Using evidence to inform equity assessment in health services

A cardiac rehabilitation case study

Jennifer Anne Stewart Williams

BCom(Econ), MCom(Econ), GradDipClinEpi

A thesis submitted for the degree of Doctor of Philosophy

School of Medicine and Public Health

Faculty of Health

University of Newcastle

March 2008
Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying subject to the provisions of the Copyright Act 1968.

I hereby certify that the work embodied in this Thesis is the result of original research, the greater part of which was completed subsequent to admission to candidature for the degree.

______________________________
Jennifer Anne Stewart Williams

Date
Acknowledgements

First and foremost I wish to thank my supervisors, Professor Julie Byles and Drs Kerry Inder and Amanda Neil for their intellectual input, support, encouragement, mentoring and friendship. I am indebted to Julie for her insightful brilliance and for keeping me focused, to Kerry for providing me with a firm basis upon which to build the empirical analyses, and to Amanda who introduced me to the Oaxaca-Blinder decomposition methods. Sincere appreciation is also expressed to Richard Gibson and Dr Ian Watson for their generosity and quality advice during our statistical consultations and to Jane McDonald for her valuable assistance in formatting the dissertation. I would also like to mention a friend and colleague, the late Janet Fisher, who patiently worked with me in the early days to better inform my knowledge of the Heart and Stroke Register. Additionally gratitude is also expressed to Dr Rosemary Aldrich who encouraged me to take the step from health administration to health equity research.

To family and friends, I thank you for your love and patience. In particular, I thank my friend, Dr Helen Tolhurst, with whom I have shared many ups and downs during our concurrent doctoral journeys. From the bottom of my heart, I thank my three adult sons, Tristram, Evan and Gareth, and daughter-in-law Melissa, and my wonderful ever-supportive husband, Brian, who is my rock, giving unreserved love and encouragement, and instilling in me confidence to aim for excellence. The person whom I have known the longest and to whom I owe a huge debt of gratitude is my mother, Clare Stewart, who in her ninth decade, never ceases to be an inspiration to all who know and love her.

Finally I wish to dedicate this thesis to the memory of my father, Trevor Stewart, who died soon after my enrolment in the doctoral program.
# Table of Contents

Declaration ...................................................................................................................... ii
Acknowledgements ...................................................................................................... iii
Synopsis ........................................................................................................................... 1

Chapter 1  Introduction and conceptual framework ............................................ 3
  1.1  Introduction .................................................................................................... 3
  1.2  Background .................................................................................................. 5
    1.2.1  Rationale and significance .................................................................... 5
    1.2.2  Aims ....................................................................................................... 7
    1.2.3  Chapter overview .................................................................................. 8
  1.3  Equity and equality ...................................................................................... 10
    1.3.1  Conceptual definitions .......................................................................... 10
    1.3.2  Health inequities and inequalities ..................................................... 13
    1.3.3  Social determinants of health ............................................................. 15
  1.4  Evidence-based decision-making .................................................................. 16
  1.5  Behavioural Model ....................................................................................... 19
    1.5.1  Development and application ............................................................ 19
    1.5.2  Determinants of service utilisation .................................................... 23
    1.5.3  Dimensions of access ........................................................................... 27
    1.5.4  Application to EACR study .................................................................. 31
  1.6  Chapter summary ........................................................................................ 32

Chapter 2  Literature review and discussion ...................................................... 33
  2.1  Contextual background ............................................................................... 33
    2.1.1  Equity in health .................................................................................... 33
    2.1.2  Evidence-based best practice CR ....................................................... 35
    2.1.3  Under-representation in CR ................................................................. 36
    2.1.4  Case study ............................................................................................. 37
  2.2  Methods ......................................................................................................... 39
    2.2.1  Aims ....................................................................................................... 39
    2.2.2  Cardiac rehabilitation search and yield ............................................. 40
    2.2.3  Equity assessment search and yield ................................................... 41
  2.3  Results ............................................................................................................ 42
    2.3.1  Cardiac rehabilitation review ............................................................... 42
    2.3.2  Equity assessment review .................................................................... 54
  2.4  Discussion ..................................................................................................... 58
  2.5  Chapter summary ........................................................................................ 63

