss in the value of health, whereby, disability

impacting on individuals and premature loss of life would equal approximately \$12.3 billion (Access Economics, 2009, p. 5). Broken down to the total cost per AMI, Chew expects the average cost to be \$281,000 per event. This is known as burden of disease. The most effective way of reducing burden of disease in ACS is early access to treatment.

5.2 Manuscript (under journal review)

Influence of patient sex on treatment and mortality for patients admitted to Victorian public hospitals with ST-segment elevation myocardial infarction: a retrospective database study

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LK, KP, MAR and LWC conceived and designed the study. LK conducted the literature review. LK, KP and LWC collected the data. LK and KP analysed the data. LK prepared the manuscript. All authors revised and edited the manuscript draft prior to submission and approved the final manuscript. LK submitted the manuscript.

Abstract

Background. Death from acute coronary syndrome (ACS) is avoidable with early reperfusion therapy, however, evidence suggests inequity in women's ACS treatment within a number of international healthcare systems, when compared to men's. Research indicates mortality rates are higher in some age groups of women when compared to men for the sub-group of ACS known as ST-segment elevation myocardial infarction (STEMI).

Objective. To determine whether patient sex was associated with patterns of reperfusion treatment variation or increased in-hospital mortality in patients with STEMI.

Methods. We undertook retrospective analyses on a government database for patients admitted to Victorian public hospitals with STEMI. Patients were categorised into two age groups: 18 – 64 and 65 – 84 years (inclusive), to determine whether patient sex and these age groups influenced treatment from 2005 – 2008 and mortality from 2005 – 2010.

Results. Both younger and older women were less likely to receive angioplasty with stent and were more likely to receive no reperfusion treatment than men in corresponding younger and older age groups ($p = 0.006$ and $p < 0.001$, respectively). Overall, women in both age groups were more likely to die in-hospital than men from equivalent age groups with STEMI ($p < 0.001$, both groups).

Conclusions. Both younger and older women appeared to be less likely to receive interventional reperfusion therapy for STEMI than their male cohorts, and were more likely to die during admission than men. Further research needs to be undertaken to verify the findings and causes, and guide future research to ensure application of evidence to treatment in patients with STEMI.

Key words. Database; Equity; Gender; Mortality; Reperfusion; Retrospective; STEMI; Women

INTRODUCTION

Acute coronary syndrome (ACS) is a leading cause of morbidity and mortality worldwide, including in Australia (AIHW, 2012; White & Chew, 2008; WHO, 2011). In many developed countries, mortality rates from ACS, which include acute myocardial infarction (AMI) and unstable angina, have fallen dramatically over recent decades (ABS, 2010; WHO, 2011), but improvements have not been equitable between the sexes, with reports that women's ACS rates of death are either stabilising or increasing (Blomkalns et al., 2005; Gulati et al., 2012; Towfighi et al., 2009). Fewer women experience ACS, but depending on their age, they have higher mortality rates (Roger et al., 2012; Shaw et al., 2009; Vaccarino et al., 2001). Women are more likely to have repeat ACS events than men, which are more often fatal than those experienced by men (Deloitte Access Economics, 2011). First and subsequent ACS events are predicted to increase further in the next decade due to the ageing population (Deloitte Access Economics, 2011; Shaw et al., 2009), making investigation of ACS paramount.

ST-segment elevation myocardial infarction (STEMI) is a type of ACS acknowledged to be a cardiac emergency (Brieger & Redfern, 2013). It accounts for approximately one-quarter of all ACS events (Brieger & Redfern, 2013), and is more common in men (Gulati et al., 2012). Comprehensive management of ACS using evidence-based guidelines is critical to patient outcome. This includes re-establishing patency of occluded coronary arteries with percutaneous coronary intervention (PCI) or fibrinolytic therapy early enough to enable reperfusion of affected myocardial cells to prevent permanent myocardial damage, which is associated with high rates of morbidity and death. Access to early reperfusion therapy has been found to reduce deaths from STEMI by up to 78% (Huynh et al., 2010).

White and Chew (2008) estimated that maximising numbers of patients treated with reperfusion therapy would save a further 270 lives per 10 000 patients with STEMI (White & Chew, 2008). They made the point that although numerous novel treatment options continue to be developed, most future gains would likely come from implementing the therapies already available, properly (White & Chew, 2008).

Two important studies investigating ACS in Australia and New Zealand over the last decade were the ACACIA Registry (Chew et al., 2008; Hung et al., 2009) and SNAPSHOT ACS study (Chew et al., 2013). Through a number of reports arising from these studies, an issue

identified as of critical significance for the future reduction of morbidity and mortality from ACS was access to treatment (Chew et al., 2013; Huynh et al., 2010). Other studies have reported between 30 and 40 percent of patients did not receive reperfusion therapy to which they were eligible (Aliprandi-Costa et al., 2011; Scott, 2010), which was similar to under-treated proportions of STEMI populations reported in North America (Eagle et al., 2002) and Europe (Maas et al., 2011).

Despite the consistency in ACS guidelines across the United States' (O'Gara et al., 2013), Europe (Steg et al., 2012), and Australia and New Zealand (Aroney et al., 2006; Chew et al., 2011), knowledge translation into clinical practice is often suboptimal (Brieger & Redfern, 2013; Huynh et al., 2010; White & Chew, 2008). Recent Australian reports concur that although knowledge of recommended ACS-care is high, implementation of the guidelines is poor (Chew et al., 2013; Huynh et al., 2010). A number of international studies report figures of under-treatment related to patient sex which adversely affect women (Jneid et al., 2008; Radovanovic et al., 2007; Vaccarino et al., 2013).

Although ACS guidelines are 'gender neutral' (Blomkalns et al., 2005), there are reports of differences in ACS management related to patient sex (Jneid et al., 2008). Some overseas studies document disparities in the application of evidence-based treatment of STEMI in inpatient hospital settings due to patient sex (Jneid et al., 2008; Radovanovic et al., 2007), but we were unable to ascertain if similar differences existed in Australia. We wanted to evaluate reperfusion therapy and mortality patterns for Victorian patients over several years for STEMI, comparing treatment access and inhospital mortality between the sexes.

The current study seeks to further this discussion with inhospital patient data to answer the following research questions and null hypothesis for each:

1. Is interventional reperfusion therapy equally provided to younger and older men and women patients admitted to Victorian public hospitals with STEMI?

H₀: Patient sex and age are not associated with interventional reperfusion therapy provided for patients admitted to Victorian public hospitals with STEMI; and

2. Are patterns of in-hospital mortality different between younger and older men and women patients admitted to Victorian public hospitals with STEMI?

H_0 : Patient demographic factors of sex and age are not associated with mortality patterns for patients admitted to Victorian public hospitals with STEMI.

MATERIALS AND METHODS

Retrospective analyses of the State Government, Department of Health (DoH) Victorian Admitted Episodes Dataset (VAED) for patients aged 18 to 85 years admitted to Victorian hospitals with the principal diagnosis of STEMI were conducted ($n = 13\,744$). We compared reperfusion treatment patterns and mortality rates for men and women patients in both younger (<65 years) and older (≥ 65 years) age groups to enable comparison of patient age separately because of women's longer average life expectancy (ABS, 2012). Data were available for interventional (percutaneous coronary intervention, *PCI*) and surgical (coronary artery bypass graft, *CABG*) treatment for STEMI for 3 years (1 July 2005 – 30 June 2008) and for inpatient mortality for 5 years (1 July 2005 – 30 June 2010). Data were not available for fibrinolytic therapy. Private hospitals were excluded from analysis because some were not reporting complete data to DoH for the entire study period.

Data definitions and coding

The VAED provides non-identifiable data for patient admissions with principal diagnoses coded upon separation, based on the International Classification of Diseases and Health Related Conditions, tenth Revision Australian Modification (ICD-10-AM). We used data for STEMI coded as I21.0 (Acute transmural myocardial infarction of anterior wall), I21.1 (Acute transmural myocardial infarction of inferior wall), I21.2 (Acute transmural infarction of other sites) and I21.3 (Acute transmural infarction of unspecified site). The latter two codes were aggregated because both were non-specific.

Location of residence data were provided in Local Government Area (LGA) codes and were converted to 'metropolitan' and 'regional' areas according to Australian Standard Geographical Classification (ASGC) Boundaries for Victoria (2004).

Length of stay was recorded in days and was the total time a patient was admitted to hospital. Length of stay for coronary care unit (CCU) and intensive care unit (ICU) admissions were recorded separately in hours, with rounding up to the nearest hour. If patients had multiple admissions to CCU or ICU throughout their periods of admission, these were summed totals of all such durations.

Results were reported for the whole population from 18 to 85 years, and for men and women aged under 65, and from 65 to 85. Age was reported for the whole group, and then divided and reported according to the two age groups. Sixty-five was chosen as it is the age commonly associated with the aged pension onset in Australia and the average age of retirement for men and women is 61 and 63 years respectively (ABS, 2011). It is understood more aged people with ACS die with or from the disease (AIHW, 2012) and this may inflate the mortality rate in older patients, who are most likely to be women.

Data analyses

Statistical analyses were undertaken using SPSS Statistics Version 21.0 (SPSS Inc., an IBM Company, Chicago, Ill, USA) software. Continuous variables were compared using the Wilcoxon rank-sum test and Student's *t*-test and categorical variables were compared using chi-squared test (χ^2). Age is reported as mean with standard deviation (\pm SD), non-parametric continuous variables (length of stay) are presented as medians and interquartile ranges (IQR, 25-75), and categorical variables are presented as counts with numbers and percentages. All statistical tests were two-sided and *p*-values of less than 0.05 were considered to indicate statistical significance.

To enable further analysis and interpretation of the treatment data, angioplasties (i.e. PCI) with or without balloon inflation were aggregated, and angioplasties with stent implantation were analysed separately. For coronary artery bypass graft (CABG) surgery, arterial and venous donor sites were aggregated; thus, if the same patient had venous and arterial grafts during bypass, data were managed to ensure they only counted as one

patient having undergone CABG surgery in the analysis. Investigation with angiography was a dichotomous variable (*yes* or *no*). We did not have data for fibrinolytic therapy use in the VAED data.

Ethics approval

The current paper reports the findings of research approved by a university Human Research Ethics Committee approved the study (HREC V2009 83). The Victorian Department of Human Services 'Conditions of Release of Patient Level Data sets' were also met.

RESULTS

Patient demographic characteristics, 2005 – 2010

A total of 13 744 patient admissions for 18 to 85 year olds were recorded in 136 Victorian public hospitals with STEMI diagnoses for the 5 years (July 1st, 2005 to June 30th, 2010). STEMI of the inferior myocardial wall were most commonly diagnosed for both sexes (Table 1). There were more men than women in all groups ($p < 0.001$). The mean patient age was 61.8 (± 12.7) years. Overall, women ($n = 3501$; 25.5%) were older than men ($n = 10243$; 74.5%) by more than six years [66.6 (± 12.9) vs. 60.2 (± 12.3) years respectively, $p < 0.001$]. Mean ages for the older and younger groups are presented in Table 2. Most patients (58%) resided in metropolitan areas, but more young women lived outside of metropolitan areas than men ($p < 0.001$). The majority identified English as their preferred language ($n = 12\,738$; 93%) and less than 1% identified themselves as being Indigenous ($n = 97$; 0.7%).

Table 1. Principal STEMI diagnoses for Victorian patients, 2005 – 2010

STEMI site	All n (%)	Women n (%)	Men n (%)
Anterior wall	5140 (37.4)	1315 (37.6)	3825 (37.3)
Inferior wall	6691 (48.7)	1628 (46.5)	5063 (49.4)
Other unspecified	1913 (13.9)	558 (15.9)	9410 (13.3)
Total	13 744 (100)	3501 (100)	10 243 (100)

Table 2. Demographic characteristics for 13 744 patients admitted to Victorian public hospitals with ST-segment elevation myocardial infarction, 2005 – 2010

Characteristic	All 18 – 85 years	<65 years		<i>p</i>	≥65 years		<i>p</i>
		Male (%)	Female (%)		Male (%)	Female (%)	
Admissions, n	13744 (100)	6465 (82.3)	1391 (17.7)		3778 (64.2)	2110 (35.8)	<0.001
Mean age, years [±SD]	61.8 [12.7]	52.6 [8]	53.1 [8.3]	0.025	73.2 [5.6]	75.4 [5.5]	<0.001
Metropolitan	8022 (58.4)	3939 (60.9)	781 (56.1)	0.001	2094 (55.4)	1208 (57.3)	0.18
Married	8853 (64.4)	4311 (66.7)	807 (58)	<0.001	2733 (72.3)	1002 (47.5)	<0.001
English	12738 (92.7)	6153 (95.2)	1305 (93.8)	0.43	3430 (90.8)	1850 (87.7)	<0.001
Died	747 (5.4)	138 (2.1)	54 (3.9)	<0.001	292 (7.7)	263 (12.5)	<0.001

±SD, standard deviation

*compared across groups

Management, 2005 – 2008

Reperfusion therapy provision (or not), angiographic investigation and admission statistics were then calculated for patients from 18 – 64 years (inclusive) and 65 – 84 years (inclusive), for both patient sexes in order to provide age-relevant comparisons in large samples.

Results related to clinical characteristics for patient admissions with STEMI (n = 8404) over three years are presented in Table 3. More than half of this patient group were investigated with angiography (n = 4607; 55%). Men received more angiography (n = 3503; 56%) during their admissions compared to women (n = 1104; 51%) ($p < 0.001$). Of the total patients with STEMI who received PCI treatment (n = 3770; 45%), 822 (38% within patient sex) were women, compared to 2948 (47% within patient sex) men ($p < 0.001$). Only five percent (n = 407; 4.8%) of patients underwent CABG surgery. Compared to women, men with STEMI were more treated with CABG (men = 322, 5% vs. Women=85, 4%). Just over half of the patients admitted with STEMI (n = 4293; 51%), received no PCI or CABGs. We do not have data for fibrinolytic therapy. Women with STEMI received significantly less PCI and CABG treatment than men (men = 3029; 59% vs. women = 1264; 49%, $p < 0.001$).

Median (\pm SD) inpatient lengths of stay (LOS) were longer for older women than men from the same group ($p < 0.019$). Younger women had longer periods of admission in CCU ($p = 0.013$), with details provided in Table 3.

