



MONASH University

Individual, community and societal burden following acute hand and wrist injury

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BOccTherapy (Hons)

A thesis submitted in fulfilment of the requirement of the
Doctor of Philosophy
(Thesis by Publications)

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Health is more than the absence of disease; it is about economics, education, environment, empowerment, and community. The health and well-being of the people is critically dependent upon the health system that services them. It must provide the best possible health with the least disparities and respond equally well to everyone.

Joycelyn Elders, Former Surgeon General of the United States

Abstract

Background:

Injuries to the hand and wrist are common, accounting for between 10-30% of all emergency department presentations. While the majority of individuals with these injuries will recover full function, some will require a long period of recovery and rehabilitation, and a proportion will face the potential of long-term disability. The burden placed on the individual, community and society as a result of these injuries can be significant, however, the actual cost of these injuries in Australia is mostly unknown. Accurate estimates of the direct (i.e. medical), indirect (i.e. lost productivity) and intangible (i.e. reduction in quality of life) costs of this patient group are imperative to identify and propose strategies to minimise the impact observed by the individual patients, their families, and broader society.

Aim:

The primary aim of this thesis is to explore and provide insight into the individual, community and societal burden of acute hand and wrist injuries from an international and Australian perspective. It aims to answer six research questions that were developed as a result of clinical experiences, reviews of published literature and findings of earlier investigations completed.

Methods:

A variety of methods have been employed to answer the research questions developed within this thesis. These include a systematic review, three retrospective cost-of-illness studies, one pilot, prospective longitudinal cost-of-illness study, and a qualitative study. The study settings included two Australian public health services located in Melbourne, Victoria.

Results:

The results of this thesis are presented using an adapted version of the Injury Outcome Framework (IOF) relating specifically to acute hand and wrist injuries. The investigations conducted confirm that these injuries are common (5% of emergency department presentations), result in significant direct costs at one public health service (\$2 million per year of direct costs in the emergency

department alone; \$1.2 million per year for injuries requiring surgical intervention and outpatient resources; \$790,000 per year for sport and exercise-related injuries), and have the potential to lead to significant indirect and intangible costs. Indirect costs, which were found to account for between 64.5-68% of the total cost burden, failure to attend appointments, and injuries sustained from lacerations and Australian Rules Football were identified as key drivers in observed cost burden. The integrated findings of the investigations in this thesis, which found that males aged in their economically productive years are more likely to sustain acute hand and wrist injuries, align with previously published international literature.

Conclusion:

The research conducted within this thesis has established that hand and wrist injuries have the potential to lead to substantial costs and impacts for the individual patient, their families, the workplace, the public health system and broader society. The key implications arising from this thesis are that allied health professionals working in hand therapy have an important role to play in both researching and potentially reducing the burden of acute hand and wrist injuries at the individual, community and societal levels which could lead to better outcomes for all.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature:

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Date: 30th of November 2019

Publications during enrolment

Peer reviewed publications arising from this thesis

Robinson, L. S., & O'Brien, L. (2019). A description and cost-analysis of Emergency Department attendances for hand and wrist injuries. *Emergency Medicine Australasia*, *31*(5), 772-779. doi: 10.1111/1742-6723.13246

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Robinson, L. S., Brown, T., & O'Brien, L. (2019, under review). Is capturing the cost acute fractures, tendon and nerve injuries of the hand and wrist from the individual and societal perspective feasible? *Hand Therapy*

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Peer reviewed publications co-authored by the candidate in research beyond this thesis

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Young, N., Terrington, N., Francis, D., & **Robinson, L. S.** (2018). Orthotic management of fixed flexion deformity of the proximal interphalangeal joint following traumatic injury: A systematic review. *Hong Kong Journal of Occupational Therapy*, 31(1), 3-13. doi: 10.1177/1569186118764067

O'Brien, L., **Robinson, L.**, & O'Sullivan, H. (2018). Cumulative Incidence of Carpal Instability in the Second Year after a Fall onto Outstretched Hand. *Journal of Hand Therapy*, 31(1), 149. doi: 10.1016/j.jht.2017.11.014

Cole, T., **Robinson, L.**, Romero, L., & O'Brien, L. (2017). Effectiveness of interventions to improve therapy adherence in people with upper limb conditions: A systematic review. *Journal of Hand Therapy*, 32(2), 175-183. doi: 10.1016/j.ht.2017.11.040

O'Brien, L., **Robinson, L. S.**, O'Sullivan, H., & Lim, E. (2016). Carpal instability after a fall onto outstretched hand: an incidence study. *Hand*, 11(1 suppl), 138S.

Book chapters co-authored by the candidate beyond this thesis

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Government reports co-authored by the candidate beyond this thesis

Moore, T., Bourke-Taylor, H., Greenland, N., McDougall, S., Bromfield, L., **Robinson, L.** &

Brown, T., (2019). Young carers and their engagement with education: 'No space in my brain to learn'. Adelaide, SA: University of South Australia.

N.B. this report is under Embargo until National launch scheduled for February 2020.

Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes three original papers published in peer reviewed journals and four submitted publications. The core theme of the thesis is the individual, community and societal burden of acute hand and wrist injuries. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Faculty of Medicine, Nursing and Health Sciences (Department of Occupational Therapy) under the supervision of Associate Professor Lisa O'Brien and Associate Professor Ted Brown.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research. In the case of Chapters 3 to 9 my contribution to the work involved the following:

Thesis Chapter	Publication Title	Publication Status	Nature and extent of candidate's contribution	Co-author name(s) and extent of co-author's contribution*	Co-author(s), Monash student Y/N
3	Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review	<i>Accepted Injury</i>	Conception of the study, undertook data collection, led data analysis and synthesis, drafted and prepared the manuscript for publication 80%	Sarkies, M: Contributed independent data extraction 5%	Y
				Brown, T.: Contributed to the conception of the study, assisted in drafting of the manuscript 5%	N
				O'Brien, L.: Contributed to the conception of the study, supervised data analysis, assisted in drafting of the manuscript 10%	N

4	Description and cost - analysis of emergency department attendances for hand and wrist injuries	<i>Accepted</i> Emergency Medicine Australasia	Conception of the study, undertook data collection, led data analysis and synthesis, drafted and prepared the manuscript for publication 85%	O'Brien, L.: Contributed to the conception of the study, supervised data analysis, assisted in drafting of the manuscript 15%	N
5	Cost-analysis, epidemiology and post-operative resource use for surgically managed acute hand and wrist injuries with emergency department presentation	<i>Under review</i> Journal of Hand Therapy	Conception of the study, undertook data collection, led data analysis and synthesis, drafted and prepared the manuscript for publication 85%	Brown, T.: Supervised data analysis, assisted in drafting of the manuscript 5% O'Brien, L.: Contributed to the conception of the study, supervised data analysis, assisted in drafting of the manuscript 10%	N N
6	Profile and cost-analysis of sport and physical activity related hand and wrist injuries with Emergency Department presentation	<i>Under review</i> Journal of Science and Medicine in Sport	Conception of the study, undertook data collection, led data analysis and synthesis, drafted and prepared the manuscript for publication 85%	Brown, T.: Supervised data analysis, assisted in drafting of the manuscript 5% O'Brien, L.: Contributed to the conception of the study, supervised data analysis, assisted in drafting of the manuscript 10%	N N
7	Is capturing the cost acute fractures, tendon and nerve injuries of the hand and wrist from the individual and societal perspective feasible	<i>Under review</i> Hand Therapy	Contributed to the conception of the study, undertook data collection, led data analysis and synthesis, drafted and prepared the manuscript for publication 72.5%	Brown, T.: Supervised data analysis, assisted in drafting of the manuscript 2.5% O'Brien, L.: Conception of the study idea, supervised data analysis, assisted in drafting of the manuscript 25%	N N
8	Workplace, Family and Social Participation following acute hand injury	<i>Under review</i> Journal of Hand Therapy	Contributed to the conception of the study, undertook data collection, led data analysis and synthesis, drafted and prepared the	Robinson, A.: Contributed independent data analysis, assisted in drafting of the manuscript 5% O'Brien, L.: Conception of the study idea, supervised data	N N

			manuscript for publication 65%	analysis, assisted in drafting of the manuscript 30%	
				Brown, T.: Contributed to the conception of the viewpoint and assisted in drafting of the manuscript 7.5%	N
9	Embracing an occupational perspective: Occupation-based interventions in hand therapy practice	<i>Accepted</i> Australian Occupational Therapy Journal	Conception of the viewpoint, drafted and prepared the manuscript for publication 85%	O'Brien, L.: Contributed to the conception of the viewpoint and assisted in drafting of the manuscript 7.5%	N

I have renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis. In addition, chapters that contain submitted or published papers are presented in a manner that ensures the thesis is iterative and linear for the reader rather than by publication date. I have used AMA referencing throughout this thesis as the majority of the seven manuscripts submitted used this or a similar format. In order to maintain consistency, this was selected as the most appropriate referencing style.

Student signature:

Date: 30th of November 2019

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author, I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor signature:

Date: 30th of November 2019

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During my candidature, several papers were presented at conferences and published in peer-reviewed journals. I am very thankful for all the constructive comments, feedback and questions that allowed me to strengthen and further develop my work. Many thanks go to all the anonymous participants who generously donated their time, thoughts, and personal stories, for no little or no reward to help others. Your willingness to help out a PhD student was greatly appreciated.

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Table of Contents

<i>Abstract</i>	4
<i>Declaration</i>	6
<i>Publications during enrolment</i>	7
<i>Acknowledgements</i>	13
<i>Chapter 1 Introduction</i>	25
1.1 General Introduction.....	25
1.2 Overview of Thesis Structure.....	27
1.3 Background.....	30
1.3.1 Healthcare expenditure in Australia.....	30
1.3.2 Defining acute hand and wrist injuries.....	31
1.3.3 Health economics.....	32
1.3.3.1 Cost-of-illness studies.....	34
1.3.3.1.1 Types of costs.....	36
1.3.3.1.1.1 Direct costs.....	36
1.3.3.1.1.2 Indirect costs.....	37
1.3.3.1.1.3 Intangible costs.....	40
1.3.3.1.2 Approaches of cost-of-illness studies.....	41
1.3.3.1.2.1 Prevalence and incidence-based approaches of cost-of-illness studies.....	42
1.3.3.1.2.2 Prospective and retrospective approaches of cost-of-illness studies.....	42
1.3.3.1.2.3 Top-down and bottom-up approaches of cost-of-illness studies.....	43
1.3.3.1.2.4 Perspectives of cost-of-illness studies.....	43
1.3.3.1.2.5 Methodological considerations for cost-of-illness studies.....	47
1.3.3.2 Health economic evaluations.....	47
1.3.3.2.1 Cost-effectiveness analysis.....	48
1.3.3.2.2 Cost-utility analysis.....	49
1.3.3.2.3 Cost-benefit analysis.....	49
1.3.3.2.4 Cost-minimisation analysis.....	50
1.3.4 Occupational therapy and hand therapy context.....	50
1.3.5 Conceptual frameworks and models that describe the burden and impact of injury at the individual, community and societal levels.....	51
1.3.5.1 Three dimensions of economic evaluation of clinical care.....	53
1.3.5.2 The International Classification of Functioning, Disability and Health.....	55
1.3.5.3 The Canadian Model of Occupational Performance and Engagement.....	57
1.3.5.4 List of All Deficits Framework.....	59
1.3.5.5 Injury Outcome Framework.....	60

1.4	Chapter Summary	62
1.5	References.....	64
<i>Chapter 2 Methodology</i>		69
2.1	Chapter Introduction.....	69
2.2	Research Questions.....	69
2.3	Study Settings	71
2.4	Materials and Methods	72
2.4.1	Research Question 1: In international literature, what are the reported direct, indirect and intangible costs of acute hand and wrist injuries?.....	72
2.4.2	Research Question 2: What are the total direct costs associated with resource use in the emergency departments of one Australian public health service for individuals presenting with a hand or wrist injury?	73
2.4.3	Research Question 3: What are the total direct costs associated with resource use for individuals requiring surgical intervention and outpatient follow-up following an emergency department presentation for an acute hand or wrist injury?.....	75
2.4.4	Research Question 4: What are the total direct costs associated with resource use for with individuals that require treatment for a hand or wrist injury sustained as a result of participation in a sport or exercise at one Australian public hospital service.....	77
2.4.5	Research Question 5: Is capturing the cost of acute fracture, tendon and nerve injuries of the hand and wrist from an individual and societal perspective feasible at two Australian public hospital health services?	78
2.4.6	Research Question 6: How do individuals with acute hand or wrist injury experience burden of injury?.....	80
2.5	Rationale for Viewpoint Article	81
2.6	Chapter Summary	82
2.7	References.....	83
<i>Chapter 3 Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review</i>		84
3.1	Chapter Introduction.....	84
3.2	Chapter Aims	84
3.3	Chapter Contents	84
3.4	Manuscript I.....	85
3.4.1	Abstract.....	85
3.4.2	Introduction	86
3.4.3	Methodology.....	88
3.4.4	Results	91
3.4.5	Discussion.....	95
3.4.5.1	Limitations of this review	100
3.4.6	Conclusion.....	100
3.4.7	Manuscript I: Tables.....	102
3.4.8	Manuscript I: Figure	111
3.5	Additional Commentary	112

3.6	Impacts of the Study	113
3.7	Chapter Summary	114
3.8	References.....	117
<i>Chapter 4 Description and cost-analysis of emergency department attendances for hand and wrist</i>		
<i>injuries</i>		<i>121</i>
4.1	Chapter Introduction.....	121
4.2	Chapter Aims	122
4.3	Chapter Contents	122
4.4	Manuscript II	122
4.4.1	Abstract.....	123
4.4.2	Introduction	123
4.4.3	Objectives	125
4.4.4	Methods	125
4.4.5	Results	128
4.4.6	Discussion.....	131
4.4.7	Limitations.....	133
4.4.8	Conclusions	134
4.4.9	Acknowledgements	134
4.4.10	Manuscript II Figures	136
4.4.11	Manuscript II Tables.....	138
4.4.12	Manuscript II Appendices	141
4.4.13	Manuscript II Supporting Information	142
4.5	Impacts of the Study	144
4.6	Chapter Summary	145
4.7	References.....	147
<i>Chapter 5 Cost, profile and post-operative resource use for surgically managed acute hand and wrist</i>		
<i>injuries with emergency department presentation.....</i>		<i>149</i>
5.1	Chapter Introduction.....	149
5.2	Chapter Aims	150
5.3	Chapter Contents	150
5.4	Manuscript III	150
5.4.1	Abstract.....	151
5.4.2	Introduction	151
5.4.3	Methods	153
5.4.4	Results	156
5.4.4.1	Patient care journey	157
5.4.4.2	Post-operative medical and hand therapy appointments	158
5.4.5	Discussion.....	158
5.4.6	Limitations and future research	160

5.4.7	Conclusion	161
5.4.8	Acknowledgements	162
5.4.9	Manuscript III Tables	163
5.4.10	Manuscript III Figures	170
5.4.11	Manuscript III Appendices	172
5.5	Impacts of the Study	174
5.6	Chapter Summary	174
5.7	References.....	177
<i>Chapter 6 Profile and cost of sport and exercise-related hand and wrist injuries with Emergency</i>		
<i>Department presentation</i>		<i>179</i>
6.1	Chapter Introduction.....	179
6.2	Chapter Aims	179
6.3	Chapter Contents	180
6.4	Manuscript IV	180
6.4.1	Abstract.....	180
6.4.2	Introduction	181
6.4.3	Methods	183
6.4.4	Results	185
6.4.5	Discussion.....	187
6.4.6	Conclusions	191
6.4.7	Acknowledgements	191
6.4.8	Manuscript IV Figures.....	192
6.4.9	Manuscript IV Tables	194
6.4.10	Manuscript IV Supplementary Documents	196
6.4.11	Manuscript IV Appendices.....	199
6.5	Impacts of the Study	201
6.6	Chapter Summary	201
6.7	References.....	204
<i>Chapter 7 Is it feasible to accurately capture the cost of acute hand and wrist injuries from the</i>		
<i>individual and societal perspective?.....</i>		<i>206</i>
7.1	Chapter Introduction.....	206
7.2	Chapter Aims	207
7.3	Chapter Contents	207
7.4	Manuscript V	207
7.4.1	Abstract.....	207
7.4.2	Introduction	208
7.4.3	Aims.....	210
7.4.4	Methods	211
7.4.5	Results	213

7.4.6	Discussion.....	216
7.4.7	Conclusion.....	219
7.4.8	Acknowledgements	219
7.4.9	Manuscript V Tables	220
7.4.10	Manuscript V Figures	226
7.5	Impacts of the Study	227
7.6	Chapter Summary	227
7.7	References.....	229
<i>Chapter 8 Workplace, family and social participation following acute hand injury</i>		<i>231</i>
8.1	Chapter Introduction.....	231
8.2	Chapter Aims	232
8.3	Chapter Contents	232
8.4	Manuscript VI.....	232
8.4.1	Abstract.....	232
8.4.2	Introduction	233
8.4.3	Background.....	233
8.4.4	Purpose of the study	234
8.4.5	Methods	234
8.4.6	Results	236
8.4.7	Discussion.....	244
8.4.8	Conclusion.....	247
8.4.9	Acknowledgements	247
8.4.10	Manuscript VI Tables	249
8.4.11	Manuscript VI Figures.....	251
8.4.12	Manuscript VI Appendices.....	252
8.5	Impacts of the Study	253
8.6	Chapter Summary	253
8.7	References.....	255
<i>Chapter 9 Embracing an occupational perspective: Occupation-based interventions in hand therapy practice</i>		<i>257</i>
9.1	Chapter Introduction.....	257
9.2	Viewpoint Aims.....	258
9.3	Chapter Contents	258
9.4	Manuscript VII.....	259
9.4.1	Abstract.....	259
9.4.2	Introduction	259
9.4.3	The challenge for hand therapy: Duality of focus	260
9.4.4	Theoretical and practice models: A prompt to occupation-based intervention	262
9.4.5	Occupation-based interventions	263

9.4.6	Conclusion	265
9.5	Additional Commentary	266
9.6	Impacts of the Study	266
9.7	Chapter Summary	266
9.8	References.....	268
<i>Chapter 10 Integrated discussion</i>		269
10.1	Introduction.....	269
10.2	Revisiting the Research Questions	269
10.3	Individual, Community and Societal Burden of Acute Hand and Wrist Injuries	278
10.3.1	Individual level impacts.....	278
10.3.1.1	Body structures and functions.....	278
10.3.1.2	Activity.....	281
10.3.1.3	Participation	283
10.3.2	Community level impacts.....	285
10.3.2.1	Family.....	286
10.3.2.2	Carers	287
10.3.2.3	Workplace	288
10.3.3	Societal level impacts	289
10.3.3.1	Economy.....	289
10.3.3.2	Individual perspective	290
10.3.3.3	Firm/business perspective	291
10.3.4	Healthcare system.....	293
10.3.4.1	Health service use.....	293
10.3.4.1.1	Demographic profile.....	295
10.3.4.2	Compensation system.....	297
10.4	Limitations of this Thesis	297
10.5	References.....	299
<i>Chapter 11 Conclusion</i>		302

<i>Appendices</i>	306
12.1 Appendix 1 – Ethics approvals	306
12.2 Appendix 2 – Participant information and consent form.....	312
12.3 Appendix 3 – Successful competitive grant/scholarship applications.....	317
12.4 Appendix 4 – Awards received during candidature.....	318
12.5 Appendix 5 – Invited speaker invitations received during candidature.....	319
12.6 Appendix 6 – Cover pages of peer reviewed publications arising from this thesis.....	319

List of Tables

Table 1.1 Commonly Used Methods to Calculate Indirect Cost	39
Table 1.2. Potential Intangible Costs of Acute Hand or Wrist Injuries	41
Table 1.3. Perspectives and Included Cost Component Categories in Cost-of-illness Studies	44
Table 1.4 Measurement of Cost and Consequences in Economic Evaluation.....	48
Table 1.5 Aims and Applications of the ICF	57
Table 1.6 Definition of IOF Domains.....	61
Table 3.1 Cost-of-Illness Studies: Methodological Characteristics.....	102
Table 3.2 Cost-of-Illness Studies: Reported Cost Components	104
Table 3.3 Cost-of-Illness Studies: Per Case Mean Estimates of Reported and Net Present Value Direct, Indirect and Total Costs.....	106
Table 3.4 Health Economic Evaluations: Methodological Characteristics	107
Table 3.5 Health Economic Evaluations: Reported Cost Components	109
Table 3.6 Health Economic Evaluations: Per Case Mean Estimates of Reported and Net Present Value Direct, Indirect and Total Costs.....	110
Table 3.7 Application of the Three Dimensions of Healthcare Economic Evaluations to Systematic Review Findings	112
Table 4.1 Demographics of Individuals Presenting with a Hand or Wrist Injury	138
Table 4.2 Cost Of ICD-10 Injury Types.....	140
Table 5.1 Cost and Outpatient Resource Use	163
Table 5.2 Simplified and Detailed Mechanism of Injury	165
Table 5.3 Demographic Details of Included Cases.....	167
Table 5.4 Zone of Injury for Muscle/Tendon Injuries	168
Table 5.5 Regression Results using Cost as the Criterion	169
Table 6.1 Demographics of Included Cases	194
Table 7.1 Demographics of Participants at Entry and on Completion of Six-Week Measures.....	220
Table 7.2 Mean Scores and Standard Deviations of SF-36 Subscales	224
Table 7.3 Hours Spent in Weekly Tasks and Reported Impact from Injury (SF-H&L) at Six Weeks.....	225
Table 7.4 Source and Hours of Assistance in Household Work (SF-H&L) at Six Weeks.....	225
Table 8.1 Participant Demographics and Injury Details.....	249
Table 8.2 Commonly Reported Occupations Impacted by Hand or Wrist Injury	250
Table 10.1 Key and Supplementary Research Questions and Key Findings.....	271

List of Figures

Figure 1.1 Healthcare Flow Diagram of Acute Injury.....	46
Figure 1.2 Three Dimensions of Economic Evaluation of Clinical Care	53
Figure 1.3 Three Dimensions of Clinical Economics.....	54
Figure 1.4 Three Dimensions of Healthcare Economic Evaluations.....	54
Figure 1.5 Interactions Between the Components of the ICF Framework	56
Figure 1.6 The Canadian Model of Occupational Performance and Engagement (CMOP-E).....	58
Figure 1.7 LOAD Framework	60
Figure 1.8 Injury Outcome Framework	62
Figure 3.1 PRISMA Flow Diagram of Study Selection Process	111
Figure 4.1 Simplified Flow of Health Funding in the Australian Domestic Health Sector.....	136
Figure 4.2 Top Three Mechanisms of Injury Categories (Combined Monthly Totals).....	137
Figure 5.1 Patient Care Journey.....	170
Figure 5.2 Location of Fracture and Nerve Injuries	171
Figure 6.1 Patient Pathway	192
Figure 6.2 Injury Location (a) All Injuries; (b) Fractures; (c) Joint Injuries	193
Figure 7.1 Participant, Recruitment, Retention, and Survey Completion	226
Figure 8.1 Content Analysis Methodology Flowchart	251
Figure 10.1 Adapted Injury Outcome Framework (IOF) for Acute Hand and Wrist Injuries.....	270

List of Appendices

Appendix 4.1 ICD-10 Codes Used for Case Identification	141
Appendix 5.1 ICD-10 Codes used for Case Identification	172
Appendix 5.2 Included and Excluded Cost Components	173
Appendix 6.1 ICD-10 Codes used for Case Identification	199
Appendix 6.2 Included Cost Components	200
Appendix 8.1 Semi-Structured Interview Guide	252
Appendix S6.1 Outpatient Medical and Therapy (Hand Therapy/Physiotherapy) Resource Use for Cases that had Specialist Care within the Study Setting (n=243)	196
Appendix S6.2 Cost by Treatment Location	197
Appendix S6.3 Cost by Patient Pathway	198

Chapter 1

Introduction

In this chapter, I will:

- describe the background to this collection of published works and how I developed an interest in exploring individual, community and societal burden following acute hand and wrist injury;
- provide an outline of the structure of this thesis;
- discuss the historical context of the cost of health in Australia;
- define acute hand and wrist injuries;
- provide an overview of the principles, concepts and evaluation methods of health economics;
- discuss the occupational therapy and hand therapy context of this research; and
- summarise the models and frameworks that can be used when conducting cost-of-illness studies and health economic evaluations and justify my selection of the Injury Outcome Framework (IOF) as the central framework used in this thesis.

1.1 General Introduction

The motivation for this thesis arose from my clinical practice as a hand therapist at the Royal Melbourne Hospital, Victoria, Australia, a public hospital that specialises in adult trauma. As a therapist, I observed that many patients who presented with acute hand or wrist injuries that did not have insurance (e.g. income protection insurance) or a compensation claim (e.g. WorkCover or the Transport Accident Commission (TAC) compensation) were more likely to experience involuntary prolonged time away from work, experience a loss in income combined with higher health-care costs, and present with additional physical and mental health concerns. This client-group also appeared to be more likely to report relationship issues with family, friends and employers citing triggers such as monetary concerns, disengagement in leisure activities, lack of support, or changes in mood. Likewise, they would frequently report decreased participation in meaningful activities of daily living, weight gain, boredom, low mood and overall decreased satisfaction with life.

My initial interest in the individual, community and societal burden of acute hand and wrist injuries can be traced back to one client that I managed in the clinical setting. He was a twenty-seven-year-old male who sustained a Zone II flexor tendon injury while washing a wine glass at home. He worked full time in construction as a subcontractor. He had a wife, who was not working, and a nine-month-old baby. He did not have income protection insurance at the time of his injury and was informed by his surgeon that he would not be able to complete his regular work duties for a minimum of three months. During this patient's journey, I witnessed him become frustrated, depressed, angry and upset at the circumstances that he found himself in. He reported that he was required to use what little savings he had, ended up putting on a considerable amount of weight, could not assist his wife in the care for his child, and was ineligible for social security benefits (e.g. Centrelink).

What stood out for me as a clear distinction of this client managed by the public health system and a client who had a compensation claim with WorkCover or the TAC, was the access to a return to work program and regular income payments. Return to work programs, which are commonly completed by occupational therapists, would allow clients to resume their usual productivity roles, albeit in a reduced capacity with alternative duties if they were appropriate. This process, which has been shown to have positive health benefits, appears to minimise most long-term burden on the individual, community and society in response to lower costs placed on the public health system, employers, families and potential need for additional health care services (e.g. psychologists). Without a coordinated return to work program, I observed clients attempting to return to work performing tasks against medical advice with high risk of re-injury. This placed the patient in a position that may lead to longer treatment timeframes or additional surgeries at a significant cost to society.

Looking deeper into the issue, I found that the lack of evidence and systematic approach in reporting the economic and humanistic burden of an acute hand or wrist injury limited my understanding of the overall impact of this condition, at an individual, community and societal level. This did not sit comfortably with my occupational therapy training and my profession's commitment to holistic client-centred practice, as successful treatment was often viewed as an improvement in

range of motion or strength, and not overcoming the individual burden of the occupational performance issues and difficulties faced by these clients. This reality is likely due to restrictions placed on therapists who were unable to provide comprehensive and holistic care due to economic constraints (e.g. limited funding, insufficient time and inadequate staffing levels).

This thesis, which aims to explore the individual, community and societal burden of acute hand and wrist injuries aims to estimate the direct, indirect and intangible costs observed from various perspectives. The evidence produced may be used to support business cases for additional resources for the management of acute hand and wrist injuries (e.g. an on-call advanced hand therapy practitioner in the emergency department) by highlighting the cost and consequences of these injuries. Additionally, it is hoped that the generation of credible cost data may be used by clinicians and researchers working in the field of hand therapy to leverage funding for future studies, given this field currently receives minimal research grant funding.

1.2 Overview of Thesis Structure

As this is a thesis by peer-reviewed works, it is formatted, in the main body of the thesis, as a series of six refereed research papers and one viewpoint article. Three of these are published, and four are currently under review. Included manuscripts are published in, or have been submitted to, a range of peer-reviewed journals and are presented in the format required by the respective journal (with additional commentary) in Chapters 3 to 9.