Chapter 3  The EACR Cohort ................................................................................ 65
  3.1  Objectives ..................................................................................................... 65
  3.2  Study design ................................................................................................ 66
  3.3  Hospital setting ............................................................................................. 68
  3.4  EACR data sources ....................................................................................... 71
    3.4.1  The JHH CR cohort ............................................................................... 72
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.2 Admitted Patients Data Collection</td>
<td>80</td>
</tr>
<tr>
<td>3.4.3 The Population Census</td>
<td>83</td>
</tr>
<tr>
<td>3.5 Establishing the EACR cohort</td>
<td>85</td>
</tr>
<tr>
<td>3.5.1 Eligibility for analysing the predictors of invitation</td>
<td>89</td>
</tr>
<tr>
<td>3.5.2 Eligibility for analysing the predictors of attendance</td>
<td>92</td>
</tr>
<tr>
<td>3.5.3 Eligibility for analysing the predictors of survival</td>
<td>95</td>
</tr>
<tr>
<td>3.6 Describing the EACR cohort</td>
<td>98</td>
</tr>
<tr>
<td>3.6.1 Social factors</td>
<td>99</td>
</tr>
<tr>
<td>3.6.2 Hospital events</td>
<td>103</td>
</tr>
<tr>
<td>3.6.3 Index cardiac diagnosis</td>
<td>105</td>
</tr>
<tr>
<td>3.6.4 Identifying co-morbidities and cardiac risk factors</td>
<td>107</td>
</tr>
<tr>
<td>3.6.5 Adjusting for co-morbidities</td>
<td>110</td>
</tr>
<tr>
<td>3.6.6 Power and sample size</td>
<td>115</td>
</tr>
<tr>
<td>3.7 Chapter summary</td>
<td>116</td>
</tr>
<tr>
<td>Chapter 4 Statistical methodologies</td>
<td>117</td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>117</td>
</tr>
<tr>
<td>4.1.1 Causation</td>
<td>117</td>
</tr>
<tr>
<td>4.1.2 Explaining inequalities</td>
<td>118</td>
</tr>
<tr>
<td>4.2 Statistical methods in health services research</td>
<td>120</td>
</tr>
<tr>
<td>4.2.1 Regression analysis</td>
<td>120</td>
</tr>
<tr>
<td>4.2.2 Blinder-Oaxaca linear decomposition</td>
<td>131</td>
</tr>
<tr>
<td>4.2.3 Non-linear decomposition</td>
<td>139</td>
</tr>
<tr>
<td>4.2.4 Non-linear continuous variables</td>
<td>144</td>
</tr>
<tr>
<td>4.2.5 Summary of methods</td>
<td>148</td>
</tr>
<tr>
<td>4.3 Chapter summary</td>
<td>149</td>
</tr>
<tr>
<td>Chapter 5 Factors associated with invitation</td>
<td>151</td>
</tr>
<tr>
<td>5.1 Introduction</td>
<td>151</td>
</tr>
<tr>
<td>5.1.1 Rationale</td>
<td>151</td>
</tr>
<tr>
<td>5.1.2 Study population</td>
<td>152</td>
</tr>
<tr>
<td>5.2 Methods</td>
<td>153</td>
</tr>
<tr>
<td>5.2.1 Aims and research questions</td>
<td>154</td>
</tr>
<tr>
<td>5.2.2 Conceptual framework</td>
<td>154</td>
</tr>
<tr>
<td>5.2.3 Statistical methods</td>
<td>159</td>
</tr>
<tr>
<td>5.3 Results: Logistic regression analysis of invitation</td>
<td>165</td>
</tr>
<tr>
<td>5.3.1 Uni-variable analyses of system variables</td>
<td>167</td>
</tr>
<tr>
<td>5.3.2 Uni-variable analyses of predisposing variables</td>
<td>169</td>
</tr>
<tr>
<td>5.3.3 Uni-variable analyses of enabling variables</td>
<td>176</td>
</tr>
<tr>
<td>5.3.4 Uni-variable analyses of need variables</td>
<td>176</td>
</tr>
<tr>
<td>5.3.5 Variables selected for multi-variable analyses of invitation</td>
<td>186</td>
</tr>
<tr>
<td>5.3.6 Logistic regression system sub-model</td>
<td>196</td>
</tr>
<tr>
<td>5.3.7 Logistic regression predisposing sub-model</td>
<td>198</td>
</tr>
</tbody>
</table>
Chapter 5