Table 3. Clinical characteristics for 8404 patients admitted to Victorian public hospitals with ST-segment elevation myocardial infarction, 2005 – 2008

Characteristic	All	<65 years		<i>p</i>	≥ 65 years		<i>p</i>
		Male (%)	Female (%)		Male (%)	Female (%)	
Admissions, n	8404	3915 (82.8)	815 (17.2)	<0.001	2333 (63.5)	1341 (36.5)	<0.001
Age yrs, mean [\pm SD]	62.1 [12.7]	52.6 [8]	53.3 [8.2]	0.025	73.3 [5.6]	75.5 [5.5]	<0.001
LOS days, median {IQR}	4 {1-5}	3 {1-5}	3 {1-5}	0.129	4 {1-6}	4 {1-7}	0.019
CCU hrs, median {IQR}	64 {41-93}	62 {40-89}	67 {43-95}	0.013	64 {41-97}	68 {41-102}	0.088
ICU hrs, median {IQR}	44 {22-88}	44 {22-77}	42 {18.5-101}	0.943	44 {22-89}	47 {24-91.5}	0.301
Angiogram	4607 (54.8)	2291 (58.5)	494 (60.6)	0.274	1212 (52)	610 (45.5)	<0.001
Angioplasty	184 (2.2)	86 (2.2)	15 (1.8)	0.596	53 (2.3)	30 (2.2)	1
Angioplasty + stent	3586 (42.7)	1921 (49.1)	363 (44.5)	0.019	888 (38.1)	414 (30.9)	<0.001
CABG	407 (4.8)	179 (4.6)	33 (4)	0.577	143 (6.1)	52 (3.9)	0.004
No PCI/CABG	4293 (51.1)	1763 (45)	410 (50.3)	0.006	1266 (54.3)	854 (63.7)	<0.001
Died	468 (5.6)	79 (2)	32 (3.9)	0.002	180 (7.7)	177 (13.2)	<0.001

CABG, coronary artery bypass graft; CCU, coronary care unit; hrs, hours; ICU, intensive care unit; IQR, interquartile range (25 – 75); LOS, length of stay; PCI, percutaneous coronary intervention; \pm SD, standard deviation; yrs, years

Mortality, 2005 – 2010

Of the total 18 – 85 year old group of patients admitted with STEMI ($n = 13\,744$), 747 (5.4%) died. When comparing by sex, women ($n = 317$) were proportionately more likely to die than men ($n = 430$; 9.1% vs. 4.2%, $p < 0.001$). Women younger than 65 years ($n = 54$) were proportionately more likely to die than their male counterparts ($n = 138$; 3.9% vs. 2.1%, $p < 0.001$, respectively). Of the ≥ 65 year old group, women ($n = 111$) in the 80-84 year age bracket were at greater risk of in-hospital death than men ($n = 73$) in the same group (18.2% vs. 10.9%, $p < 0.001$).

DISCUSSION

The principal findings of this exploratory database study were that, in comparison to men; women were less likely to receive reperfusion treatment for STEMI, and women experienced higher rates of inhospital mortality for STEMI. Additionally, average lengths of stay in some inpatient areas differed significantly between the sexes. We investigated average lengths of stay for patients aged younger and older than 65 years, and found younger women tended to stay longer in coronary care units (CCU), but older women were admitted for longer overall than equivalent male age groups.

These findings are important and point to differences in ACS management related to patient sex which may equate to an avoidable sex-based treatment disparity. They do not reconcile with treatment guidelines, which are based on evidence suggesting early interventional reperfusion treatment is beneficial for both sexes (Mosca et al., 2011; Wilson & Raveendran, 2008). The disparities are not new however, with a number of studies reporting women's tendency to be given less access to reperfusion therapy for STEMI than men (Daly et al., 2006; El-Menyar et al., 2013; Milcent et al., 2007; Poon et al., 2012). Two papers reporting results from the Australasian ACACIA Registry data have also reported Australian and New Zealand women were less likely to receive coronary angiography than men (Huynh et al., 2010; Roe et al., 2013). Our findings concur that overall, women were less likely to be investigated with angiography than men in Victorian public hospitals, but this was mostly caused by under-investigation of older women who were the largest group. Women aged under 65 years on the other hand, were not found to be any less likely to receive angiography than their male counterparts.

To date, we have not identified any Australian studies which have investigated women's access to PCI with stents in comparison to men's. Our findings demonstrate both younger and older women were less likely to be treated with PCI and stent than their male equivalents, representing a significant difference and possibly missed opportunities for reperfusion for both younger and older women compared to men.

Women are known to have higher risk of bleeding with cardiac interventions than men (Ahmed et al., 2009; Chew et al., 2011), which may lead to them being provided less aggressive treatment. Bleeding during ACS admission is associated with a 5-fold increase in

late mortality (White & Chew, 2008), so any patient who is more likely to bleed is at greater risk of mortality and therefore, they or their physicians may be dissuaded from interventional reperfusion treatment. Presence of diabetes, renal failure and age greater than 75 years have been associated with increased risk bleeding with PCI (Chew et al., 2011). Several studies have shown that women with high-risk of mortality from ACS are offered less PCI than men (Daly et al., 2006; Radovanovic et al., 2007; Rathore et al., 2002). If bleeding risk correlates with age, then it might be reasonable to assume more equal proportions of younger men and women would be managed with PCI with stents, but this was not the case in the Victorian population.

We found no significant statistical difference between CABG procedures performed on younger women and men, but the numbers in each group were low. In the older group, we did observe statistical significance, but again, the number of procedures was low, so we hesitate to make any assumptions regarding clinical significance without more evidence.

Advanced age is accompanied by increased comorbid disease. Comorbid diseases are reported to be associated with increased risk of death with STEMI and reperfusion methods are also administered at greater inherent risks during their application (Bailey Merz et al., 2010). Women are approximately 10 years older than men when they first experience ACS (Pepine, 2004; Vaccarino et al., 2005). Obesity and hypertension also increase with age and are risk factors for mortality in heart disease (Pepine, 2004). Treating physicians may be less inclined to intervene aggressively when patients are believed to be of generally higher risk (Radovanovic et al., 2007; Rathore et al., 2002; Scott et al., 2007). Analysis of data from the recent SNAPSHOT ACS Study uncovered that in Australia and New Zealand, high risk patients received less reperfusion therapy than those at low risk (Chew et al., 2013). In Canada, treatment has also been found to be inversely proportional to patients' increased ACS risk (Bugiardini et al., 2011). Calls have been made for increased treatment for higher risk patients to maximise outcomes (Aliprandi-Costa et al., 2011; Chew et al., 2013). Women have also been reported in other research to have higher short-term mortality after PCI and a higher 30-day morbidity and mortality than men (Lansky, 2004). Mortality rates secondary to CABG are also higher for women in the short-term (Ashley et al., 2013). In the longer-term however, outcomes for PCI and CABG are equivalent between the sexes (Bangalore et al., 2012; Jackson et al., 2011).

Under-treatment with PCI and CABG have been blamed for some of the ongoing differences in outcome between men and women with ACS (Blomkalns et al., 2005; Gulati et al., 2012; Jneid et al., 2007). Although this disparity is sometimes discounted when the older average age of women with STEMI is taken into account (Moriel et al., 2008; Wijnbergen et al., 2013), a number of authors believe age does not adequately account for the treatment disparity (Bugiardini et al., 2011; El-Menyar et al., 2013; Gulati et al., 2012; Hemingway et al., 2006; Lansky, 2004; Vaccarino et al., 1999). It may not be reasonable to preclude patients from reperfusion interventions however due to advanced age, as research suggests very elderly patients benefit from such treatment (Oqueli & Dick, 2011) regardless of their sex (Yan et al., 2006).

Differences in treatment provision may be due to late presentation or diagnosis of ACS in women. ACS symptom patterns are often reported to be different between men and women (Canto et al., 2012; DeVon et al., 2008; Regitz-Zagrosek, 2006). This has in part been blamed on the under-research of women in studies describing symptoms; generically ‘typical’ symptoms have been determined from samples predominantly of men (Douglas & Ginsberg, 1996; Lee et al., 2001; Lockyer & Bury, 2002). This may account for some of the differences reported in referral for coronary angiography investigation (Poon et al., 2012) – in our study, a smaller proportion of women were investigated with angiography than men overall, which was most notable in the older age group.

Conversely, it has previously been argued it is better to avoid an over-reliance on angiography because up to 60 percent of women do not have any flow-limiting coronary stenosis (Quyyumi, 2006). Women investigated with angiography are less likely to have obstructive disease diagnosed than men and significant disease may be missed (Gulati et al., 2009). Opportunities for patients to modify their risk factor profile and for them to be treated with evidence-based pharmacotherapy may be lost due to false negative results from angiography leading to overconfidence. Negative coronary angiography does not always suggest benign disease in women (Gulati et al., 2012; Johnson et al., 2004). Between 10 and 25 percent of women with STEMI are reported to have ‘normal’ coronary angiograms (Anderson et al., 2007; Bugiardini et al., 2011; Hochman et al., 1999). Compared to men reported as having angiographically normal coronary arteries, women

have been found to be four times more likely to be readmitted with ACS or chest pain in the 6 months after the investigation (Humphries et al., 2008).

Some researchers have found health care professionals are less likely to suspect ACS in women for a range of reasons including cultural biases and stereotypes (Arslanian-Engoren, 2009) and ineffective scoring tools (Bairey Merz et al., 2010; Mosca et al., 2005; Stramba-Badiale et al., 2006). Traditional risk stratification tools such as the Framingham study are not as effective in estimating atherosclerotic disease risk in women compared to men (Michos et al., 2006; Shaw et al., 2008). Women younger than 45 years are the least likely to present with chest pain or discomfort, and are also less likely to be investigated with angiography (Canto et al., 2012). Women in this age group are at particularly high risk of mortality (Canto et al., 2012; Ford et al., 2007).

Although more men experience ACS (AIHW, 2012), a gender gap has often been described in proportional mortality from STEMI, with women at greater risk of death (Milcent et al., 2007; Poon et al., 2012). At a recent European Society of Cardiology (2012) meeting, it was reported that, even when controlled for factors such as age, smoking, hypertension, treatment delay and management, women had higher in-hospital mortality proportionately than men (9.0% vs. 4.0%, $p < 0.0001$) (Leurent, 2013). Other international studies have also reported statistically significant mortality rate differences between the sexes (El-Menyar et al., 2013; Lansky, 2004; Poon et al., 2012; Srichaiveth et al., 2007). Our findings suggest that over a contemporary 5-year period (2005-2010), a statistically significantly higher proportion of women died of STEMI than men in Victorian public hospitals, which were proportions observably similar to the figures from the Leurent's study. We have not found similar mortality proportions previously reported in the Australian population for STEMI.

It has been suggested in a number of reports that when comparing to men, women have higher in-hospital mortality for STEMI due to their older median age at admission (Berger et al., 2009; Jneid et al., 2008; Moriel et al., 2008; Wijnbergen et al., 2013). When comparing groups above and below age 65, we found that women aged under 65 years had significantly higher rates of death than men from the same cohort overall, but so did older women than men in the equivalent age group.

Women of pre-menopausal age have been reported to have the greatest risk of mortality in ACS (Blomkalns et al., 2005; Gulati, 2012), with numerous international studies finding a notable increase in mortality rates in women aged under 55 years compared to their male counterparts (Ford et al., 2007; Radovanovic et al., 2007; Towfighi et al., 2009; Vaccarino et al., 2001). Our analysis concurred that women aged under 55 years were particularly vulnerable, but the samples were relatively small, so we are reluctant to draw any strong conclusions. In a comparatively larger sample, we found that women in the oldest age bracket also had proportionately higher in-hospital mortality rates than men in the very old group.

Limitations

Our study has a number of limitations common to studies utilising database research. First, the database used was an administrative dataset, so even though it was representative of the 18 to 85 year olds with STEMI admitted in Victoria (it was the whole population), the study was retrospective and we could only use data that were already available. The retrospective nature of the data meant we were unable to collect alternative variables, which may have been more clinically relevant to the research questions.

It was beyond the scope of the study to determine which patients experienced index STEMI events, or those who were patients with subsequent admissions, as the data were non-identifiable.

No fibrinolysis therapy data were available to us in the VAED dataset, limiting our ability to compare the differences between men and women.

An important issue in this large administrative dataset was also that we were unable to gauge concurrent morbidities that may have precluded therapy. A proportion of patients may have refused reperfusion treatment and this number may have been proportionately different between the sexes.

CONCLUSION

This research has provided evidence of possible disparity in reperfusion treatment access for STEMI between men and women in a populous Australian state. Although the findings need to be corroborated with future research, the current paper's findings are pressing because they indicate a difference in care which may be unfair and avoidable, but most importantly, may result in avoidable death. The research provides evidence of possible practice gaps in the management of patients with STEMI which can be further defined, understood and ameliorated to improve future patient outcomes. The findings may serve to heighten awareness of women's potential vulnerability to under-treatment, thereby helping to improve future practice.

The evidence that both younger and older women experienced significantly higher inhospital mortality rates compared to their male counterparts in Victoria is important and sobering, but we note this is exploratory, retrospective research. We are unable to attribute any direct causality between reduced access to reperfusion treatment with the higher inhospital mortality in women without further prospective research. Future research needs to confirm women's apparently higher inhospital STEMI mortality and adjust the findings according to comorbid risk factors. Ideally, future databases will be developed and linked with others to include more clinically relevant information, which may help gauge answer such questions on whole populations. With the benefit of clinician input into their contents, such databases could provide increasingly valuable information for monitoring and improving care.

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5.3 Summary

To increase the chances of patients' survival with STEMI, the two most important aspects in patient care have been identified as timeliness of treatment and access to treatment (Chew et al., 2008; Chew et al., 2013; Hung et al., 2009). The most important treatments include PCI, fibrinolysis and CABG, to restore blood flow. Without early implementation of reperfusion therapy, morbidity and mortality rates would be much higher, with one report suggesting that evidence-based treatments can reduce mortality by up to 78 percent (Huynh et al., 2010). The need to achieve both timeliness and access are paramount (White & Chew, 2008) and supported by ACS guidelines in healthcare systems throughout the world (Aroney et al., 2006; Chew et al., 2011; O'Gara et al., 2013; Steg et al., 2013).

The rationale for early reperfusion treatment and the contents of the ACS guidelines have been evaluated and determined to be well understood by clinicians, but unfortunately have been found to not be matched by practice (Huynh et al., 2010). It is not lack of knowledge of ACS guidelines and the evidence upon which they are based that is lacking, but an unknown factor (Huynh et al., 2010). Failure to provide timely reperfusion therapy for ACS has been widely documented, although generally without consideration of gender-based differences (Aliprandi-Costa et al., 2011; Chew et al., 2013; Eagle et al., 2002). Missed opportunities for early reperfusion in ACS in women have been reported in a number of international studies (Bugiardini et al., 2011; Gulati et al., 2012; Poon et al., 2012; Radovanovic et al., 2007), but to date no Australian research concentrating on these aspects of care in relation to women have been uncovered.

The database analysis provided in this chapter is an exploratory descriptive study based on government-collected data across a whole state. Whilst prospective studies need to investigate both the under-treatment and increased inhospital mortality in women, publication of this manuscript should serve to heighten awareness of women's risk. It provides a starting place.