This chapter provides an overview of the principles, concepts and evaluation methods of health economics as they were used to design, interpret and present findings. Also, it outlines the models and frameworks used in cost and burden of injury/illness research and defends the model that will underpin the discussion of integrated findings in this thesis. Chapter 2 details the separate methodologies used in each of the publication chapters that form this thesis.

The first of the publications, included as Chapter 3, is a systematic review on the direct, indirect, and intangible costs of acute hand and wrist injuries. The accompanying commentary in this chapter maps the findings against Bombardier and Eisenberg's three dimensions of healthcare economic evaluation model¹ to highlight the current gaps in knowledge. It provides an overview of the methodologies and cost components used in the international literature to measure the direct, indirect and intangible costs of acute hand and wrist injuries in addition to net present (at the time of publication, i.e. 2016) value estimates per injury.

Chapters 4 to 7 present individual cost-of-illness publications that were completed using participant data sourced from Alfred Health, a large public health network located in the Melbourne metropolitan region. Chapter 4 presents a retrospective cost-of-illness study which provides data on the profile and direct medical costs associated with hand and wrist injuries presenting at two emergency departments. It provides a total estimate of healthcare costs from the perspective of Alfred Health, in addition to mean costs per presentation and detailed demographic data for two financial year periods (1st of July to the 30th of June).

Chapter 5, the second cost-of-illness study, presents a retrospective cost-of-illness study which provides estimates of the direct costs associated with resource use for patients that required surgical intervention and outpatient follow-up within Alfred Health following an emergency department presentation for an acute hand or wrist injury. It includes a total estimate of yearly healthcare costs from the perspective of Alfred Health, in addition to median costs per patient presentation for all and stratified injury types, detailed demographic data (including patient care journey which considered health resources used prior and after treatment within Alfred Health) and insight into the post-operative medical and specialist hand therapy resources used by this patient population. In this study, I sought to determine if any significant predictors of the total cost for this patient population existed.

Chapter 6, the third cost-of-illness study, presents a retrospective cost-of-illness study which provides estimates of the direct costs associated with resources used for patients presenting with an

acute hand or wrist injury sustained from participation in sport- or exercise-related activities. It includes a total estimate of yearly healthcare costs from the perspective of Alfred Health, in addition to median costs per presentation for all and stratified sport and exercise categories, detailed demographic data (included patient care journey) and the inpatient and outpatient resources used by this patient population.

Chapter 7, the final cost-of-illness study, analyses the learnings from a pilot, prospective longitudinal cost-of-illness study which aimed to provide insights into the feasibility for collecting data regarding direct and intangible costs experienced at an individual patient perspective in an acute hand and wrist injury population.

Chapter 8 presents a qualitative investigation which examines the patients' experience of the burden of acute hand and wrist injuries, with a specific focus on the indirect and intangible costs encountered, and the effects on the workplace, family context and social participation. Building on from the findings of early interviews conducted as part of this investigation, Chapter 9 presents a viewpoint article which promotes the idea of adopting a duality of focus on both body structures and functions related to the presenting injury or condition, and the unique occupational being attached to the hand as a way to reduce the burden experienced by our clients (e.g. indirect and intangible costs).

Chapter 10 presents an integrated discussion drawn from all the research projects using an adapted version of the Injury Outcome Framework (IOF) which relates explicitly to acute hand and wrist injuries. It also provides suggestions for future research directions and clinical implications for those working in the field of hand therapy.

Finally, Chapter 11 presents the conclusions of this thesis, summarises the original contributions this work has made to the knowledge and understanding of the individual, community and societal burden of acute hand and wrist injuries and provides suggestions for future research directions.

The appendices contain several documents relevant to this body of research, including ethics certificates from all involved agencies, a summary of publications and competitive grants and awards received during the period of candidature. It also provides the cover page of published manuscripts relating to the research presented in this thesis.

1.3 Background

1.3.1 Healthcare expenditure in Australia

Since the late nineteenth century, the health of people living in wealthy nations has improved tremendously. In the last century, life expectancy at birth in Australia has increased dramatically for both sexes². When comparing data collected in 1881-1890 with 2015-2017, males and females can be expected to live around 33- and 34-years longer, respectively³. It is widely accepted that improvements in housing, nutrition, clean water and hygiene have contributed to this increase through a reduction in communicable diseases, rather than medical care. However, preventative medicine and curative interventions have been shown to contribute to improved health⁴. This improvement in health, however, comes at a price.

Over the past 30 years, healthcare expenditure has increased dramatically throughout the world⁵. Global costs directly related to healthcare have risen in absolute terms and as a percentage of gross domestic product⁶. With finite healthcare budgets and increases in the cost of new drugs, devices and diagnostics, governments and healthcare associations are under extreme pressure to ensure that they achieve the best value for money while maintaining high-quality healthcare. Controlling rising health care costs is an essential topic on the political agenda, which is often viewed as a complex and sensitive societal issue^{7, 8}. This type of discussion has led to increasing interest from policy-makers in cost-of-illness studies, health economic evaluations and cost-saving prevention or intervention strategies when multiple treatment options and scarcity of resources in a healthcare system exist^{9, 10}.

In Australia, the total expenditure on health was estimated at \$170.4 billion in 2015-16, an increase of 3.6% in real terms (after adjusting for inflation) from the previous 2014-15 period¹¹. Estimated expenditure per person in 2015-16 was \$7,096, which equates to \$151 more in real terms than the previous year estimates. In 2015-16, government expenditure totalled \$115 billion, or 67% of all health expenditure in Australia. Forty-one per cent (\$47 billion) was allocated to public hospital services, a 5.7% growth on the previous year. The non-government sector (e.g. private health insurance schemes and individuals) share of total expenditure was \$56 billion or 33% of total health expenditure.

Over the past decade, individual health expenditure in Australia was the fastest growing area of non-government expenditure¹². This monetary outlay by individuals increased by an average of 6.2% a year in real terms, compared with 5.3% for all non-government sources. This growth was faster than total health spending (5.0%) in the same timeframe. With the progressively increasing cost of healthcare in both the government and non-government sectors, it is important to consider the financial and non-financial economic costs of acute intentional and unintentional injuries, from both the individual, community and society perspective so that limited health resources might be used more efficiently¹³.

As this thesis aims to provide insight into the financial and non-financial economic costs of acute hand and wrist injuries from individual, community and societal perspectives, it is important to provide an operational definition of '*acute hand and wrist injuries*' in order to contextualise the results. Further, it is important to have an understanding of the principles and concepts of health economics as they were used to design, interpret and present the findings. The following sections in this chapter explore these concepts.

1.3.2 Defining acute hand and wrist injuries

Lyons et al.¹⁴, (2006) provide the operational definition of physical injuries as the “relatively sudden discernible effects due to body tissue damage from energy exchanges or ingestion of toxic substances, but not due to adverse medical events, and obtained from health care settings”^{p.64}. Injuries

are frequently referred to as a heterogeneous health problem, ranging from high frequency, minor injuries (e.g. superficial injury) to low frequency, major injuries (e.g. polytrauma)^{14, 15}. As a result of this immense range, injuries result in a variety of individual patterns of medical consumption and functional outcomes.

Injuries can be classified as acute or chronic. Acute injuries are typically the result of a sudden onset event, with symptoms or deficits that typically stabilise within three months¹⁶. Chronic injuries typically occur because of gradual onset events, such as cumulative trauma disorders, without the presence of low-energy trauma. A general distinction should also be made between unintentional injury (home and leisure, occupational and traffic accidents) and intentional injury (violence and self-inflicted injury)¹⁷.

For the purpose of this thesis, the operational definition of an ‘acute hand or wrist injury’ is an intentional or unintentional injury sustained to one or more hand or wrist structures (including bones, joints, nerves, skin, ligaments, tendons, and blood vessels)¹⁸ as a result of a sudden onset event, with symptoms or deficits that typically begin to stabilise within three months¹⁶. Therefore, chronic hand and wrist conditions, such as arthritis, carpal tunnel syndrome, Dupuytren’s contracture, repetitive motion syndrome, and wrist tendonitis are considered outside the scope of this thesis.

1.3.3 Health economics

Economics is the systematic study of resource allocation mechanisms,¹⁹ and can be applied to any social behaviour or institution where scarcity exists, and there is consequently a need for making choices^{13, 20, 21}. Fundamentally, economics assumes that the behaviour of people and institutions where scarcity exists is somewhat predictable^{19, 22}. Underlying this predictability is the assumption that individuals as a whole act in a way that makes them and/or their families better off rather than worse¹⁹. As resources are essentially limited, choices need to be made about how they will be best utilised²⁰. Economics, as a discipline, is primarily concerned with how these choices will be made in the context of scarcity^{19, 20, 22}.

Health economics lies at the interface of economics and medicine. It applies the discipline of economics to the topic of health and is considered an essential component of modern medicine that provides detailed information regarding costs associated with disease or injury²³⁻²⁶. Health economics aims to “inform decision-makers so that the choices they make maximise health benefits to the population... [it] is not concerned with saving money, but with improving the level and distribution of population health with the resources available”^{19p18}.

When trying to connect ‘health’ and ‘economics’, two statements are commonly considered²⁷. First, health is the most precious good, and to remain in ‘good health’ just about anything should be done. Second, healthcare is in a crisis, and if costs are to increase at the current rate, health might become unaffordable to most people. Although these two statements seem to be contradictory, they both agree that “health is priceless, either in an ethical sense (invaluable) or in a more economic sense (very expensive)”^{27p1}. In this context where health is observed as priceless, it is vital to ensure that the decisions affecting all its components incorporate the social determinants of health²⁸ and the value of occupation^{29, 30} despite the scarcity of resources.

The concept of measuring the economic consequences of illness/injury has a long history and shows no signs of declining²³. The first documented account of measuring economic consequences in the World Health Organization (WHO) records was in 1951, three years after the organisation was established. Winslow (1951)³¹, in his paper titled ‘*The cost of sickness and the price of health*’ advocated the collection and dissemination of evidence regarding the potential economic benefits associated with public health interventions as a method to persuade the relevant governments to allocate more resources to public health. Since this landmark publication, literature reporting the economic consequences of illness has expanded rapidly, particularly in the last four decades³² with increasing interest from clinicians, healthcare providers, health economists, and policy makers³³⁻³⁵.

In order to articulate the potential ways in which disease or injury may lead to burden, it is essential to consider what it is that individuals and society value²³. According to welfare economic theory, and subject to various constraints (such as income and time), individuals, groups or

populations seek to maximise utility, the happiness or satisfaction an individual or a group gains from consuming a good²⁰. This is achieved by combining, to the best effect, consumption (selection, adoption or use) of goods and services²². Some goods can be bought and sold (including healthcare) while others cannot, but nonetheless, have apparent value (e.g. produce that is homegrown that is directly consumed by an individual or group and not sold)²³. In addition to the consumption of goods and services, individuals and populations also generate utility by other means without financial compensation but still involve a cost value²⁰. This may include productivity roles without compensation such as caring for others, spending time with family and friends, or in other forms of leisure^{19, 22}

Research and analysis of economic consequences of burden and treatment outcomes are essential, especially when there are multiple treatment options, and scarcity of resources in the healthcare system²⁵. Estimates of health burden at a population level, whether using a state, national or global focus, has several significant benefits. Firstly, it can attract the attention of policymakers and the community by showing the size of a problem³⁶. Secondly, it can guide policy makers on how to best use limited resources by identifying the major disorders and the exposures resulting in the largest burden^{32, 36}. Finally, it can identify possible strategies for reducing the cost of injury by implementing appropriate preventative action or treatment strategies³².

The following sections will discuss in detail the concepts associated with two common evaluation methods used in health economics, namely cost-of-illness studies and health economic evaluations. A discussion of the principles, concepts and evaluation methods of health economics is presented as they were used to design, interpret and present findings in the studies presented in Chapters 3 to 8.

1.3.3.1 Cost-of-illness studies

Cost-of-illness (COI), often referred to in the literature as the economic cost-of-illness, the economic burden of illness, or the public cost-of-illness, is defined as the impact of a health problem as measured by financial cost, mortality, morbidity, disability, and impact on quality of life³⁷⁻³⁹. COI

studies measure the economic burden of a disease, injury or illness and estimate the maximum amount that could theoretically be saved, or gained, if the disease, injury or illness was to be eradicated⁴⁰. They consider multiple components of a health problem (e.g. cost, mortality and disability), and its impact on a country, specific regions or communities, families, and/or an individual⁴¹.

The cost-of-illness approach was proposed by Rice and colleagues in the late 1960's⁴² and subsequently revised on several occasions^{39, 43}. The approach represents the first codified economic evaluation technique for estimating the societal or population-level burden of disease and remains the most common measurement methodology^{23, 44}. Early incarnations of the COI approach were concerned with measuring overall disease burden, comparing the costs of several collective disease categories, and comparing major categories of direct cost-of-illness^{45, 46}. Over time, the clinical focus of COI studies shifted from collective disease categories to single, narrowly defined health problems. Two possible reasons for this shift include; “a narrowing of research objectives resulting from a shift in funding sources for cost-of-illness studies from public (e.g. government) sources to private (e.g. pharmaceutical industry) sources, and public interest in assessing the cost of high profile diseases”^{45p870}.

The fundamental goal of a COI study is to evaluate the economic burden that an illness or injury inflicts on a society. Jefferson, Demicheli and Mugford⁴⁷, state a COI study aims to be descriptive and itemise, value, and sum the costs of a health problem to give an estimate of its economic burden. This requires recognising, identifying, listing, measuring and valuing the financial and non-financial costs generated by a health problem. In doing so, Clabaugh and Ward⁴⁸ suggest they allow for “useful opportunities for communicating with the public and policymakers on the relative importance of specific diseases and injuries”^{p.20}.

There has been an increasing number of published COI studies over the past 30 years investigating a range of diseases, injuries and illnesses including, but not exclusive to, stroke⁴⁹, Alzheimer's Disease^{50, 51}, rare diseases⁵², diabetes mellitus⁵³, obesity⁵⁴, non-fatal injuries⁵⁵, and breast cancer⁵⁶. These types of studies are seen to be instrumental in public health policy debates as they can

highlight the magnitude of the impact of the injury or illness placed on society or a portion of a society⁴⁰. Further, the results can be used to determine and prioritise which injuries should be given a high priority in a policy agenda-setting and where efforts should be targeted⁴¹. They are also particularly useful for estimating the potential savings of averting a case of an illness, and therefore, can aid in cost-effective analysis, cost-benefit analysis, or illness prevention analysis by providing the baseline costs of maintaining the status quo⁴⁰.

1.3.3.1.1 Types of costs

Cost-of-illness studies traditionally stratify cost into three different categories; direct costs, indirect costs, and intangible costs³⁹. The burden, or total cost, of a health problem, is calculated as the sum of *direct*, *indirect*, and *intangible* costs^{23, 24, 26, 57}.

1.3.3.1.1.1 Direct costs

Direct costs are resources used in the design, implementation, accessing and continuation of healthcare^{20, 22}. They are costs that can be experienced from various perspectives (i.e. society as a whole, the government, the healthcare system, or the individual patient and their families) and are divided into *direct healthcare costs* and *direct non-healthcare costs*^{19, 41}.

Direct healthcare costs are related to resources where expenditure has occurred on the provision of healthcare and include costs that are essential to the implementation, receipt and continuation of health service²⁰. In contrast, *direct non-healthcare costs* are related to resources used in connection with the health service and include the price paid for supplies, maintenance of equipment, electricity, food services and program evaluations^{19, 20}.

Therefore, when considering the direct costs of acute hand or wrist injuries, both the actual medical treatment involved in the management process in addition to other peripheral costs that occur in the treatment setting (i.e. direct non-healthcare costs) must be considered^{24, 26, 57}. It has been suggested that the actual cost of these injuries depends on a range of variables including the location

of the injury, treatment, interventions, complications and salvage, and category of severity of the Hand Injury Severity Scoring System (HISS)^{58, 59}.

Commonly reported components of direct cost expenses for acute hand and wrist injuries are dependent on the treatment methods and interventions used. They may include but are not exclusive to, emergency department visits, surgery and related equipment costs, inpatient admission, internal or external fixation systems, medications, orthoses, tapes, dressings, treatment modalities (e.g. ultrasound, paraffin baths), laboratory testing, imaging, hand therapy, and prolonged postoperative care^{24, 25, 57, 58, 60-72}. With the advancement of surgical techniques, the introduction of new internal fixation systems, regular inflation and increased patient expectations for timely care and recovery, direct costs relating to treatment for many common hand and wrist injuries are observed to be rising all over the western world^{19, 57}.

Calculation of direct healthcare costs estimates is usually performed through the use of health information systems that provide unit cost prices for inpatient, outpatient, and community-based services, interventions or resources^{19, 20, 22}. For the completion of national estimates of the direct cost of acute hand and wrist injuries, the availability of a national injury surveillance system, such as the Dutch Injury Surveillance System (DISS) observed in the Netherlands is required⁶⁰. Currently, Australia does not have such a system, making national estimates of direct costs not possible or feasible. It has been suggested that direct costs account for approximately 20% of the total cost for hand injuries⁷³, however, the absence of a synthesis of published studies means that insight into the probable portion of total costs that direct costs account for is mostly unknown.

1.3.3.1.1.2 Indirect costs

Indirect costs most commonly relate to productivity losses due to morbidity and mortality that are borne by the individual, family, society, community or the employer^{24, 41, 57}. These costs are due to work absences resulting in foregone productivity (absenteeism), reduced work capacity due to impairment related to their condition (presenteeism), and unpaid productivity (reduced possibilities of

performing usual activities at home such as housework or caring for family members) due to illness or disease^{19, 20, 22, 41, 74}. In addition to productivity losses or costs, indirect costs also relate to expenditure and impacts relating to morbidity, mortality, and time spent by family and friends assisting or providing informal care to an individual with a health problem^{41, 61}.

Indirect costs are often harder to calculate than direct costs as it is difficult to measure productivity, when considering presenteeism or unpaid roles, objectively or with certainty⁷⁵. Nonetheless, their inclusion is viewed by many to be vital in providing cost estimates as they often represent a significant percentage of the total cost associated with an illness or injury⁷⁶. When measuring indirect costs, three commonly used methods are discussed, namely the human capital approach, the friction cost approach, and the willingness to pay method. A description of these methods is summarised in Table 1.1.

Table 1.1 Commonly Used Methods to Calculate Indirect Cost

Approach	
<i>Human capital approach</i>	Attempts to quantify the loss of a person's marginal productivity because of a health problem – i.e. the marginal loss in economic output that results from a person not being able to work. This approach assumes that everyone contributes to society's productivity. The monetary value of lost productivity due to a health problem is calculated by multiplying the duration of the illness by the amount that the individual would be earning (i.e. the market price of their labour) during the time they were unable to fulfil their role. ^{20, 23}
<i>Friction cost approach</i>	Used as an alternate to the human capital approach, this method takes into account that productivity losses from absences can be reduced in the short term by using excess capacity in the workforce and in the long term by replacing workers with unemployed individuals or by relocation of employees. ²²
<i>Willingness-to pay</i>	This approach values human life per the amount individuals are willing to pay for a change that reduces the probability of illness or death. It assumes an individual perspective and incorporates all aspects of well-being, including labour and non-labour income, and the value of leisure, pain and suffering. ²²

Indirect costs of acute hand injuries to the individual and to society can be considerable, with suggestions that they frequently surpass direct cost estimates⁵⁷. However, a lack of synthesis of published studies means that insight into the probable portion of total costs that indirect costs represent is mostly unknown.

1.3.3.1.1.3 Intangible costs

Intangible costs extend beyond financial-economic costs and include other sequelae such as functional limitations, decreased social interaction, pain, suffering, and psychological distress^{61, 62, 77}. This spectrum of negative consequences, or decreased quality of life, has the potential to lead to many activity limitations and participation restrictions at a cost to the individual, their families, communities and society.

The inclusion of intangible costs in calculating COI is varied because an accurate quantification in monetary terms is difficult^{23, 39, 43, 78}. Rice and colleagues, the pioneers of this method, do not include the cost measurement of pain and suffering to the individual, albeit acknowledging their contribution to the total cost of disease⁴³. This is one potential limitation to the approach proposed by Rice and colleagues⁴².

While the importance and magnitude of the burden of intangible costs of an injury or illness is increasingly recognised⁵⁷, a systematic understanding of the impact on the individual and society is limited by the lack of understanding of what aspects of a person's life are affected, and what comprehensive measures can be used to measure such burden effectively. As a result, generic tools, such as the Short Form-36 (SF-36)⁷⁹, which is a comprehensive multidimensional measurement of health status concepts that includes a physical functioning scale, two scales that distinguish between role limitations because of 'physical health' or 'mental health', a social functioning scale, a mental health scale, and a vitality and general health perception scale, are commonly used⁵⁷. It is, however, important to recognise that the sequelae associated with an illness or injury combine to create a burden for the individual that although may defy economic calculation, should not detract from their humanitarian consideration in the economic equation⁸⁰. Therefore, careful consideration, attention and analysis should be taken when selecting the most appropriate generic and condition-specific measures to capture intangible costs COI research.

Although a scarcity of literature exists regarding intangible costs in the context of burden of acute hand or wrist injury, there is a significant body of research surrounding psychosocial issues and effects on quality of life following acute hand or wrist injury⁸¹⁻⁸⁶. A summary of potential intangible costs contributing to the burden of hand or wrist injury, as identified in the literature, is presented in Table 1.2. This existing literature can be helpful when deciding what tools or measures are best suited to the measurement of the intangible costs experienced from sustaining a hand or wrist injury.

Table 1.2. Potential Intangible Costs of Acute Hand or Wrist Injuries

Domain	
<i>Cognitive</i>	Flashbacks, nightmares, concentration/attention difficulties, boredom ^{82-83, 85} .
<i>Affective</i>	Anxiety, depression, irritability, hostility, insecurity, frustration, isolation, low self-esteem, low resilience ⁸¹⁻⁸⁶ .
<i>Physical</i>	Motor and/or sensory impairment, sexual dysfunction, phantom sensations ^{82-83, 85-86} .
<i>Behavioural</i>	Avoidance, denial, drug / alcohol dependence, marital distress ⁸⁴ .
<i>Pain</i>	Discomfort, avoidance, social isolation ^{81-83, 85-86} .

Source: Chan & Spencer; Grob, Papadopoulos, Zimmermann, Biemer, & Kovacs; Gustafsson & Ahlstrom; Gustafsson, Hagberg, & Holmefur; Gustafsson, Persson, & Amilon; Hannah⁸¹⁻⁸⁶

1.3.3.1.2 Approaches of cost-of-illness studies

When designing, conducting and interpreting results of COI studies, several approaches exist for data collection and analysis. The following sections will discuss prevalence and incidence-based

COI approaches, prospective and retrospective COI approaches, and bottom-up, top-down and econometric COI approaches.

1.3.3.1.2.1 Prevalence and incidence-based approaches of cost-of-illness studies

Cost estimates obtained using COI analysis are based on prevalence or incidence data⁸⁷. Prevalence-based studies estimate the economic burden that an injury, disease or illness has on society during a specified period as a result of the prevalence of the disease, irrespective of the time of disease onset^{78, 87}.

In contrast, incidence-based studies represent the lifetime cost resulting from an injury, disease or illness, based on all cases with onset of disease in a given year⁷⁸. Although COI studies were primarily developed for national purposes to estimate burden at a larger scale societal or population-level perspective, the number of per capita studies utilising this method is growing^{46, 78}.

1.3.3.1.2.2 Prospective and retrospective approaches of cost-of-illness studies

Two temporal approaches, prospective and retrospective, may be considered when designing and conducting a COI study. When using a retrospective approach, all relevant health events have already occurred when the data collection commences. This therefore involves the use of previously recorded health data⁴¹. Conversely, a prospective approach measures health events by following patients directly after a health event. Both prevalence and incidence-based COI studies can be conducted using prospective and retrospective approaches⁴⁴.

Both prospective and retrospective approaches have their advantages and disadvantages. The significant advantage of a retrospective approach is that they are less costly than prospective studies as all events have already occurred and cost can be measured and analysed from a pre-recorded dataset⁴⁴. The significant disadvantage of the retrospective approach is the uncontrollable limitations or restrictions that may be present due to insufficient observational datasets⁴¹. The major advantage of the prospective approach is the ability to design the data collection systems to capture desirable data

by using carefully selected questionnaires provided to patients, family members and/or healthcare providers. Investigating health events that have a significant duration using a prospective incidence-approach, however, can be extremely expensive and time consuming⁴¹.

1.3.3.1.2.3 Top-down and bottom-up approaches of cost-of-illness studies

The top-down (population-based) approach to cost estimation uses health statistic data to derive acceptable cost estimates by allocating claims from databases to specific diagnoses^{78, 88}. The bottom-up (person-based) approach is based on the medical resource consumption of the individual patient and may extrapolate costs from interviews or diaries about health-care utilisation and costs^{41, 74}. The econometric approach attempts to estimate the difference between a cohort with the disease and another cohort without the disease⁴¹. When using an econometric approach, the two cohorts are matched, often using a series of regression analyses, by various demographics and mediating factors and other chronic conditions. Estimation of cost can be completed using a comparison of means or a multiple-stage regression approach.

1.3.3.1.2.4 Perspectives of cost-of-illness studies

The perspective of a COI study refers to the standpoint at which costs are realised and can be carried out from a range of perspectives, which ultimately leads to a wide range of results for the same health event under investigation⁸⁹. Therefore, when designing this type of research, it is important for researchers to clearly define the perspective from which costs have been estimated in order for the intended audience (i.e. the general public, health networks, policymakers) to make informed decisions based on results. Each perspective can provide valuable information about the costs associated with each group, with selection ultimately guided by the focus of the study and the data available⁸⁹. Table 1.3 outlines the cost component categories that are associated with each perspective category.

Table 1.3. Perspectives and Included Cost Component Categories in Cost-of-illness Studies

Perspective	Medical costs	Morbidity costs	Mortality costs	Transportation / nonmedical costs	Transfer payments
Societal	All costs	All costs	All costs	All costs	-
Healthcare System	All costs	-	-	-	-
Third-party Payer	Covered costs	-	Covered costs	-	-
Business	Covered costs (self-insured)	Productivity losses (absenteeism)	Productivity losses	-	-
Government	Covered (medical aid)	-	-	Criminal justice costs	Attributable to illness
Individuals and Families	Out-of-pocket costs	Wage losses/household production	Wage losses / household production	Out-of-pocket costs	Amount received

Source Jo.⁴¹

Conducting COI studies from the societal perspective is often favoured as the impact of the condition is not isolated to the individual or health organisations that are directly involved⁹⁰. This perspective is the most comprehensive approach as it includes all direct and indirect costs for all members in a society when they are involved⁹¹. Further, it allows for a complete form of analysis where all opportunity costs (i.e. costs of resources consumed in terms of the benefits foregone) attributable to an illness, injury, or disease are considered.

Lyons and colleagues¹⁴ present a Healthcare Flow diagram of acute injury (refer Figure 1.1), which presents 43 different possible flows of medical consumption. It was initially developed by two authors and refined with the input of 13 other members from ten European countries. It demonstrates that the true incidence and cost of an injury can never be measured because of the number of possible pathways to receiving treatment. As such, when attempting to establish incidence and cost of injuries, it is essential to clearly define the population from where you are collecting data (e.g. cases could theoretically be captured from emergency departments, hospital discharge registers, and mortality statistics) in addition to the perspective chosen.