5.3.8 Logistic regression enabling sub-model ................................................. 203
5.3.9 Logistic regression need sub-model......................................................... 203
5.3.10 Best-fit logistic regression composite model ........................................ 211
5.4 Discussion ................................................................................................. 221
5.5 Chapter summary ..................................................................................... 228

Chapter 6

Chapter 6 Factors associated with attendance .............................................. 229
6.1 Introduction ............................................................................................... 229
6.1.1 Rationale ............................................................................................ 229
6.1.2 Eligibility ............................................................................................ 230
6.1.3 Measures of attendance ...................................................................... 230
6.1.4 Program entry .................................................................................... 231
6.1.5 Program participation ......................................................................... 232
6.2 Methods .................................................................................................... 233
6.2.1 Aims and research questions .............................................................. 233
6.2.2 Conceptual framework ....................................................................... 234
6.2.3 Statistical methods ............................................................................ 237
6.3 Results: Logistic regression analysis of attendance .................................. 238
6.3.1 Uni-variable analyses ......................................................................... 239
6.3.2 Variables selected for analyses of entry and participation .................. 251
6.3.3 Interaction .......................................................................................... 257
6.3.4 Logistic regression models for entry .................................................. 259
6.3.5 Logistic regression models for participation ........................................ 270
6.4 Discussion ............................................................................................... 276
6.5 Chapter summary ..................................................................................... 279

Chapter 7

Chapter 7 Factors associated with survival .................................................. 281
7.1 Introduction ............................................................................................. 281
7.1.1 Rationale ........................................................................................... 281
7.1.2 Censoring .......................................................................................... 283
7.1.3 Eligibility for survival analysis ............................................................ 284
7.1.4 Exposure to CR .................................................................................. 285
7.1.5 Cause of death ................................................................................... 289
7.1.6 Assumptions ...................................................................................... 291
7.2 Methods .................................................................................................. 292
7.2.1 Aims and research questions .............................................................. 292
7.2.2 Selection of variables ........................................................................ 293
7.2.3 Statistical methods ............................................................................ 298
7.3 Survival Analysis ..................................................................................... 301
7.3.1 Uni-variable analysis .......................................................................... 302
7.3.2 Multi-variable analysis ....................................................................... 312
7.4 Discussion ............................................................................................... 332
7.5 Chapter summary ..................................................................................... 337

Chapter 8

Chapter 8 Decomposing gender inequalities .................................................. 339
8.1 Introduction ............................................................................................. 339
8.1.1 Gender inequality in the literature ..................................................339
8.1.2 Policy implications .............................................................................340
8.1.3 Gender inequality in the EACR study ............................................342
8.1.4 Blinder-Oaxaca ...................................................................................344
8.2 Methods .......................................................................................................345
  8.2.1 Aims and research questions ............................................................346
8.2.2 Statistical methods .............................................................................346
8.3 Results: Logistic decomposition analysis of invitation .........................349
8.4 Discussion ....................................................................................................356
8.5 Chapter summary ......................................................................................358
Chapter 9 Conclusions .........................................................................................361
References ........................................................................................................369
Appendix 1: EACR Study literature search ............................................................399
  Cardiac rehabilitation ....................................................................................399
  equity assessment ..........................................................................................402
Appendix 2: Sub-classification of clinical codes .............................................405
Appendix 3: Charlson Co-morbidity Index ....................................................407
Appendix 4: Power calculations ......................................................................409
Appendix 5: Adjusting for co-morbidities .....................................................417
Appendix 6: Kaplan-Meier plots ..................................................................419
Table of Tables