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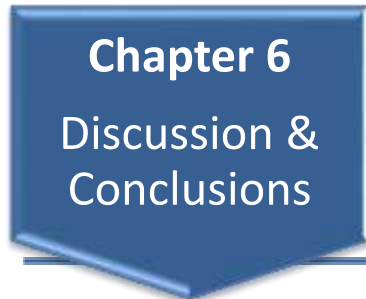
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Chapter 6

Discussion and conclusions



- Overview
 - Contribution to new knowledge – research objectives and key findings, new knowledge informing areas for future investigation and research limitations
 - Conclusions
-

6.1 Introduction

The purpose of this chapter is to synthesise the findings of the preceding chapters and highlight the original contributions each has made to knowledge through this programme of research. Key findings will be summarised from the chapters in relation to the research objectives and the overall contribution of the research to healthcare knowledge generally will be discussed.

The chapter will begin with a brief revision of the research subject and rationale elaborated upon in Chapter 1, followed by a review of the research objectives and key findings.

Knowledge emerging from individual studies within the programme, and examined in the thesis will be discussed with a view to guiding future research, prior to exploring a number of limitations of the current research.

6.2 Overview

Coronary heart disease (CHD) is the leading killer of women and men throughout the world, and not by a narrow margin. As such, research of the disease is critical to the ongoing health of countries with developed healthcare systems, including Australia, as well as those with systems currently undergoing rapid development. Research of the disease and how to improve its outlook are vital for people and the societies within which they live. The research papers presented in this thesis were borne from Australian data, but the conception of the research programme came from international research, which is where gaps in the knowledge related to ED care of women's heart disease were identified. A number of findings may be relevant and have the potential to be transferrable to overseas health systems, particularly in developed countries. Most developed healthcare systems have organised triage processes by which to ensure patients with time-sensitive, life-threatening conditions are prioritised for early treatment to minimise harm, so the findings presented in this thesis will likely be of value and may encourage enquiry to ensure disparities uncovered here can be mitigated or avoided in the other systems.

Acute coronary syndrome (ACS), which includes acute myocardial infarction (AMI) and unstable angina, is the predominant subset of CHD. Mortality rates from ACS have dropped considerably in recent years, but there has been a levelling off of these gains recently, particularly in women and morbidity and mortality from ACS are expected to rise again due to the increasingly aged population. Older age tends to be accompanied by numerous risk factor increases, including diabetes, obesity, hypertension, and for women, living longer after reaching menopause and the associated loss of cardiovascular protection afforded by oestrogen. Women generally live longer than men and are likely to carry a large proportion of the burden of future increases in ACS incidence. Women have historically been under-represented in cardiovascular research and have been established in a number of countries to have been under-evaluated and under-treated for ACS during various stages in the healthcare process. Due to the knowledge that women benefit from treatment in the same way as men, this may amount to systematic inequity at multiple stages in their trajectories of care.

Despite the focus on women's ACS, men's management and outcomes have also been reported, both to enable comparison, but also in recognition that coronary heart disease, is

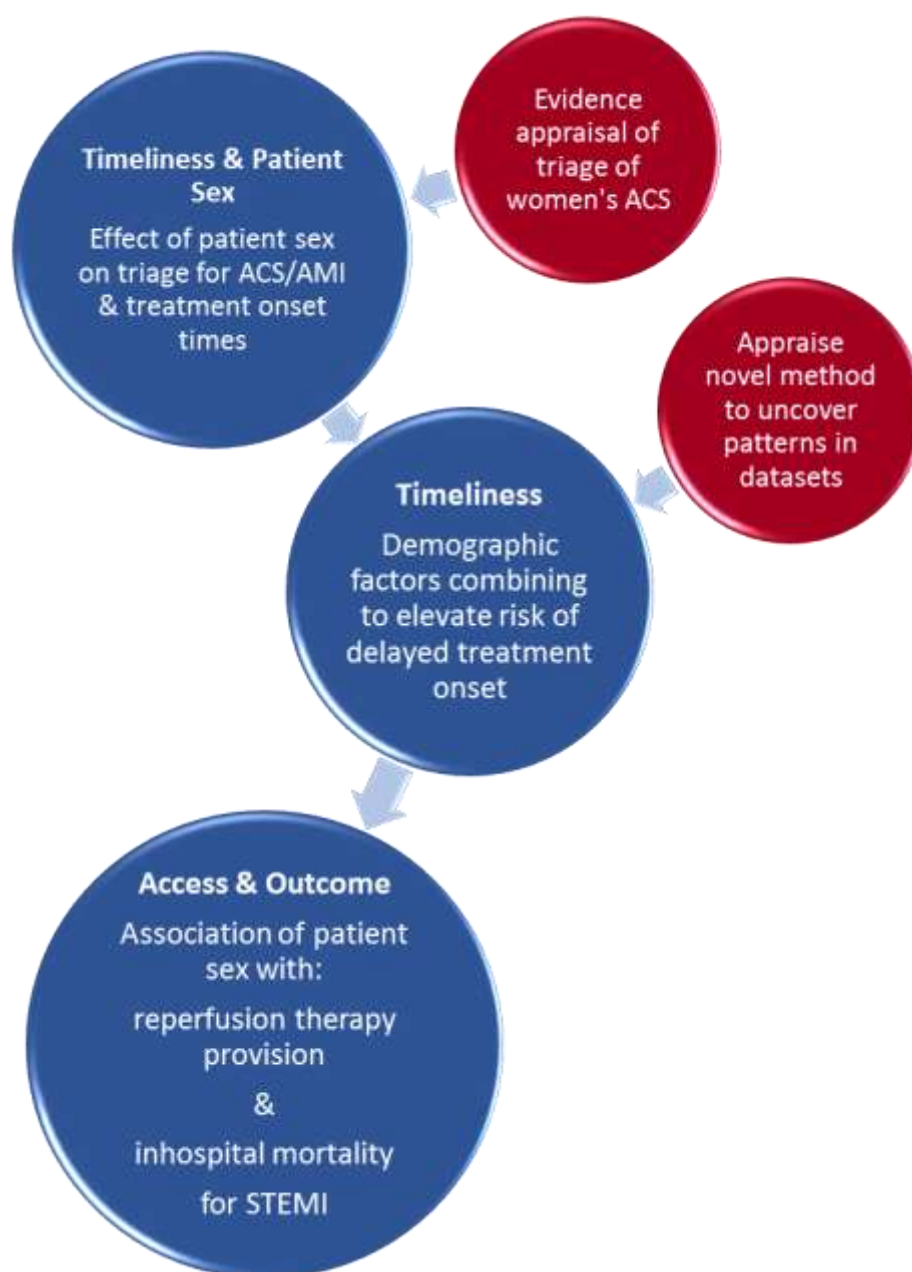
the leading killer for this sex as well, both internationally and in Australia. Healthcare should be measured for both sexes to improve management and outcomes wherever possible for the whole population. The concentration on women in this research was a conscious decision made because of disparities uncovered during review of the literature at various, mostly non-ED points in women's in-hospital ACS care, in comparison to that received by men.

Novel treatment techniques and new drugs for managing ACS are continually under development, however, the most gains in terms of lives saved and morbidity reduced after onset of ACS will likely come from two main areas: First, increased access to currently available ACS therapy according to existing guidelines; and second, improved timeliness of the implementation of these therapies and subsequently reduced myocardial damage. EDs, as the most common entry points to hospitals for AMI, are an important and largely overlooked area of research for these two areas of potential benefit. ED triage nurses are the first hospital health professionals to assess patients presenting to EDs, and are responsible for allocating triage acuity scores with explicit maximum suggested times to treatment. The ability to alter the time of onset to treatment means current practice needs to be explored, quantified and where necessary, altered to ensure maximised patient outcomes are achieved. Likewise, it is important to ensure women have equal access to ACS care and are afforded the greatest chance of minimising morbidity and mortality.

The objective of this empirically-based research programme was to add to the collective emergency and cardiovascular nursing knowledge around the efficacy in hospital ED triage assessment and subsequent in-hospital management and outcomes of ACS in women in Australia's second most populous state. It revolved around the understanding that women's ischaemia and infarction must be diagnosed and managed early to optimise patient outcomes, as it should also be for their male counterparts. Women and men patients should have access to reperfusion treatment wherever it is evaluated to be warranted, and with equity. The studies have not been designed to lead to linear conclusions about what is and what is not working effectively or equitably for women's heart disease in Victoria, as the subject is broad and complicated. Instead, the studies represent stepping stones towards building a more complete picture and answering important questions around the principles of timeliness and access to ACS treatment (Figure 6.1). They represent the beginning of the PhD Candidate's

research journey, with future research directions suggested and those the Researcher intends to pursue after the PhD is completed discussed.

Figure 6.1. Relationships between timeliness and access to ACS treatment and publications in the DaME II study



ACS, acute coronary syndrome; AMI, acute myocardial infarction; STEMI, ST-segment elevation myocardial infarction

6.3 Contribution to knowledge and recommendations for future research

Key findings for each of the chapters and related research publications are shown in Table 6.1. The table is used to highlight the contribution each discrete study has added to knowledge. New knowledge has evolved through the programme of research in relation to early ED evaluation at triage and factors affecting access to timely treatment in the ED, in addition to inhospital reperfusion therapy provision and mortality for women and men with ACS using different patient data, taken from the same state's population. Each of the research projects were separate and undertaken to add to healthcare knowledge in specific ways regarding early ED and inhospital management of women's ACS. Although each of the studies were independent, they were all used to inform the overall research programme.

In addition to the research manuscripts, another manuscript was developed during the DaME II study which is also an important contribution to nursing research. Situated in Chapter 4, this publication describes the utility, methodology and limitations of classification and regression tree (CaRT) method, as it applies to nursing research. The paper is not listed in Table 6.1 because it is not a research manuscript. The publication describes quantitative research method, novel to nursing, which is likely to be an important adjunct to the future development of nursing research. The method discussion paper has been published (currently available online, ahead of print) in an important peer-reviewed nursing journal. It is hoped this paper's publication and the growing interest in the CaRT method will encourage future nursing research using large datasets, where enormous amounts of information can be found in relation to treatment patterns, patient vulnerabilities and outcomes, and that new knowledge may come from nurses regularly employing such methods to investigate large, otherwise clinically (although not administratively) superfluous sources of data. The potential future benefit of 'big data' to nursing knowledge and recommendations to help realise this are explored immediately after Table 6.2 ('6.4.1 Recommended system change to accommodate 'big data'') in recognition that although it does not represent research *per se*, it comes from scholarly writing likely to add to future nursing research and knowledge.

Table 6.1. Summary of DaME II research key findings for ED and in-hospital ACS management

Aim	Ch.	Objective	Key findings
Examine triage patterns and treatment onset times for women and men with ACS	2	Appraise existing evidence for influence of patient sex on ED triage for ACS	<ul style="list-style-type: none"> • Triage nurses inconsistently suspect women of experiencing ACS • Sex-based presentation differences can affect ACS assessment quality and triage decision-making • Advanced patient age can alter triage decision making for ACS • There may be bias against managing women's ACS in parity with men's at ED triage
	3	Explore current practice of triage score allocation for ACS and subsequent treatment onset times in relation to patient sex	<ul style="list-style-type: none"> • Incorrect triage of women and men with ACS and AMI is common, but is worse in women • Incorrect triage delays treatment onset for ACS • Correct triage is important to timeliness of treatment onset for ACS and AMI and if triage is 'correct', treatment onset occurs within suggested timeframes
	4	Determine if non-clinical demographic factors influence triage and treatment onset time for ACS in EDs	<ul style="list-style-type: none"> • Patterns of patient characteristics causing vulnerability to delayed treatment onset on arrival at EDs were identified • Factors resulting in risk of delayed ACS treatment onset included correct triage score allocation, mode of arrival, area of residence, English-speaking background and patient sex • Other patient variables including advanced age and patient sex (again) were implicated in risk of delayed treatment onset, but need further investigation
Describe and compare in-hospital treatment and outcomes for ACS in women and men	5*	Determine if patient sex influences hospital access to reperfusion treatment for ACS, and whether mortality rates from ACS were influenced by patient sex and age	<p>Compared to younger men, younger women were:</p> <ul style="list-style-type: none"> • More likely to die • Less likely to receive PCI with stent • More likely to spend more time in CCU <p>Compared to older men, older women were:</p> <ul style="list-style-type: none"> • Older on admission • More likely to die • Less likely to be investigated with angiography • Less likely to receive a PCI with stent or CABG • Have a longer in-hospital LOS

ACS, acute coronary syndrome; AMI, acute myocardial infarction; CABG, coronary artery bypass graft; CCU, coronary care unit; Ch., chapter; LOS, length of stay; PCI, percutaneous coronary intervention

* Chapter manuscript under journal review

By summarising key findings in relation to each study's objective and guiding aim in Table 6.1, significant and original understandings arising from each of the publications are listed. These findings are extrapolated more fully in relation to each research objective in turn below with a statement of the main outcome for each and suggestions for future research, as informed by the DaME II study.

6.3.1 Research objective 1.

Appraise existing evidence for influence of patient sex on ED triage for ACS

Appraisal of existing literature and publication of the review's findings were part of an important first formal stage of this doctoral thesis by publication. This review was prompted by reading research about differences in symptoms experienced by women with ACS and delays in diagnosis because the general understanding of patterns of ACS presentation ('typical symptoms') were determined by research undertaken predominantly on men. I had spent a number of years practicing in the clinical role of triage nurse and teaching other post-graduate students to do the same, when I moved into a research team with Professor Worrall-Carter and Doctor Page, who were both already established in areas around women's CVD. I then started to wonder how much more difficult triaging women with heart disease could be due to the phenomenon of 'atypical' presentations when there were only usually a couple of minutes to perform an entire triage evaluation, on the background of busy and noisy EDs. Curiosity and working in the research environment made me question if triage nurses were accurately triaging women with ACS, and whether such decisions influenced time to treatment onset in the ED – the thesis grew from this early curiosity and fear my colleagues and I may have been incorrectly triaging women with ACS over the years, perhaps delaying the onset of treatment and reducing the effectiveness of the reperfusion therapy (if they were still eligible to receive it).

Review of the literature uncovered a small amount of North American research on the subject, with most of it completed by the same lead author, but did not answer the question of whether patient sex did influence triage score allocation and whether this affected time to treatment onset satisfactorily. Despite this, there were a range of important findings

reported, with the majority indicating difficulty triaging women with ACS. A great deal of excellent ACS-research continues to be completed in Australia. However, the research published to date rarely investigates (or reports) comparative findings between men and women. This may be because such evidence has not been found (in which case, negative reports would be useful and may be forthcoming) or has not been investigated because it may seem unlikely patient sex would affect patient care for ACS in Australian EDs. With so much research reporting that ‘time is muscle’ and ‘every minute counts’ in ACS, it seemed like a very important area of investigation.

The aggregated findings from the literature review were that most available research revealed women’s presentations with ACS to ED triage nurses were difficult to assess and were often not managed with parity with men’s ACS.