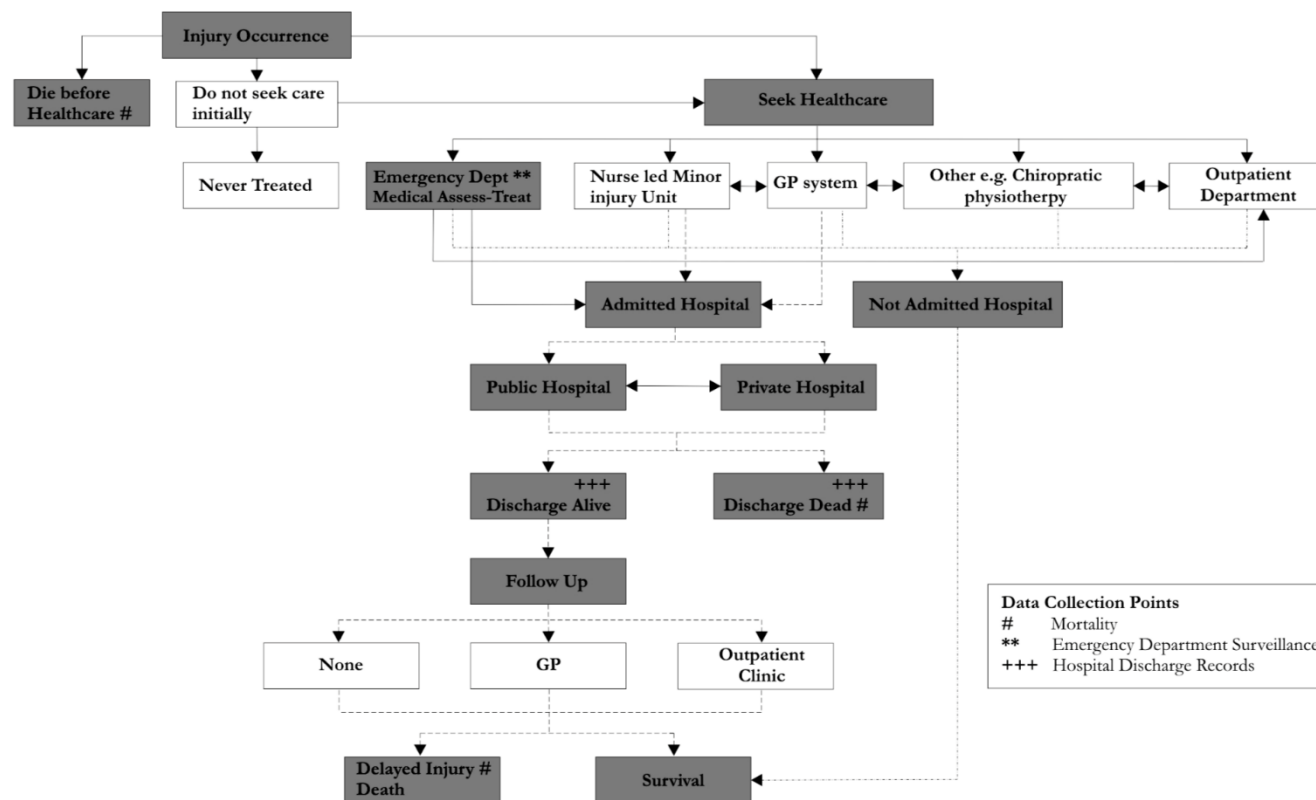


Figure 1.1
 Healthcare Flow Diagram of Acute Injury
 Data from Lyons et al.¹⁴
 (reproduced with permission)

1.3.3.1.2.5 Methodological considerations for cost-of-illness studies

Historically, COI studies have been subject to many critiques,^{23, 45} their methodology for estimating economic burden widely debated, and their reliability and consistency as a decision-making tool questioned by many health-economists^{44, 91, 92}. Scrutiny is centred around the variety of different approaches used to estimate direct and indirect costs which limit the comparability of results across studies^{45, 93}. The use of the human capital approach, an approach that uses wages to measure the value of productivity lost through illness to estimate indirect cost (absenteeism), is often argued to lack a theoretical foundation and to overestimate actual economic losses⁹⁴. The willingness-to-pay method, which values human life according to the amount that individuals are willing to pay for a change in the probability of illness or death, has been proposed as an alternative⁹⁵. However, this approach requires substantial development during a study's design phase prior to its implementation⁹⁶.

Criticism of the COI methodology is often refuted by claims that the appropriate method of completing these studies is contextual and depends on the perspective, disease state and reason why the study is being conducted, and as such has remained durable and continues to be implemented^{45, 92}. Despite their limitations, COI studies are commonly used for international economic studies in healthcare and are frequently used by organisations such as the World Bank, World Health Organization, and the US National Institute of Health⁹⁷.

1.3.3.2 Health economic evaluations

Health economic evaluations are focused on evaluating the cost and consequences of alternative interventions rather than solely estimating the cost of a particular disease⁹⁸. Unlike COI studies, they are a form of comparative analysis which compares treatment options in terms of their costs (direct, indirect and intangible) and consequences²⁰. Methods of health economic evaluation include cost-effectiveness analysis (CEA), and cost-utility analysis (CUA), cost-benefit analysis (CBA), and cost-minimisation analysis (CMA)⁹⁸. The measurement of cost (units) and methods for identifying and measuring consequences in each type of economic evaluation are summarised in Table 1.4.

Table 1.4 Measurement of Cost and Consequences in Economic Evaluation

Method	Identification of consequences	Measurement/valuation of consequences	Measurement/valuation of costs of both alternatives
Cost-effectiveness analysis (CEA)	Single effect of interest, common to both alternatives, but achieved to different degrees	Natural units (e.g. life-years gained, disability days saved)	Monetary units
Cost-utility analysis (CUA)	Single or multiple effects, not necessarily common to both alternatives	Health years (this is typically measured in quality-adjusted life-years (QALYs))	Monetary units
Cost-benefit analysis (CBA)	Single or multiple effects, not necessarily common to both alternatives	Monetary units	Monetary units
Cost-minimisation analysis (CMA)	Single effect, common to both alternatives, but achieved to different cost expense	Monetary units	Monetary units

Adapted from Drummond et al.⁹

1.3.3.2.1 Cost-effectiveness analysis

Cost-effectiveness analysis (CEA) compares different interventions that achieve an outcome measured in a common metric in an attempt to identify the least costly per unit outcome^{99, 100}. They are the most common analyses used in health economics and assist in the selection of different treatments for

the same health problem⁸⁹. CEA is used when interventions or programmes used may have differential success in outcomes, as well as differential costs, but the outcome must be common (e.g. life-years gained).

For example, Hansen and colleagues¹⁰¹, present a comparison of the cost-effectiveness of the use of MRI or standard radiography in managing suspected scaphoid fractures. In any CEA study, it is not the cheapest treatment per se which is of interest; it is the most efficient treatment regarding cost per unit effect. In this example, the use of MRI reduced immobilisation time, sick leave and non-hospital costs, and was found to be the most cost-effective treatment despite resulting in increased direct costs observed.

1.3.3.2.2 Cost-utility analysis

Cost-utility analysis (CUA) compare different interventions that achieve an outcome measured in a common metric to identify the one that has the least cost per unit outcome⁹⁹. In CUA, utility (which refers to the value of a particular health state or an improvement in that health state¹⁰⁰) is valued between 0 and 1, where 0 is equivalent to death and 1 is equivalent to perfect health. Values are estimated using published literature, or they may be measured directly using methods such as the Standard Gamble or the Time Trade-Off¹⁰². Utility-based measures are usually expressed in terms of quality adjusted life years (QALYs) gained, which are calculated by multiplying the change in utility value because of medical intervention by the years of life remaining⁹⁹. After this, a cost per QALYs is calculated, which can be used to produce ‘league tables’, which list interventions in order of cost per QALYs. This list is then used to guide resource allocation.

1.3.3.2.3 Cost-benefit analysis

Cost-benefit analysis (CBA) investigates the outcomes of two health programs that differ but have a common denominator to allow comparisons of outcome¹⁰⁰. They aim to compare all the costs and benefits of a given intervention, both measured in the same metric (usually monetary units), to determine if the outcomes are worth achieving given the costs (i.e. if the costs required to achieve the outcome are

worthwhile)⁹⁹. In CBAs, benefits are valued in monetary terms by placing values on individuals observed or stated preferences, that are usually based on the willingness-to-pay method^{22, 89}.

1.3.3.2.4 Cost-minimisation analysis

Cost-minimisation analysis (CMA) is used when the outcomes of two interventions being compared are identical⁹⁹. Typically, CMA is used to describe a situation where the consequences of two or more interventions or programs are broadly equivalent, so the difference between them reduces to a comparison of costs⁹.

In summary, both cost-of-illness studies and health economic evaluations are useful in determining the cost burden of acute hand and wrist injuries. A systematic review of the literature relating to the direct, indirect and intangible costs of acute hand and wrist injuries using both COI studies and health economic evaluations was published as part of this candidature and is presented in Chapter 3 of this thesis. The following section will briefly describe the occupational therapy and hand therapy context of research into the burden of acute hand and wrist injuries.

1.3.4 Occupational therapy and hand therapy context

Allied health, medicine, and nursing together constitute the patient care workforce, with each clinical discipline contributing unique and essential skills to provide high-quality patient-centred care. The clinical disciplines can be considered the three pillars of the patient care workforce¹⁰³, with each being equally important for the stability, functioning and outcomes of an individual group of clients. Despite comprising approximately 20% of Australia's healthcare workforce, allied health's contribution to improving health outcomes remains poorly understood and largely invisible in the Australian health policy and reform environment¹⁰³. The unrealised potential of allied health represents a significantly underutilised resource that has the potential to address many of the challenges facing our healthcare system. Health economists have traditionally completed COI studies and health economic evaluations, however, there is an increasing trend for healthcare clinicians to conduct studies that estimate the burden of disease^{46, 104}.

Occupational Therapy, “a client-centred health profession concerned with promoting health and well-being through occupation,”^{105p1} is a health care profession that has the potential to contribute to this type of research. The primary goal of occupational therapy is to enable individuals to participate in activities of everyday life by “working with people and communities to enhance their ability to engage in occupations they want to, need to, or are expected to do, or by modifying the occupation or the environment to better support their occupational engagement”^{105p1}. This occupational view of health, which recognises the importance of self-care, productivity and leisure for health and wellbeing³⁰, identifies that the loss of roles, changes in occupational performance, activity limitations and participation restrictions²⁹ can be experienced in varying degrees after injury or illness.

By having this theoretical underpinning, occupational therapists working in the specialisation of hand therapy, “the art and science of rehabilitation of the upper quarter of the human,”^{106p1} can assist in providing a comprehensive understanding of the burden of hand and wrist injuries. Hand therapists are certified or registered occupational therapist or physiotherapists, who have developed expertise and knowledge in the assessment and treatment of upper quarter conditions through clinical experience, advanced continuing education, post-graduate study, and independent learning. Therapists practising as hand therapists can identify and address key drivers of lost productivity, family, social, and community impacts as a result of their training and clinical expertise. This knowledge and experience, therefore, put the profession in good standing when designing methodologies that attempt to capture the burden that these injuries place on the individual, community and society.

1.3.5 Conceptual frameworks and models that describe the burden and impact of injury at the individual, community and societal levels

In the past few decades, several conceptual models and frameworks that describe the burden and impact of injury have been established in both health economics and medicine and health sciences (including occupational therapy) literature. These can be used to provide necessary guidance for policy development at various levels by providing structure and direction on key issues, which in turn, streamlines the communication and translation of ideas¹⁰⁷. Further, they can also be used to direct

outcome measurement to facilitate a clear understanding of the impact or need for preventative, treatment, and rehabilitation strategies.

Health economic models used by health economists and health professionals, such as the *Three Dimensions of Economic Evaluation of Clinical Care*¹ and the *Three Dimensions of Healthcare Economic Evaluations*¹⁰⁸ can be used to guide and identify the scope and perspective in which research occurs. Models and frameworks proposed by the medicine and health science professions, sometimes in conjunction with health economists, are inclined to consider the burden and impact of injury beyond a monetary value. While some are context-specific, for example, injuries that have occurred in the workplace (e.g. *The Social Context of Occupational Injuries and Illness Framework*¹⁰⁹), others can be used to consider burden and impact from an individual (*The International Classification of Functioning, Disability and Health [ICF]*¹¹⁰, and the *Canadian Model of Occupational Performance and Engagement [CMOP-E]*^{30, 111}) or societal perspective (*The Load of All Deficits [LOAD] Framework*¹¹², and *The Injury Outcome Framework [IOF]*¹⁰⁷).

Health economic, medical, and health sciences models and frameworks provide a basis for the investigations of the burden and impact of acute hand and wrist injuries that form this thesis. Guiding frames of reference for economic analyses are vital for researchers to ensure that any evaluation of cost and burden of injury has a sound rationale, consistency and structure, and incorporates an empirical basis.

The following sections summarise several models and frames of reference that were determined to be applicable to contextualise individual, community and societal burden resulting from acute hand and wrist injuries following multiple database searches, reviews of pivotal health economic, medical and health sciences texts, as well as grey literature. Models or frames of reference that were context-specific, (e.g. *The Social Context of Occupational Injuries and Illness Framework*¹⁰⁹) and could not contextualise the burden of non-specific acute hand and wrist injuries were not considered.

1.3.5.1 Three dimensions of economic evaluation of clinical care

Incorporating concepts included within the cost-of-illness approach, Bombardier and Eisenberg¹ have suggested a model for the economic evaluation of clinical care that includes three dimensions (refer Figure 1.2). The model was established to estimate the lifetime cost of rheumatoid arthritis and provides a directive for the assessment of the relative value of potential costs predicated on three aspects of healthcare economic evaluation. One axis represents the types of costs and benefits associated with healthcare technology or innovation. This includes direct, indirect and intangible costs. The second axis reflects the different audiences that will use collected information and includes the patient, payer, healthcare provider, and society. The third axis of the model incorporates the type of analysis used and includes identification, effectiveness and benefit.

This model has undergone two revisions, the first in 1989 (refer Figure 1.3) to stratify the types of costs further (i.e. direct medical, direct non-medical) by the original authors, and the second by Robinson and Vetter¹⁰⁸ in 2009 (refer Figure 1.4), to include the particular cost analysis methodologies in preference of the types of cost analysis. This model has continued to be used in the economic evaluation of clinical care since its conception in 1985¹¹³⁻¹¹⁵.

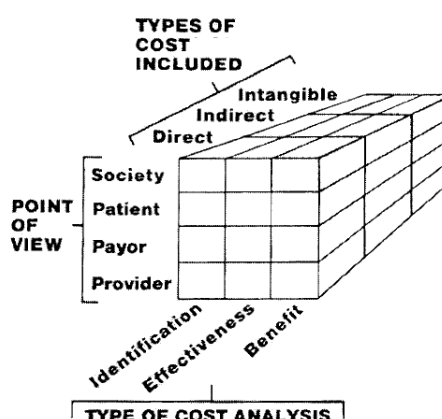


Figure 1.2 Three Dimensions of Economic Evaluation of Clinical Care

Data from Bombardier and Eisenberg.¹

(reproduced with permission)

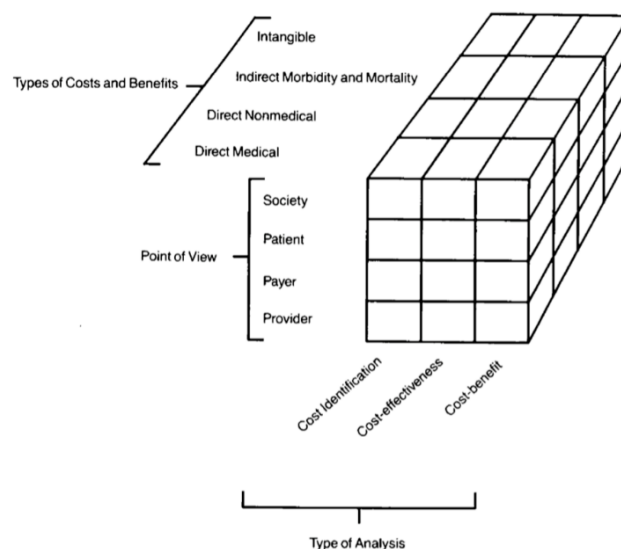


Figure 1.3 Three Dimensions of Clinical Economics

Data from Eisenberg.¹³

(reproduced with permission)

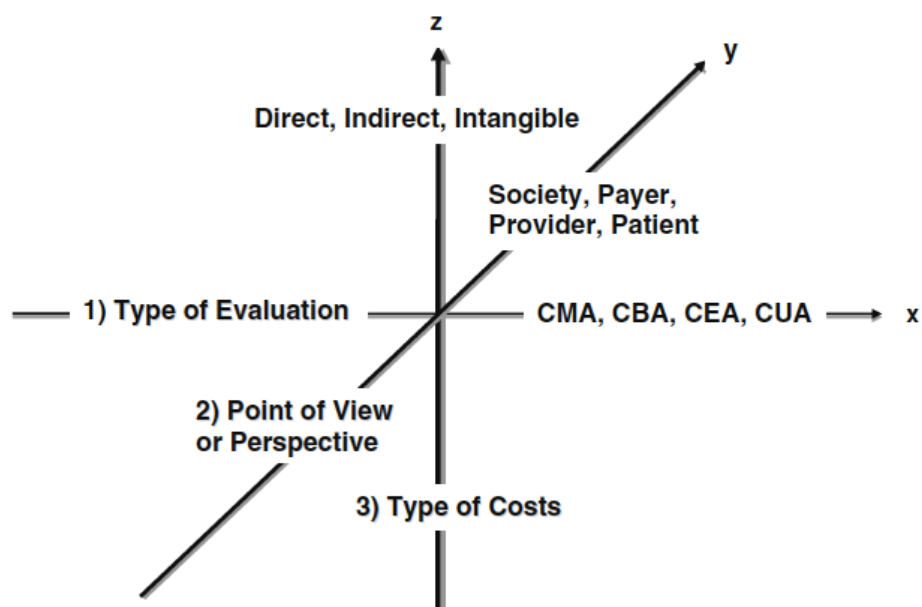


Figure 1.4 Three Dimensions of Healthcare Economic Evaluations

Data from Robinson and Vetter.¹⁰⁸

(reproduced with permission)

1.3.5.2 The International Classification of Functioning, Disability and Health

The International Classification of Functioning, Disability and Health (ICF) is a multipurpose classification designed to serve various disciplines and sectors with various aims and applications (refer to Table 1.5)¹¹⁶. Based on a bio-psychosocial model of health, the ICF provides a conceptual base for the understanding and measurement of health and disability and was approved and endorsed in 2001 at the 54th World Health Assembly. It provides a globally-agreed upon framework (refer Figure 1.5) that captures information on functioning and disability and provides a means for describing how an individual's body functions, what they can do in usual daily activities, ranging from simple to complex, and what is his or her actual participation or involvement in these domains, in relation to the prevailing environment ¹¹⁷.

The ICF observes functioning and disability as occurring at several different levels¹¹⁷. First, it considers impairments, which can occur in the structures and functions of the body, as a significant deviation or loss. At the second level, ICF observes functioning in terms of the individual's activities and the limitations on them. This can be viewed as the capacity of the individual to carry out an action or task in a standard or uniform environment. An assessment, which considers environmental factors, of such abilities reflects the individual's health status. At the third level, the framework observes the individual's functioning in society and considers participation restrictions in community participation. As a result of its global language and widespread international application, the ICF has been used to assist in the design of economic analyses and to provide evidence of how to best allocate funding¹¹⁸.

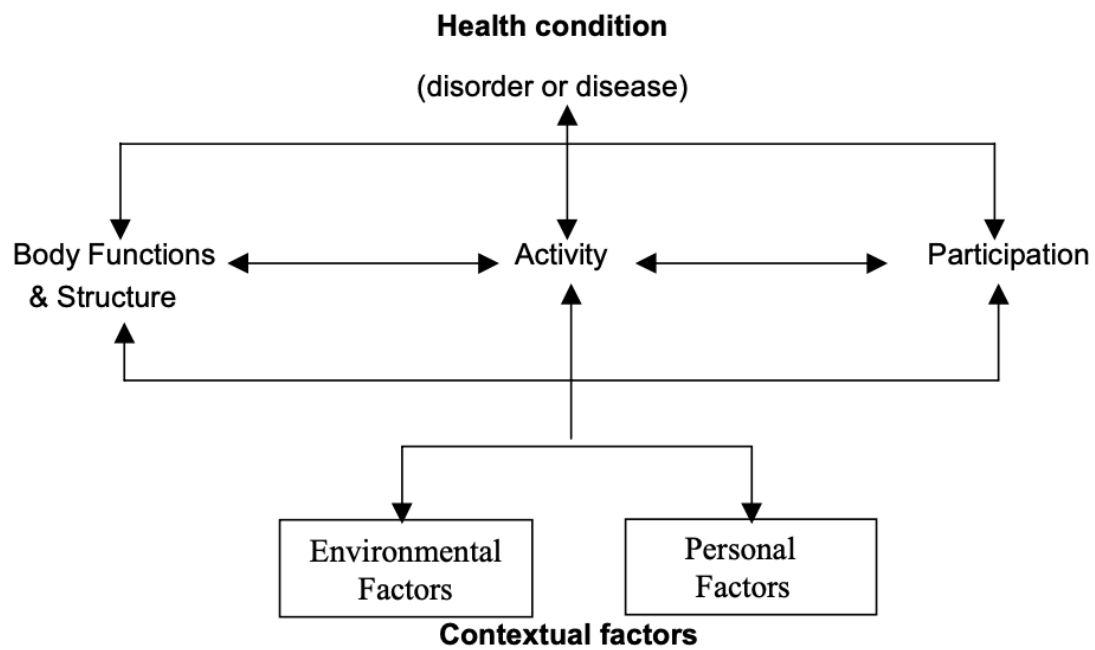


Figure 1.5 Interactions Between the Components of the ICF Framework

Data from the World Health Organization¹¹⁷.

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Table 1.5 Aims and Applications of the ICF

ICF	
Aims	<ul style="list-style-type: none"> • To provide a scientific basis for understanding and studying health and health-related states, outcomes and determinants; • To establish a common language for describing health and health-related states to improve communication between different users, such as healthcare workers, researchers, policy makers and the public, including people with disabilities; • To permit comparison of data across countries, healthcare disciplines, services and time; and • To provide a systematic coding scheme for health information systems.
Applications	<ul style="list-style-type: none"> • As a statistical tool – in the collection and recording of data; • As a research tool – to measure the outcomes, quality of life or environmental factors; • As a clinical tool – in needs assessment, matching treatments with specific conditions, vocational assessment, rehabilitation and outcome evaluation; • A policy development tool – to provide a framework for comprehensive and coherent disability related social policy; and • An economic analysis tool – to cost the economic impact of functional limitations as compared to the costs of modifying the built and social environments by providing a consistent and standard classification of health and health-related outcomes.

Adapted from the World Health Organization.¹¹⁶

1.3.5.3 The Canadian Model of Occupational Performance and Engagement

The Canadian Model of Occupational Performance and Engagement (CMOP-E)^{30, 111} was first published in 1997 by the Canadian Association of Occupational Therapists. The model builds on the 1983 publication titled ‘Client-Centred Guidelines for the Practice of Occupational Therapy’ (Figure 1.6). The

CMOP-E considers occupational performance as the result of the dynamic and ongoing relations between the ‘person’ (comprising of physical, cognitive and affective domains) with spirituality at its core; their ‘occupations’ (self-care, productivity and leisure); and their environments (physical, social, cultural and institutional). This model contends that changes in the involvement or engagement in meaningful occupations, and therefore changes in occupational performance, has the potential to affect an individual’s health and wellbeing and how they give meaning to their life³⁰. Therefore, an acute hand or wrist injury that prevents occupational engagement can be a source of stress and disruption to daily life and can significantly change the ability to perform life roles satisfactorily and successfully¹¹⁹ which can lead to a significant burden.

While this model has not been used previously in studies investigating cost burden, its theoretical underpinnings can assist in methodological considerations when determining measures to best capture intangible costs experienced due to injury or illness.

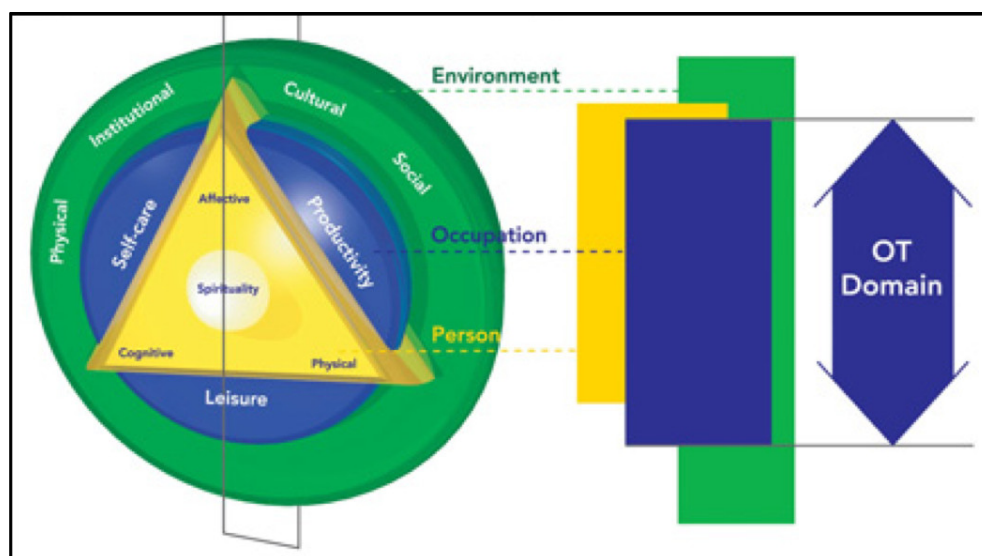


Figure 1.6 The Canadian Model of Occupational Performance and Engagement (CMOP-E)

Data from Townsend et al.³⁰

(reproduced with permission)

1.3.5.4 List of All Deficits Framework

The List of All Deficits (LOAD) Framework first began development in 2004 during expert consensus discussions among international attendees of the Measuring the Burden of Injury meeting¹¹². The conceptual framework was designed to facilitate the measurement of burden by conceptualising the full range of deficits and adverse outcomes following injury and violence.

Further development and refinement of the framework occurred during discussions at various seminars and conferences between 2004 and 2008 and it was eventually published in 2009. To support the consensus opinions proposed during its development, evidence to support the LOAD framework components was sourced from published literature. The framework (refer Figure 1.7), considers burden resulting after injury from the perspective of both the injured individual and non-injured family members and society and is presented in terms of categories (i.e. Individual (I), Society (S), and Family (F)) and sub-categories (i.e. I-2 “pain and discomfort”). Such classification allows for the determination of the scope of negative impacts of injury, which should be considered when planning research and also placing the existing burden of injury studies into context. The framework is currently being revised using qualitative data and when presented recently at a conference, it was suggested it will be expanded to include new injury consequences such as impacts on education, social activity, labour demands, transport and housing¹²⁰.