Table 1.1 Dimensions of access to medical care and suggested indicators ..........................30
Table 2.1 Some factors that impact positively upon potential and actual utilisation of CR ..........................................................53
Table 3.1 Data components of the JHH CR Assessment Template ........................................75
Table 3.2 ICD Versions 9 and 10 CHD codes in JHH CR study ...........................................78
Table 3.3 ICD-10-AM codes used in the EACR study ......................................................88
Table 3.4 Distribution of premature deaths by invitation, percentage in parentheses (n=2,375) .................................................................97
Table 3.5 Premature deaths distribution by gender and invitation, percentage in parentheses (n=186) ..................................................................................97
Table 3.6 Distribution of index cardiac diagnosis by gender, percentages in parentheses (n=2,375) .............................................................................107
Table 3.7 Clinical markers of co-morbidities identified in the EACR cohort .....................109
Table 3.8 Distribution of Charlson Index weights and cumulative percentages in EACR cohort, individual percentages in parentheses (n=2,275) .........................................................112
Table 3.9 Distribution of collapsed categories of Charlson Index weights, percentages in parentheses (n=2,275) ........................................................113
Table 3.10 Methods used to adjust for co-morbid illness ..................................................114
Table 3.11 Distribution of coded co-morbidities, percentages in parentheses (n=2,375) .................................................................................................................115
Table 5.1 Behavioural framework of factors relevant to CR utilisation .............................156
Table 5.2 Factors relevant to invitation as potential access to CR ....................................158
Table 5.3 Unadjusted uni-variable logistic regression of co-morbidities associated with invitation (n=2,375) ........................................................................182
Table 5.4 Unadjusted uni-variable logistic regression of risk factors associated with invitation (n=2,375) ........................................................................184
Table 5.5 Unadjusted uni-variable logistic regression of interventions associated with invitation (n=2,375) ........................................................................185
Table 5.6 Results of unadjusted uni-variable analyses of variables considered for multivariable logistic regression of factors associated with invitation (n=2,375) ................188
Table 5.7 Likelihood ratio tests comparing models with main effects and interaction terms for CR invitation (n=2,375) ................................................................................192
Table 5.8 Distribution of males by invitation and IRSD, percentage in parentheses (n=1,487) .........................................................................................193
Table 5.9 Distribution of females by invitation and IRSD, percentage in parentheses (n=868) ...............................................................................................193
Table 5.10 Distribution of low IRSD patients by gender and invitation, percentage in parentheses (n=634) .................................................................193
Table 5.11 Forward selection and adjustment of variables: system sub-model by invitation (n=2,375) ..............................................................197
Table 5.12 Forward selection and adjustment of variables: predisposing sub-model by invitation (n=2,375) ..............................................................199
Table 5.13 Summary statistics for models that differently adjust for co-morbidities ....204
Table 5.14 Forward selection and adjustment of variables: need sub-model by invitation (n=2,375) ..............................................................206
Table 5.15 Forward selection of sub-models: adjusted model for invitation (n=2,375) 213
Table 6.1 Factors relevant to attendance as actual access to CR ................................................................. 235
Table 6.2 Results of unadjusted uni-variable analyses of variables considered for multivariable logistic regression of entry, as defined by attendance at more than one available session of CR (n=1,140) ................................................................................................................ 252
Table 6.3 Results of unadjusted uni-variable analyses of variables considered for multivariable logistic regression of factors associated with participation, as defined by attendance at 85% or more available sessions of CR (n=801) ............................................................. 255
Table 6.4 Likelihood ratio tests comparing models with main effects and interaction terms for CR entry as defined by attendance at more than one session of available CR (n=1,140) ................................................................................................................................. 258
Table 6.5 Likelihood ratio tests comparing models with main effects and interaction terms for CR participation as defined by attendance at 85% or more of available CR session (n=801) ............................................................................................................................................. 258
Table 6.6 Forward selection and adjustment of variables: system sub-model by entry (n=1,140) ......................................................................................................................................................... 259
Table 6.7 Forward selection and adjustment of variables: predisposing sub-model by entry (n=1,140) .................................................................................................................................................. 261
Table 6.8 Forward selection and adjustment of variables: enabling sub-model by entry (n=1,140) ...................................................................................................................................................... 262
Table 6.9 Forward selection and adjustment of variables: need sub-model by entry (n=1,140) ......................................................................................................................................................... 264
Table 6.10 Forward selection of sub-models: adjusted composite model for entry (n=1,140) ................................................................................................................................................................. 267
Table 6.11 Forward selection and adjustment of variables: predisposing sub-model by participation (n=801) ................................................................................................................................................. 271
Table 6.12 Forward selection and adjustment of variables: need sub-model by participation (n=801) .............................................................................................................................................................. 273
Table 6.13 Forward selection of sub-models: adjusted model for participation (n=801) ......................... 274
Table 7.1 Distribution of all-cause mortality within CR exposure groups, percentages in parentheses, unadjusted (n=2,184) ............................................................................................................................................. 287
Table 7.2 Distribution of deaths within CR exposure groups by intervals following index hospitalisation, percentages in parentheses, unadjusted (n=344) ................................................................. 288
Table 7.3 Distribution of cause of death, percentages in parentheses, unadjusted (n=343) .......................................................... 290
Table 7.4 Cumulative deaths and percentages by all-cause and CHD deaths by intervals following index hospitalisation, unadjusted (n=344) ................................................................. 291
Table 7.5 Variables considered for survival analysis ...................................................................................... 295
Table 7.6 Uni-variable Cox regression of invitation, attendance and other factors associated with all-cause mortality (n=2,184) ................................................................................................................. 305
Table 7.7 Multi-variable Cox regression of invitation, attendance and other factors associated with all-cause mortality (n=2,184) ................................................................................................................. 313
Table 7.8 Multi-variable Cox regression of invitation and other factors associated with all-cause mortality (n=2,184) ................................................................................................................. 318
Table 7.9 Multi-variable Cox regression of factors associated with all-cause mortality for males (n=1,390)..................................................................................................................321
Table 7.10 Multi-variable Cox regression of factors associated with all-cause mortality for females (n=794) .................................................................323
Table 7.11 Hazard Ratios Confidence Intervals for all-cause mortality common to both males (n=1,390) and females (n=794) sub-groups ........................................324
Table 7.12 Multi-variable Cox regression of factors associated with all-cause mortality for patients < 65 years at index separation (n=879).........................328
Table 7.13 Multi-variable Cox regression of factors associated with all-cause mortality for patients >= 65 years at index separation (n=1,305).........................329
Table 7.14 Hazard Ratios Confidence Intervals for all-cause mortality common to both <65 (n=879) and >=65 (n=1,305) sub-groups ........................................330
Table 8.1 Non-linear decomposition of gender inequality in CR invitation using male sub-samples to estimate contribution of coefficients (n=2,375)..................351
Table 8.2 Comparative sampling methods for non-linear decomposition of gender inequality in CR invitation due to differences in group characteristics (n=2,375) ....355
Table of Figures