Future research needs to look further into the reasons behind the difficulties reported in assessing women with ACS at ED triage. There continues to be no strong explanation as to why triage of women’s ACS is different to men’s, apart from possible symptom differences. It was highlighted in the literature review that women’s symptoms may sometimes be different than men’s, but it was found through clinical vignettes that even when the symptoms of ACS were the same between the sexes, the triage decisions reached were often different. The question of differences in patient cues which prompt certain decisions is therefore, not straightforward. If a triage nurse suspects a patient is suffering from a time-sensitive ACS but does not triage them accordingly, and the way they would if the woman was a man, then there is a bias, albeit likely subconscious, requiring a great deal more investigation. Further questions needed to be asked around the impact of patient sex on ACS triage and timeliness to treatment onset, which guided the DaME II study into the first research publication of this thesis (Chapter 3).

6.3.2 Research objective 2.

Explore current practice of triage score allocation for ACS and subsequent treatment onset times in relation to patient sex

Findings from the literature review presented in Chapter 2 prompted investigation of parity in triage score allocation and subsequent time to treatment onset for women and men with ACS using Australian ED data. Previous studies reported in the literature review had used a range of mixed qualitative and quantitative methods with similar, but sometimes inconsistent results when using small sample sizes. To overcome this, a large government dataset was used with appropriate Ethics Committee and Department of Health (DoH) approvals, in addition to successful applications for data extraction from DoH, to enable analysis of thousands of triage score decisions for patients with actual or suspected ACS and AMI. Analysis of the Victorian Emergency Minimum Dataset (VEMD) data for a period of five concurrent years was undertaken for more than 260 000 patient presentations for all general public hospital EDs across the State of Victoria. This was felt to be ideal because the data could provide a true reflection of what was happening across the one state's EDs. With such a large sample of EDs, patient presentations and ED triage nurses, findings were likely to represent what was happening generally, and not just from one or two hospitals' EDs. A criticism which has previously been aimed at randomised controlled trials (Steg et al., 2007), as critical as they are to knowledge acquisition, is that patients selected are often not representative of the population they are designed for. The DoH database was state-wide, which helped overcome this. Analysis of the large database reported from hospitals, away from the bedside and validated through government agencies (Duckett & Jackson, 2008), helped to ensure a picture of what was really happening for a broad group of patients aged 18 – 85 years when arriving at ED triage desks for evaluation and sorting. Data were analysed for triage score allocation and time to treatment onset in minutes for men and women with actual and suspected ACS.

Major findings emergent from analysis were that incorrect triage score allocation for patients with ACS, including AMI was common for both sexes, but worse in women. Proportionately less women received *expected* or *correct* triage for AMI than men, and correct triage score was found to influence timeliness to treatment onset.

Future research in relation to this objective and findings are warranted and need to be conducted in other EDs including those in private hospitals and possibly overseas. This is feasible because most countries' EDs use organised triage processes and report data to their governments or boards using the International Classification of Diseases and Related Health Conditions (ICD-10), which is maintained and updated by the World Health Organization, making broader exploration of the uncovered phenomena feasible.

Further examination needs to evaluate whether triage nurses in Australia are cognizant of the differences between men's and women's presentations common in ACS and investigate decision-making rationale and equity between patient sexes. In lieu of this, an online survey using 20 real cases from the St Vincent's Hospital ED database has been designed to investigate this further during post-doctoral studies. The survey has Ethics Committee approval (Appendices G & H) and has been reviewed and approved by the College of Emergency Nursing Australasia (CENA) Research Sub-committee for dissemination through its membership. This request to CENA will be updated and resubmitted during preparations to move this research forward. Original plans to implement were delayed due to other triage-oriented surveys being distributed through the CENA membership at the time of the original request and caution to avoid fatiguing potential participants of research was exercised, with further important database research undertaken instead. The survey has been positively evaluated for face validity by five ED nurse experts and will be further validated prior to amending where necessary and disseminating online to Australian ED nurses via the CENA membership (Appendix I).

Another question to be explored through research is whether or not well-defined patterns in patient presentation complaints when arriving at ED triage with ACS actually exist. It has been established that part of the problem in assessing women with ACS is that the patterns of symptoms to observe for have been generated using data from male patients with ACS. As described in Chapter 1, numerous researchers have investigated differences in women's symptomatology over the last 10 to 15 years, however, findings are inconsistent. The methods previously employed have included various qualitative and quantitative techniques, but none have been found to have used text mining with R programmes on a large dataset. ED triage nurses at St Vincent's Hospital (Public, Melbourne) record detailed digital notes regarding patients' presenting complaints at triage. With Ethics Committee approval

(Appendix H), the clinical triage notes for patients later diagnosed with ACS from 2005 – 2012 have been extracted and are being cleaned and prepared for text mining using a novel technique with a number of programmes within R. A programme has been written by the Researcher and Mr John Ward (statistician), with conceptual input from the Researcher's doctoral supervisors to find patterns, clusters and correlations quantitatively amongst data to determine whether there are discrete patterns belonging to each patient sex for ACS. The R programmes have only recently become available and have not been used on these type of data in this way before. The findings will be reported by publication early in the Researcher's post-doctoral work and may help inform future sex-specific heart disease triage research and education.

Of note, recent international reports have described changing triage systems to 'first-come – first-served' services in which nurses and/or doctors will begin treating patients upon first greeting them in the ED, dramatically altering current ED triage practice (Alonso, 2013, Naik et al., 2012). The changes are a response to prolonged waiting times in ED waiting rooms and are based on lean thinking principles (Naik et al., 2012; Piggott et al., 2011; Welch et al., 2012). This is a newly developing topic of discussion and is not, to the best of the Researcher's knowledge currently mooted for Australia. Should triage processes change in future however, the research presented in this thesis and proposed post-doctoral research will still prove valuable: Women will still present to ED staff with ACS and require time-sensitive disease to be assessed and recognised early to enable prompt access to reperfusion therapy. Hence, patients' needs will remain the same, but identification of inequitable treatment delays may be more difficult to recognise without the structure of the Australasian Triage Scale (ATS). Nonetheless, the ATS and its predecessor, the National Triage Scale have been shown to be valid and reliable instruments for sorting patients in ways that optimise clinical outcomes in Australian EDs (Dilley & Standen, 1998; FitzGerald, 1989; Gerdts et al., 2009; Jelinek & Little, 1996), and mean they are likely to remain important in the Australian ED landscape for the foreseeable future.

6.3.3 Research objective 3.

Determine if non-clinical demographic factors influence triage and treatment onset time for ACS in EDs

It has been reiterated in this thesis that assignment of a triage score using the ATS is based on the triage nurse's evaluation of a patient's level of urgency. The evaluation of urgency is purely a clinical decision. It was important to determine whether other non-clinical factors were associated with delayed treatment onset for ACS from the time of patients' arrival at EDs and should, therefore, be incorporated into future education and training efforts. To do this, the Researcher learned to utilise regression tree method, a technique which has rarely been used in nursing research, and analysed the VEMD data further in search of patterns, previously unknown which may have prompted patient vulnerability to undertriage and prolonged treatment onset times for AMI. AMI was selected rather than the broader ACS diagnosis because of the need to concentrate on those patients who were most likely to have benefited from the earliest possible treatment onset, which was measured in minutes.

Key findings arising from this research were that first, a number of patterns in non-clinical variables exist which lead patients to be at risk of delayed treatment onset for AMI. These include correct triage score allocation (although this was to be expected, the regression tree analysis algorithm did not know this and merely checked all variables against each other repeatedly for patterns), mode of arrival, reported area of residence, English as preferred language and patient sex. Other variables of interest include increased patient age and patient sex (again). Differences in timeliness to treatment were identified as causing increased risk to women patients with AMI who presented to metropolitan EDs by private car, and were more likely to have been undertriaged. The risk was greatest for those who did not speak English.

Future research is necessary to determine whether the identified delays lead to differences in patient outcomes from AMI. This will require improved linkage between datasets to be able to further investigate relationships between triage score allocation and timeliness to treatment onset, with adverse in-hospital and post-discharge patient outcomes such as repeat AMIs and death. Ideally, future database research will be possible with robust non-identifiable linked Medicare data for patient presentation to general practitioners or other

healthcare institutions, ambulance, VEMD, VAED, the Pharmaceutical Benefits Scheme (PBS) and registries of mortality.

6.3.4 Research objective 4.

Determine whether patient sex influenced access to evidence-based treatment for ACS in Victorian public hospitals, and whether mortality rates from ACS were influenced by patient sex

Chapter 5 includes a research manuscript which has been submitted to a peer-reviewed, scientific journal. The manuscript examines two issues: The first is patient access to reperfusion therapy (PCI and CABG) when admitted with ST-segment elevation myocardial infarction (STEMI) to Victorian hospitals; and the second is inhospital mortality with STEMI, according to patient sex. The sample is separated into pre- and post-retirement age to investigate patterns of treatment provision and death that may be related to patient age as well as sex. The research questions guiding this research, new contributions to knowledge and suggestions for future research are discussed separately below.

a. Is interventional reperfusion therapy equally provided to younger and older men and women patients admitted to Victorian public hospitals with STEMI?

Reduction of morbidity and mortality in STEMI is most effectively achieved through timely access to evidence-based treatment. Patient sex has been found to influence access to treatment for ACS in a number of international studies discussed in Chapters 1 and 2, but there has been little research reported on treatment equity according to patient sex for ACS (including STEMI) in the Australian context. The database research reported in Chapter 5 limited analysis to patients who were admitted to Victorian hospitals over consecutive years with STEMI to enable investigation of treatment provision for patients with the type of AMI shown to derive most benefit from early reperfusion therapy.

Analysis of the Victorian Admitted Episodes Dataset (VAED) data, divided into two groups; pre- and post-retirement age, revealed the important findings that younger women were less likely than younger men to receive interventional reperfusion treatment for STEMI, but were

more likely to have longer lengths of stay in coronary care units (CCUs). Older women, when compared to older men, were less likely to receive stents or other PCI or CABG therapy, but were more likely to be older than men on admission and have longer average in-hospital lengths of stay. The younger women may have longer CCU stays because they are sicker by the time they are treated. A high proportion of them may also be subsequent MIs, which may be more severe (Deloitte Access Economics, 2011). The older women may have outlived their husbands due to their longevity (ABS, 2011). Without further evidence, these are just suppositions however.

Future research needs to be undertaken to investigate reasons for reduced treatment access to younger and older women and variations in lengths of stay in CCU for younger women, and the general wards for older women. It is not known if variations in decisions to treat are due to other patient factors, physician preferences or biases, or patient decision-making and preferences. It seems unlikely a statistically significant proportion of younger women would opt for non-interventional treatment of STEMI, and be responsible for under-treatment in both older and younger women's age groups. Prospective research needs to capture reasons for decision variations between the sexes in younger and older patient groups, which is likely to require more detailed analysis of patient medical histories (audits) and physician survey. Fibrinolytic therapy administration also needs to be incorporated into future VAED analysis.

b. Are patterns of in-hospital mortality different between younger and older men and women patients admitted to Victorian public hospitals with STEMI?

The second part of the research question addressed in Chapter 5 investigated whether there were differences in in-hospital mortality between men and women with STEMI. A number of previous international researchers have reported women's in-hospital mortality was higher than men's for STEMI, but others have argued against the voracity of these findings because women with STEMI have tended to be older and therefore, at greater risk because they have usually accumulated more co-morbid diseases. Although the notion that it was reasonable to expect and just accept that older patients (predominantly women) would die from STEMI seemed difficult to justify and unfair, the mortality analysis was split into younger and older age groups to enable comparison between younger and older patients of each sex.

The major finding was that both younger and older women were overall, more likely to die when admitted to hospital with STEMI than men from similar age groups.

Future research needs to investigate why proportionately significantly more women die inhospital with STEMI than men. It may be partly because of variations in reperfusion treatment provision, but causation cannot be determined through the findings from the descriptive research paper under development in Chapter 5. Without more research, the findings between treatment and mortality cannot be said to be causally associated and although this represents an important addition to knowledge of ACS experienced in Australia, it cannot be claimed to be more than this. Future prospective observational research is necessary to investigate the higher inhospital mortality experienced by younger and older women, when compared to their male counterparts at much greater depth. Mortality differences may be due to under-treatment and treatment delays caused by women presenting later for treatment or delays in treatment onset through EDs, or they might be due to sex-based variations in pathophysiology causing more difficult to treat STEMI or aberrant reactions to treatment. All of these questions require further research, which is most likely to include a mixture of qualitative and quantitative investigations.

6.4 Synthesis of suggestions for future research

The discrete research studies undertaken in the DaME II programme have resulted in a number of findings important to the future early assessment and in-hospital management of women's ACS. Some of the findings are original contributions to emergency and cardiovascular healthcare on an international level, whilst others reflect findings similar to those from past international research, but as far as can be ascertained through review of indexed and published (English) literature, have not been demonstrated in the Australian context. Most of the research presented in this thesis, whilst important, is retrospective and descriptive exploratory database research. Exploratory database research is a vital and underutilised method of research available to nursing because through analysis of large datasets, patterns of care variation and patient vulnerabilities can be determined and future research guided in an informed way, not possible with local level data. The use of whole-of-population data increase the volume of accessible information and avoids issues related to individual clinician or institution *opting-in* or *-out*, thereby avoiding selection bias.

Table 6.2 presents a summary of recommendations for future research which have evolved through findings uncovered in the DaME II study. It is used to demonstrate where research from knowledge gained from the research programme fits with the underlying principal areas of timeliness and access to treatment, and a third important principal emergent from mortality data which relates to outcomes. It suggests directions for future investigations, a number of which will be undertaken in early post-doctoral research. A sub-section (6.4.1) after Table 6.2 is provided in text to outline possible future research related to 'big data', which was briefly touched on in Chapter 4 because CaRT analysis fits within this research paradigm.