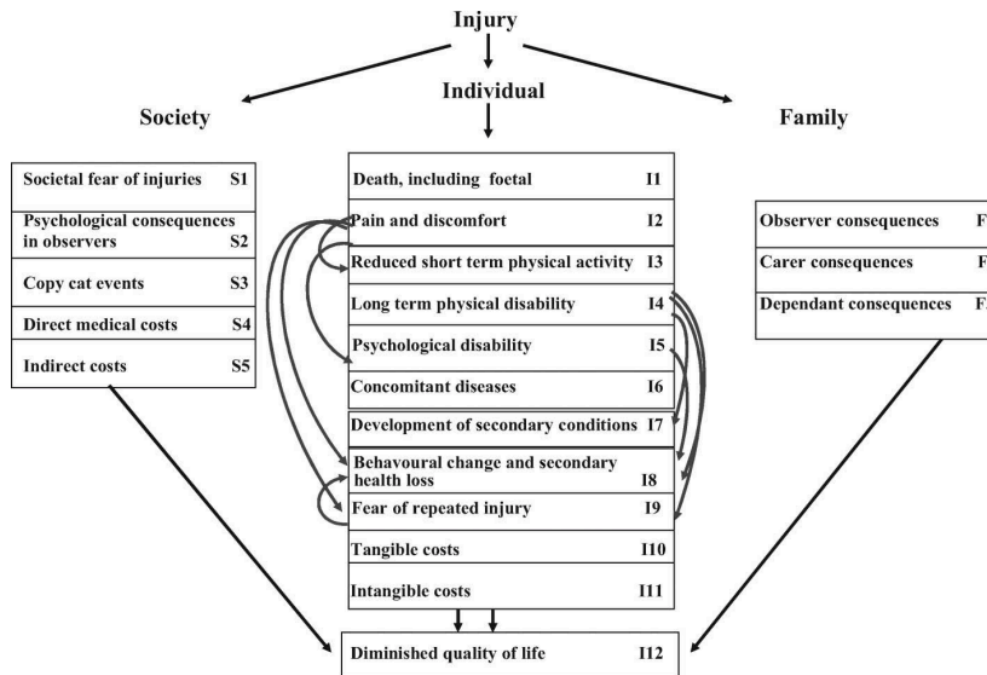


Figure 1.7 LOAD Framework

Data from Lyons et al.¹¹²

(reproduced with permission)

1.3.5.5 Injury Outcome Framework

The Injury Outcome Framework (IOF)¹⁰⁷, first published in 2014, is a conceptual framework that was developed in an attempt to better understand the impact of an injury on the injured individual, the community groups connected to the injured individual and broader society. Unlike the ICF (which conceptualises the impact of injury predominantly at an individual level); or the LOAD framework (which does not recognise the impacts on co-workers or employers); the IOF attempts to conceptualise the complete impact of an injury by considering “the consequences of change in physical, psychological, economic, or other circumstances that could be directly or indirectly attributed to the injury”^{107p589}. Such impacts are considered in the domains of the individual, the community and broader society (refer Table 1.6 for domain definitions).

Table 1.6 Definition of IOF Domains

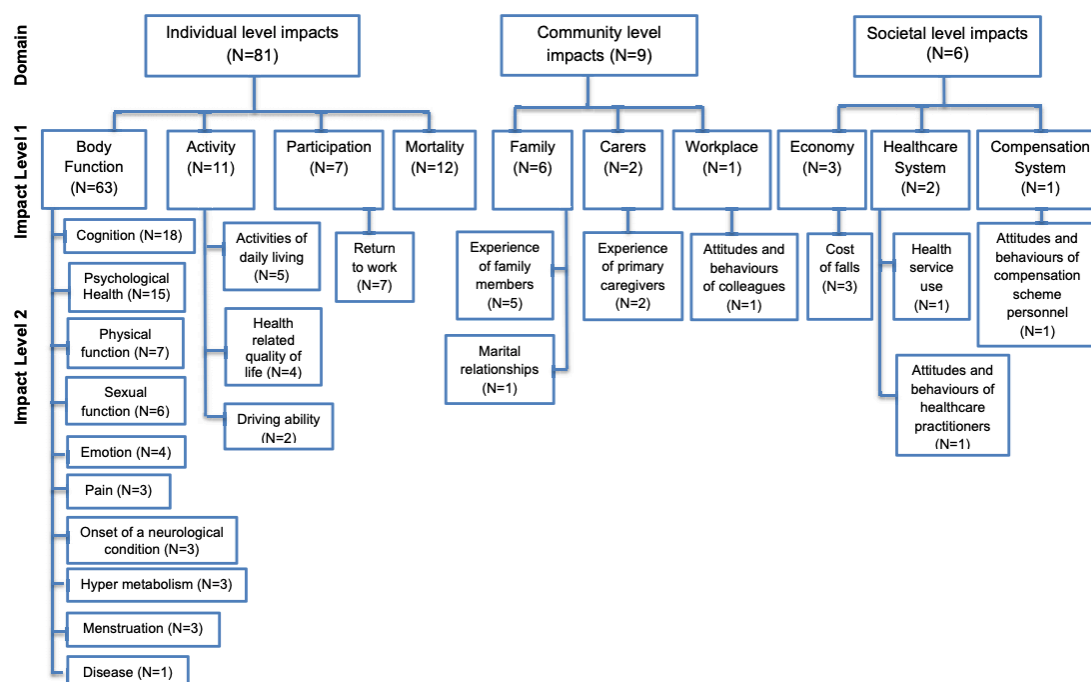
Domain	Definition	Level of Impact One
Individual Level	Impacts of injury directly experienced by an injured person	The ICF ¹²¹ impact areas of Body Function, Body Structure, Activity and Participation
Community Level	Impacts of injury on individuals in personal contact with the injured person before or after injury Level of Impact 1: Family, workplace, carers	The LOAD framework ¹¹² impact areas of Family, Carers and the Workplace
Societal Level	Impacts of injury on the social and/or economic organisations of the broader community/groups in society that the injured person interacts with in the rehabilitation and recovery of injury	The LOAD framework ¹¹² impact areas of the Healthcare and Compensation Systems (direct and indirect costs) and also considers the broader economy

Adapted from Newnam et al.¹⁰⁷

The framework, which was developed from a systematic meta-review of injury outcomes research literature (n=78), considers two impact levels in the domains of the individual, community and society (refer to Figure 1.8). The first level of impact was defined by the authors (refer to Table 1.6), using existing frameworks, the results of the meta-review process defined the second level of impact. One significant strength of this framework is that it considers the impact on the work environment and work colleagues, a vital component to consider when investigating the impact and burden of acute hand and wrist injuries.¹⁰⁹

As this is a relatively new model, there is a need for testing in future studies to strengthen its evidence-base. It does, however, consider key areas for consideration of where cost burden can occur⁹ and

can be used as a communication tool to highlight specific drivers of cost. This model was selected to summarise the key findings of the investigations completed within this thesis (Chapter 10) as it allows exploration of cost burden across the domains of the individual, community and society clearly and coherently.



(n=): The number of studies included from meta-review that informed the inclusion of each impact level

Figure 1.8 Injury Outcome Framework

Data from Newnam et al.¹⁰⁷

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1.4 Chapter Summary

As this thesis aims to provide insight into the economic burden of hand and wrist injuries from the individual, community and societal perspectives, this chapter sought to present an overview of the principles, concepts, and evaluation methods of health economics as they were used to design, interpret and present findings. Further, it provided insight into the occupational therapy and hand therapy context of this type of research and concluded with an exploration of the models and frameworks which can be used in cost burden research and have helped guide the investigations that appear in Chapters 3 to 8 of this thesis.

In the next chapter, I will outline the six key research questions that are answered in the thesis publications that form Chapters 3 to 8. I will also outline and justify the aims and methodology chosen for each separate study and provide the rationale of including a published viewpoint article in Chapter 9.

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Chapter 2

Methodology

2.1 Chapter Introduction

The previous chapter presented an overview of the principles, concepts, and evaluation methods that underpin the field of health economics to provide background for the collection of studies in this thesis that explore the individual, community and societal burden of acute hand and wrist injuries. It provided insight into my motivation for completing this thesis and discussed the occupational therapy and hand therapy context of this type of research. It concluded with an exploration of the models and frameworks which can be used in cost burden research and provided a justification for my selection of the Injury Outcome Framework (IOF) to be the central framework used in this thesis.

In this chapter, I will list the six key research questions, in addition to supplementary questions, that guided this doctoral thesis and are addressed in the investigations that form Chapters 3 to 8. The separate methodologies for each of the investigations will be described and justified. Further, the aims of each investigation, in addition to the data collection and data analysis procedures, will be outlined.

This chapter will highlight the breadth of methodologies conducted in the investigations that form this thesis, which includes a systematic review, three retrospective cost-of-illness studies, a pilot prospective longitudinal cost-of-illness study and a qualitative study.

2.2 Research Questions

Following a search of multiple medical, allied health and health economics databases and grey literature for both Australian and international literature relating to the burden of acute hand and wrist injuries, several gaps in knowledge were identified. This led to the development of six key research questions, each with accompanying supplementary questions. Findings of earlier investigations helped to inform some of the supplementary research questions and, therefore, guided the methodologies used.

1. In international literature, what are the reported direct, indirect and intangible costs of acute hand and wrist injuries?
 - a. What analytical tools and methodologies have been used to measure direct, indirect and intangible costs associated with acute hand and wrist injuries?
 - b. What cost components are included when estimating the direct, indirect and intangible costs of acute hand and wrist injuries?
2. What are the total direct costs associated with resource use in the emergency departments of one Australian public health service for individuals presenting with a hand or wrist injury?
 - a. What is the demographic profile of this patient population at this health service?
 - b. Has there been an increase in the direct costs associated with resource use in this patient population between two financial years at this health service?
 - c. Has there been an increase in the number of individuals presenting with hand and wrist injuries between two financial years at this health service?
3. What are the total direct costs associated with resource use for individuals requiring surgical intervention and outpatient follow-up following an emergency department presentation for an acute hand or wrist injury at one Australian public hospital health service?
 - a. What is the demographic profile and patient care journey of this patient population at this health service?
 - b. What post-operative medical and specialist hand therapy resources are used by this patient population at this health service?
 - c. What demographic variables, if any, are significantly associated with direct costs?
4. What are the total direct costs associated with resource use for individuals that require treatment for a hand or wrist injury sustained as a result of participation in a sport or exercise at one Australian public hospital service?
 - a. What is the demographic profile and patient care journey of this patient population at this health service?

- b. How much medical and specialist hand therapy resources are used by this patient population at this health service?
 - c. What sport and exercise activities lead to the most significant cost burden at this health service?
- 5. Is capturing the cost of acute fracture, tendon and nerve injuries of the hand and wrist from an individual and societal perspective feasible at two Australian public hospital health services?
 - a. What are the major costs associated with hand fracture, tendon and nerve injuries?
 - b. What are the specific key drivers of economic and individual, family and social burden?
 - c. Can a prediction of the total cost of injury be made by a model that includes the duration of disability and productivity impairment?
- 6. What do individuals with an acute hand or wrist injury perceive as the most important impacts of experience burden of injury?
 - a. What do individuals with an acute hand or wrist injury perceive as the most significant costs?
 - b. Which of these are indirect costs of injury?
 - c. Which of these are intangible costs of injury?

The remainder of this chapter will present the aims and methodologies used to answer the six key research questions proposed in this thesis. As each of the questions approaches the individual and societal burden of acute hand and wrist injuries from different perspectives, including cost components or injury types, the methodologies required to answer them are different. Therefore, the methodology for each investigation will be explored separately.

2.3 Study Settings

Relevant data to answer the research questions (excluding Research Question 1) were collected from hospitals within two major public healthcare networks and included the Alfred Hospital (Alfred Health), Sandringham Hospital (Alfred Health) and Dandenong Hospital (Monash Health). The setting or

settings selected within each investigation was guided by the selected perspective from which the study was conducted.

The Alfred Hospital is a 680-bed tertiary referral teaching hospital that is a major provider of specialist state-wide services (e.g. burns, trauma) to residents of Victoria and has approximately 65,000 visits per year.¹ The Sandringham Hospital is a 100-bed tertiary referral teaching hospital and has approximately 34,000 visits per year. The Dandenong Hospital is a 573-bed tertiary referral teaching hospital that is a provider of general and specialist services to the people of Dandenong and surrounding areas and has approximately 70,000 visits per year².

2.4 Materials and Methods

2.4.1 Research Question 1: In international literature, what are the reported direct, indirect and intangible costs of acute hand and wrist injuries?

Aims:

- To systematically review cost-of-illness studies and health economic evaluations reporting the economic burden of acute hand and wrist injuries with a specific focus on direct, indirect and intangible costs;
- To describe the study design, methodology and cost components used in international literature;
- To compare reported costs by calculating current net value estimates, and;
- To provide recommendations for future research in this area.

Methodology chosen:

- Systematic Review (SR)

Level of evidence:

- 2A (SR with homogeneity of Level >2 economic studies)³

Justification:

A systematic review of the literature on direct, indirect and intangible costs of acute hand and wrist injuries was used to answer this research question as it required the process of gathering, appraising, synthesising, and analysing as much eligible literature as possible⁴. No previous systematic review on the direct, indirect and intangible costs of acute hand and wrist injuries had been published and, therefore, this investigation adds to the field of knowledge of the economic burden of acute hand and wrist injuries. The advantages of this method are the ability to find all relevant studies and to summarise and assess the level of consistency in the methods, perspectives and included cost components used when estimating the direct, indirect and intangible costs of these injuries. Both cost-of-illness (COI) studies and health economic evaluations were included as both designs report on the specific costs of interest and allowed for a more comprehensive insight into adopted methodologies.

Methods:

A search of cost-of-illness studies and health economic evaluations of acute hand and wrist injuries in various databases was conducted. Data extracted by two authors for each included study were: design, population, intervention, and estimates and measurement methodologies of direct, indirect and intangible costs. Reported costs were converted into US-dollars using historical exchange rates and then adjusted into 2015 US-dollars using an inflation calculator to allow for comparison between published studies.

The complete methodology used to conduct this systematic review is described in full in Chapter 3 (refer 3.4.3).

2.4.2 Research Question 2: What are the total direct costs associated with resource use in the emergency departments of one Australian public health service for individuals presenting with a hand or wrist injury?**Aims:**

- To estimate the direct costs associated with resource use in the emergency departments of one Australian public health service for individuals presenting with a hand or wrist injury; and

- To examine the demographic profile of this patient population.

Methodology chosen:

- Retrospective File Audit Cost-of-illness Study

Level of Evidence:

- 2C (Audit or outcomes research)³

Justification:

In Australia, comprehensive epidemiological and cost data for individual disease or injury is problematic due to the absence of a national systematic procedure for capturing specific patient resource use.⁵ Whilst conducting the literature review, we found no Australian investigations examining the cost and profile of acute hand and wrist injuries.

A retrospective file audit was chosen as it is a relatively inexpensive and efficient method to investigate direct costs of acute hand and wrist injuries across a large sample⁶. This method eliminates limitations with loss of participant follow-up or selection bias, thus providing a full dataset for participants meeting the study's inclusion criteria. In this investigation, the selected design enabled an estimation of yearly expenditure for acute hand and wrist injuries in the emergency department, in addition to allowing for a between-year comparison.

The acknowledged disadvantages of this study design include incomplete documentation (e.g. missing charts, unrecorded information), difficulty interpreting information found in the documentation (e.g. jargon, acronyms, poor photocopies), incorrect data entry (e.g. ICD-10 codes, cost allocation), problematic verification of information, and variance in the quality of information recorded by medical professionals⁷. In order to address these limitations, included cases were required to adhere to a set of inclusion criteria which included full documentation within the billing record and a complete cost record. Also, well-defined research questions, data extraction forms, and clearly defined variables under investigation were established before the collection of data suggested by Vassar and Holzmann (2013)⁸.

Methods:

Using ICD-10 codes involving the hand and wrist, 10,024 consecutive patients from the electronic billing records of two financial year periods (2014-15 and 2015-16) who attended the Alfred or Sandringham emergency department were identified. All costs from a healthcare service perspective (Alfred Health) that resulted from the treatment of any acute hand or wrist injury across the two-year period were calculated and are presented by age, sex, injury type, and mechanism of injury.

The complete methodology used to conduct this cost-of-illness study is described in full in Chapter 4 (refer 4.4.4).

2.4.3 Research Question 3: What are the total direct costs associated with resource use for individuals requiring surgical intervention and outpatient follow-up following an emergency department presentation for an acute hand or wrist injury?**Aims:**

- To estimate the costs associated with resource use for patients requiring surgical interventions and outpatient follow-up following an emergency department presentation for an acute hand or wrist injury;
- To illustrate the demographic profile and patient care journey of this patient population;
- To calculate the post-operative medical and specialist hand therapy resources used by this patient population; and
- To assess whether any variables are significantly associated with cost.

Methodology chosen:

- Retrospective File Audit Cost-of-illness Study

Level of Evidence:

- 2C (Audit or outcomes research)³

Justification:

As per the previous study, a retrospective file audit was chosen as it is a relatively inexpensive and efficient method to investigate the direct cost, patient pathway and resource use for acute hand and wrist injuries across a large sample. The limitations of this study design were addressed by having a clear inclusion/exclusion criterion that was applied when completing a full medical record review. The methods used in this investigation allowed for an appropriate estimation of the direct costs that resulted from acute hand and wrist injuries that required surgical intervention within the study setting, in addition to a comprehensive summary of the demographic profile and patient care journey of the target population. Further, this methodology allowed data analysis of outpatient resource use (e.g. speciality medical apportionments and hand therapy), and occasions when patients failed to attend (FTA) their scheduled appointments.

Methods:

Using 33 primary diagnosis ICD-10 codes involving the hand and wrist, 453 consecutive patients from 2014-15 with electronic billing records who attended the Alfred Hospital emergency department and received consequent surgical intervention and outpatient follow-up were identified. In order to capture this data, a piece of software was developed in conjunction with the Costing Services department at Alfred Health. Electronic medical records were reviewed to extract demographic data which included injury type and location, in addition to days between injury and presentation to the emergency department. Costs were calculated from the perspective of the healthcare service (Alfred Health) from resource use in the emergency department, inpatient and outpatient settings. Results are presented by demographics, injury type, mechanism of injury and patient care journey. A multiple linear regression was completed to investigate if there were any significant predictors of cost.

The complete methodology used to conduct this cost-of-illness study is described in full in Chapter 5 (refer 4.4.3).

2.4.4 Research Question 4: What are the total direct costs associated with resource use for with individuals that require treatment for a hand or wrist injury sustained as a result of participation in a sport or exercise at one Australian public hospital service.

Aims:

- To estimate the costs associated with resource use following a sport or exercise-related hand or wrist injury from the perspective of the health care service;
- To illustrate the demographic profile and patient care journey of this patient population;
- To evaluate the outpatient resources used by this patient; and
- To identify the sport and exercise that lead to the largest burden.

Methodology chosen:

- Retrospective File Audit Cost-of-illness Study

Level of Evidence:

- 2C (Audit or outcomes research)³

Justification:

Injuries that were sustained from participation in sport or exercise were chosen for the focus of this cost-of-illness study as they were identified as contributing to 16% of all injuries in the findings when answering Research Question 2 (refer 2.4.2). Again, a retrospective file audit was chosen as an efficient method to answer the research question using data from a large sample. Further, it allowed for insight into the demographic profile and patient care journey of individuals presenting to a public health service (i.e. those who presented to their general practitioner before an emergency department presentation, number of outpatient appointments, discharge location following treatment cessation within the study setting) with these types of injuries.

Methods:

Using ICD-10 diagnostic codes and electronic billing records, 778 potential cases for inclusion in this study were identified who had presented to the Alfred or Sandringham hospitals. Electronic medical records were screened and reviewed to extract targeted demographic and patient care journey data. Costs from the perspective of the healthcare service (Alfred Health) for 692 individuals were calculated from resource use in the emergency department, inpatient and outpatient settings. Patient care journeys were mapped in order to present data on health services used prior to entering and after leaving the healthcare service in addition to failed to attend rates.

The complete methodology used to conduct this cost-of-illness study is described in full in Chapter 6 (refer 6.4.3).

2.4.5 Research Question 5: Is capturing the cost of acute fracture, tendon and nerve injuries of the hand and wrist from an individual and societal perspective feasible at two Australian public hospital health services?**Aims:**

- To evaluate the feasibility of prospectively collecting data regarding direct and intangible costs experienced at an individual patient perspective in an acute hand/wrist injury population;
- To provide a preliminary estimate of the profile of costs incurred by injury type: either fracture, tendon or nerve injuries; and
- To identify whether there are specific key drivers of economic and individual, family and social burden.

Methodology chosen: Pilot, prospective longitudinal cost-of-illness study

Level of Evidence:

- 2B (Cohort study)³

Justification:

A pilot, prospective longitudinal cost-of-illness study was chosen to establish the feasibility of the proposed study protocol, including recruitment and retention of a representative sample, as well as its ability to provide a preliminary estimate of the individual and societal economic implications that arise from acute fractures, tendon or nerve injuries to the hand or wrist. A prospective design was adopted for its stronger validity when compared to retrospective studies⁹ and to allow for accurate quantification of the economic burden as it was experienced at six-weeks, twelve-weeks, and six-months after injury. The decision to conduct a pilot of the study protocol was made as the acknowledged disadvantages of this study design are that they are resource-intensive and prone to issues with recruitment and retention of a representative sample of participants¹⁰. Another disadvantage of this method is that participants may inflate the cost burden associated with their injury, and therefore careful instructions to guide participant response should be considered during survey design to reduce this potential over-estimation.

Methods:

Participants who had sustained a hand or wrist fracture, tendon or nerve injury and met the selection criteria were recruited from two Australian public hospital health networks (Alfred and Monash Health). Participants were asked to complete surveys (either online, in writing, or via telephone) at six-week, three-months and six-months which included information on demographics, injury details, employment status prior to injury, current employment status, and persons dependent on family income. Patients were also asked to complete the Patient-Rated Wrist and Hand Evaluation (PRWHE)¹¹, the SF-36 - short form of the Health Status measure¹²; and the Short Form of Health and Labour questionnaire (SF-H&L)¹³ to measure individual and societal cost burden.

The complete methodology used to conduct this pilot, prospective longitudinal cost-of-illness study is described in full in Chapter 7 (refer 7.4.5).

2.4.6 Research Question 6: How do individuals with acute hand or wrist injury experience burden of injury?

Aims:

- To explore the perceived burden experienced as a result of an acute hand or wrist injury in the context of work, family and social participation; and
- To identify individuals' perceptions of the key drivers of economic and family/social burden following an acute hand or wrist injury.

Methodology chosen:

- Qualitative

Justification:

A qualitative methodology, using key informant interviews and manifest and latent content analysis, was selected as first-person accounts provide researchers and clinicians with a richer understanding of patients' experience of burden as a result of their acute hand or wrist injury. This data analysis technique was selected as it provides a careful, detailed interpretation and systematic examination of a particular body of material with the aim of identifying patterns, themes, assumptions, and meanings¹⁴.

Methods:

Twelve adults with acute hand and/or wrist injuries recruited from the Alfred Hospital who met the selection criteria were interviewed using a semi-structured interview schedule developed for this study. Questions were designed to elicit responses that explored the participants' perception of the burden that their injury placed on their work, family and social participation. Interviews were recorded using a digital voice recorder and transcribed verbatim. The text and audio recordings were analysed using manifest (which focuses on the surface structural meaning presented in the message) and latent (which focuses on the deep structure meaning or underlying meaning conveyed in the message) content

analysis¹⁴. In order to ensure the trustworthiness of the results, various methods were used to establish credibility, dependability, confirmability and transferability.

The complete methodology used to conduct this qualitative study is described in full in Chapter 8 (refer 8.4.5).

2.5 Rationale for Viewpoint Article

The final publication presented in this thesis, which forms Chapter 9, is a viewpoint article titled ‘Embracing an Occupational Perspective: Occupation-Based Interventions in Hand Therapy Practice’. This publication, which poses the question ‘*should hand therapists endeavour to focus more on embracing an occupational perspective and incorporate interventions that are grounded in the key principles of the profession?*’ was written in response to trends observed in the early phases of collecting data to answer Research Questions 5 and 6.

Comments made by participants in the qualitative interviews conducted to answer Research Question 6, highlighted a lack of clarity or distinction in instruction from therapists regarding what the patient ‘*should be doing, and what [they] shouldn’t be doing*’ which caused confusion regarding resumption of pre-injury occupations and, in some cases, lost work roles and/or distress. Participants also commented that therapy provided sometimes lacked a ‘*holistic*’ approach implying that, at times, therapists appeared to primarily focus on body structures and functions. This observation led me to write a viewpoint article which encourages therapists to consider contextualising the injury with a particular focus on the individual’s usual occupational patterns and roles. I proposed that occupation-based interviews as part of hand therapy practice could address these issues, and in turn, potentially minimise the indirect and intangible costs experienced from an individual perspective.

2.6 Chapter Summary

This chapter lists six key research questions, in addition to supplementary questions, that were developed from gaps in Australian and international literature and, in some instances, from findings of earlier investigations. It justifies the selected methodology used to answer each of the proposed questions. As the research questions vary in terms of perspectives of the cost burden, in addition to included costs, this doctoral thesis encompasses a variety of methodologies. Further, it provides the rationale for a viewpoint article which was written in response to data collected to answer the research questions.

To lay the foundation for this thesis, the next chapter presents a systematic review of the published evidence on direct, indirect and intangible costs of acute hand and wrist injuries and the methods used to estimate reported costs.

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Chapter 3

Direct, indirect and intangible costs of acute hand and wrist injuries:

A systematic review

3.1 Chapter Introduction

Chapter 2 outlined the methodology for each of the studies included in this thesis. This chapter is the first of seven publication chapters and presents a systematic review of the published evidence on direct, indirect and intangible costs of acute hand and wrist injuries. This paper highlights heterogeneity of methodologies and cost components used to estimate costs, the absence of Australian cost-of-illness and health economic evaluation studies, and the need for further research. To the best of my knowledge, no previous systematic review has been completed or published which investigates the direct, indirect and intangible costs of these injuries.

3.2 Chapter Aims

This chapter aims to provide an accurate estimate of the direct, indirect and intangible costs of acute hand and wrist injuries using cost-of-illness studies and health economic evaluations by systematically reviewing published estimates relating to acute hand and wrist injuries. It examines the study design, methodology and cost components used in international literature; compares reported costs by calculating current net value estimates, and, provides recommendations for future research in this area.

3.3 Chapter Contents

Citation:

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3.4 Manuscript I

Manuscript I, as it appears in this chapter, is presented in the format that was required for publication in the *Injury* journal.

3.4.1 Abstract

Background

Injuries sustained to the hand and wrist are common, accounting for 20% of all emergency presentations. The economic burden of these injuries, comprised of direct (medical expenses incurred), indirect (value of lost productivity) and intangible costs, can be extensive and rise sharply with the increase of severity.

Objective

This paper systematically reviews cost-of-illness studies and health economic evaluations of acute hand and wrist injuries with a particular focus on direct, indirect and intangible costs. It aims to provide economic cost estimates of burden and discuss the cost components used in international literature.

Materials and Methods

A search of cost-of-illness studies and health economic evaluations of acute hand and wrist injuries in various databases was conducted. Data extracted for each included study were: design, population, intervention, and estimates and measurement methodologies of direct, indirect and intangible costs. Reported costs were converted into US-dollars using historical exchange rates and then adjusted into 2015 US-dollars using an inflation calculator

Results

The search yielded 764 studies, of which 21 met the inclusion criteria. Twelve studies were cost-of-illness studies, and seven were health economic evaluations. The methodology used to derive direct, indirect and intangible costs differed markedly across all studies. Indirect costs represented a large portion of total cost in both cost-of-illness studies [64.5% (IQR 50.75-88.25)] and health economic evaluations [68% (IQR 49.25-73.5)]. The median total cost per case of all injury types was US\$6,951 (IQR \$3,357-\$22,274) for

cost-of-illness studies and US\$8,297 (IQR \$3858-\$33,939) for health economic evaluations. Few studies reported intangible cost data associated with acute hand and wrist injuries.

Conclusions

Several studies have attempted to estimate the direct, indirect and intangible costs associated with acute hand and wrist injuries in various countries using heterogeneous methodologies. Estimates of the economic costs of different acute hand and wrist injuries varied greatly depending on the study methodology, however, by any standards, these injuries should be considered a substantial burden on the individual and society. Further research using standardised methodologies could provide guidance to relevant policy makers on how to best distribute limited resources by identifying the major disorders and exposures resulting in the largest burden.

3.4.2 Introduction

Injuries sustained to the hand and wrist are common and account for approximately 20% of all emergency department presentations^{1,2}. While most people with uncomplicated injuries will recover full function, some will require a long period of recovery and rehabilitation, and a proportion of these individuals face the potential of long-term disability. The burden of these injuries can be very extensive and is thought to rise sharply with the increase of severity contributing significant cost to both the individual and society²⁻⁴.