Figure 1.1 Framework for viewing health services utilisation [85] ................................. 24
Figure 1.2 Individual determinants of health service utilisation [85] ............................... 25
Figure 1.3 Conceptual framework for the study of access [86] ........................................ 28
Figure 3.1 Defining the historic prospective cohort for the JHH CR study .................... 79
Figure 3.2 Defining the EACR historic prospective patient cohort for the analysis of invitation ................................................................................................................................. 90
Figure 3.3 Defining the EACR historic prospective patient cohort for the analysis of attendance .................................................................................................................................. 94
Figure 3.4 Defining the EACR historic prospective patient cohort for the survival analysis ........................................................................................................................................ 96
Figure 3.5 Comparative distribution of IRSD for EACR cohort and Australia at ABS Census of Population and Housing 1996 ................................................................. 102
Figure 4.1 Example of football attendance as a confounding variable in heart disease124
Figure 5.1 Predicted probability of invitation by age in unadjusted model ....................... 170
Figure 5.2 Predicted probability of invitation by age transformed in unadjusted model .... 172
Figure 5.3 Predicted probability of invitation by length of stay in days in unadjusted model ............................................................................................................................. 178
Figure 5.4 Predicted probability of invitation by length of stay transformed in unadjusted model ..................................................................................................................... 180
Figure 5.5 Predicted probability of invitation by age for males unadjusted ........................ 194
Figure 5.6 Predicted probability of invitation by age for females unadjusted ................. 195
Figure 5.7 Predicted probability of invitation by age and gender unadjusted .................. 196
Figure 5.8 Predicted probability of invitation by age transformed in fully adjusted model ............................................................................................................................... 218
Figure 5.9 Predicted probability of invitation by length of stay transformed in fully adjusted model ................................................................................................................ 219
Figure 6.1 Predicted probability of entry by age in unadjusted model ............................. 244
Figure 6.2 Predicted probability of entry by age transformed in unadjusted model ... 245
Figure 6.3 Predicted probability of participation by age in unadjusted model ............... 246
Figure 6.4 Predicted probability of participation by age transformed in unadjusted model ............................................................................................................................... 248
Figure 6.5 Predicted probability of participation by length of stay in days in unadjusted model ..................................................................................................................... 249
Figure 6.6 Predicted probability of participation by length of stay transformed in unadjusted model ............................................................................................................... 250
Figure 6.7 Predicted probability of entry by age transformed in fully adjusted model269
Figure 6.8 Predicted probability of participation by age transformed in fully adjusted model ............................................................................................................................... 275
Figure 7.1 EACR historic prospective patient cohort for the survival analysis ............... 285
Figure 7.2 Kaplan-Meier survival plot for all-cause mortality unadjusted (n=2,184) . 303
Figure 7.3 Kaplan-Meier survival plots all-cause death by CR exposure unadjusted . 304
Synopsis