Table 6.2. Summary of recommendations for future research for women's ACS

Underlying principle	Knowledge guiding recommendation	Future research recommendations
Timeliness	<ul style="list-style-type: none"> • Triage nurses inconsistently suspect women's ACS compared to men's, with the two main factors implicated being <i>atypical</i> symptom presentation patterns and advanced age, which may increase or decrease level of assigned triage acuity • Evidence is sparse, but women may be susceptible to undertriage for ACS even when triage nurses are aware of symptom differences • Women are susceptible to undertriage for AMI in Victoria, Australia • Undertriage leads to delayed treatment onset for AMI • The combination of a number of identified non-clinical factors determine time to patient onset for AMI in the ED when present in identifiable patterns 	<ol style="list-style-type: none"> a. Survey Australian triage nurses to understand the cues most commonly used to discriminate ACS in women and men, and investigate their beliefs related to incidence and severity of women's heart disease b. Use a novel method to those used in previous triage of ACS research to examine for quantifiable features of women's ACS presentations that may be used to provide better cues for discriminating ACS from other conditions c. Examine triage nurse clinical-decision making processes for ACS evaluation and values employed to assign triage acuity decisions to knowledge of potential presentation differences due to patient sex, age and comorbid disease in Australian triage nurses d. Determine if there is a generalised and identifiable gender-bias in Australian ED triage nurse decision-making towards triage evaluation of women with suspected ACS and the basis for any differences e. If patterns of symptoms more likely to be sensitive and specific to identifying ACS in women can be established (see 'b'), incorporate these into triage assessment to enable research of focused ED 'fast-track' to ECG and high-sensitivity troponin assay, and notification of a ED personnel able to mobilise early PCI where ischaemia and infarction are suspected; and where PCI facilities are not possible, early fibrinolytic therapy administration. f. Further examine and corroborate variables shown by regression tree analysis to increase time to treatment for patients with AMI in EDs such as non-arrival by ambulance in Victorian and interstate EDs to enable incorporation into teaching material designed to mitigate risk of delayed treatment onset to patients belonging to vulnerable groups

Access	<ul style="list-style-type: none"> Victorian women receive less PCI with stent reperfusion therapy for STEMI 	<p>g. Develop an audit tool to evaluate access to reperfusion therapy and rationale for non-access for all men and women presenting to EDs to ensure all patients eligible (and consenting) to treatment able to abort or minimise AMI receive the treatment within recommended timeframes. Reasons for patients and treating physicians and cardiologists opting to, or not to treat with reperfusion therapy and the most beneficial medications should be evaluated to ensure application of guidelines in practice.</p>
Outcomes	<ul style="list-style-type: none"> Victorian women both above and below retirement age experience greater in-hospital mortality than their male counterparts 	<p>h. Develop an audit tool to measure patient ED and inpatient in-hospital LOS, morbidity and mortality. This would ideally first be state-based and then national, employing mixed methods to enable qualification of the patient experience as well as quantification of the following:</p> <ul style="list-style-type: none"> i. Morbidity measurement should include patient or staff reports of major adverse cardiac events including heart failure, cardiogenic shock, major bleeding, readmission and repeated infarction in-hospital and for up to 12 months post-discharge ii. Mortality should be measurable in-hospital, and at 30-days, six- and 12-months after discharge

ACS, acute coronary syndrome; AMI, acute myocardial infarction; ECG, electrocardiogram; ED, emergency department; LOS, length of stay; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction

6.4.1 Recommended system change to accommodate 'big data'

Database research has entered the realm of 'big data', where massive amounts of information can be searched, clustered, correlated or separated and with guidance from researchers, analysed in search of meaningful patterns amongst data. Patient healthcare data may be data mined to, amongst other things; improve timeliness of, and access to care, in addition to evaluation of equity in care delivery. Privacy issues are important, but confidentiality can be maintained through diligence and continued use of aggregated, non-identifiable data in algorithm development.

Digitalisation is the first step in the process and is well underway with projects designed to digitalise everything that has ever been published in history (Mayer-Schönberger & Cukier, 2013). Significant amounts of non-written health data have already been digitalised in recent decades: Radiological images for instance, may be added to databases. The stage beyond digitalisation is known as ‘datafication’ (Mayer-Schönberger & Cukier, 2013), which is where information is rendered useful for big data analysis. To enhance monitoring and guide improvement of healthcare, data need to be *datafied* further at two levels.

First, data needs to be nationalised and more large datasets linked. Some of this may be already underway, but it needs to be made available to clinicians and statisticians able to utilise the information meaningfully. Such change has previously been advocated for in the Australian healthcare system in the form of clinical-quality registries (McNeil et al., 2010). McNeil et al. (2010), in describing the National Health and Hospitals Reform Commission’s 2009 report finding that improved monitoring of service delivery is a critical element in health system reform, argued development of registries would enable benchmarking of clinical outcomes and stimulate competition. McNeil and colleagues proposed the data repositories would provide information on safety and efficacy of treatment, and could be used to determine if patients have access to timely treatment and whether it is delivered in line with best practice (McNeil et al., 2010). A similar registry for cardiac outcomes has been called for (CSANZ, 2011) and may collect the necessary data to build on findings emanating from the current thesis and be used to help complete several of the research recommendations summarised in Table 6.2.

Second, data at the point of patient care needs to be increasingly digitalised and datafied to enable development of algorithms to reduce risk for patients with ACS. Numerous studies, including research presented in this thesis, have shown some patients; women in particular, are at risk of delayed treatment onset and reduced access to reperfusion therapy for ACS. Although the causes are likely to be multifactorial, women are also at risk of greater in-hospital mortality. Computerised warning systems could be developed to ensure patients who fit certain profiles do not receive unnecessarily delayed treatment or are under-treated for ACS. Ideally, data for patient presentations would be de-identified and encrypted to enable establishment of patterns of risk for general practitioner visits, drug prescriptions, ambulance care, ED and inpatient hospital care, discharge, major adverse cardiac events and mortality.

Clinical patient data not normally available in database research in Australia such as comorbid diseases, ejection fractions and Killip Class scores, coronary vessel involvement, enzyme rises, ECG changes, hypotension or hypertension, blood sugar levels, pain scores and length of time between symptom development and arrival at healthcare facilities, and patient preference for treatment, would all be useful for future research around levels of risk in patients presenting with ACS and should all be evaluated for possible inclusion in future database and registry developments.

6.5 Limitations of the research programme

There are particular limitations relevant to this research which need to be acknowledged towards the conclusion of this thesis, in addition to those discussed in each of the publications. These issues include: Database research *per se*; and, Australian healthcare database limitations.

6.5.1 Database research generally

An important limitation of database research is that it is carried out using secondary data which are often collected for administrative purposes. Research questions are limited in many respects to what is available in the data, suggesting that research completed in this PhD is exploratory. The series of research questions explored on more than one dataset has helped to ensure meaningful knowledge was added to the area of women's early assessment and management of ischaemia and infarction in this instance. In the current research programme, access to two large datasets, coupled with *insider knowledge* and clinical experience in the area of investigation was beneficial and has enabled the evaluation of where there are systemic differences in the assessment, treatment and outcomes of ACS in women – many of which have not been reported previously. Without database research, the understanding of what is happening across all of Victoria's or any other state's or territories' public hospitals would not be possible on such a large scale and over an extended period of time. Due to the requirement that data are reported to the Department of Health (DoH) and institutional remuneration is tied in with records of treatment and disease provided within them (Duckett & Jackson, 2008), the data are representative of the population of interest. Triage score allocation is uniform, ICD-10 coding is uniform, DoH conducts its own data integrity audit procedures (DoH, 2011) and, apart from a problem discovered in the records of treatment with PCI and some CABGs over the last two years, there were minimal missing data.

6.5.2 Australian healthcare database limitations

There are a number of factors which impede database research, many of which could be overcome with pre-planning of what is collected with clinicians who are familiar with the healthcare systems from which the data are drawn. Ideally, the clinicians could also use or guide the use of data in ways that make datasets meaningful and able to monitor, guide and measure the application of evidence-based guidelines into healthcare delivery. The data extractions, with ethics approvals and modification processes, DoH processes and numerous telephone, email and face-to-face meetings took 2½ years to extract in the format used in the publications included in this thesis. Critical support and input was provided by a DoH data analyst, however, when the analyst moved to another government agency, processes were not in place to retrieve further data. Individuals subsequently assigned to assist extract the missing PCI and CABG data were unable to retrieve it in a timeframe which suited the requirements of the DaME II study.

Not all delays in accessing the datasets were negative however because each time the formal requests were revisited or more discussions took place with DoH staff, more data became available and in greater detail. Early extractions contained non-identifiable data for patient presentations and admissions aggregated in 5-year age groups. By the time data were extracted in their final form, more (still non-identifiable) data were available and with patient age provided in single years. This was advantageous for a number of statistical procedures because of the continuous nature of the variable and the greater volume of information available for analysis.

It seems wasteful to have so much data integral to monitoring important aspects of the healthcare system, sitting in storage and not adding to the wellbeing of the State. If healthcare could be better monitored to ensure guideline-based care is systematically employed in practice, it may be possible more morbidity and mortality could be avoided.

6.6 Conclusion of the DaME II research programme

The DaME II study has provided research-based analytic insight and new knowledge into ED triage score allocation and treatment onset times, in addition to proportional reperfusion therapy provision and mortality for women and men patients with ACS admitted into the Victorian public hospital system. The study has added to the understanding of efficacy and equity in public hospital ED triage of heart disease in women, and in-hospital treatment and outcomes, compared to their male cohort. The thesis included a series of separate studies which employed a range of methods of quantitative analysis to answer research questions. As a PhD by Publication, the various publications incorporated a number of different methodologies appropriate to meet the needs of each investigation's research aims and questions.

Research from this thesis has provided knowledge, not previously appreciated about ED triage nurses' influence on the time to access evidence-based management for women patients with ACS. It also investigated in-hospital treatment provision for the most commonly used and guideline-recommended therapy, PCI.

It is anticipated that future investigative and interventional research will result in significant positive clinical outcomes for women's cardiovascular health as novel ways of imparting new knowledge are developed in response to these findings and those of future studies.

Implementation of research findings into practice will require a number of approaches to improve the timeliness and access of women presenting with ACS to current evidence-based guidelines. In essence, the degree of suspicion for ACS and knowledge in relation to women's heart disease will need to be further heightened to encourage care of this patient group to be appropriately expedited and managed.

Recommendations for future research have been outlined and findings from the current DaME II study will be shared through presentations nationally and internationally, and published in peer-reviewed and easily accessed journals.

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Appendices

Ethicolegal & Miscellaneous

- Definition and classification of MI
 - Human Research Ethics Committee (HREC) approvals
 - Copyright material, permissions to use or legal waivers
 - Grey and online literature
 - Research portfolio
-

- A. Current universal classification of MI (Thygesen et al., 2007)
- B. Current universal definition of MI (Thygesen et al., 2007)
- C. HREC Application – V2009 83 (version 1)
- D. HREC Application – V2009 83 (version 2)
- E. HREC Application – V200708138
- F. DHS Conditions of Release of Patient Level Data Sets from the Victorian Health Information Reporting System
- G. HREC Application – V2010 133
- H. HREC Applications – QA30/10
- I. Expert review tool and survey with HREC approvals – V2010 133 & QA30/10
- J. Permission / right to reproduce published article in the thesis – Chapter 2
- K. Permission / right to reproduce published article in the thesis – Chapter 3
- L. Permission / right to reproduce published article in the thesis – Chapter 4i
- M. Permission / right to reproduce published article in the thesis – Chapter 4ii
- N. Grey and online literature related to the thesis
- O. Grey and online literature related to the thesis
- P. Research portfolio

Appendix A

Current universal classification of MI

Ref: Thygesen, K., Alpert, J.S., White, H.D. on behalf of the Joint ESC/ACCF/AHA/WHF Task force for the Redefinition of Myocardial Infarction (2007). Universal Definition of Myocardial Infarction, *Circulation*, 116, 2634-2653.

Clinical classification of different types of myocardial infarction	
Type 1	Spontaneous myocardial infarction related to ischaemia due to a primary coronary event such as plaque erosion and/or rupture, fissuring or dissection
Type 2	Myocardial infarction secondary to ischaemia due to either increased oxygen demand or decreased supply, e.g. coronary artery spasm, coronary embolism, anaemia, arrhythmias, hypertension, or hypotension
Type 3	Sudden unexpected cardiac death, including cardiac arrest, often with symptoms suggestive of myocardial ischaemia, accompanied by presumably new ST elevation, or new LBBB, or evidence of fresh thrombus in a coronary artery by angiography and/or at autopsy, but death occurring before blood samples could be obtained, or at a time before the appearance of cardiac biomarkers in the blood
Type 4a	Myocardial infarction associated with PCI
Type 4b	Myocardial infarction associated with stent thrombosis as documented by angiography or at autopsy
Type 5	Myocardial infarction association with CABG

CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention

Appendix B

Current universal definition of MI

Ref: Thygesen, K., Alpert, J.S., White, H.D. on behalf of the Joint ESC/ACCF/AHA/WHF Task force for the Redefinition of Myocardial Infarction (2007). Universal Definition of Myocardial Infarction, *Circulation*, 116, 2634-2653.

Definition of myocardial infarction

Criteria for AMI

The term MI should be used when there is evidence of myocardial necrosis in a setting consistent with myocardial ischaemia. Under these conditions any of the following criteria meets the diagnosis for MI:

Detection of rise and/or fall of cardiac biomarkers (preferably troponin) with a least one value above the 99th percentile of the URL together with evidence of myocardial ischaemia with at least one of the following:

- Symptoms of ischaemia;
- ECG changes indicative of new ischaemia [new ST-T changes or new LBBB]
- Development of pathological Q waves in the ECG
- Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality

Sudden, unexpected cardiac death, involving cardiac arrest, often with symptoms suggestive of myocardial ischaemia, and accompanied by presumably new ST elevation, or new LBBB, and/or evidence of fresh thrombus by coronary angiography and/or at autopsy, but death occurring before blood samples could be obtained, or at a time before the appearance of cardiac biomarkers in the blood.

For PCI in patients with normal baseline troponin values, elevations of cardiac biomarkers above the 99th percentile URL are indicative of peri-procedural myocardial necrosis. By convention, increases in biomarkers greater than 3 x 99th percentile URL have been designated as defining PCI-related MI. A subtype related to a documented stent thrombosis is recognized.

For CABG in patients with normal baseline troponin values, elevations of cardiac biomarkers above the 99th percentile URL are indicative of peri-procedural myocardial necrosis. By convention, increases in biomarkers greater than 5 x 99th percentile URL plus either new pathological Q waves or new LBBB, or angiographically documented new graft or native coronary artery occlusion, or imaging evidence of new loss of viable myocardium have been designated as defining CABG-related MI.

Pathological findings of an AMI

Criteria for prior MI

Any one of the following criteria meets the diagnosis for prior MI:

Development of new pathological Q waves with or without symptoms.

Imaging evidence of a region loss of viable myocardium that is thinned and fails to contract, in the absence of a non-ischaemic cause.

Pathological findings of a healed or healing MI.

AMI, acute myocardial infarction; CABG, coronary artery bypass graft; ECG, electrocardiogram; LBBB, left bundle branch block; MI, myocardial infarction; PCI, percutaneous coronary intervention; URL, upper reference limit

Appendix C

HREC Application – V2009 83 (version 1)

The following ethics approval pertained to use of the VAED and VEMD Department of Health datasets. Data from these were used in Chapters 3, 4 and 5.

ACU. The study has been to ACU HREC several times as it has developed. Appendix D is the last of the modification approvals.

Lisa Kuhn

From: Jasmine Sym <Jasmine.Sym@acu.edu.au> on behalf of Res Ethics
<Res.Ethics@acu.edu.au>
Sent: Monday, 14 December 2009 4:59 PM
Subject: V2009 83 Modification Approved

Dear Linda and Lisa

Thank you for submitting the request to modify form for your project V2009 83 - Early management practice for acute coronary syndrome (ACS) in Victoria

The Chair of the Human Research Ethics Committee has approved the modification, please take this email as confirmation of your approval.

We wish you well in this ongoing research project.