Literature to date has mostly provided isolated descriptions of burden in specific health systems, with high levels of heterogeneity in methodology³. These variations can make it difficult to guide decisions based on evidence-based research and can lead to misinformed strategies when attempting to mitigate the burden. Accurate and consistent estimates of health burden at a population level, whether using a state, national or global focus have several significant benefits. First, they can attract the attention of policy makers and the community by showing the size of a problem. Second, they can provide guidance to policymakers on how to allocate limited resources by identifying the major disorders and the exposures resulting in the largest burden. Finally, they can identify possible strategies for reducing the cost of injury by implementing appropriate preventative action or treatment strategies^{5,6}.

We therefore aimed to provide an accurate estimate of the burden of injury from a societal perspective using cost-of-illness (COI) studies and health economic evaluations by systematically reviewing published estimates relating to acute hand and wrist injuries. To assist readers in understanding some of the basic principles of health economics pertinent to the studies summarised in this review, a brief overview of important concepts related to COI and health economic evaluation studies is presented below.

Cost-of-illness (COI) studies

The economic burden of a disease is described as the sum of all costs associated with a condition that would not be incurred if that disease did not exist^{7,8}. This approach calculates how much a society spends on a particular disease by totalling direct, indirect, and intangible costs^{1,3,6,9}.

Direct medical costs relate to diagnostics and the actual treatment provided (e.g. surgery, inpatient admission, medications, imaging, and postoperative care)^{3,9}. Direct non-medical costs are costs and resources used in connection with the health service but are not health sector costs (e.g. transport to and from medical facility). These expenses are easily overlooked when estimating disease burden but can be significant.

Indirect costs most commonly relate to productivity losses due to morbidity and mortality that are borne by the individual, family, society or the employer^{3,8,9}. These costs are due to work absences resulting in foregone productivity (absenteeism), reduced work capacity due to impairment related to their condition (presenteeism), and unpaid productivity (reduced possibilities of performing usual activities at home such as housework or caring for family members) due to illness or disease^{7,8,10-12}. Indirect costs are often harder to calculate than direct costs as it is difficult to measure productivity when considering presenteeism or unpaid roles objectively or with certainty.

Intangible costs extend beyond the monetary costs of goods and services and include other sequelae that reflect decreased enjoyment of life because of illness. Such costs are associated with functional limitations, pain, psychological distress, and decreased social interaction¹³. The inclusion of

intangible costs when estimating the economic burden varies because an accurate quantification in monetary terms is difficult^{6, 14-16}. It is, however, important to recognise that the consequences of a given condition combine to create a burden for the individual that, while difficult to calculate, should still be considered in the economic equation^{17, 18}.

Health economic evaluations

Health economic evaluations are focused on evaluating the cost and consequences of alternative interventions rather than solely estimating the cost of a particular disease¹⁹. They are a form of comparative analysis which compares treatment options in terms of their costs (direct, indirect and intangible) and consequences¹¹. Methods of health economic evaluation include cost-benefit analysis (the monetary value of the resources consumed by health intervention is compared with the monetary value of outcomes achieved by the intervention), cost-effectiveness analysis (the value of resources spent on an intervention is compared with the quantity of health gained as a result), and cost-utility analysis (outcomes expressed in health units that capture both quantity and quality of life)¹⁹.

Cost measurement approaches

Cost measurement of economic burden can be estimated using two approaches. The top-down (population-based) approach to cost estimation uses health statistic data to derive acceptable cost estimates by allocating claims from databases to specific diagnoses^{16, 20}. The bottom-up (person-based) approach is based on medical resource consumption of the individual patient and may extrapolate costs from interviews or diaries about health-care utilisation and costs^{7, 8}.

3.4.3 Methodology

This article systematically reviews all COI studies and health economic evaluations investigating acute hand and wrist injuries with a specific focus on direct, indirect and intangible costs. Our objectives were to:

- (i) describe the study design, methodology and cost components used in the international literature;
- (ii) compare reported costs by calculating current net value estimates, and;

- (iii) provide recommendations for future research in this area.

Search strategy

Relevant articles were identified from a search of Ovid Medline (1946 to September 2015), AMED (1985 to September 2015), EMBASE (1974 to September 2015 update), Cochrane Central Register of Controlled Trials (August 2015 update), SCOPUS (September 2015 update), and CINHALL (1937 – September 2015). A combination of search terms relating to acute hand and wrist injuries and direct, indirect and intangible costs was developed in consultation with a medical librarian (refer Appendix 1). The search was restricted to publications in English with the following selection criteria applied:

1. The study presented methodological characteristics and cost estimates for direct and indirect costs that could be calculated as costs per case.
2. The study reported cost estimates in US dollars (\$US). Studies that reported an alternative currency were included if published after 1990 due to limited exchange rate data.
3. The study was confined to an adult population that included participants 18 years or older.
4. The study sample included persons who had sustained an acute injury to the hand or wrist. Gradual onset injuries, such as cumulative trauma disorders without the presence of low-energy trauma, were excluded as they have fundamentally different injury mechanisms. An acute hand or wrist injury was defined as a new injury to the bones, joints, nerves, tendons, and muscles of the hand or wrist, that would typically stabilise within three-months.
5. The study was published in a peer-reviewed journal. Abstracts presented at conferences and editorials were excluded. Theses and dissertations were also excluded.

Method of review

The initial search of the databases yielded 764 unique studies (refer Figure 3.1). Two reviewers (LR, MS) independently screened all potentially eligible studies by reviewing the title and abstract of the articles using Covidence²¹, an online data management service. Full text of all references that met the screening criteria was retrieved, and eligibility decided independently by the two reviewers. Any disagreements were resolved by consensus and, if necessary, adjudication by a third author (LOB).

Seventy-three potentially relevant abstracts were found following initial screening by abstract and title. Fifty articles did not meet inclusion criteria and were excluded after full text screening, with a further two excluded during data extraction. These papers were excluded as the cost estimates reported were unable to be calculated per case²² or medical students were used to hypothesise anticipated costs²³. Twenty-one articles were included for analysis in the review.

Data extraction

Two reviewers (LR and MS) independently extracted data for each included study regarding study design, population, injury/intervention, and measurement methodology for direct, indirect and intangible costs. Estimates of cost were converted into US dollar (\$US) current value estimates to compare results. Foreign currencies were converted to \$US using a historical currency converter (<http://www.oanda.com/convert/classic>), with exchange rates taken from the date stated within each paper. When no date was specified, December 31st of the year that data analysis was completed was used, and in the case where the year of data analysis was not specified, the year data collection was ceased was used.

Contact was made with the corresponding authors if mean direct and indirect cost estimates were not presented within the paper. Where no mean data was available, an estimation of mean using the median was performed using the methodology outlined by Hoza, Djulbegovic and Hoza²⁴. In the case where data was presented graphically, a scale ruler was used to determine the reported cost estimates.

Data synthesis

Synthesis of data was primarily narrative due to the heterogeneity of studies (differing acute hand and wrist injuries, reported direct and indirect cost components, study design and methodologies). Mean costs per case of all COI studies and health economic evaluations are reported as published in addition to net current (December 2015) value estimates.

3.4.4 Results

Description of included studies

Twenty-one studies involving 264,978 (range 30-266,000) individuals with acute hand and wrist injuries and published over a 22-year period (1993-2015) were deemed suitable for inclusion in this review. All papers included direct and indirect cost estimates of acute hand and wrist injuries, with twelve also including intangible cost data. Settings included Austria²⁵, China²⁶, Denmark²⁷, Ireland²⁸, Netherlands¹, Slovenia²⁹, Sweden^{4, 30-37}, Switzerland^{38, 39}, Turkey⁹, and the United States of America^{40, 41}. Investigated injuries included non-specific acute hand injuries (n=8), scaphoid fractures (n=6), osteoporotic wrist fractures (n=3), digit amputation (n=1), ulnar and/or median nerve repair (n=1), digital nerve injury (n=1) and zone II flexor tendon repair (n=1). Fourteen included papers were COI studies, and seven were health economic evaluations.

Cost-of-illness studies

The fourteen included COI studies are summarised in Table 3.1. Twelve studies used a bottom-up approach to estimate costs, whereby estimation is based on the medical resource consumption of the individual patient⁴². Both retrospective (n=8) and prospective (n=6) data collection were used, ranging from fifteen weeks to ten years.

Cost components

Table 3.2 gives an overview of the cost components included in each of the fourteen COI studies. Reported cost components used in calculating direct, indirect and intangible costs were largely heterogeneous between studies. All studies reported direct costs including both inpatient and outpatient costs. Several studies did not report cost estimates for inpatient and outpatient expenditure separately but did include both in the total direct cost estimate. Additional cost components reported were occupational therapy / physiotherapy (n=7), pharmaceutical (n=4), radiology (n=3), and cast changes (n=1). Direct non-medical costs were reported by three studies, which provided estimates of medically related transportation costs. Additional cost components reported were sick/injury benefits (n=7), accident compensation (n=4), temporary/permanent disability pensions (n=2), early retirement (n=2), impact on

gross national product (n=1), mortality (n=1), community care (n=1) and morbidity (n=1). Eight studies included intangible costs, with seven reporting data on functional status and three on quality of life.

Measurement of costs

Methods used in the measurement and monetary valuing of costs varied between studies (refer Table 3.1). The use of unit cost prices paid by a referring hospital was the most common method for estimating direct costs. This method involved the multiplication of the quantity of each resource used by its corresponding value (i.e. unit costs) to determine a total cost. The human capital approach was the most commonly reported method (n=6) of estimating indirect costs. This approach measures the potential loss in production for society as the consequence of an illness, namely in terms of lost earnings. It is based on the assumption that each individual contributes to a society's productivity. The monetary value of lost productivity is calculated by multiplying the duration of the illness by the amount that the person would be earning (i.e. the market price of their labor) during the time they were unable to fulfil their role⁶. The majority of remaining studies used methods consistent with, but not specified as, the human capital approach. One study reported the use of the friction cost method, which takes into account that productivity losses from absences can be reduced in the short term by using excess capacity in the workforce and the long term by replacing workers with unemployed individuals or by the relocation of employees¹⁰. When reporting intangible costs, six studies used one or more standardised or non-standardised outcome measures. These included the EuroQol (EQ-5D)⁴³ (n=3), the Disabilities of the Arm, Shoulder, and Hand (DASH)⁴⁴ (n=3), the Short Form (SF-36)⁴⁵ (n=1), the Quick DASH (Q-DASH)⁴⁶ (n=1), the Duruöz Hand Index (DHI)⁴⁷ (n=1), and the Rosén and Lundborg scoring system⁴⁸. Two papers^{34, 41} reported quality of life data but did not provide measurement methodology. One study³⁶ used the findings of outcome measures to quantify a financial figure of intangible cost by reporting quality-adjusted-life-years (QALYs).

Table 3.3 shows the mean reported, and net current value cost estimates per case for each of the fourteen included COI studies. An estimated mean was calculated for one study⁴⁹ where data was not available. Data for eighteen participants in one study³⁴ and one participant in another³³ were not available for data analysis and therefore were omitted when calculating per case cost estimates.

Median figures for both net current value estimates and percentage of direct and indirect costs for all COI studies were calculated as the data were skewed when checked for normality. The median net current value cost estimate per case of all COI studies was US\$6,951 (IQR \$3,357-\$22,274). Regardless of adopted methodological approach, indirect costs (i.e. those associated with lost productivity) represented the largest portion of total cost [64% (IQR 50.75-88.25%)] with a median cost of US\$5,223 (IQR \$1,089.75-\$10,654.50). Higher direct cost figures were associated with an increase of severity of injury^{4, 9, 33, 50}, as determined by Hand Injury Severity Scoring System (HISS) severity categories or by non-standardised categorisation used by the authors. Direct costs for all COI studies ranged from US\$340 to US\$25,966 [median US\$1900.50 (IQR \$1,225.50-\$6,332.50)]

Eight COI studies investigated non-specific acute hand injuries that included, but were not limited to, fractures, tendon repairs and nerve injuries. Two studies^{4, 9} reported cost estimates that were stratified into HISS severity categories while one study investigating non-specific acute hand injuries caused by electric saw⁵⁰ stratified injury severity by a self-developed scale. The median net present value cost per case for all eight studies was US\$6,951 (IQR \$4,681.25-\$27,841.75), with indirect costs [median 64.5% (IQR 61.25-73.75%)] accounting for a higher percentage than direct cost estimates.

Estimates of the burden of wrist fractures were reported in four studies. Data for two studies^{29, 51} were extracted from larger studies investigating the cost of osteoporotic fractures that also investigated hip and spinal fractures. One study focused on conservatively managed undisplaced scaphoid fractures³⁸. Direct costs [median US\$1,281 (IQR \$975.50-\$1,829.750)] accounted for a marginally higher portion of total cost [median 54% (IQR 15.25-91.25%)] when compared to indirect cost. The total net value cost was calculated to be US\$2,551 (IQR \$1,345.25-\$5752.50).

Health economic evaluations

The seven included health economic evaluations are summarised in Table 3.4. The methodology employed in the studies included cost-effectiveness analysis^{27, 31, 35, 52, 53}, cost-benefit analysis²⁵, and cost-utility analysis⁵⁴. Both retrospective (n=3) and prospective (n=4) data collection were used, ranging from

three months to ten years. The majority of evaluations investigated scaphoid fractures by examining costs associated with conservative and operative management^{25, 38, 52}, diagnosis using MRI or radiography²⁷, and exposure to pulsed electromagnetic field (PEMF) or a placebo⁵⁴.

Cost components

Table 3.5 gives an overview of the cost components included in each of the health economic evaluations. Reporting of specific cost components for direct, indirect and intangible costs varied between studies. All studies reported direct costs including both inpatient and outpatient costs. Similar to included COI studies, several evaluations did not report individual cost estimates for inpatient and outpatient expenditure. Additional cost components reported were occupational therapy / physiotherapy (n=4), radiology (n=5), cast changes (n=1), and pharmaceutical costs (n=1). Direct non-medical costs were reported in two studies that included medically related transportation costs. Indirect costs were reported in all studies using an absenteeism approach for calculating lost productivity cost estimates. Additional cost components reported were sick/injury benefits (n=2) and early retirement (n=1). Four studies reported intangible costs including functional status (n=3), pain (n=2), and quality of life (n=1).

Measurement of costs

The methodology of measurement and monetary valuing of costs used in included health economic evaluations differed between studies (refer Table 3.4). All studies used unit cost prices paid by a referring hospital or cost records of all services during delivery of service when estimating direct costs. When calculating indirect costs, a methodology consistent with, but not specified as the human capital approach was used in six studies. One study reported using the human capital approach and another the friction cost method. When reporting intangible costs, three studies used one or more standardised or non-standardised outcome measures. These included the Visual Analogue Scale (VAS) for pain (n=3), the DASH (n=1), the Patient Rated Wrist and Hand Evaluation⁵⁵ (PRWHE) (n=1), the EQ-5D (n=1), and the Sollerman hand function test⁵⁶ (n=1).

Table 3.6 shows mean reported and net current value estimates of direct and indirect costs of included health economic evaluations. An estimated mean was calculated for two studies^{31, 35} where data was not available.

The median net current value cost estimate per case of all treatment exposures was US\$8,207 (IQR \$3,858-\$33,939). Indirect costs accounted for 68% (IQR 49.25-73.5%) of total cost with a median cost of \$US\$7,999 (IQR \$2,612.25-\$16,843.50). The median direct cost of all exposures was US\$2,520 (IQR \$1,278.50-\$10,061).

A comparison of conservative and operative management of scaphoid fractures was conducted in three studies. The median net present value cost per case was higher when fractures were managed operatively [US\$4,237 (IQR \$3,627-\$6,125)] compared to conservatively [US\$3,859 (IQR \$3,628-\$9,012.50)]. Median indirect costs were higher when managed operatively [US\$4,237 (IQR \$2,262.50-\$6,125)] compared to conservatively [US\$2,786 (IQR \$2,438-\$7,697.50)]. However, the percentage of indirect cost of the total cost was observed as being significantly less for operative management [37% (IQR 23.5-63%)] compared to conservative management [71% (IQR 68.5-71.5)].

3.4.5 Discussion

Despite acute hand and wrist injuries resulting in frequent emergency department presentations and, for some injuries, lengthy rehabilitation, we identified only fourteen cost-of-illness studies and seven health economic evaluations that investigated both direct and indirect costs. A significant portion of fully reviewed papers was excluded as they did not fulfil the selection criteria by adopting a health care system perspective and thus only reporting direct medical costs⁸. Included studies were mostly conducted in industrialised countries in Europe, with close to half conducted in Sweden, highlighting a gap in the available literature for Africa, Asia, Australia, New Zealand and South America.

Scaphoid fractures, which account for 10% of all hand fractures⁵⁷, were the most investigated specific injury in all papers reviewed. This may be attributed to their high prevalence of delayed union, nonunion and avascular necrosis as a result of poor vascularity which, if unsuccessfully managed, can

progress to carpal collapse and degenerative arthritis⁵⁸. As these complications commonly lead to lengthy rehabilitation and absence or decreased performance in chosen productivity roles⁵⁹, there is a large potential for significant direct and indirect costs to accumulate for both the individual and society. Subsequently, a focus of research on reducing the burden of these particular injuries is evident.

Non-specific hand injuries were examined in over half of the reviewed COI studies, which were conducted in five different countries. All studies aimed to demonstrate the magnitude of the health problem in financial terms, in addition to identifying the major disorders and cost drivers resulting in the largest burden. Indirect cost was found to be the major cost driver in both COI studies [64.5% (IQR 50.75-88.25)] and health economic evaluations [68% (IQR 49.25-73.5)], suggesting a need for further health economic evaluations of interventions that promote early return to productivity roles in order to reduce overall burden. Occupational therapy and physiotherapy services were found to contribute as little as 0.01%²⁶ of the total cost but have the potential to play a large role in reducing indirect costs, and therefore overall burden by addressing individual and workplace-related factors that impact return to work timeframes⁶⁰.

As predicted, injuries with a higher HISS score resulted in higher direct costs estimates. However, this did not have a large observable effect on the percentage of total cost, suggesting a link between severity and higher productivity loss. Again, this reinforces the need for further research into appropriate interventions that facilitate the suitable return to work schedules that could reduce consequential indirect costs.

One of the most notable findings of this review was that the methodology used to derive acute hand and wrist injury cost estimates varied considerably among the 21 studies examined. In spite of these differences, which produced a wide range of cost-of-illness and health economic evaluation estimates, it was apparent that these injuries represent an important economic burden regardless of injury sustained, included cost components, or study location. This was highlighted in one National COI study which concluded that hand and wrist injuries ranked first in the order of most expensive injury group, ahead of knee, hip, and skull-brain injuries due to the volume of injuries sustained annually¹.

When interpreting direct, indirect and intangible costs relating to acute hand and wrist injuries from COI studies and health economic evaluations, there are several methodological differences that should be considered. These include sources of data and cost categories for estimating direct costs, approaches to estimating indirect costs from lost productivity, approaches to determining intangible costs and delays in publication. Each is briefly discussed below.

Sources of data and cost categories for estimating direct medical costs

The reported data sources for direct cost estimates in the included studies were mostly public or private hospital and health insurer claims databases that used unit cost prices. Although the majority of studies included in this systematic review used bottom-up approaches to estimate medical resource consumption of the individual patient, none reported additional out of pocket medical or other expenses that may contribute to overall cost burden using sources such as patient diaries. This may have resulted in an underestimation of direct costs. For example, exercise putty, often used as a strengthening modality, is frequently prescribed as part of a home exercise program by occupational therapists and physiotherapists. The cost is charged directly to the patient or may be added to the set unit cost price for therapy. In the studies reviewed it is unclear if such modalities or similar additional out of pocket expenses were included within reported direct cost estimates.

The number of categories of direct costs that were measured in a study was likely to influence the magnitude and precision of the estimates. All included studies reported costs relating to inpatient and outpatient costs; however, few studies included costs involving occupational therapy, physiotherapy, pharmacy, radiology, wound care, or cast changes. No included study reported primary health care costs associated with consulting with a general practitioner and few reported direct non-medical costs. These omissions may result in an underestimation of total direct costs and therefore fail to capture the full burden associated with these injuries comprehensively. Furthermore, the time period between primary consultation with a health care professional and presentation to an emergency service may be a source of missed lost productivity costs.

Approaches to estimating indirect costs from lost productivity

There were noticeable differences in the assumptions made to estimate the indirect costs of acute hand and wrist injuries attributable to lost productivity, which was identified as being the major cost driver. For example, wage rates used to calculate costs were taken from national databases estimates, patient reports, researcher assumptions or amount of sick days reported in patient files. Such inconsistencies in data sources across studies may have led to an under or overestimation of true indirect costs involved with these injuries.

The human capital approach was the most frequent method reported for estimating indirect costs from lost productivity for all studies. A limitation of this approach is that it assumes the presence of a full employment economy, whereby the loss of each affected individual cannot be offset by another worker⁶. It fails to consider the cost associated with people attending work but performing in a reduced role (presenteeism). Further, the approach does not consider people without paid employment who are contributing in other ways to the economy such as caring for children, viewing these activities as having no statistical life value⁶¹.

Calculating indirect costs using patient diaries or employer records, albeit a more time-consuming method, may result in a more accurate measure of the true cost of these injuries, as researchers can design data collection systems according to the desired cost variables⁸. Researchers can prospectively collect complete datasets on the injury and loss of productivity using specifically designed questionnaires provided to the patient, family members and/or the patient's employer. This method could also allow for an estimation of the financial cost of presenteeism by using a suitable and reliable outcome measure, such as the Health-Related Productivity Questionnaire Diary (HRPQ-D)⁶² or the Health and Labor Questionnaire⁶³ as part of the study design⁶⁴.

Approaches to determine intangible costs

Less than half the studies reviewed reported intangible costs associated with acute hand or wrist injury. The finding of such low rates of reported financial estimates of intangible costs is consistent with burden of injury literature, supporting the notion that valuation of these costs is contentious and not

considered appropriate for all study designs²⁰. Despite this, in order to fully understand the costs inflicted on individuals and their families or friends, methods such as the willingness-to-pay approach or use of QALY estimates converted into monetary values should be considered to represent the true burden of these injuries⁶⁵.

Delays in publication

A significant delay between data collection and study publication was observed in the reviewed studies. This should be examined carefully to ensure that conclusions are not drawn from outdated data. For example, two studies published in the same year could be reporting estimates based on data from as little as one-year ago⁵² or as much as eight years ago³⁶. The year of publication is therefore not sufficient to identify how current the cost estimate may be. Although some authors may attempt to compensate for these delays by adjusting older cost data for inflation with a consumer price index, such methods are likely prone to error and will fail to capture other changes that may have occurred in the ensuing years.

In spite of varying injuries investigated and methodological disparities in included studies, an estimate of median cost per case for COI studies and health economics was calculated to be US\$6,951 and US\$8,297 respectively. These estimates, combined with knowledge of the frequency and volume for these injuries, suggests a significant societal burden of which the true magnitude remains largely unknown.

Further COI studies and health economic evaluations are required to further understand and address the burden associated with acute hand and wrist injuries. Future research should attempt to quantify burden more robustly with a consensus on the cost categories and cost components to be included in both COI and economic evaluations.

The List of All Deficits (LOAD) Framework⁶⁶, which recognises the multidimensional nature of injury burden across individual, family and societal domains, is particularly useful in supporting comprehensiveness in burden of illness studies. It attempts to capture all negative consequences of injury, and incorporates concepts such as psychological trauma, behavioural change, family consequences and

secondary health loss. Despite overlooking the impacts on co-workers or employers, which are considered as significant burden variables⁶⁷, the LOAD framework has been used increasingly in burden of illness studies investigating trauma related costs⁶⁸⁻⁷⁰ and should be considered when designing acute hand and wrist injury COI studies.

In order to ensure adequate reporting of health economic evaluations the use of quality assurance mechanisms have been proposed⁷¹. The Consolidated Health Economic Evaluation Reporting Standards (CHEERS)⁷² statement aims to provide recommendations in the form of a 24-item checklist to optimise the reporting of health economic evaluations. Co-published in ten health economic and medical journals to encourage dissemination and use of a single international standard for reporting, adoption of the CHEERS checklist has steadily increased in published economic evaluations⁷³. It is suggested that future health economic evaluations involving acute hand and wrist injuries should be guided by the CHEERS checklist.

3.4.5.1 Limitations of this review

The findings of this study are limited by having examined only medically based database for studies published in English. It is possible that a wider search of additional databases (i.e. economic databases; theses and dissertations) and grey literature may have uncovered additional cost-of-illness studies and health economic evaluations with different results. It should be noted that the methodology for calculating mean cost estimates per case using historical exchange rates and inflation indices may be prone to some error.

3.4.6 Conclusion

This review identified several studies that have attempted to estimate the direct, indirect and intangible costs associated with acute hand and wrist injuries in various countries using heterogeneous methodology. Estimates of the economic costs of different acute hand and wrist injuries varied greatly depending on the study design and methodology, but by any standards should be considered a substantial burden on the individual and society. Indirect costs were found to represent the major cost driver accounting for 64.5-68% of total costs. Further research using standardised methodologies and a

consensus of cost components could provide guidance to relevant policymakers on how to best distribute limited resources by identifying the major disorders and exposures resulting in the largest burden.

3.4.7 Manuscript I: Tables

Table 3.1 Cost-of-Illness Studies: Methodological Characteristics

Study	Country	Year(s) of data collection	Sample size	Injury	Study Population	Study Design / Data collection period	Direct cost measurement methodology	Indirect cost measurement methodology	Intangible cost measurement methodology
Borgström et al. 2006	Sweden	2002-2004	635*	Osteoporotic wrist fracture	Seven hospitals	Bottom-up; Prospective 18 months (baseline, 4 months, 1 year, 18 months)	Unit costs based on price paid by referring hospital	Human capital approach	EQ-5D
de Putter et al. 2012	Netherlands	2007	260,000*	Non-specific acute hand injury	National	Top-down; Retrospective 1 year	Incidence-based cost model using National database and patient surveys	Friction cost method	
Dzajkowska et al. 2007	Slovenia	2003	1,789*	Osteoporotic wrist fracture	National	Top-down Retrospective 1 year	Wholesale prices provided by National database	Human capital approach	
Eriksson et al. 2011	Sweden	1999-2003	57	Major or severe acute hand injury	Single Hospital	Bottom-up; Prospective Injury stabilisation	Unit costs based on price paid by referring hospital	Human capital approach	DASH EQ-5D used to calculate QALYs
Fusetti et al. 2003	Switzerland	1990-2000	54	Undisplaced scaphoid fracture	Single hospital	Bottom-up Retrospective Injury stabilisation	Cost records of all medical and paramedical services	National public insurance system	
Hoxie et al. 2009	USA	2000-2006	134	Non-specific acute hand injury caused by electric saw	Single hospital	Bottom-up; Retrospective Injury stabilisation	Billing records of costs charged to insurance carriers	Estimated where possible using mean income of Minnesota	
O'Sullivan et al. 1993	Ireland	1990	156	Non-specific acute hand injury	Single hospital	Bottom-up; Prospective 15 weeks	Unit costs based on price paid by referring hospital	Estimated using patient reported figures and social welfare payments	
Qu et al. 2014	China	2010-2012	292*	Osteoporotic wrist fracture	Three hospitals	Bottom-up; Prospective 1 year	Unit costs based on public health administration tariff	Estimated using daily wage of manual unskilled worker. Long-term sick leave and early retirement based on providence average income.	
Rosberg et al. 2005a	Sweden	2002-2003	140	Non-specific acute hand injury	Single hospital	Bottom-up; Prospective 1 year (baseline, 3 months, 6 months, 1 year)	Unit costs based on price paid by referring hospital	Human capital approach	DASH SF-36
Rosberg et al. 2005b	Sweden	1991-1998	69	Acute median or ulnar nerve injury (<50% transection of one or both nerves up to	Single hospital	Bottom-up; Prospective 5 years	Unit costs based on price paid by referring hospital	Estimated using reported employment status and sick leave in hospital files using market wage data	Rosen and Lundborg scoring system

				10cm proximal to wrist).					
Rosberg et al. 2013	Sweden	2005-2007	45	Major or severe acute hand injury	Single hospital	Bottom-up; Prospective 1 year (3 months, 6 months, 1 year)	Unit costs based on price paid by referring hospital	Human capital approach	DASH EQ-5D
Sahin et al. 2013	Turkey	2009-2011	79	Non-specific acute hand injury	Single hospital	Bottom-up; Prospective Until return to work or disablement report	Unit costs based on price paid by referring hospital	Human capital approach	Q-DASH DHI
Thorsén et al. 2012	Sweden	1995-2005	176	Digital nerve injury	Single hospital	Bottom-up; Retrospective Injury stabilisation	Unit costs based on price paid by referring hospital	Sick leave information from patient files.	Pain (methodology not reported) Impact on ADL (methodology not reported).
Trybus et al 2006	USA	1999-2000	170	Non-specific acute hand injury	Single hospital	Bottom-up; Prospective Injury stabilisation	Unit costs based on National healthcare fund financial estimates	Amount of GNP that was not produced due to sick leave. GNP per capita per day was calculated by dividing GNP by professionally active citizens. This was then multiplied by number of sick leave used by each person.	Swanson scale (methodology not reported).