The Equity Assessment Cardiac Rehabilitation (EACR) study uses a hospital outpatient cardiac rehabilitation (CR) program as the vehicle for demonstrating ways of using evidence to inform equity assessment in health services. This is achieved by demonstrating methods which policy and decision-makers can use to measure, deconstruct and interpret inequalities in service access, defined by selection and utilisation. Some of these methods are familiar in epidemiology and health services research and others less so.

Chapter 1 defines equity and equality in health, and introduces the conceptual classification used here to analyse socio-behavioural factors that impact upon utilisation of the hospital outpatient CR program. Chapter 2 reports the results of a search of the international literature on ways of similarly addressing inequalities and inequities in healthcare services and programs, and also factors associated with the recruitment and retention of patients to hospital outpatient CR programs. Chapter 3 describes the methods used in the development and construction of the EACR patient cohort. Chapter 4 explains the theoretical basis for the statistical applications demonstrated in this dissertation.

Analyses are conducted on the cohort in accordance with patients’ index hospitalisation. Chapter 5 applies multi-variable logistic regression to analyse factors associated with CR invitation and Chapter 6 uses similar methods to analyse factors associated with attendance for invited patients and Chapter 7 tests the effects of invitation and attendance on survival in accordance with age and gender. Using the results of the regression models presented in Chapter 5, Chapter 8 demonstrates post-estimation non-linear decomposition of gender-based inequalities in invitation to CR. This is a novel application in health services research. Chapter 9 concludes this body of work.