Kind regards,
Jasmine

Research Services Officer (Ethics)
Australian Catholic University Limited
St Patricks Campus
Level 5, 250 Victoria Parade, Fitzroy VIC 3065 Locked Bag 4115, Fitzroy VIC 3065
Ph: +61 3 9953 3150
Fax: +61 3 9953 3315
Email: res.ethics@acu.edu.au<<mailto:res.ethics@acu.edu.au>>
Jasmine.Sym@acu.edu.au<<mailto:Jasmine.Sym@acu.edu.au>>

ABN 15 050 192 660
CRICOS Registration: 00004G, 00112C, 00873F, 00885B

Appendix D

HREC Application – V2009 83 (version 2)

This is a copy of the amended HREC application approval for the VEMD and VAED study.

Due to availability of small data cell sizes, further HREC approval was obtained. This is the final confirmation letter.



St Patricks Campus
Level 5, 250 Victoria Parade, Fitzroy VIC
3065, Locked Bag 4115, Fitzroy VIC 3065
Ph: +61 3 9953 3150
Fax: +61 3 9953 3315
Email: res.ethics@acu.edu.au

Monday 9th August 2010

Dear Linda, Lisa and Karen

Thank you for submitting the request to modify form for your project V2009 83 -Early management practice for acute coronary syndrome (ACS) in Victoria.

The Chair of the Human Research Ethics Committee has approved the following modification(s):

1. Request actual age at hospital presentation as opposed to 5 year age groups.
2. Extension of project until 30.06.14.

We wish you well in this ongoing research project.

Kind Regards

A handwritten signature in black ink, appearing to read 'John Ozolins', written over a light blue horizontal line.

Associate Professor Janis (John) Ozolins
Chairperson, HREC
Tel: (03) 9953 3140
Fax: (03) 9495 6082
Email: john.ozolins@acu.edu.au

Australian Catholic University Limited
ABN 15 050 192 660
CRICOS registered provider:
00004G, 00112C, 00873F, 00885B

Appendix E

HREC Application – V200708138

This is a copy of the first application for HREC approval for the VEMD and VAED study. The first submission was assessed as a quality assurance initiative and the application (V200708138, Appendix F) was “noted and placed on file”. Staff at the Department of Health requested this go through HREC Approval, which was then completed and approved (Appendix C and D).

Australian Catholic University
Brisbane Sydney Canberra Ballarat Melbourne



Australian Catholic University Limited
ABN 15 050 192 660
Melbourne Campus (St Patrick's)
115 Victoria Parade Fitzroy VIC 3065
Locked Bag 41115 Fitzroy MDC VIC 3065
Telephone 613 9953 3000
Facsimile 613 9953 3005
www.acu.edu.au

16/01/2009

Ms Lisa Kuhn
25 Gordon St
Balwyn VIC 3103

Dear Ms Kuhn,

Thank you for your recent correspondence advising HREC of your project:
Diagnose and Manage Early: Women's Ischaemia and Infarction (DAME II).

HREC notes that the project will be using previously collected non-identifiable data which does not require ethics approval. Your application has been noted and placed on file.

Thank you.

Kind regards,

A handwritten signature in black ink, appearing to read 'Ivy Hajduk'.

Ivy Hajduk

Ethics Administrative Officer
ACU National HREC

Appendix F

Department of Human Services Conditions of Release of Patient Level Data Sets from the Victorian Health Information Reporting System (VHIRS)

This is a copy of the document signed and retained on file at DHS, for VEMD and VAED data.

ATTACHMENT C

DEPARTMENT OF HUMAN SERVICES

CONDITIONS OF RELEASE OF PATIENT LEVEL DATA SETS FROM THE VICTORIAN HEALTH INFORMATION REPORTING SYSTEM (VHIRS)

"Department" means the Department of Human Services, a Government Department of the State of Victoria.

These conditions relate to the release of patient level data sets from the Victorian Health Information Reporting System (VHIRS) by the Department to **Lisa Kuhn**, hereafter named "the recipient", for the purposes of research, as specified in the request detailed in **REQUEST: 2382**.

The data are released by the Department in reliance on the recipient agreeing to abide and ensuring that any other persons with access to the data agree to abide, and so abiding, by the following conditions and acknowledgements.

COPYRIGHT

The State of Victoria owns the copyright in the Department's datasets. The recipient(s) of these datasets agree not to reproduce, distribute or commercialise them, or any product or service derived from or incorporating them or part of them (whether or not amounting to copyright reproduction) other than as allowed by these Conditions of Release or with the prior written consent of the State of Victoria.

Where such consent is sought the State of Victoria reserves the right to set an appropriate charge or to require a revenue sharing arrangement.

The recipient(s) is permitted to quote an insubstantial part of the statistical data contained in the datasets (whether or not copyright subsists in the datasets), providing that:

- an 'insubstantial part' means a fair dealing as defined in Sections 40, 41, 42 and 43 of the Copyright Act 1968;
- the Department is cited as the source of the data used;
- the terminology used is that used by the Department for describing data; and
- any analysis or transformation of the data is not attributed to the Department.

Where a dataset consists of data in computer readable form, or software, the State of Victoria authorises the recipient(s) to use on a non-transferable and non-exclusive basis, this data or software personally or for internal purposes of its organisation (as the case may be).

The recipient is permitted to publish any analyses of the data but not the data itself, subject to the confidentiality conditions set out below. Any publication must be solely for the purpose specified in the recipient's request for data and the Department must be acknowledged as the data source. The recipient undertakes to advise the Department of any publication containing such analyses and to provide the Department with a copy of any such publication at least three days prior to its release to the public.

In these Conditions, 'commercialise' in respect of a product or derivative of that product, means to manufacture, sell, distribute, hire or otherwise exploit a product or process, or to provide a service incorporating the product or any other product or service derived from that product, or to license a third party to do any of these things.

ACKNOWLEDGED

DATE

 12.5.2009

CONFIDENTIALITY

The data must not be used, published or disseminated in a way that might enable the identity of individual patients or the service profiles of individual doctors to be ascertained or published or disseminated in any way that might enable the identity of individual private hospitals to be ascertained. In particular, statistical tables with cells showing less than five cases must not be published.

The data file is provided solely to the recipient and must not be communicated to other persons or organisations, or linked with files of personal information of other sources, without the prior agreement of the Department.

The data will only be used for the purpose(s) outlined by the recipient in requesting the data or for purposes approved by the Department's Ethics Committee.

Data files are to be maintained and stored in a secure manner in an environment where they cannot be linked (either electronically or by personal inspection) with other patient records or patient level data or personal information.

When no longer required, the data files are to be destroyed or returned to the Department of Human Services and the Department is to be notified of such destruction.

Not relevant for all agreements. Delete where not applicable.

Where a public health service or public hospital as defined in Schedules 1 and 5 of the *Health Services Act 1988* (the hospital) is provided with patient level data on patients of other campuses, such data may only be used for the purpose of service planning by the hospital's secretariat (including consultants engaged by the hospital secretariat) or for purposes approved by either the Department's Ethics Committee or the hospital's own ethics committee. Such data may only be released to personnel of the hospital's campuses, as appropriate, for specific research projects approved by one of these ethics committees.

The recipient must ensure that all persons to whom data files are made available are aware of the conditions of release including the requirements in relation to the need for confidentiality and the need to comply with them.

LIMITATION OF LIABILITY

The State of Victoria gives no warranty, other than a warranty that may be implied by law, that the products are free from errors, are complete, have any particular quality, are suitable for any purpose or otherwise.

Subject to any warranty, which may be implied by law, the State of Victoria's liability to the recipient(s) for any loss, damage or injury howsoever caused by the State of Victoria, whether due to negligence or otherwise, in relation to a product shall be limited to providing a replacement copy of that product.

INDEMNITY

The recipient(s) of the data indemnifies and shall keep indemnified the State of Victoria and its servants, officers, agents and contractors against any action, claim, suit, demand, or damage, loss, expense or liability (including costs on a solicitor and client basis) caused by or flowing from:

- (a) a breach by the recipient(s) or any personnel employed or retained by the recipients of the data of the conditions on which this data is released;
- (b) any wilful, negligent or unlawful act or omission of the recipient(s) of this data in connection with this data.

It is not necessary for the State of Victoria to make or receive any payment before enforcing such an indemnity.

C:\Documents and Settings\Administrator\Local Settings\Temporary Internet Files\Content.IE5\9TBC5D72\VHIRS Access Policy Document v1 External Users.doc

INSURANCE

The recipient(s) of this information shall ensure that the research activity proposed to be undertaken by the recipient is, on and from the date of receiving this data, insured with:

- (a) public liability insurance coverage with a limit of indemnity of at least \$5 million for any one occurrence; and
- (b) professional indemnity insurance coverage with a limit of indemnity of at least \$2 million for any one claim

with an insurer(s) authorised under the Insurance Act 1973, and shall provide certificates of currency if the Department so requests.

The insurance policy may be in the recipient's own name or in the name of an organisation that the recipient is affiliated, provided that the policy adequately covers the proposed research activity.

The recipient(s) shall maintain the professional indemnity insurance coverage for no less than 6 years after the date on which the recipient(s) has notified the Department that the data is no longer to be used.

This Deed shall be construed in accordance with the law of the State of Victoria and I submit to the jurisdiction of the courts of Victoria (including the federal courts).

EXECUTED AS A DEED

Dated: 12/05/2009

SIGNED SEALED AND DELIVERED by:

Lisa Kuhn



Signature

FURTHER INFORMATION

If the recipient wishes to commercialise the product, or reproduce the product other than as permitted by these Conditions, or has any further questions related to these Conditions, they should contact:

Manager, Health Information Provision Unit
Metropolitan Health and Aged Care Services Division
Department of Human Services
GPO Box 4057
MELBOURNE 3001

Telephone: (03) 9096 0327
Fax: (03) 9096 7764.

The recipient is reminded that additional Conditions of Sale or Release may apply to the Department's products.

Appendix G

HREC Application – V2010 133

The following ethics approval pertained to use of the St Vincent's Hospital (STV) Emergency Department (ED) Datasets and data were obtained in order to prepare the survey questions in the online survey, which has had face validity testing and approval from STV and the College of Emergency Nursing Australasia (CENA) Research Sub-committee for future dissemination, in addition to audit of triage and other treatment variables. This is the ACU HREC Approval, the STV's approval is located in Appendix G.



Human Research Ethics Committee

Committee Approval Form

Principal Investigator/Supervisor: Prof Linda Worrall-Carter Melbourne Campus
Co-Investigators: Melbourne Campus
Student Researcher: Lisa Kuhn Melbourne Campus

Ethics approval has been granted for the following project:
 Triage of Potential Coronary Heart Disease in Australian Emergency Departments: A Survey
for the period: 20/12/2010-01/12/2014
Human Research Ethics Committee (HREC) Register Number: V2010 133

The following standard conditions as stipulated in the *National Statement on Ethical Conduct in Research Involving Humans (2007)* apply:

- (i) that Principal Investigators / Supervisors provide, on the form supplied by the Human Research Ethics Committee, annual reports on matters such as:
 - security of records
 - compliance with approved consent procedures and documentation
 - compliance with special conditions, and
- (ii) that researchers report to the HREC immediately any matter that might affect the ethical acceptability of the protocol, such as:
 - proposed changes to the protocol
 - unforeseen circumstances or events
 - adverse effects on participants

The HREC will conduct an audit each year of all projects deemed to be of more than low risk. There will also be random audits of a sample of projects considered to be of negligible risk and low risk on all campuses each year.

Within one month of the conclusion of the project, researchers are required to complete a *Final Report Form* and submit it to the local Research Services Officer.

If the project continues for more than one year, researchers are required to complete an *Annual Progress Report Form* and submit it to the local Research Services Officer within one month of the anniversary date of the ethics approval.

Signed: Date:20.12.2010.....
 (Research Services Officer, Melbourne Campus)

Appendix H

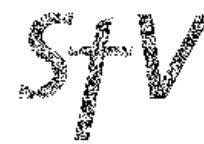
HREC Applications – QA30/10

The following ethics approval pertained to use of the St Vincent's Hospital (STV) Emergency Department (ED) Datasets and was obtained in order to prepare the survey questions in the online survey, which has had face validity testing and approval from STV and the College of Emergency Nursing Australasia (CENA) Research Sub-committee for future dissemination, in addition to audit of triage and other treatment variables.

St Vincent's Hospital ED.

The research has been discussed fully with the Nurse Unit Manager, Ms Sue Cowling and the Medical Director, Dr Craig Winter on a number of occasions as it has evolved. A number of senior nursing staff have also been included in conversations about women's heart disease generally and how this study will be used to try to improve any deficits in knowledge and/or practice from an ED perspective.

I would like to acknowledge the assistance and support provided by Professor George Jelinek and Dr Tracey Weiland from the ED Research Centre, in addition to those in the clinical roles and managerial roles in the ED for their support and warm camaraderie.



Dr Linda Wormal-Carter
STV/ATU Centre for Nursing Research
St Vincent's Hospital (Melbourne)

13 October 2010

Dear Dr Wormal-Carter,

QA 030/10 – 'Diagnose and manage early: Women's Ischaemia and Infarction (DaME) Study'
Emergency Department, St Vincent's Hospital (Melbourne)
Telephone: 03 9594 2200
www.stvincents.org.au

Thank you for submitting your application for approval of Quality Assurance activity. The Quality Assurance Sub-committee of Human Research Ethics Committee (HREC)-A has approved the above mentioned project as a Quality Assurance activity at the following sites:

1. St Vincent's Hospital (Melbourne);


This approval will be ratified by St Vincent's Hospital (Melbourne) HREC-A at the next meeting.

The project complies with the principles of the National Statement on the Ethical Conduct of Human Research (NHMRC, 2007).

Terms of approval

1. It is the responsibility of the Principal Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as specified in the application.
2. You should notify the Research Governance Unit immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
3. **Amendments to the approved project:** Changes to any aspect of the project require the submission of a Request for Amendment to the Quality Assurance Sub-committee and must not begin without written approval. Substantial variations may require a new application.
4. **Future correspondence:** Please quote the reference number and project title above in any further correspondence.
5. **Final report:** A Final Report must be provided at the conclusion of the project.
6. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by the Research Governance Unit at any time.

We wish you well with your project.


Jane Threlkeld
On behalf of HREC-A Secretary
Research Governance Unit
St Vincent's Hospital (Melbourne)



*Please accept sincerest apologies for the quality of this print – it is as it was received
(enlarging the text box made it more difficult to read)*

Appendix I

Expert review tool and survey with HREC approvals – V2010 133 & QA30/10

Expert Review of Patient Scenarios & Questions for Triage Survey

Reliability of Survey Tool Scenarios to Measure Decision Making for Triage of Possible Acute Coronary Syndrome

Introduction

The acute coronary syndromes (ACSs) are amongst the most time-sensitive conditions with which patients present to emergency departments (EDs). Myocardial damage can be averted or minimised if patients receive timely therapy.

We are undertaking a multi-faceted study examining the early assessment and management of patients with possible ACS in EDs. We believe decisions made by emergency triage nurses are critical to the early and effective treatment of these conditions.

An important component of this study is to better understand how emergency nurses arrive at clinical decisions and allocate triage categories to possible ACS-affected patients using the Australasian Triage Scale (ATS).