*Sample extracted from a larger study sample

EQ-5D: EuroQol; DASH: The Disabilities of the Arm, Shoulder, and Hand; SF-36 Short Form 36; Q-DASH: Quick DASH; DHI Duruöz Hand Index; GNP: Gross National Product

Table 3.2 Cost-of-Illness Studies: Reported Cost Components

	Borgström et al. 2006	Dzajkovska et al. 2007	De Putter et al. 2012	Eriksson et al. 2011	Fusetti et al. 2003	Hoxie et al. 2009	O'Sullivan et al. 1993	Qu et al. 2014	Rosberg et al. 2005a	Rosberg et al. 2005b	Rosberg et al. 2013	Sahin et al. 2013	Thorsén et al. 2012	Trybus et al. 2006
Cost components														
<i>Direct medical costs</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Inpatient costs (including surgery)	+	+	*	*	*	*	+	+	*	+	*	+	+	*
Outpatient costs	+	+	*	*	*	*	+	+	*	+	*	+	+	*
Pharmaceutical costs	+	+						+				+		
Occupational Therapy/Physiotherapy	+	+				*		+		+		+	+	
Radiology	+							+				+		
Cast Changes												+		
<i>Direct non-medical costs</i>	+		+					+						
Transportation	+		*					+						
<i>Indirect costs</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Loss productivity	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Community care	+	*		+		+			
Accident compensation		*		+				+	*
Sick/injury benefits	+	*	+	+		*	+		*
Temporary / permanent disability pensions			+				+		*
Gross National Product									*
Early retirement			+				+		
Mortality		+							
Morbidity		+							
<i>Intangible costs</i>	+		+				+	+	+
Quality of life	+						+	+	
Functional status			+				+	+	+

(+) yes; (*) yes, but figure not reported; (**) yes, but method not stated

Table 3.3 Cost-of-Illness Studies: Per Case Mean Estimates of Reported and Net Present Value
Direct, Indirect and Total Costs

Study (year of pricing)	Injury	Direct Cost			Indirect Cost			Total Cost	
		<i>Reported</i>	<i>Net present value</i>	<i>(%) Total Cost</i>	<i>Reported</i>	<i>Net present value</i>	<i>(%) Total Cost</i>	<i>Reported</i>	<i>Net present value</i>
Borgström et al. 2006 (2004)	Osteoporotic wrist fracture	€ 1,950	US\$3,323	91	€ 196	US\$334	9	€ 2,147	US\$3,657
Dzajkowska et al 2006 (2003)	Osteoporotic wrist fracture	€ 131	US\$212	17	€ 647	US\$834	83	€ 778	US\$1,046
de Putter et al. 2012 (2007)	Non-specific acute hand injury	US\$1265	US\$1,448	44	US\$1,580	US\$1,809	56	US\$2,845	US\$3,257
Eriksson et al. 2011 (2003)	Major or severe acute hand injury	€ 4,239	US\$6,877	9	€ 45,062 SFr	US\$73,098	91	€ 49,301	US\$79,975
Fusetti et al. 2003 (2000)	Scaphoid fracture	SFr 1,438 US\$22,08	US\$1,230	10	12,639	US\$10,809	90	SFr 14,077 US\$30,75	US\$12,039
Hoxie et al. 2009 (2006)	Non-specific acute hand injury caused by saw	6	US\$25,966	72	US\$8,668	US\$10,191	28		US\$36,157
O'Sullivan et al. 1993 (1990)	Non-specific acute hand injury	IR£210 RMB	US\$677	44	IR£264	US\$850	66	IR£474 RMB	US\$1,528
Qu et al. 2014 (2012)	Osteoporotic wrist fracture	8,133	US\$1,332	92	RMB 695	US\$114	8	8,828	US\$1,445
Rosberg et al. 2005 (2003)	Non-specific acute hand injury	€ 5,806	US\$9,405	32	€ 12,160	US\$15,665	68	€ 17,966	US\$25,070
Rosberg et al. 2005b (1998)	Acute median or ulnar nerve injury	€ 6,015	US\$10,206		€ 45,820	US\$53,467		€ 51,835	US\$87,953
		** € 2,770	US\$4,699	3	€ 97,072	US\$164,710	97		US\$169,408
Rosberg et al. 2013 (2009)	Major or severe acute hand injury	€ 1,219	US\$1,934	37	€ 2,030	US\$3,222	63	€ 3,249	US\$5,156
Sahin et al. 2013 (2011)	Non-specific acute hand injury	US\$1,772	US\$1,867	37	US\$3,370	US\$3,551	63	US\$5,142	US\$5,418
Thorsên et al. 2012 (2009)	Digital nerve injury	€ 4,403	US\$6,990	51	€ 4,344	US\$6,895	49	€ 8,747	US\$13,885
Trybus et al. 2006 (2002)	Non-specific acute hand injury	US\$247	US\$340	4	US\$5,916	US\$8,143	96	US\$6,163	US\$8,483

*reported median; **estimated mean

Table 3.4 Health Economic Evaluations: Methodological Characteristics

Study	Country	Year(s) of data collection	Sample size	Injury	Study Population	Study Design / Data collection period	Direct cost measurement methodology	Indirect cost measurement methodology	Intangible cost measurement methodology
Arora et al. 2007	Austria	2003-2005	44	Acute non-displaced waist scaphoid fracture	Single hospital; Immobilisation (n=23) or surgical fixation (n=21)	Bottom-up; Prospective controlled trial; cost-benefit analysis 6 months	Cost records of all medical services kept during delivery of service	Assumed according to National standard wages	DASH VAS pain scale
Hansen et al. 2009	Denmark	2007	64	Suspected scaphoid fracture	Two hospitals; conservative management with casting diagnosed by radiography (n=27) or MRI (n=27)	Bottom-up; Prospective; cost-effectiveness analysis 3 months	Unit costs per hospital visit and radiograph / MRI	Assumed according to National database average wage for employed participants, daily wage rate obtained from previous study.	
Hannemann et al. 2015	Netherlands	2010-2011	102	Acute, unilateral displaced fractures of the scaphoid (types A1, A2, B1 or B2 according to the Herbert Classification ⁷⁴)	Five hospitals; conservative management with placebo (n=51) or with active bone growth stimulation using PEMF (n=51)	Bottom-up; Prospective; randomized controlled trial; cost-utility analysis 12 months (6, 9, 12, 24 and 52 weeks)	Unit cost prices (real resource use) using hospital information systems	Friction cost method	EQ-5D PRWHE
Holmberg et al. 1996	Sweden	1988-1990	30	Total amputation or total interruption of the circulation to the thumb and/or two or more of the fingers proximal to the PIPJ and distal to the MCPJ	Single hospital; Successful replantation/revascularisation (n=24), Unsuccessful replantation/revascularisation (n=3), Primary amputation (n=3).	Bottom-up; Retrospective; cost-effectiveness analysis 2 to 5 years	Administrative prices paid by the referring hospitals	Patient reported sick leave multiplied by their monthly income before injury including employers' contribution to social insurance and tax. The cost of half sick leave was taken as half the monthly income	Sollerman hand function test VAS (Function, pain and cosmetic problems) Discharge
Papaloizos et al. 2004	Switzerland	1998-2003	85	Isolated, undisplaced waist fracture of the scaphoid	Two hospitals; conservative management (n=62) or internal fixation and early mobilisation (n=32)	Bottom-up; Prospective; Cost-effectiveness study 2 years	Unit cost prices using hospital information-management systems	Assumed according to national standard wages for the European professional categories	
Rosberg et al. 2003	Sweden	1989-1998	135	Zone II flexor tendon injury	Single hospital; Active protocol (n=45), rubber band traction protocol (n=50),	Bottom-up; Retrospective; Multiple regression cost-effectiveness analysis	Unit costs based on price paid by referring hospital	Human capital approach	

					immobilisation protocol (n=40)	Injury stabilisation		
Vinnars et al. 2007	Sweden	1992- 1997	52	Acute scaphoid fractures with displacement ≤1mm that was not a Herbert type A1 or open fracture	Single hospital; Conservative management (n=26) or surgical intervention (n=26)	Bottom-up; Prospective; cost- effectiveness analysis Injury stabilisation	Unit cost prices for inpatient and outpatient items listed in medical records	Estimated using sick leave records (insurance database or patient report). Payroll and value-added tax were not included

DASH: The Disabilities of the Arm, Shoulder, and Hand; VAS: Visual Analogue Scale; PEMF: Pulsed Electromagnetic Field; EQ-5D: EuroQol;
PRWHE: Patient Rated Wrist and Hand Evaluation; PIPJ: Proximal Interphalangeal Joint; MCPJ: Metacarpophalangeal Joint

Table 3.5 Health Economic Evaluations: Reported Cost Components

Cost components	Arora et al. 2007	Hannemann et al. 2015	Hansen et al. 2009	Holmberg et al. 1996	Papalpoizos et al. 2004	Rosberg et al. 2005b	Vinnars et al. 2007
<i>Direct medical costs</i>	+	+	+	+	+	+	+
Inpatient costs (including surgery)	+	*	+	+	+	+	+
Outpatient costs	+	+	+	+	+	+	+
Pharmaceutical costs					+		
Occupational Therapy/Physiotherapy	+			+	+	+	
Radiology	+	+	+		+		*
Cast Changes	+	+					
<i>Direct non-medical costs</i>			+	+			
Transportation			+	+			
<i>Indirect costs</i>	+	+	+	+	+	+	+
Loss productivity	+	+	+	+	+	+	+
Accident compensation							
Sick/injury benefits	+						+
Temporary / permanent disability pensions							
Early retirement		+					
<i>Intangible costs</i>	+	+		+		+	
Quality of life		+					
Functional status	+			+		+	
Pain	+			*			

(+) yes; (*) yes, but figure not reported; (**) yes, but method not stated

Table 3.6 Health Economic Evaluations: Per Case Mean Estimates of Reported and Net Present Value Direct, Indirect and Total Costs

Study (year of pricing)	Injury		Direct Cost			Indirect Cost			Total Cost	
			Reported	Net present value	(%) Total Cost	Reported	Net present value	(%) Total Cost	Reported	Net present value
Arora et al. 2007 (2005)	Scaphoid fracture	Operative	€ 1,897	US\$2,729	90	€ 200	US\$288	10	€ 2,097	US\$3,017
		Conservative	€ 908	US\$1,306	34	€ 1,453	US\$2,091	66	€ 2,361	US\$3,397
Hansen et al. 2009 (2007)	Scaphoid fracture	Radiography	€ 354	US\$596	7	€ 4,746	US\$7,985	93	€ 5,100	US\$8,581
		MRI	€ 505	US\$850	22	€ 1,877	US\$3,158	78	€ 2,382	US\$4,008
Hannemann et al. 2014 (2011)	Scaphoid fracture	PEMF	€ 1,594	US\$2,179	56	€ 1,226	US\$1,676	44	€ 2,827	US\$3,855
		Placebo	€ 875	US\$1,196	39	€ 1,423	US\$1,945	61	€ 2,253	US\$3,142
Papaloizos et al 2004 (2003)	Scaphoid fracture	Conservative	€ 906	US\$1557	29	€ 7,773	US\$12,609	71	€ 8,710	US\$14,166
		Operative	€ 1,441	US\$2337	11	€ 3,499	US\$8,013	89	€ 4,940	US\$8,013
Vinnars et al 2007 (2003)	Scaphoid fracture	Conservative*	€ 688	US\$1,114		€ 1,913	US\$3,099		€ 2,507	US\$4,061
		Conservative**	€ 661	US\$1,073	28	€ 1,717	US\$2,786*	72	€ 2,378	US\$3,859
		Operative*	€ 1,649	US\$2,671		€ 777	US\$1,1259		€ 3,155	US\$5,111
		Operative**	€ 1,666	US\$2,703	63	€ 946	US\$4,237	37	€ 2,612	US\$4,237
			SEK166,37			SEK169,86			SEK336,23	
Holmberg et al. 1996 (1993)	Digit amputation	Successful replantation	1	US\$32,764	49	4	US\$33,452	51	6	US\$66,215
		Unsuccessful replantation	SEK157,780	US\$31,072	59	SEK107,393	US\$21,149	41	SEK265,173	US\$52,221
		Primary amputation	SEK81,180	US\$15,987	47	SEK90,733	US\$17,868	53	SEK171,913	US\$33,856
Rosberg at al. 2003 (2002)	Zone II flexor tendon	Active*	SEK49,271	US\$8,805		SEK103,288	US\$18,458		SEK151,025	US\$26,989
		Active**	SEK57,039	US\$10,193	30	SEK134,274	US\$16,502	70	SEK191,313	US\$34,189
		Rubberband Traction*	SEK51,297	US\$9,167		SEK82,442	US\$14,733.04		SEK130,472	US\$23,316
		Rubberband Traction**	SEK56,054	US\$10,017	22	SEK193,022	US\$23,722	88	SEK249,076	US\$44,584
		Immobilisation*	SEK44,396	US\$7,934		SEK103,637	US\$18,521		SEK147,438	US\$26,348
		Immobilisation**	SEK48,006	US\$8,579	28	SEK123,165	US\$15,137	72	SEK171,171	US\$30,590

*reported median; **estimated mean

3.4.8 Manuscript I: Figure

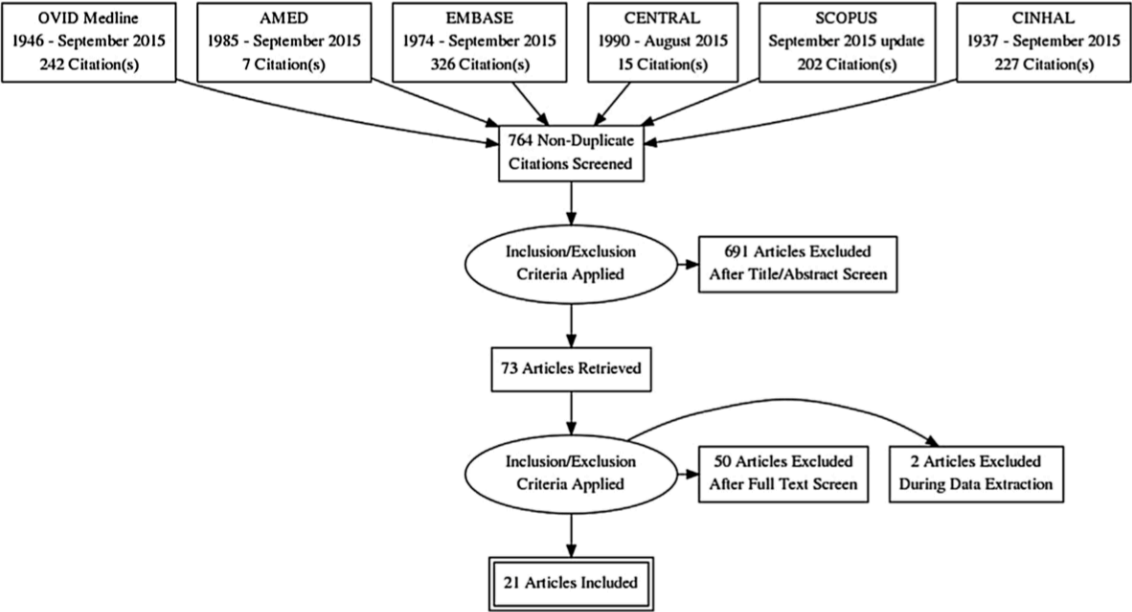


Figure 3.1 PRISMA Flow Diagram of Study Selection Process

3.5 Additional Commentary

This systematic review provides an accurate estimate of the burden of injury of acute hand and wrist injuries from a societal perspective using cost-of-illness studies and health economic evaluations. It highlights the gaps in international literature, especially the noticeable absence of Australian literature.

When contextualising the findings using the three dimensions of healthcare economic evaluations⁷⁵ (Table 3.7), it is observed that the majority of included studies used a cost-of-illness methodology with few studies using an evaluation design which investigated cost alternatives. Further, the majority of studies were conducted from a health-system perspective, which limits the generalisability of findings both locally and internationally but provides some insight into the cost burden of these injuries.

Table 3.7 Application of the Three Dimensions of Healthcare Economic Evaluations to Systematic Review Findings

Type of Evaluation	<ul style="list-style-type: none">○ Cost-of-illness (n=14)○ Cost-effectiveness analysis (n=5)○ Cost-benefit analysis (n=1)○ Cost-utility analysis (n=1)
Point of View or Perspective	<ul style="list-style-type: none">○ Health-system perspective (n=19)○ National (n=2)
Type of Costs	<ul style="list-style-type: none">○ Direct costs (n=21)○ Indirect costs (n=21)○ Intangible costs (n=12)

Adapted from Robinson & Vetter.⁷⁵

3.6 Impacts of the Study

Journal Metrics:

Impact Factor (2015): 1.91

5 Year Impact Factor (2015): 2.406

Article Influence (2015): 0.720

Eigenfactor (2015): 0.019

Source-Normalised Impact Per Paper (SNIP) (2015): 1.337 [2616 citations; 1250 papers]

SCImago Journal Rank (SKR) (2015): 0.982

This paper was presented to the Victorian Division of the Australian Hand Therapy Association (AHTA) and led to discussions for potential collaborative investigation of economic burden for public (Peninsula Health, Austin Health) and private patients (Peninsula Hand Therapy, Rewired Hand Therapy) for both acute, chronic and cumulative traumas. This paper has also been presented at various national and international conferences (see below) and has been cited in high impact journals, including *Public Health*, *Emergency Medicine Australasia*, *Journal of Bone and Joint Surgery*, and *Hand*.

Conferences:

Robinson, L., S., Sarkies, M., Brown, T., & O'Brien, L. (2016). Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review. Poster presentation. International Federation of Societies for Surgery of the Hand / International Federation of Societies of Hand Therapy Congress, 24-28th October, Buenos Aires, Argentina.

Robinson, L., S., Sarkies, M., Brown, T., & O'Brien, L. (2017). Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review. Poster presentation. Victorian Allied Health Research Conference: Allied Health Future Directions, 17th March, Melbourne, Australia.

Robinson, L., S., Sarkies, M., Brown, T., & O'Brien, L. (2017). Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review. Oral presentation. Canadian Association of Occupational Therapists (CAOT), 21st - 24th June, Prince Edward Island, Canada.

Robinson, L., S., Sarkies, M., Brown, T., & O'Brien, L. (2017). Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review. Poster presentation. Victorian Allied Health Research Conference: Allied Health Future Directions, 17th March, Melbourne, Australia.

Robinson, L., S., Sarkies, M., Brown, T., & O'Brien, L. (2018). Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review. Poster presentation. Conference of the Australian Hand Therapy Association, 19th – 21st of October, Melbourne, Australia.

3.7 Chapter Summary

In the previous chapter, the methodology for each of the studies included in this thesis was outlined. In this chapter we aimed to systematically review cost-of-illness and health economic evaluations of acute hand and wrist injuries with a focus on direct, indirect and intangible costs. Twenty-one eligible studies were identified from searches of OVID Medline, AMED, EMBASE, CENTRAL, SCOPUS, and CINHAL. Due to the heterogeneity of studies (differing acute hand and wrist injuries, reported direct and indirect cost components, study design, and methodologies), synthesis of data collected was primarily narrative as pooling of results was not possible.

Key Findings:

- The methodology used to derive direct, indirect and intangibles costs differed markedly across all studies.

- Indirect costs represented a large portion of total cost in cost-of-illness studies [64.5% (IQR 50.75-88.25)] and health economic evaluations [68% (IQR 49.25-73.5)].
- The median total cost per case of all injury types using a cost-of-illness methodology was US\$6,951 (IQR \$3,357-\$22,274).
- The median total cost per case of all injury types using a health economic evaluation methodology was US\$8,297 (IQR \$3,858-\$33,939).
- Occupational therapy and physiotherapy services were found to contribute to as little as 0.01% of total cost but have the potential to play a large role in reducing indirect costs by addressing individual and workplace-related factors that impact return to work timeframes.
- When interpreting direct, indirect and intangible costs relating to acute hand and wrist injuries there are several methodological differences that should be considered:
 - Sources of data and cost categories for estimating direct costs;
 - Approaches to estimating indirect costs from lost productivity;
 - Approaches to determining intangible costs; and
 - Delays in publication.
- Estimates of the economic costs of different acute hand and wrist injuries varied greatly depending on the study methodology, however, by any standards, should be considered a substantial burden on the individual and society.

In summary, this is a field with little published evidence, and future research using standardised methodologies and a consensus of cost components is required. Such research could provide insight into the costs experienced from an individual, community and societal perspective and also provide guidance to relevant policymakers on how to best distribute limited resources by identifying the major disorders and exposures resulting in the largest burden. The unrealised potential of allied health represents a significantly underutilised resource that has the potential to address many of the challenges facing our healthcare system.

The following chapters seek to provide insight and estimates of the individual, community and societal burden of acute hand and wrist injuries and aim to serve as exemplars by highlighting these internationally important issues from a local level. The investigations were conducted at one major public health network within Australia (Alfred Health), with the exception of Chapter 7, which involves two major public health networks. The first of these will provide estimates of the direct costs associated with resource use in two emergency departments within Alfred Health for individuals presenting with an acute hand or wrist injury.

3.8 References

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Chapter 4

Description and cost-analysis of emergency department attendances for hand and wrist injuries

4.1 Chapter Introduction

Chapter 3 systematically reviewed the existing literature that reported the direct, indirect and intangible costs of acute hand and wrist injuries. We reported that the median cost per case for all injury types using a cost-of-illness methodology was US\$6,951 (IQR \$3,357-\$22,274) and US\$8,297 (IQR \$3,858-\$33,939) for health economic evaluations. A key finding of the review was that indirect costs represented the most significant portion of the total cost for both cost-of-illness studies [64.5% (IQR 50.75-88.25)] and health economic evaluations [68% (IQR 49.25-73.5)]. This is an important finding as we also found that occupational therapy and physiotherapy services were found to contribute to as little as 0.01% of total cost despite having significant potential to reduce this burden by addressing individual and workplace-related factors that could influence the timing and success of return to work plans. The review also highlighted the heterogeneity of methodologies and cost components used to estimate costs, the absence of Australian cost-of-illness and health economic evaluation studies and provided recommendations for future research.

In this and the two subsequent chapters I aimed to address the gap in Australian evidence by exploring the economic burden of acute hand and wrist injuries from a health-system perspective using data from one Australian public hospital network. This first investigation focuses on the costs relating to resource use that occurs exclusively within the emergency department.

4.2 Chapter Aims

This chapter presents a cost-of-illness study that focuses on individuals who presented with hand or wrist injuries at two emergency departments within one Australian public health service. It provides insight into the cost and demographic profile of this population and estimates the direct costs associated with resource use in the service's emergency departments. Further, it comprehensively describes the demographic and injury profile of this population, an area that is noticeably absent in currently published literature relating to these injuries in Australia.

4.3 Chapter Contents

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4.4 Manuscript II

Manuscript II, as it appears in this chapter, is presented in the format that was required for publication in the *Emergency Medicine Australasia* journal.

4.4.1 Abstract

Introduction: Injuries to the hand and wrist are estimated to account for between 10-30% of all Emergency Department (ED) presentations. The economic burden placed on the healthcare system can be extensive and rise sharply with the increase of severity.

Objectives: This cost-analysis was performed with the aim of estimating the economic implications of ED attendances for hand and wrist injuries from the perspective of one Australian public health network.

Methods: Data from two EDs were retrieved from the electronic billing records of one large health network across two financial year periods (2014-15 and 2015-16) using ICD-10 codes. All costs that resulted from the treatment of any acute hand or wrist injury across the two-year period were calculated and are presented by age, sex, injury type, and mechanism of injury.

Results: A total of 10,024 individuals presented to the two EDs in the two-year period, accounting for approximately 5.4% of all presentations. The most common presentations were males (62.2%); people aged 25-34 years (26.9%); and lacerations (31.2%). The total cost in the two-year study period was \$3,959,535.38 (\$1,923,852.38 in 2014-15; \$2,035,683.00 in 2015-16). The mean cost per presentation was \$383 (95% CI [\$373, \$393]) in 2014-15 and \$407 (95% CI [\$394, \$421]) in 2015-16.

Conclusions: Acute hand and wrist injuries contribute to a significant volume of ED presentations each year in one Australian public health network leading to significant expenditure and health resources. Further research into how to best utilise resources and reduce avoidable injuries should be priority areas to reduce the cost of these injuries to the healthcare system and society.

4.4.2 Introduction

Injuries to the hand and wrist are common, with reports suggesting they account for between 10-30% of all ED presentations¹⁻³, and typically affect young and economically productive populations.^{1,4} While most uncomplicated injuries will recover fully, accurate assessment and

treatment are vital as mismanagement can result in delayed recovery and potential long-term disability at a significant cost to the individual, healthcare system and society.³⁻⁸

The administration of the Australian health care system is complex, involving all three levels of government in addition to other stakeholders that include private and public service providers⁹. The Australian government has a responsibility for the tax-funded universal public health insurance scheme, Medicare, which involves subsidising medical services, such as public ED funding, and providing some funding for private health networks¹⁰. The private sector, however, is largely funded by premiums paid by households (e.g. private health insurance or the Victorian Transport Accident Commission (TAC) levy which funds treatment for individuals with injuries because of road trauma) and employers (e.g. WorkCover insurance which provides a compensation system for individuals injured at work).

Public hospitals are funded by the state, territory and Australian governments, but are managed by state and territory governments, whereas private hospitals are owned and operated by the private sector but are licensed and regulated by the government⁹. In some circumstances, the individual seeking health services may be required to self-fund additional out of pocket costs that are not covered by government or health insurance funds. This may include a gap payment, medications, or other treatment modalities. A simplified flow of health funding in the Australian domestic health sector is illustrated in Figure 4.1.

In Australia, comprehensive epidemiological and cost data for individual disease or injury is problematic due to the absence of a national systematic procedure for capturing specific patient resource use.¹¹ The fragmentation of the Australian health care system, due to multiple layers of administration, service delivery and financing, further complicates the ability to calculate cost burden.¹² As a result, knowledge of the cost and profile of hand and wrist injuries is limited to workers' compensation claim data.^{13,14} Such population-based information about direct costs, the

resources used in the design, implementation, and provision of healthcare¹⁵, is of interest to policymakers for resource allocation and cost-minimisation, but such an analysis has not been completed for hand and wrist injuries in Australia. This study focuses on individuals presenting with hand and wrist injuries to two public Australian EDs within one Australian public health service to provide insight into the cost and demographic profile of this population.

4.4.3 Objectives

This cost-analysis study was performed with the purpose of estimating the economic implications of attendances for hand and wrist injuries presenting to two metropolitan EDs in one Australian public health service over a two-year period.

Specifically, we aimed to:

1. Present an estimate of the direct costs associated with resource use in the EDs of one Australian public health service for individuals presenting with a hand or wrist injury; and
2. Describe the demographic profile of individuals that utilise ED resources in one Australian public hospital health service following a hand or wrist injury.

4.4.4 Methods

Target population and subgroups

This study included data from 10,024 consecutive patients of any age who received care for a hand or wrist injury at the EDs of the Alfred and Sandringham Hospitals, Melbourne, Australia, from July 1st 2014 to June 31st 2016. The sample included all ED visits, whether subsequently discharged home or admitted to the hospital, with any listed diagnosis of a hand or wrist injury according to ICD-10 diagnostic codes (refer Appendix 1) during the specified period. To avoid contamination of data, we excluded cases where the hand/wrist injury was not listed as their primary reason for presentation (e.g. if a head strike and hand injury occurred in the same accident and the head strike was listed as the primary diagnosis).

We selected this population to allow insights into the volume and resource use in the ED of individuals presenting with a hand or wrist injury at one Australian public health service.

Additionally, subgroups including injury type (as defined by ICD-10 code) and mechanism of injury were selected to examine if any key drivers of cost within the selected population exist. Ethics was approved by Alfred Health (233/16) and Monash University (CF16/2268 – 20160001119).

Setting and location

The Alfred Hospital is a 680-bed tertiary referral teaching hospital that is a major provider of specialist state-wide services (e.g. burns, trauma) to residents of Victoria. The ED has about 65,000 visits per year.¹⁶ The Sandringham Hospital is a 100-bed tertiary referral teaching hospital and has about 34,000 visits per year and is open 24 hours/day. Both hospitals, which are part of a public healthcare network (Alfred Health), serve a metropolitan population of approximately 700,000 residents.

Study perspective

We used a prevalence approach to costing illness, where the economic burden that an injury, disease or illness has on society during a specified period irrespective of the time of disease onset¹⁷⁻¹⁹, is used to quantify the economic burden. Direct costs (e.g. costs relating to medical resource use) were estimated from the perspective of the EDs at Alfred Health and were calculated for all services used by patients receiving care for a hand or wrist injury within the Alfred and Sandringham hospital EDs. This approach is commonly referred to as costing from a ‘health care system perspective’²⁰ where morbidity and mortality are not considered.¹⁹

Indirect costs due to loss of productivity (e.g. paid or unpaid work), child-care, transport or other out-of-pocket costs are not included in cost estimates. As the study setting was restricted to the

two-public hospital EDs, cost associated with resources used prior to presentation (e.g. ambulance, general practitioner (GP) consultation) or after presentation (e.g. public or private inpatient admission, public or private surgical management, public or private medical or allied health outpatient management) are not included. Cost that occurred when a patient was transferred from the ED to another ward (costs associated with a short stay unit admission or the operating theatre) was also not included.

Both EDs are funded by the Victorian and Australian governments and are managed by the Victorian government. Therefore, cost estimates in this study are contained within the two tax-funded universal public health system EDs.

Estimating resources and costs

Details relating to cost and resource use per patient for the two-year time horizon (July 1st, 2014 to June 31st, 2016) were extracted from hospital electronic billing records. This allowed for a between years' analysis of cost and demographics. Included cost components were services associated with allied health, ED medical, imaging, pathology and pharmacy as well as indirect medical costs (e.g. overhead costs such as electricity, laundry services). Cost estimates were not adjusted (0% discount rate) and are presented as routine costs and prices billed during the two-year time horizon. As our adopted study design was a cost-analysis and not an economic evaluation, no compactors, decision-analytical model or measures of effectiveness and health outcomes were included.

Epidemiological approach

Data relating to demographics, mechanism of injury, and trends were sourced from electronic medical records. Seasonal trends were examined by calculating volume of injuries, ICD-

10 codes and mechanism of injuries that occurred during the Australian seasons and compared between years.

The mechanism of injury for all 10,024 records was reviewed and recoded by allocating a simplified (e.g. ‘laceration’) and detailed (e.g. ‘knife/scissors’) mechanism of injury label where possible. In the case where a simplified or detailed mechanism was not able to be determined due to insufficient or missing data, records were labeled as ‘uncoded’. Eighty-eight percent of all cases (n=8,829) were assigned a simplified mechanism of injury.

Data analysis

Descriptive statistics were used to report epidemiological, demographic and cost data. A biostatistician checked the data analysis procedures to ensure the accuracy of reported findings. All reported costs are presented in Australian Dollars (AUD). Data analysis was performed using R studio²¹ and Microsoft Excel²².

4.4.5 Results

Volume of ED visits

Over the two-year period of this study, hand or wrist injury presentations to the EDs of the participating hospitals represented approximately 5.4% of the total presentations within the health network.²³ Differences between the volume of presentations during the two financial year periods, 2014-15 (n=5,028) and 2015-16 (n=4,996), was negligible.

Demographics

Males comprised approximately two-thirds (62.19%) of all ED presentations during the two-year study period (refer Table 4.1). The mean age of patients was 36.36 (95% CI [35.80, 36.91]) and

36.22 (95% CI [35.67, 36.76]) years in the 2014-15 and 2015-16 financial years respectively.

Patients aged between 25 and 34 years accounted for the largest group of presentations (26.85%).

Over two-thirds of all presentations were sustained by individuals aged between 18 and 54 years. As the Alfred Hospital is an adult trauma centre, most patients under the age of 17 (85%) attended the ED at Sandringham Hospital.

A summary of the frequency of presentations of included ICD-10 codes are shown in Table 4.2. Overall, in the combined two-year period, patients were most likely to present with an open wound to the wrist or hand (34.4%) followed by fracture of parts of hand or wrist (28.9%), sprain of hand (7.4%), or superficial injury of wrist and hand (7.1%). Differences between the proportions of presentations for each of the ICD-10 categories during the two financial year periods were negligible.

Mechanism of injury

Descriptions of the simplified and detailed mechanisms are shown in Table S1. Overall, in the two-year period, patients were most likely to present following a laceration (31.2%), fall or fall on outstretched hand (FOOSH) (20.1%), sports-related incident (15.6%), crush (7.4%) or direct blow (5.1%). Patients who had sustained their injury from a laceration were most likely to have cut their hand using a knife/scissors (31.8%), glass (10.9%) or power tool (10.5%). Differences between the numbers of presentations for each simplified mechanism of injury category between the two financial year periods were negligible.

Trends

No clear cyclic pattern of the volume of ED visits by season existed in the two-year study period. When considering the volume of presentations for the top three simplified mechanisms of injuries, two peaks of presentations were observed for sport (May and August), while a drop-in fall

or FOOSH related injuries was observed at the start of winter (June) (refer Figure 4.2). The peak presentation for lacerations was observed in October.

During the two-year period, individuals were most likely to present to the ED on a Sunday (16.6%) followed by Saturday (16.4%) and Monday (15.0%) (refer Table 4.1). The percentage of presentations for sports injuries (37.6%), lacerations (33.9%) and falls or FOOSH (30.2%) was observed to be higher on weekends than weekdays.

Costs

The total cost of ED related direct and indirect medical costs in the two-year study period was \$3,959,535.38 (\$1,923,852.38 in 2014-15; \$2,035,683.00 in 2015-16) (refer Table 4.2). The mean cost per presentation was \$383 (95% CI [\$373, \$393]) in 2014-15 and \$407 (95% CI [\$394, \$421]) in 2015-16. There was no statistically significant difference noted between the costs encountered at the Alfred and Sandringham hospitals.

Fractures of the wrist and hand were the second most frequent ICD-10 category (n=2,895; 28.9%) and accounted for the largest proportion (38.3%; \$1,514,967.33) of total costs with a mean cost per ED episode of care of \$489 (95% CI [\$465, \$513]) in 2014-15 and \$558 (95% CI [\$522, \$594]) in 2015-16 financial year periods. Open wounds of the wrist and hand (n=3,448) accounted for 34.4% of total costs (\$1,170,964.38) with a mean cost per episode of \$331 (95% CI [\$318, \$346]) and \$347 (95% CI [\$328, \$366]) for the 2014-15 and 2015-16 periods respectively.

When considering mechanism of injury, fall or FOOSH accounted for the highest costs (\$1,025,588.58) over the two-year period, followed by lacerations (\$985,339.50), and sports injuries (\$562,849.42) (refer Table S1).

4.4.6 Discussion

This study provides a comprehensive estimate of the volume, profile and cost of hand and wrist injuries seen in two Australian EDs over a two-year period. We have shown that these injuries are associated with a considerable volume of visits (over 5% of all ED visits) within the health network. This finding is significantly less than the estimated 10-30% proposed in international literature¹⁻³. One possible explanation for our finding is that we conducted our study from the perspective of one health network. It is possible that a population-based study could demonstrate that Alfred Health presentations are lower than the national average due to its close proximity to other major hospital networks or other unknown factors.

We have also shown that these visits resulted in approximately two-million dollars of healthcare charges for the two included hospitals per year. Although these results provide insight into possible national cost estimates, such figures are difficult to extrapolate with certainty due to the absence of a national injury surveillance system. Using such resources, US researchers found that acute hand injuries resulted in 34.4 million encounters costing US\$40.9-US\$48.6 billion in healthcare charges annually.²⁴ Future researchers should consider an approach that includes a cross-section of Australian EDs in order to calculate national estimates.

Our study also provides important information in other domains. Our findings demonstrate that most individuals presenting with hand and wrist injuries in our sample are male (62.2%), which is higher than the Australian ED Care 2015-16 statistics (50.5%)²⁵ and the United States estimates (52.4%)²⁴, but similar to those reported in the Netherlands (62.0%) and Denmark (59.0%).²⁶ Our finding that the group which accounted for the largest number of hand and wrist injury presentations were individuals aged between 25 and 34 years is consistent with Australia-wide statistics for all ED presentations²⁵ and supports the notion that hand and wrist injuries typically affect individuals during their economically productive years.^{1,4}

Lacerations were observed to be the most frequent mechanism of injury (31.2%) in our study, contrasting the findings of Colen and Colleagues²⁴ (19.7%) who report falls (26.2%) to be the most frequent mechanism for hand injury in the United States. Additionally, we found that lacerations were the most common cause for presentation for most age groups except for the young (11 years or younger) and the elderly (65 years or older), who most frequently presented with injuries following a fall or FOOSH. Based on our findings that 10.5% of lacerations were sustained using a power tool and considering the potential severity, complexity and cost of these injuries, there may be value in mandating design features such as SawStop, a system that detects skin contact using the body's natural electrical current²⁷ or in-built kickback gauges which regulate the depth to which the teeth can cut²⁸ to reduce the amount of avoidable injuries.

We did not observe any cyclic trends across seasons in the number of presentations during the two-year data collection period. This observation does not correlate with an investigation conducted over a four-year period in the United States that found an increase in hand injury presentations in the summer months and reduced visits in the wintertime (n= 34.4 million).²⁴ We did, however, observe an increase in presentations for sport-related injuries in the months of May and August, which coincide with the beginning or end of the Australian Rules Football, Netball, Soccer and Cricket seasons in the state of Victoria. Interestingly, we observed a reduction in injuries sustained as the result of a fall or FOOSH at the start of winter, which could be explained by the decrease of participation in outdoor activities during this time.

Our data reveal that individuals with hand and wrist injuries were most likely to present to an ED on the weekend (Saturday and Sunday; 33.0%) or a Monday (15.0%). This is likely due to participation in sport, home renovations, garden maintenance and general activity outside of the home and workplace that typically occurs by most Australians over the weekend period.²⁹ This observation may provide preliminary support for an on-call advanced practitioner hand therapist in busier EDs over the weekend to assist in triage and timely treatment of injuries that can be

conservatively managed, such as dislocations, closed mallet injuries, and undisplaced fractures. This approach has been observed in the management of musculoskeletal injuries by physiotherapists with the available evidence suggesting they may be more cost-effective than medical providers in managing low urgency conditions in the ED.³⁰ A well designed economic evaluation, incorporating cost-effectiveness and cost-benefit methodologies would further validate this proposal.

4.4.7 Limitations

Our study must be considered in the context of several limitations. First is the variation in reporting and coding of clinical details and description of injury – for example, the anatomic location of a fracture, the fracture type, or whether the fracture was open or closed. Second, our data collection process relied on some non-specific ICD-10 codes, such as ‘fracture of other nonspecific part of wrist and hand’, used by the healthcare provider. Therefore, the precise distribution of injuries, for example metacarpal fractures, is not known. In addition, the accuracy of retrospectively using ICD-10 codes is a limitation of this study as the data entered at the time of presentation may be an incorrect representation of the injury sustained. Third, we were not able to clearly define individuals who sustained their injury at work, home or during leisure occupations due to a lack of available information. Fourth, individuals presenting to the Alfred and Sandringham hospitals are likely to self-refer to the ED which is likely to result in a skewed patient population. Fifth, although we describe the direct cost of hand and wrist related injuries presenting to the ED from the perspective of the Alfred Health, our study does not consider the entire possible cost burden that an acute hand or wrist injury may result in. We did not account for costs that occurred prior to the ED presentation (e.g. ambulance or GP consultation) or after. Further, we did not account for indirect costs that occur due to loss of productivity (estimated to be between 64.5-68% of total costs²⁰) and other costs out of pocket costs borne by the individuals themselves (e.g. medications, orthoses).

Finally, it is likely that costs presented in this study are underestimated. This could be due to patients being transferred from the ED to another ward for ongoing care, cost shifting, or data entry

error. A recent perspective article published in *Emergency Medicine Australasia* suggests that a single ED visit to a public hospital in Australia is approximately \$605.³¹ Therefore, our results should be interpreted with caution.

Despite these limitations, our study had several notable strengths. First, we had a large dataset collected over a two-year period that allowed for a detailed analysis and comparison. Second, we made attempts to avoid contamination of data by only including presentations that documented a hand or wrist injury as the primary reason of visit. Third, we recoded the mechanism of injury for all 10,024 presentations to allow for a detailed description and analysis. Finally, we were able to fill an important void in hand injury literature in Australia regarding the demographics, incidence and cost of emergency hand care.

4.4.8 Conclusions

Acute hand and wrist injuries contribute to a significant volume of ED presentations each year in two Australian hospitals leading to significant ED expenditure and health resources. Further research using stringent data collection methods is required to establish epidemiological data and a national cost estimate of ED care for acute hand and wrist injuries in addition to resource allocation and viable injury prevention strategies to decrease the number of avoidable injuries.

4.4.9 Acknowledgements

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Conflict of Interest Statement

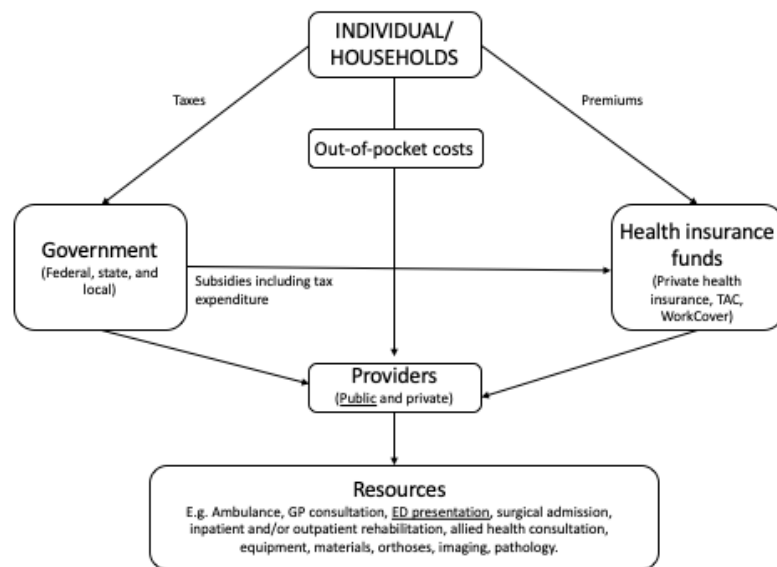
The authors have no conflict of interest to declare.

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4.4.10 Manuscript II Figures



Adapted from Duckett & Willcox (2015)

Figure 4.1 Simplified Flow of Health Funding in the Australian Domestic Health Sector (underline text indicates cost provider and resources estimated in this investigation)

Adapted from Duckett and Willcox.¹⁰

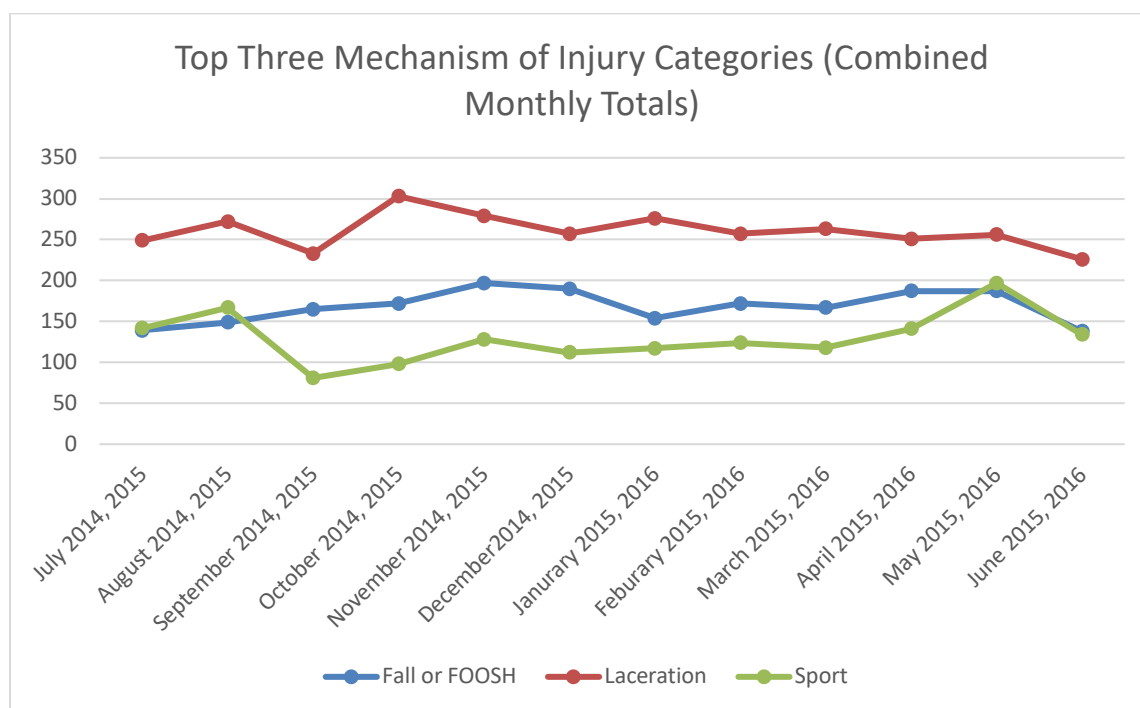


Figure 4.2 Top Three Mechanisms of Injury Categories (Combined Monthly Totals)

4.4.11 Manuscript II Tables

Table 4.1 Demographics of Individuals Presenting with a Hand or Wrist Injury

		2014-2015		2015-2016		Total	
Presentations		502		499		1002	
(n)		8		6		4	
Sex		316		307			
	Male, n (%)	0	62.85%	4	61.53%	6234	62.19%
	Female, n (%)	186		192			
		8	37.15%	2	38.47%	3790	37.81%
Age	Mean years (95% CI)	36.3	(35.80,	36.2	(35.67,	36.2	(35.90,
		6	36.91)	2	36.76)	9	36.67)
	11 years or younger, n (%)	378	7.52%	336	6.73%	714	7.12%
	12-17 years, n (%)	384	7.64%	410	8.21%	794	7.92%
	18-24 years, n (%)	732	14.56%	741	14.83%	1473	14.69%
	25-34 years, n (%)	135		133			
	35-44 years, n (%)	4	26.93%	7	26.76%	2691	26.85%
	45-54 years, n (%)	717	14.26%	730	14.61%	1447	14.44%
	55-64 years, n (%)	526	10.46%	535	10.71%	1061	10.58%
	65-74 years, n (%)	395	7.86%	389	7.79%	784	7.82%
Simplified Mechanism of Injury	75 years or older, n (%)	237	4.71%	248	4.96%	485	4.84%
	Alleged Assault, n (%)	305	6.07%	270	5.40%	575	5.74%
	Bite, n (%)	53	1.05%	26	0.52%	79	0.79%
	Crush, n (%)	162	3.22%	144	2.88%	306	3.05%
	Direct Blow, n (%)	367	7.30%	373	7.47%	740	7.38%
	Fall or FOOSH, n (%)	256	5.09%	251	5.02%	507	5.06%
	Laceration, n (%)	104		104			
	Misc, n (%)	977	19.43%	0	20.82%	2017	20.12%
	Not stated, n (%)	154		157			
	Puncture, n (%)	8	30.79%	4	31.51%	3122	31.15%
	Sport, n (%)	95	1.89%	87	1.74%	182	1.82%
	Transport (Car/Motorbike), n (%)	639	12.71%	556	11.13%	1195	11.92%
Day of Presentation	Monday, n (%)	75	1.49%	103	2.06%	178	1.78%
	Tuesday, n (%)	799	15.89%	760	15.21%	1559	15.55%
	Wednesday, n (%)	57	1.13%	82	1.64%	139	1.39%
	Thursday, n (%)	57	1.13%	82	1.64%	139	1.39%

Friday, n (%)	634	12.61%	605	12.11%	1239	12.36%
Saturday, n (%)	857	17.04%	785	15.71%	1642	16.38%
Sunday, n (%)	850	16.91%	818	16.37%	1668	16.64%

Table 4.2 Cost Of ICD-10 Injury Types

Injury type by ICD-10	2014-2015					2015-2016					Combined Total	
	n	%	Total (AUD)	Mean	CI [95%]	n	%	Total (AUD)	Mean	CI [95%]	n	Total (AUD)
Crushing injury of other and unspecified parts of wrist and hand, n (%)	190	3.78%	\$78,128	\$411	(\$357, \$465)	161	3.22%	\$71,572	\$445	(\$386, \$503)	351	\$149,700
Dislocation of finger, part unspecified, n (%)	132	2.63%	\$55,995	\$424	(\$378, \$471)	167	3.34%	\$76,321	\$457	(\$420, \$494)	299	\$132,316
Dislocation of wrist, part unspecified, n (%)	4	0.08%	\$2,255	\$563	(\$227, \$900)	4	0.08%	\$2,905	\$726	(\$212, \$1,241)	8	\$5,160
Fracture of other and unspecified parts of wrist and hand, n (%)	1455	28.94%	\$711,827	\$489	(\$465, \$513)	1440	28.82%	\$803,140	\$558	(\$522, \$594)	2895	\$1,514,967
Injury of unspecified blood vessel at wrist and hand level, n (%)	12	0.24%	\$6,497	\$541	(\$136, \$1,219)	7	0.14%	\$2,226	\$318	(\$181, \$455)	19	\$8,723
Injury of unspecified muscle and tendon at wrist and hand level, n (%)	294	5.85%	\$125,276	\$426	(\$383, \$469)	240	4.80%	\$101,043	\$421	(\$351, \$491)	534	\$226,319
Injury of unspecified nerve at wrist and hand level, n (%)	21	0.42%	\$7,241	\$345	(\$205, \$484)	18	0.36%	\$12,395	\$689	(\$464, \$914)	39	\$19,636
Multiple injuries of wrist and hand, n (%)	16	0.32%	\$12,031	\$752	(\$420, \$1,083)	23	0.46%	\$15,849	\$688	(\$427, \$951)	39	\$27,880
Open wound of wrist and hand part, part unspecified, n (%)	1671	33.23%	\$554,438	\$331	(\$318, \$346)	1777	35.57%	\$616,526	\$347	(\$328, \$366)	3448	\$1,170,964
Other specified injuries of wrist and hand, n (%)	77	1.53%	\$28,934	\$376	(\$278, \$474)	74	1.48%	\$23,194	\$313	(\$258, \$369)	151	\$52,128
Sprain and strain of other and unspecified parts of hand, n (%)	371	7.38%	\$105,786	\$285	(\$263, \$307)	367	7.35%	\$99,324	\$271	(\$252, \$290)	738	\$205,110
Sprain and strain of wrist, part unspecified, n (%)	328	6.52%	\$97,118	\$296	(\$275, \$317)	287	5.74%	\$89,638	\$312	(\$285, \$339)	615	\$186,756
Superficial injury of wrist and hand, unspecified, n (%)	357	7.10%	\$87,574	\$245	(\$224, \$266)	356	7.13%	\$85,653	\$241	(\$215, \$266)	713	\$173,227
Traumatic amputation of wrist and hand, level unspecified, n (%)	47	0.93%	\$30,421	\$647	(\$533, \$761)	27	0.54%	\$19,419	\$719	(\$562, \$876)	74	\$49,840
Unspecified injury of wrist and hand, n (%)	53	1.05%	\$20,329	\$384	(\$297, \$469)	48	0.96%	\$16,478	\$343	(\$238, \$449)	101	\$36,807
Total	5028	100.00%	\$1,923,852	\$383	(\$373, \$393)	4996	100.00%	\$2,035,683	\$407	(\$394, \$421)	10024	\$3,959,535

4.4.12 Manuscript II Appendices

Appendix 4.1 ICD-10 Codes Used for Case Identification

ICD-10 Code	Description
S609	Superficial injury of wrist and hand, unspecified
S619	Open wound of wrist and hand part, part unspecified
S628	Fracture of other and unspecified parts of wrist and hand
S6300	Dislocation of wrist, part unspecified
S6310	Dislocation of finger, part unspecified
S6350	Sprain and strain of wrist, part unspecified
S637	Sprain and strain of other and unspecified parts of hand
S649	Injury of unspecified nerve at wrist and hand level
S659	Injury of unspecified blood vessel at wrist and hand level
S669	Injury of unspecified muscle and tendon at wrist and hand level
S678	Crushing injury of other and unspecified parts of wrist and hand
S684	Traumatic amputation of hand at wrist level
S689	Traumatic amputation of wrist and hand, level unspecified
S697	Multiple injuries of wrist and hand
S698	Other specified injuries of wrist and hand
S699	Unspecified injury of wrist and hand

4.4.13 Manuscript II Supporting Information

Table S1 Mechanism and Related Costs of Injury

Mechanism of Injury	(n)	2014-2015		2015-2016		Combined Total	
		Total ED Costs (AUD)	(n)	Total ED Costs (AUD)	(n)	Total ED Costs (AUD)	
Alleged Assault	53	\$22,207	26	\$15,018	79	\$37,226	
Bite							
Cat	31	\$9,232	27	\$14,246	58	\$23,478	
Dog	89	\$34,884	74	\$27,257	163	\$62,141	
Insect	27	\$6,320	16	\$2,722	43	\$9,042	
Misc	15	\$4,915	27	\$6,603	42	\$11,518	
<i>Total count</i>	162	\$55,351	144	\$50,827	306	\$106,179	
Crush							
Brick/Metal/Concrete	28	\$11,503	32	\$17,207	60	\$28,710	
Car Door/Boot	54	\$17,784	67	\$20,511	121	\$38,295	
Door	96	\$31,118	89	\$32,851	185	\$63,968	
Furniture	23	\$10,833	12	\$3,987	35	\$14,820	
Machinery or Tool	44	\$20,547	30	\$13,418	74	\$33,965	
Misc	122	\$44,817	143	\$59,275	265	\$104,092	
<i>Total count</i>	367	\$136,601	373	\$147,249	740	\$283,850	
Direct Blow							
Furniture or Machine	28	\$8,064	17	\$4,259	45	\$12,322	
Misc	41	\$11,241	74	\$22,695	115	\$33,936	
Punch	187	\$64,287	160	\$48,261	347	\$112,548	
<i>Total count</i>	256	\$83,592	251	\$75,215	507	\$158,807	
Fall/FOOSH							
Ladder/Stairs	29	\$20,630	38	\$35,516	67	\$56,146	
Unspecified Fall or FOOSH	948	\$463,702	100	\$505,740	195	\$969,442	
			2		0		
			104		201		
<i>Total count</i>	977	\$484,332	0	\$541,256	7	\$1,025,589	
Laceration							
Angle Grinder	36	\$16,499	32	\$13,535	68	\$30,034	
Blender	26	\$10,519	28	\$10,875	54	\$21,394	
Circular Saw/Drop Saw/Chainsaw	69	\$33,911	73	\$43,962	142	\$77,873	
Drinking Glass/Mug/Plate/Bowl	70	\$23,101	67	\$22,132	137	\$45,233	
Glass	180	\$53,635	160	\$54,034	340	\$107,669	
Knife/Scissors	482	\$130,072	509	\$127,613	991	\$257,685	
Lawn Mower/Secateurs/Garden Equipment	29	\$7,440	26	\$10,368	55	\$17,808	
Machinery	20	\$7,227	10	\$4,606	30	\$11,832	
Metal/Tin Can	76	\$21,547	103	\$28,278	179	\$49,826	