Current Survey Tool Objective

To maximise reliability of the triage survey tool: the triage scenarios will consistently reflect patient presentations correctly triaged as Category 2 according to the ATS as judged by experts in the application of this system. The secondary objectives address utility of the tool: scenarios and associated questions are easily understood by triage nurse experts.

Final Survey Tool Objective

To examine and describe nurse triage decision making for ACS in Australian emergency departments.

Desired respondents

The expert panel will consist of 5 registered nurses (Division 1) who have practised the role of nurse triage in an Australian ED for 5 or more years.

Invitation

You have been nominated by your colleague(s) as an expert in emergency nurse triage using the ATS. We therefore, invite you to provide your opinion regarding the reliability of the following patient scenarios and questions. We are also interested in which differential diagnoses emergency triage nurses consider when making decisions and how patient cues affect their decisions. The scenarios have been developed from real cases and have been altered to ensure patient identities are protected whilst enough clinical information is available to undertake appropriate triage. We are asking that you tell us if the scenarios represent patients who should be correctly assigned ATS Category 2 and the related questions are clear and unambiguous. Study participants will only be provided a selection of these upon logging onto the online survey link, but we would be extremely grateful if you could triage all of them to ensure overall consistency of the scenarios.

Confidentiality

Your confidentiality is important to us. We will not collect or store any information regarding your name, address, date of birth or the name of your workplace. At the beginning of the survey are a number of questions regarding general demographics to enable us to ensure suitable rigour in this process.

Emergency nurses are a relatively small group of highly skilled professionals. This is the first test we will apply during the development of this survey and we ask that you do not discuss its contents with any of your colleagues to avoid biasing the outcomes of the final survey.

You may of course cite your participation as an expert reviewer for reliability of our tool in your curriculum vitae.

Feedback

We will be very happy to discuss your evaluation of the scenarios and any questions over the telephone if this will assist your review.

Thank you for sharing your time with us – we know it is valuable.

Lisa Kuhn

PhD Student/Emergency Nurse, Australian Catholic University/St Vincent's Hospital; Mobile: 0404 05 2727 | Email: L.kuhn@acupond.net.au or lisa.kuhn@acu.edu.au; Supervisors: Prof. Linda Worrall-Carter and Assoc. Prof. Karen Page; St Vincent's Centre for Nursing Research, 03 9953 3678.

Participant Demographics

STUDY QUESTIONNAIRE

Survey No: [1 1 1 1]

Emergency Triage Staff Survey

DEMOGRAPHIC DATA

Age: _____

☐ Female

☐ Male

1. How many years of experience do you have as an emergency nurse (practising in an ED)?

_____ years (complete to closest whole year)

2. Please identify the patient population of the ED in which you currently work the most:

☐ Adult only

☐ Paediatric only

☐ Adult & paediatric (mixed)

☐ Oncological or palliative

☐ Obstetric or gynaecological only

☐ Eye & Ear only

3. Please identify the location of the ED in which you currently work the most:

☐ Metropolitan

☐ Rural

☐ Other _____

4. Please identify the type of ED in which you currently work the most:

☐ Public Hospital

☐ Private Hospital

☐ Other _____

5. Please identify the highest level of cardiac care available at the hospital in which you work the most:

☐ No cardiology services onsite

☐ 24 hour (emergency) catheter laboratory on-site

☐ Cardiology services onsite (e.g. catheter laboratory, but not for emergencies)

☐ Coronary artery bypass grafts done at hospital

6. Which nursing qualifications do you hold? (tick all that apply)

☐ Diploma

☐ Graduate Diploma

☐ Emergency Certificate

☐ Bachelor Degree

☐ Masters

☐ Intensive Care Certificate

☐ Honours Degree

☐ PhD

☐ Mixed Emergency/Critical Care Certificate

☐ Other (please specify) _____

Participant Demographics (continued)

7. Employment:

- ☐ Full-time ☐ Part-time ☐ Casual
No. of hours per month _____ No. of hours per month _____

8. Usual shift worked:

- ☐ Days only ☐ Nights only ☐ Day/night

9. Triage nurse experience:

How many years have you been rostered shifts as an Emergency Triage Nurse? (to closest year you can recall) _____

10. Triage nurse education:

How were you originally educated to undertake the triage nurse role?

- ☐ No official triage education ☐ Part of post-registration course
☐ In-department education ☐ Other (please specify) _____

11. Is there ongoing education for triage in your ED?

- ☐ Yes ☐ No

12. Please rate your knowledge of the Australasian Triage Scale (ATS) as a percentage: ____%

13. What percentage of the time do you feel you are able to apply the ATS? ____%

14. If the percentages you've answered in Questions 12 and 13 differ, what are the main reasons for this (please use 20 words or less to explain)?

15. Do you feel there is adequate support for your triage decisions in your ED?

- ☐ Yes ☐ No

16. Do you ever feel pressure to change your triage decisions by colleagues or others?

- ☐ Yes ☐ No

17. If so, what are the reasons for this (mark or state all that apply)?

- ☐ Clinical (such as disagreement on decision)
☐ Non-clinical (such as over-crowding or inadequate staffing)
☐ Other (please specify)? _____

Explanation for Use of Table

The following are a number of scenarios based on real patient presentations

Please read the clinical notes and

1. Assign an ATS triage category (1 – 5) based on your clinical decision in the space provided;
2. Rank the cues you used in order of importance in the boxes provided (1 = highest to 10 = lowest).

Below is a table listing the cues likely to be used, exemplars for each and a box for you to insert numbers to indicate how you came to your triage decision. [The online survey will only display a limited number of mixed male and female scenarios for each participant, with a single scenario and the simplified table on each webpage. Scenarios have been included in the current expert reviewer version in a numbered list to enable faster review and comment by you.]

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Cue groups	Chief complaint	General appearance	Objective data	Subjective data	Limited past history	Co-morbid conditions	Socio-demographic data	Mode of arrival	Referral source	Other (please specify and rank)
E.g. of patient cue(s)	Chest pain Shortness of breath Fainting Collapse	Asym the room Anxious (distressed) Cyanosis Diaphoretic Circulatory state	Primary survey Defect Heart rate Blood pressure Diaphoretic Available electrocardiograph at blood test	History of pain Description of associated symptoms (onset, location, duration, character, aggravating or relieving factors, response to treatment)	Medical history (e.g. coronary artery grafts, stroke) Past medical history (e.g. diabetes, heart attack, angina) Previous family history for heart disease	Diabetes Obesity Smoker Hypertension	Gender Age Race Marital status	Ambulance road, air Own transport Brought from other acute department (e.g. by wheelchair) Public transport	Local doctor Other hospital department Other hospital	Other patient not included in above cue groups
E.g. of participant response	3	9	4	2	5	7	6	8	1	...please write...
Use each ranking only once										

[Embedded table with explanation of cue groups. The participant will click to open the table for more elaboration as necessary on each page with a scenario.]

[The online survey will also ask the participants to list the three most likely differential diagnoses for each patient scenario. However, to enable you to rapidly triage all of the following scenarios, we are not asking you to do this. The wording of this part of the survey is likely to be as follows. There is space for you to comment on this section if you would like to do so and feel strongly about it.]

Although emergency nursing does not require us to assign medical diagnoses at the ED triage desk, what are the three top differential diagnoses you considered when assigning the ATS category for the above patient?
e.g. acute myocardial infarction, stable angina, pleurisy, unstable angina, pneumonia, aortic aneurysm, cholecystitis, anxiety, muscular injury

1. _____
2. _____
3. _____

Reviewer Comments on Assignment of Differential Diagnoses at Triage (Optional):

Patient Scenarios

Males

1. A 42-year-old Australian born male presents via ambulance having woken with epigastric pain 1 hour ago which he rated 8/10. He collapsed to his knees when he first stood up and says he was dizzy, clammy and short of breath. His wife called the ambulance. He has no known allergies, but has a history of mild asthma. He has been given Morphine, Aspirin, Atropine and Maxolon en route. His heart rate is 42 beats per minute and his respiratory rate is 22 breaths per minute.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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2. A 47-year-old Sri Lankan male presents via Metropolitan Intensive Care Ambulance with a history of 2 hours of unrelieved chest pain. He was given 2 sublingual Glyceryl Trinitrate (GTN), followed by a GTN patch and 7.5 mg of Morphine by the paramedics. He still rates his pain 8/10. His blood pressure is 130/85 on arrival and heart rate is 92 beats per minute. Past medical history includes an acute myocardial infarction 9 years earlier, which was treated with a cardiac stent.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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3. A 45-year-old never married Australian born male presents via private car complaining of sudden onset of left-sided chest pain 1 hour earlier with associated shortness of breath which he reports as being worse on inspiration. He has no dizziness and reports no past history. He rates his pain 6/10 and his heart rate is 120 beats per minute, systolic blood pressure is 150/radial and his respiratory rate is 24 breaths per minute.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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4. A 51-year-old Australian born male presents by private car with a 3 day history of lethargy and associated right scapula pain. The pain is non-radiating, but he states it is similar to a "heart attack". He has no nausea or vomiting, but is very diaphoretic with a strong pulse. His blood pressure is recorded as 152/92, heart rate is 78 beats per minute, pulse oximetry is 97 percent and temperature is 35.3°C. The patient's past history includes the insertion of 5 stents.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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5. A 53-year-old Yugoslav male presents via ambulance complaining of one week of intermittent chest pain. On arrival he is bradycardic with a heart rate of 50 beats per minute and is hypotensive at 85/R (radial pulse). He was given 600 mcg of Atropine by the paramedics. He says he was treated at the same hospital 1 year earlier for a "STEMI" (S-T segment elevation acute myocardial infarction).

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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6. A 53-year-old Australian born male presents via ambulance complaining of central chest pain, radiating to his jaw when mowing the lawn at home. The paramedics gave him 1 ½ sublingual Anginine, a Glyceryl Trinitrate patch and Aspirin. He continues to have "chest heaviness" on arrival and is reported to have a blood pressure of 140/R (radial pulse) and a heart rate of 70 beats per minute, which was shown to be in a normal sinus rhythm on the ambulance electrocardiograph. The patient's de facto wife says he has a history of 2 ventricular fibrillation arrests, 2 heart attacks with insertion of stents.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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7. A 61-year-old married Maltese male presents via ambulance having woken 4 hours ago with central chest to diaphragmatic pain. He was complaining of left arm numbness and shortness of breath when he called the ambulance. The paramedics gave him 1 ½ Anginine with good relief. On arrival the patient is diaphoretic and continues to complain of chest pain 4/10. His systolic blood pressure is 220/R (radial pulse). Past history includes Type 1 diabetes mellitus.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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8. A 69-year old married Greek male presents via ambulance complaining of 3 days of "crushing" chest pain. He reports nausea and vomiting for the last 3 hours, at which time the pain became "burning" in his chest. His general practitioner did a Troponin level, which was 21.4. He has been given Aspirin, Maxolon, Morphine 5 mg and a Glyceryl Trinitrate patch prior to arrival. Radially, the paramedics found his blood pressure to be 110/R. He now rates his chest pain 3/10.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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9. A 70-year-old married Croatian male presents via ambulance complaining of 6/10 chest pain, shortness of breath and nausea. The pain started 4 hours earlier and has not eased at all with 2 Panadeine Forte an hour earlier or 20 mg Morphine the paramedics gave him intravenously en route. His heart rate is 104 beats per minute and blood pressure is 150/95. The patient's hospital card shows he had an anterior acute myocardial infarction treated with coronary artery bypass graft surgery in 2 coronary arteries 12 years ago.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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10. A 78-year-old married Italian male presents by private car complaining 6 hours of central chest pain and shortness of breath. He has a past history of angina and a positive family history for heart disease. His heart rate is 96 beats per minute and blood pressure is 180/100.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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11. An 81-year-old Greek male presents via ambulance from his local doctor complaining of a few days of central chest pain. It has been resolving with his Anginine until today, which caused him to go to his local doctor. The doctor did an electrocardiograph which showed some S-T segment changes on sinus rhythm. His pain has improved, but he continues to have central, non-radiating pain after Glyceryl Trinitrate and Morphine. His blood pressure is found to be 95/60 and heart rate is 70 beats per minute and regular. The patient has a history of ischaemic heart disease, hypertension, coronary artery bypass grafts and chronic obstructed pulmonary disease.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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12. An 81-year-old married Irish male presents via ambulance with central chest pain that has resolved with intravenous Morphine. After the Morphine, the paramedics gave him Aspirin and called through to the emergency department's "BAT" phone stating the patient has S-T segment elevation in electrocardiograph leads II and III. His heart rate is 102 beats per minute and blood pressure is 115/R (radial pulse).

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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13. An 83-year-old married Macedonian male with a history of dementia presents via ambulance following 2 hours of central chest pain this afternoon. The paramedics called the emergency "BAT" phone to warn of the patient's arrival after finding S-T depression in Leads I and II on his electrocardiograph. His blood pressure is 140/R (radial pulse) and heart rate is 92 beats per minute and irregular.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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Females

1. A 45-year-old never married Australian-born female presents via the ambulance complaining of a single episode of chest discomfort she scored as 6 out of 10 a fortnight ago. At the time, she was assessed, managed and discharged from another major hospital's emergency department. Today, she presents with central chest pain which she rates 6 out of a maximum of 10, radiating to her left arm, which is associated with shortness of breath and diaphoresis. The paramedics gave her Anginine and Aspirin en route and she is now pain-free. Her heart rate is 104 beats per minute and blood pressure is 130/85.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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2. A 46-year-old Russian widow presents via ambulance complaining of intermittent central, non-radiating chest pain with shortness of breath overnight. She is now pain-free, although continues to complain of nausea. Her heart rate is 60 beats per minute and blood pressure is recorded at 105/R (radial pulse). She has no cardiac history, but smokes 1 packet of cigarettes per day.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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3. A 49-year-old never married Swedish born female presents by private car complaining right-sided lower rib to right upper quadrant sharp pain, which is radiating through to her back. She has shortness of breath, but no nausea. She felt minimal pain yesterday, but awoke today with severe pain which she rates 8/10. Her heart rate is 120 beats per minute, respiratory rate is 20 breaths per minute and her pulse oximetry is 100 percent.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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4. A 51-year-old married, Australian born female presents via ambulance from a rural hospital complaining of having woken with "sore muscles in chest" this morning. She went to her local doctor who telephoned through the following results: Troponin = 0.61, Creatine kinase = 256, Electrocardiogram = normal sinus rhythm. Her heart rate is 86 beats per minute on arrival. The admitting Cardiology Medical Unit was notified of her intended transfer. She has a past medical history of polymyalgia, hyperlipidaemia and hypertension. The patient was given Aspirin at her local hospital, but continues to complain of central chest "soreness" similar to what she experienced in the morning.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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5. A 52-year-old never married Aboriginal female presents via ambulance from her local doctor's office complaining of chest pain since early this morning. She says the pain was radiating into her jaw and she was sweaty when she had pain. The pain resolved with sublingual Anginine given by her doctor. She has a past medical history of diabetes, renal calculi and had a normal stress test approximately 5 years ago.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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6. A 54-year-old married Australian born female presents via ambulance complaining of pain in her arm and pallor for 30 minutes. She is unable to say if she had chest pain. First ECG showed no abnormalities, however, it now shows the development of S-T segment elevation in Lead III and the precordial leads. Troponin levels were reported by her general practitioner as elevated. She is overweight and smokes. She is currently pain-free with a Glyceryl Trinitrate patch in situ. Her heart rate is "strong" and "regular" at 78 beats per minute.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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7. A 57-year-old married Australian born woman arrives by private car complaining of central chest and back discomfort since straining to open her bowels this morning. The pain remains constant. She reports a past medical history of hypertension, neuralgia, hypercholesterolaemia and asthma. Her heart rate is 62 beats per minute and her blood pressure is 125/R (radial pulse).

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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8. A 60-year-old separated German woman presents via ambulance complaining of 1 day of intermittent chest pain radiating through to her back and possibly down her right arm. She is finding it difficult to recall where she felt the pain, but denies any shortness of breath or diaphoresis. She says she has felt nauseated and has vomited since onset of the pain. On arrival, the patient's blood pressure is recorded at 160/R (radial pulse), her heart rate is 90 with sinus rhythm and peaked T waves on Lead III on the continuous cardiac monitor. The paramedics gave her 1/2 a tablet of sublingual Glyceryl Trinitrate and Aspirin en route and she is now pain-free. She has no relevant past medical history.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each ranking only once										
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9. A 66-year-old separated Macedonian female presents having driven herself to hospital complaining of 1 hour of central, left-side “squeezing” chest pain. She has a history of angina and is very upset at the triage window after having had an altercation with her son tonight. She says she had to call the police after he tried to smash a window of her house. Her heart rate is 124 beats per minute and blood pressure is 155/90.

Please state the ATS triage category you would assign after reading this patient’s triage notes: _____

Use each ranking only once										
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10. A 69-year-old married Italian male presents via ambulance having awoken 7 hours ago complaining of central chest pain, radiating to his left arm. He took 5 sprays of Glyceryl Trinitrate (GTN) with minimal relief. He was given further GTN and 2.5 mg Morphine en route with little effect. The patient reports a history of an acute myocardial infarction which was previously treated with coronary artery bypass grafts. His heart rate is 108 on arrival and blood pressure is recorded at 105/R (radial pulse).

Please state the ATS triage category you would assign after reading this patient’s triage notes: _____

Use each ranking only once										
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11. A 74-year-old married Greek female presents via private car from her local doctor with central chest pain. The pain has been constant and non-radiating for the last 3 days. She has no shortness of breath, no cardiac history and no history of recent trauma. Her blood pressure is recorded at 160/95 and heart rate is 92 and irregular.

Please state the ATS triage category you would assign after reading this patient’s triage notes: _____

Use each ranking only once										
----------------------------	--	--	--	--	--	--	--	--	--	--

12. A 79-year-old Australian-born widow presents via ambulance from an affiliated smaller hospital’s in-patient medical ward where she had been an inpatient for 2 days with pneumonia and a urinary tract infection. The Medical Registrar has been advised of her arrival and says she is “for active management, but not for resuscitation”. At the time of leaving the other hospital, she had chest “heaviness” and was in respiratory distress with a blood pressure (BP) of 80/systolic. At triage, she reports no chest pain, but is in respiratory distress, with her BP remaining 80/systolic.

Please state the ATS triage category you would assign after reading this patient’s triage notes: _____

Use each ranking only once										
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13. An 80-year-old Australian widow has been transferred from the Surgical Outpatients' Department in a wheelchair complaining of acute shortness of breath and chest pain, which she says is radiating up her neck and through to her back. Her past medical history includes a 3.5 cm abdominal aortic aneurysm, 2 acute myocardial infarctions, and non-insulin dependent diabetes mellitus. She now has left hand numbness and a heart rate of 90 beats per minute.

Please state the ATS triage category you would assign after reading this patient's triage notes: _____

Use each marking only once										
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End of patient scenarios

Triage Expert Nurse Review of Survey Design and Patient Scenarios

Can you please comment on the following or tick (✓) the circle where requested?

1. How long did it take you to complete the triage of these patient scenarios? _____
(approximate minutes)

2. Please rate your agreement for the following statements:

	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
a. The wording of the survey questions was easy to understand	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. The Participant Demographic section was easy to complete	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. The patient scenarios reflected possible real life situations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Each patient scenario was clearly written?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. If you have any comments on any scenario, you please list the scenario (e.g., *Male 11* or *Female 2*) and make any comment you feel is necessary to improve the quality of the survey below?

4. Please rate your agreement for the following statements:

	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
a. It was easy to assign a triage decision (ATS category) using the patient scenarios provided	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. The table for ranking of cues used in triage decision was easy to understand	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. Do you have any other comments you would like to make to improve the quality of this survey?

Thank you very much for taking the time to give us your expert opinion regarding this survey.

Yours sincerely,

Lisa, Linda & Karen.

Appendix J

Permission / right to reproduce published article in the thesis – Chapter 2

Kuhn L, Page K, Davidson PM, Worrall-Carter L. Triaging women with acute coronary syndrome: a review of the literature. The Journal of cardiovascular nursing. 2011 Sep-Oct;26(5):395-407. DOI: 10.1097/JCN.0b013e31820598f6 [License No.: 3164160889425, License Date: Jun 08, 2013, Wolters Kluwer Health]

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Volume Number	26
Issue Number	5
Type of Use	Dissertation/Thesis
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Licensed content author	Lisa Kuhn, Linda Worrall-Carter, John Ward, Karen Page
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Appendix N

Grey and online literature related to the thesis

Online literature related to the candidature and thesis

Wilcken H. AMI patients undertriaged. Cardiology update. Twitter post; 17 October, 2013.

Retrieved from: <http://www.cardiologyupdate.com.au/latest-news/ami-patients-undertriaged> [retrieved 17.10.2013].

The screenshot shows the homepage of the 'Cardiology update' website. The main article is titled 'AMI patients undertriaged' by Hugo Wilcken, dated 17 October 2013. The article text discusses a study by Victorian researchers finding that more than one in three AMI patients are undertriaged. It mentions that non-ambulance arrivals were less likely to be triaged correctly and that the time to treatment was double for those who did not arrive by ambulance. The article also notes that area of residence impacted on treatment onset, with undertriaged patients in regional areas seen on average eight minutes faster than their metropolitan counterparts. A video player is embedded in the article, showing a person in a white coat running. The website has a navigation bar with links to Home, Latest News, Other News, Clinical News, Policies, Opinion, and Jobs. There is a search bar and a 'Become a member' link. The footer of the website shows the URL 'http://www.cardiologyupdate.com.au/latest-news/ami-patients-undertriaged' and the date '17/10/2013'.

Cardiology update

Brilliant machines are helping local LNG compete on a global scale.

AMI patients undertriaged

17 October 2013 Hugo Wilcken

Poor triage of patients suffering acute myocardial infarction is delaying critical treatment, say Victorian researchers.

More than one in three Victorian patients with AMI is being triaged at a lower category than needed for optimum treatment. **data from over 21,000 AMI patients showed.**

This may be due to differences of presentation in some groups such as women or elderly patients who are more likely to have atypical symptoms, the authors from the Australian Catholic University in Melbourne said.

Not arriving by ambulance was another major factor inhibiting the speed of care delivery for AMI, their analysis showed.

Non-ambulance arrivals were less likely to be triaged correctly, but even if the triage was correct it took an extra two minutes for them to be treated. For those undertriaged, time to treatment was double for those who did not arrive by ambulance.

Area of residence also impacted on treatment onset, with undertriaged patients in regional areas seen on average eight minutes faster than their metropolitan counterparts.

This was not a surprise, the authors said, given the differences in volumes of patients seen between regional and metropolitan emergency departments, but it was nonetheless a rare positive healthcare finding for regional Australia.

However there was a gender disadvantage for regional patients, with men seen on average seven minutes faster than women.

This was consistent with previous Australian research on triage for AMI which found a disadvantage for women, the authors noted.

One of the most significant findings of the study was that if nurses gave correct triage scores to AMI patients, they did receive treatment within an acceptable timeframe, the authors said.

"The problem is that for whatever reason, a significant portion of patients with AMI are not receiving an adequate triage score for AMI and the associated delayed treatment onset may affect cardiovascular outcomes for affected patients," they warned.

Australian Emergency Nursing Journal 2013; online

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Appendix O

Grey and online literature related to the thesis

Grey literature related to the candidature and thesis

Goss S. Nurses leading clinical research. Postgraduate Opportunities, Advertising Feature, The Age, 29 June, 2009, p. 4.

4 THE AGE Monday, June 29, 2009

Postgraduate Opportunities

ADVERTISING FEATURE

Nurses are often at the forefront of patient care and now many more are leading research projects, based on their bedside observations. SUE GOSS reports.

Nurses leading clinical research

Nurses have been working in teams with other health professionals since the day they graduated. However, despite their immense experience in the ward and unparalleled clinical understanding, nurses rarely see themselves as postgraduate material. They upgrade their qualifications but what do masters and PhDs have to do with them?

Professor Linda Worrell-Carter, the director of the Centre for Nursing Research at St Vincent's Hospital, says that academic pathways in a clinical environment are a necessary way for senior nurses to share their observations with all health professionals.

"This has to be embedded within a health care organisation rather than attempting to do it only through a university," she says.

"We collaborate with the nursing school at ACU and the supervisors for our students are within the team at the Centre for Nursing Research. What is more exciting at St Vincent's is that many senior doctors see the value of our senior nurses collaborating with — and in fact leading — clinical research projects.

"The projects which our masters and PhD students are working on have been funded directly to the Nursing Research Centre and we collaborate with specialists such as cardiologists and psychiatrists in our research."

One of the nurses now completing her PhD at the centre is Lisa Kuhn, whose work concerns the timely management for recognising and responding to serious heart problems in women who present in the emergency department.

"I have been specialising in emergency since I began nursing and everything I've done since has centred around improving the care of the patient from early arrival. Heart disease in men has improved greatly over the last few years but the symptoms in women are different and they don't recognise them early enough," says Ms Kuhn.

"I'm developing myself as a researcher in my own field, but I would like all nurses to know that whatever they are interested in they should go for it!"

Nurses are with patients all day. They can talk medical language, patient language and policy language. Now they can talk research language and say what must be implemented, also interpreting other people's research and putting that into practice.

"You might find many nurses in a hospital working out a unique way of caring for patients and if even 20 per cent of them realised they can change things, our health care would be magnificent," says Ms Kuhn. "They have to study why it works, how it works and get the news out there in a clinically proven way."

Prof Worrell-Carter says that setting the sights higher for nurses with masters and PhDs is essential to keeping senior nurses with enormous experience in the clinical area.

"Working in the Centre for Nursing Research we can offer a different career pathway for nurses who want to stay in the profession and do research as part of their clinical work and as part of postgraduate study.

"There is also a new generation of nurses coming through and they want to look well ahead, have some diversity in their role and plan their career, and it is important that we have something to offer."



PhD student Lisa Kuhn (centre), with her supervisors Professor Linda Worrell-Carter (left) and Dr Karen Page (right) on the cardiac ward at St Vincent's Hospital.

Appendix P

Research portfolio

The following information relates to matters not already addressed in this thesis.

Funding

Kuhn L, Worrall-Carter L, Page K, Davidson P. 2008. Diagnose and Manage Early: Women's Ischaemia and Infarction (DAME II Study). Australian Postgraduate Award with Stipend (2008, \$19,800; 2009, \$20,247; 2010, ~\$22,400; 2011; 6 months' extension, \$12,000)

Kuhn L, Worrall-Carter L, Page K, Davidson P. 2008. Diagnose and Manage Early: Women's Ischaemia and Infarction (DAME II Study). Royal College of Nursing, Australia, National Research and Scholarship Fund: Bequest Fund for Research (\$10,000-, April 2008)

Worrall-Carter L, Jelinek G, Page K, Swift R, **Kuhn L**, Ski C. 2010. Optimising Early Assessment and Outcomes in Acute Coronary Syndrome: ACU Faculty Research Grant (\$15,000-).

Kuhn L. Faculty Research Student Scheme (FRSSS), ACU National (\$1000-, September 2010)

Kuhn L. Faculty Research Student Scheme (FRSSS), ACU National (\$990-, September 2009)

Kuhn L. Faculty Research Student Scheme (FRSSS), ACU National (\$1000-, September 2008)

Peer review activities

Thesis Examinations

Master of Nursing (Research), Victoria University, The 48 hour patient – who reaps the rewards? (R. Crozier, 2008)

Bachelor of Health Science – Nursing (Honours), Victoria University, Cardiac rehabilitation patient's subjective experience of chest pain post percutaneous transluminal coronary angioplasty. (J. O'Dowd, 2008)

Registered and regular peer reviewer for scientific, blind, peer-reviewed journals

American Journal of Critical Care Nursing, Australian Critical Care Nursing Journal, Australasian Emergency Nursing Journal, British Journal of Cardiac Nursing, Journal of Clinical Nursing, Journal of Emergency Nursing and Collegian

Educational activities (one or more full days)

1-day seminar by Dr Nick Hopwood, UTS, Writing a thesis and for publication, 1st May, 2013, ACU, Melbourne

1-day seminar by Dr Nick Hopwood, UTS, Academic practice and development for HDRs, 20th March, 2013, ACU, Melbourne

NVIVO 9.2 Higher Degree Research 2 Day Workshop. Convened at ACU, 11th – 12th April, 2012; Melbourne, Australia

Higher Degree Research Student Workshop. Convened at St Vincent's/ACU Centre for Nursing Research, 16th – 17th June, 2010; Melbourne, Australia

Statistics for research workers. A/Prof Ian Gordon and Dr Sue Finch, Statistical Consulting Centre, The University of Melbourne, 11th – 18th November, 2009; Melbourne, Australia

Design and analysis of surveys. Dr Graham Hepworth, Statistical Consulting Centre, The University of Melbourne, 9th – 14th July, 2009; Melbourne, Australia

Developing a Protocol for a Systematic Review. One day workshop, Australasian Cochrane Centre, 12th June, 2008; Melbourne, Australia

Introduction to Analysis, One day workshop. Australasian Cochrane Centre, 13th June, 2008; Melbourne, Australia

Seminar program for research students and staff engaged in (or planning) a research project. Conducted by Dr Pat Bazeley, Quality of Life & Social Justice Flagship, ACU National, 11th June, 2008; Melbourne, Australia

Professional affiliations

Member, Australian College of Critical Care Nurses (ACCCN)

Member, Australasian Cardiovascular Nursing College (ACNC)

Member, Australian Nursing Federation (ANF)

Member, College of Emergency Nursing Australia (CENA)

Affiliate Member, Cardiac Society of Australia and New Zealand (CSANZ)

Member, Australian College of Nursing (MACN)