Misc	511	\$157,381	521	\$164,600	103 2	\$321,981
Power Tool	32	\$11,332	30	\$11,865	62	\$23,198
Self-harm	17	\$7,178	15	\$13,629	32	\$20,807
<i>Total count</i>	<i>154</i> 8	<i>157</i> \$479,842	<i>157</i> 4	<i>312</i> \$505,497	<i>312</i> 2	<i>103</i> \$985,339
Misc						
Amputation	20	\$12,024	7	\$5,211	27	\$17,235
Foreign Body / Splinter	8	\$2,311	5	\$1,120	13	\$3,432
Gunshot	2	\$973	4	\$788	6	\$1,761
Jarred	11	\$2,737	6	\$2,204	17	\$4,941
Ring Catch	5	\$993	1	\$1,105	6	\$2,098
Scratch	7	\$1,588	25	\$6,614	32	\$8,202
Burn	4	\$1,348	9	\$3,286	13	\$4,634
Playground Equipment	38	\$15,245	30	\$13,906	68	\$29,152
<i>Total count</i>	<i>95</i>	<i>182</i> \$37,221	<i>119</i> 87	<i>182</i> \$34,235	<i>119</i> 5	<i>182</i> \$71,455
Not stated	639	\$261,293	556	\$229,749	5	\$491,042
Puncture						
Misc	9	\$4,161	15	\$6,870	24	\$11,031
Nail gun/Screw Driver/Nail/Screw	31	\$13,937	45	\$18,059	76	\$31,996
Needlestick Injury	35	\$10,272	43	\$11,786	78	\$22,058
<i>Total count</i>	<i>75</i>	<i>103</i> \$28,370	<i>103</i>	<i>178</i> \$36,715	<i>178</i>	<i>178</i> \$65,085
Sport						
Australian Rules Football	148	\$52,206	151	\$51,039	299	\$103,245
Baseball/Softball/Squash/Tennis	10	\$4,370	10	\$5,369	20	\$9,739
Basketball	77	\$22,016	79	\$22,722	156	\$44,738
Bicycle/Scooter/Skateboard/Roller -skating	194	\$83,817	188	\$97,548	382	\$181,365
Boxing/Martial Arts	24	\$6,149	17	\$3,990	41	\$10,139
Cricket	37	\$10,084	37	\$13,678	74	\$23,762
Hockey/Ice Hockey	14	\$4,674	15	\$4,397	29	\$9,071
Misc	129	\$40,692	124	\$40,020	253	\$80,712
Netball	54	\$17,538	35	\$8,893	89	\$26,431
Rugby	20	\$6,238	25	\$7,575	45	\$13,812
Skiing/Snowboarding/Ice-skating	17	\$6,537	25	\$9,085	42	\$15,621
Soccer	55	\$19,937	45	\$15,163	100	\$35,100
Water Sports	20	\$6,782	9	\$2,332	29	\$9,113
<i>Total count</i>	<i>799</i>	<i>760</i> \$281,040	<i>760</i>	<i>155</i> \$281,809	<i>155</i> 9	<i>155</i> \$562,849
Transport (Car/Motorbike)	57	\$54,001	82	\$118,109	139	\$172,111

4.5 Impacts of the Study

Journal Metrics:

Impact Factor (2018): 1.500

5 Year Impact Factor (2018): 1.717

Article Influence (2018): 0.533

Eigenfactor (2018): 0.00321

Source-Normalised Impact Per Paper (SNIP) (2018): 0.73

SCImago Journal Rank (SKR) (2018): 0.664

- **Emergency Medicine (2018):** Q1 (20th of 50)
- **Medicine (miscellaneous) (2018):** Q2 (1,005th of 2,836)

This paper was presented to the Victorian Division of the Australian Hand Therapy Association (AHTA) which led to discussions with hand therapists working in the public health system (Peninsula Health, Austin Health, Monash Health) and in the private sector (Peninsula Hand Therapy, Rewired Hand Therapy) of the need for more detailed information regarding patient presentation pathways (including location of first medical treatment prior to emergency department presentation and discharge reason and/or destination), patient and injury demographics and outpatient resource use (including hand therapy and specialist medical appointments) for acute hand and wrist injuries. These discussions helped to refine the development of the methodology used in investigations that form Chapters 4 and 5 in this doctoral thesis. This paper has also been presented at the AHTA national conference and an international hand therapy and hand surgery conference.

Invited Speaker

Robinson, L. S. (2018). Costs and epidemiology of acute hand and wrist injuries. Australian Hand Therapy Association National Congress, 19th – 21st October, Melbourne Australia.

Conferences:

Robinson, L. S., & O'Brien, L. (2019). A description and cost-analysis of Emergency Department attendances for hand and wrist injuries. 14th IFSSH & 11th IFSHT Triennial Congress with combined FESSH Congress, 17th – 21th June, Berlin, Germany.

4.6 Chapter Summary

In the previous chapter, we systematically reviewed the international literature presenting cost-of-illness studies and health economic evaluations for acute hand and wrist injuries with a focus on direct, indirect and intangible costs. In this retrospective file audit, we aimed to provide an estimate of the direct costs associated with the resources used in two emergency departments of one Australian public health service for individuals presenting with a hand or wrist injury. Further, we provided a comprehensive description of the demographic and injury profile of the study population.

Key Findings:

- Acute hand and wrist injuries account for approximately 5.4% of all yearly emergency department presentations within one Australian public health service.
- Males were more likely to present with these injuries than females (62% of presentations).
- The mean age of individuals presenting was 36 years, with those aged between 25- and 34-years accounting for the largest proportion of presentations (27%).

- The most common reasons for presentation were an open wound to the wrist or hand (34%) then fracture of the hand or wrist (29%).
- Lacerations from miscellaneous objects, knives or glass were the most common mechanism for presentation (31%).
- These injuries contribute considerable cost (approximately \$2 million per year) at one Australian public health network.
- The mean cost per presentation was \$383 in 2014-15 and \$407 in 2015-16.
- Fractures of the wrist and hand accounted for the most significant portion of total costs (38%, \$1.5 million over two years).

The next chapter presents a cost-of-illness study which investigates the costs associated with resource use for patients requiring surgical intervention and outpatient follow-up following an emergency department presentation for an acute hand or wrist injury.

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Chapter 5

Cost, profile and post-operative resource use for surgically managed acute hand and wrist injuries with emergency department presentation

5.1 Chapter Introduction

Chapter 4 presented a retrospective file audit that aimed to estimate the direct emergency department resource consumption costs for individuals presenting with a hand or wrist injury. It also provided a detailed description of the demographic and injury profile for this population. We found that these injuries account for approximately 5.4% of all emergency department presentations within the public health service at the cost of \$2 million per year. We also found that males, individuals aged between 25- and 34-years, and those with an open wound to their hand or wrist made up the bulk of hand and wrist presentations to the emergency department within the study settings. While fractures of the hand and wrist were found to be the second most common reason for presenting to the emergency department, they were found to contribute the most significant portion of the total yearly cost of approximately \$750,000.

Building on these findings, we sought to understand the direct cost burden experienced from a health-system perspective for patients that then underwent surgical intervention following their emergency department presentation. We were particularly interested in the total costs of all resources used within the health service to provide treatment for these injuries (including hand therapy), whether there was an association between the total cost of injury and delayed presentation, age or gender, and wanted to provide an insight into the patient care journey of this

population (e.g. first health care professional interaction to discharge destination from the healthcare service)

5.2 Chapter Aims

This chapter presents a cost-of-illness study which focuses on estimating the costs associated with resource use for patients undergoing surgical intervention and outpatient follow-up following an emergency department presentation for an acute hand or wrist injury. It illustrates the demographic profile and patient care journey and describes the post-operative medical and specialist hand therapy resources used by this patient population.

5.3 Chapter Contents

The manuscript presented in this chapter was reviewed by the *Journal of Hand Therapy* resulting in requested amendments. This proposed citation of this manuscript is:

Robinson, L. S., Brown, T. & O'Brien, L. (2019, under review). Cost-analysis, epidemiology and post-operative resource use for surgically managed acute hand and wrist injuries with emergency department presentation. *Journal of Hand Therapy*.

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5.4 Manuscript III

Manuscript III, as it appears in this chapter, is the amended form required for consideration of publication in the *Journal of Hand Therapy*.

5.4.1 Abstract

Background: Injuries to the hand and wrist are common. Most uncomplicated and stable upper extremity injuries recover with conservative management; however, some require surgical intervention. The economic burden on the healthcare system from such injuries can be considerable.

Purpose: To estimate the economic implications of surgically managed acute hand and wrist injuries at one urban healthcare network.

Study Design: Retrospective cost-of-illness study

Methods: Using 33 primary diagnosis ICD-10 codes involving the hand and wrist, 453 consecutive patients from 2014-15 electronic billing records who attended the study setting emergency department (ED) and received consequent surgical intervention and outpatient follow-up were identified. Electronic medical records were reviewed to extract demographic data. Costs were calculated from resource use in the ED, inpatient and outpatient settings. Results are presented by demographics, injury type, mechanism of injury and patient pathway.

Results: 226 individuals, (n=264 surgeries), were included. The total cost of all injuries was \$1,204,606. The median cost per injury for non-compensable cases (n=191) was \$4,508 [IQR \$3,993 - \$6,172] and \$5057 [IQR \$3957 - \$6730] for compensable cases (n=35). The median number of post-operative appointments with a surgeon was 2.00 (IQR 1.00 - 3.00) for both compensable and non-compensable cases. The number of hand therapy appointments for non-compensable cases and compensable cases was 4 [IQR 2-6] and 2 [IQR 1-3] respectively.

Conclusion: Surgically managed hand and wrist injuries contribute to a significant financial burden on the healthcare system. Further research using stringent data collection methods are required to establish epidemiological data and national estimates of cost burden.

5.4.2 Introduction

Hand injuries lead to activity and participation restrictions in domains such as work, self-care and leisure^{1,2} because humans primarily interact with their environments using their hands.

Hand and wrist injuries account for 10-30% of all emergency department (ED) presentations³⁻⁶, 28% of all musculoskeletal injuries⁷, and 6.6%⁸ to 28.6%^{9, 10} of all injuries. They typically affect young individuals during their economically productive years^{3, 11} and direct medical costs (i.e. those directly involved in healthcare) make up 32-35.5% of the total cost of injury¹².

In Australia, a lack of literature exists that explores the epidemiology, costs and the post-operative resources used for surgically managed acute hand and wrist injuries due to the absence of a national systematic database capturing specific patient resource use¹³. As a result, knowledge of the cost and profile of acute hand injuries is limited to workers' compensation claim data^{14, 15}. Accurate information about the direct medical costs and resources used in the design, implementation, and provision of healthcare is essential to policymakers and health service managers for planning and resource distribution¹⁶.

Objectives

In this cost-of-illness study, we aimed to:

1. estimate the costs associated with resource use for patients requiring surgical intervention and outpatient follow-up following an Emergency Department (ED) presentation for an acute hand or wrist injury;
2. illustrate the demographic profile and patient care journey (e.g. first health care professional interaction to discharge destination from the health-care service) of this patient population;
3. describe the post-operative medical and specialist hand therapy resources used by this patient population; and
4. determine whether any variables are significantly associated with cost.

5.4.3 Methods

Target population and subgroups

We included patients of any age who required surgical intervention(s) for an acute hand or wrist injury who had presented to one health network's two hospital EDs prior to surgery and had a minimum of one outpatient appointment to allow insight into the presentation pathway, volume, cost and resource use at one large Australian public hospital.

Using 33 primary diagnosis ICD-10 codes involving the hand and wrist (refer Appendix 1) we identified 453 consecutive patients from hospital electronic billing records who received surgical intervention for a hand or wrist injury at the Alfred Hospital, Melbourne, Australia, from July 1st, 2014 to June 31st, 2015. Electronic medical records were screened to identify patients who met our selection criteria of having had (1) an acute hand or wrist injury requiring surgical intervention, (2) an ED presentation prior to surgery and (3) a minimum one outpatient appointment. Cases were excluded if the patient presented with additional injuries (e.g. head injury) to ensure estimates were not contaminated.

Cases where treatment was partially or fully funded by the Transport Accident Commission (TAC) or WorkCover (insurance-based compensation systems for individuals with injuries sustained in transport accidents or at work respectively), referred to as compensable cases, are reported as a separate group as they are commonly streamed to private outpatient care outside the study setting post-surgery. Additionally, using diagnosis descriptions extracted from medical records, we assigned a primary injury type as either (1) fracture, (2) muscle/tendon injury, (3) nerve injury, (4) simple laceration or (5) combination of injuries (e.g. surgically managed fracture and tendon injury) to allow further analysis.

Study setting and location

The Alfred Hospital, which is part of a public health network (Alfred Health), is a 680-bed tertiary referral teaching hospital that is a major provider of specialist state-wide services (e.g. burns, trauma) to residents of Victoria. Alfred Health has two ED's which serve a metropolitan population of approximately 700,000 residents, has about 65,000 visits per year¹⁷. Both ED's stream acute hand/wrist cases requiring specialist care, which includes surgery, to the Alfred Hospital (the main campus). Ethics approval for the project was provided by Alfred Health (233/16) and Monash University (CF16/2268 – 20160001119).

Study perspective

We used a prevalence-based approach to costing illness, where the economic burden that an injury, disease or illness has during a specified period irrespective of the time of disease onset¹⁸,¹⁹, is used to quantify the economic burden. Medical costs were estimated from the perspective of Alfred Health and were calculated for all resources used during ED presentations, inpatient surgical procedures, and outpatient appointments (refer to Appendix 2 for included and excluded cost components). Consistent with this method, morbidity and mortality were not considered¹⁹.

Indirect costs due to the loss of productivity (e.g. paid, unpaid or volunteer work), transport or other out-of-pocket expenses are not included in our cost estimates as this data is not routinely collected by the health service. As the study setting was restricted to one public hospital, costs associated with any resources used prior to an emergency department presentation (e.g. general practitioner (GP) consultation, other hospital ED presentation), or after treatment within the study setting (e.g. general practitioner (GP) review, private hand therapy consultation) were also not included.

Estimating costs and outpatient resources

Details relating to costs incurred in the ED and inpatient settings were extracted from hospital electronic billing records which are routinely collected for the health service's clinical, admissions and financial records systems. These cost estimates were not adjusted (0% discount rate) and were presented as billed/recorded during the one-year time horizon (July 1st, 2014 to June 31st, 2015) (e.g. no inflation calculation performed) in Australian dollars (AUD). All outpatient resource usage related to the injury was extracted from screening electronic medical records, with costs calculated using unit cost prices (2015) (refer to Table S2). The total cost of injury for each case was calculated by summing resource use in the ED, during inpatient admissions, and for outpatient appointments attended.

Epidemiological approach

Demographic data, injury details, inpatient length of stay (LOS), patient care journey (e.g. first health care professional interaction to discharge destination from the health-care service) and outpatient resource use were extracted from electronic medical records. Where an occupation was reported, it was classified using the Australian Standard Classification of Occupations (ASCO)²⁰. When information was not available, an occupation of 'not stated' was allocated. The mechanism of injury for all eligible records was reviewed and recoded by allocating a simplified (e.g. 'laceration') and detailed (e.g. 'knife/scissors') mechanism of injury label.

Data analysis and statistics

All data were checked for normality and, if skewed, presented as a Median (Mdn) and Interquartile Range [IQR]. A correlation analysis was completed to investigate the degree of association between the variables of cost and delayed presentation (days between date of injury (DOI) and ED presentation), age, and gender. Multiple linear regression was then completed to investigate if there were any significant predictors of cost. A biostatistician checked all data

analysis procedures to ensure the accuracy of reported findings. Cost data is presented in Australian dollars (AUD). Data analysis was performed using R studio²¹ and Microsoft Excel²².

5.4.4 Results

A total of 226 eligible patients, with a total of 232 surgeries, who attended the XXX Hospital for treatment for an acute hand or wrist injury were included in this study. This represents approximately 5% of all hand and wrist injury ED presentations observed by XXX Health EDs during the 2014-2015 data collection period²³. Two-hundred and twenty-seven cases were excluded (refer Fig 1).

Costs associated with resource use within the study setting

The total cost for all included cases was \$1,204,606. Inpatient costs (\$889,045) accounted for the highest proportion of total health care costs (73.8%), followed by outpatient (\$187,540; 15.6%) and ED (\$128,021; 10.6%) costs. The median cost per injury for non-compensable cases (i.e. treatment funded by Australian government tax-funded universal public health insurance scheme) (n=191) was \$4,508 [IQR \$3,993 - \$6,172] and \$5057 [IQR \$3957 - \$6730] for compensable cases (i.e. treatment funded by a compensation claim from transport accident or worker's compensation) (n=35). Refer to Table 5.1 for median cost for primary injury types. For all isolated fractures cases (compensable and non-compensable), sport (n=45) was found to be the most frequent cause of injury at a combined cost of \$230,490 (Mdn: \$4295 IQR [\$3852 - \$5595]) with Australian Rules Football being the most common sport leading to a fracture (n=12; Mdn \$4295 [IQR \$3581 - \$5878]). The total costs relating to specific and detailed mechanism of injury can be seen in Table 5.2.

Demographic profile of patients

Males comprised the majority (81%) of included cases (refer Table 5.3). The median age of included participants was 31.6 years (IQR 24.8 – 42.9), with patients aged between 25- and 34-

years accounting for the largest group of clinical presentations (37.1%). The most common classifications of occupations were laborers (18.6%) and tradespersons (15.9%), with both job roles being heavily dependent on hand and wrist function.

The mean inpatient length of stay for non-compensable cases (n=191) was 1.21 days (95% CI [1.14; 1.29]) and 1.26 days (95% CI [1.08; 1.43]) for compensable cases (n=35). The median length of days within the health service, which was calculated from the day of ED presentation to the final attended outpatient appointment (medical or hand therapy) was 62 days [IQR 34.5 – 91.5] for non-compensable cases and 26 days [IQR 15.0 – 52.5] for compensable cases (refer Fig 1).

Location and mechanism of injury

From the 226 cases, a total of 312 individual zones of injury (ZOI) were recorded (refer Figure 5.2 for fracture and nerve ZOIs and Table 5.4 for tendon/muscle ZOI locations; simple lacerations and ligaments are not represented). The most common simplified mechanism of injury for all cases was laceration (n=100; 44.3%) followed by sport (n=55; 24.3%) (refer Table 5.1). When considering detailed mechanism of injury for all cases, power tools were the most common specific mechanism (n=31) (refer Table 5.2).

5.4.4.1 Patient care journey

The patient care journeys for all cases are depicted in Figure 5.1. For the majority of cases the location of first medical consultation was the XXX Hospital ED (62.3%) or XXX Hospital ED (18.8%), with only 13.2% consulting their GP prior to ED attendance. A total of 15 patients (6.6%) re-presented to the XXX Hospital ED following surgery, with two presenting twice. Reasons included pain, plaster or dressing change, and concerns regarding infection or re-injury.

While 59% of non-compensable cases completed their care within the setting, 28% (n=54) ended their care by failing to attend (FTA) their scheduled outpatient appointment. When considering both non-compensable and compensable cases, 34% (n=77) FTA ≥ 1 appointment during their patient pathway with a combined total of 114 FTAs recorded.

5.4.4.2 Post-operative medical and hand therapy appointments

The median number of post-operative appointments with a surgeon (or Registrar/Resident Medical Officer) was 2 [IQR 1-3] for both compensable and non-compensable cases (refer Table 5.1). The median number of hand therapy (HT) appointments delivered at the hospital for non-compensable cases and compensable cases was 4 [IQR 2-6] and 2 [IQR 1-3] respectively. Refer to Table 5.1 for median number of appointments for primary injury types.

Significant predictors of cost

Multiple linear regression was used to test if delayed presentation, age or gender predicted cost within the health-care service. The results of the regression indicated that there was no significant predictors of cost ($R^2=0.008$, $F(3,222)=0.63$, $p=0.59$) (refer Table 5.5). No statistically significant correlations between the variables of cost and delayed presentation ($r(224)=0.09$, $p=0.19$), age ($r(224)=0.04$, $p=0.54$) or gender ($r(224)=0.01$, $p=0.86$) were found.

5.4.5 Discussion

Epidemiological and cost data for acute hand and wrist injuries that require surgical intervention in the Australian healthcare system have been largely absent from the clinical and empirical literature. This study found that injuries presenting to ED that require surgical intervention and post-operative care account for approximately 5% of all hand and wrist injury-related ED visits at one hospital in a financial year. We also found that these injuries resulted in over \$1.2 million of direct healthcare costs at one urban healthcare network. This represents a

potentially significant component of healthcare resource use in the context of unavoidable rising costs, increasing patient service requirements and increasing staffing demands.

The large majority of individuals in our sample were male (78.99%), which appears consistent with the international literature²⁴⁻²⁸. The median age of our sample was 31.6 years, supporting previous findings that these injuries typically affect individuals within the active working age^{3, 5, 7, 11, 29}. Nevertheless, this should be interpreted in the context that the study setting which is an adult trauma center with only one participant included in the data analysis who was under the age of 18. Since no significant correlations were found between cost and delayed presentation, age or gender this suggests that these factors may be influenced by other variables, such as the severity of injury. It is suggested that future research attempt to measure severity of injury using a standardised measure (e.g. hand injury severity score (HISS))³⁰ to confirm this supposition.

Our finding that the most common mechanisms of injury - laceration (44.3%) followed by sport (24.3%) - may have implications for potential health promotion strategies for reducing preventable injuries. For example, awareness campaigns for the safe operation of power tools^{31, 32} or protective equipment worn in sport³³ may be best-targeted towards males aged between 25 and 34 years old. In order to examine the effectiveness of such interventions, well-designed economic evaluations using a model such as the RE-AIM Framework³⁴, which assesses five dimensions (reach, efficacy, adoption, implementation, and maintenance) at multiple levels (individual, clinic, community), may be considered.

A key finding of this study was the high percentage of cases that were discharged from the health service due to failing to attend (FTA) their final appointment (28.2% of non-compensable cases; 3% of compensable cases). Additionally, we found a high percentage of patients who also

FTA one or more appointments during their patient pathway (34%). This figure, while at the higher end, falls within previously published FTA outpatient appointment data estimates³⁵. This represents approximately of \$20,000 additional costs to the healthcare service in a one-year period. Beyond additional cost burden, high FTA rates can also lead to inefficient use of facilities with unnecessary delays in the waiting times to assess or review other patients resulting in poorer clinical outcomes³⁶. At the time of data collection, the study setting was not using a text-messaging service, which has been shown to have low to moderate quality of evidence to support their use³⁷. However, other strategies that place the responsibility on the patient to book follow-up appointments could be examined in further research using appropriate economic evaluation methods (e.g. cost-benefit or cost-effectiveness analysis). This proposed research could determine if a reduction of cost is achievable and if patient outcomes improve due to a reduction in unnecessary delays in treatment.

5.4.6 Limitations and future research

Our study must be considered in the context of several limitations. As our study sample was restricted to a single-center with a stringent inclusion protocol resulting in a small sample size, caution should be taken when generalising the findings reported to the Australian population. Although we describe the direct cost of hand and wrist related injuries presenting to the ED and their consequent surgical and outpatient follow-up costs, our study did not consider the entire burden that encompasses indirect costs that occur due to loss of productivity (estimated to be between 64.5-68% of total costs)¹² and other costs borne by the individuals themselves. To present a comprehensive estimate of the burden of these injuries, studies from the societal perspective (which include medical, morbidity, mortality, transportation and non-medical costs) are recommended¹⁹. Further, we did not account for costs that occurred prior to the ED presentation (e.g. ambulance or GP consultation) or after discharge from this hospital's outpatient service. Finally, it is likely that the costs reported in this study are underestimated. This may be attributed to cost shifting, data entry error, or other miscellaneous reasons.

Although these results provide some insights into possible state and national cost estimates, it is difficult to calculate with certainty due to the absence of a national injury surveillance system such as the one that is currently available in the Netherlands which allows for a cross-section or national study of injuries over a selected timeframe³.

Future research

Future research into surgically managed acute hand and wrist injuries should be conducted using multiple health systems across Australia over a longer data collection period to assess how trends in presentations and costs change in the context of increasing dependence on the public healthcare system. To truly capture the total cost burden of these injuries, it is suggested that a prospective study from the societal perspective is conducted. Such a design should include appropriate standardized measures of injury severity; indirect costs (e.g. loss of productivity); costs that incurred at other health services (e.g. GP consultation); intangible costs, which consider quality of life (e.g. pain, functional impact), and other costs borne by the individuals themselves (e.g. parking costs, orthotics, or other products such as dressings, tape). This would allow for a more comprehensive national estimate and could influence policymakers and health service managers for planning and resource distribution with the view to improved patient outcomes.

Further, future research into the cost-effectiveness and cost-benefit of post-operative hand therapy management techniques used for acute hand and wrist injuries (e.g. orthotic design) is encouraged to determine the best methods for reducing the cost and improving patient outcomes.

5.4.7 Conclusion

Surgically managed hand and wrist injuries contribute to a significant financial burden on the healthcare system. Our study found that they represent > \$1.2 million of direct healthcare costs at one urban healthcare network. This represents a potentially significant component of healthcare resource use in the context of unavoidable rising costs, increasing patient service requirements and

increasing staffing demands. Future research is required to determine the true burden that these injuries place on a state and national scale.

5.4.8 Acknowledgements

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Conflict of Interest Statement

The authors have no conflict of interest to declare.

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5.4.9 Manuscript III Tables

Table 5.1 Cost and Outpatient Resource Use

			Non-compensable cases	Compensable cases
Combination	<i>Cost (Median [IQR])</i>	n	29	11
		ED	\$447 [\$366 - \$676]	\$595 [\$342 - \$615]
		IP	\$5310 [\$4344 - \$5879]	\$3378 [\$2757 - \$4802]
		OP	\$630 [\$550 - \$973]	\$620 [\$430 - \$1000]
		Total	\$6684 [\$5605 - \$7632]	\$5343 [\$4321 - \$5805]
	<i>Appointments (Median [IQR])</i>	Medical	1 [1 - 2]	2 [1 - 3]
		Hand Therapy	4 [2 - 5]	2 [1 - 3]
Fracture	<i>Cost (Median [IQR])</i>	n	97	11
		ED	\$405 [\$227 - \$644]	\$475 [\$436 - \$626]
		IP	\$2891 [\$2223 - \$4046]	\$3123 [\$2516 - \$3577]
		OP	\$860 [\$620 - \$1090]	\$540 [\$483 - \$1030]
		Total	\$4178 [\$3572 - \$5566]	\$4282 [\$3791 - \$4654]
	<i>Appointments (Median [IQR])</i>	Medical	2 [2 - 3]	2 [2 - 3]
		Hand Therapy	4 [3 - 6]	1 {1 - 2}
Nerve	<i>Cost (Median [IQR])</i>	n	11	1
		ED	\$473 [\$427 - \$545]	\$863
		IP	\$3117 [\$2756 - \$3447]	\$4,386
		OP	\$310 [\$310 - \$490]	\$310
		Total	\$4234 [\$4234 - \$4553]	\$5,560
	<i>Appointments (Median [IQR])</i>	Medical	2 [1 - 2]	1
		Hand Therapy	3 [2- 5]	1
Muscle/Tendon	<i>Cost (Median [IQR])</i>	n	53	11
		ED	\$428 [\$310 - \$666]	\$509 [\$457 - \$799]
		IP	\$3420 [\$2749 - \$4088]	\$5441 [\$4220 - \$6205]
		OP	\$710 [\$470 - \$1090]	\$700 [\$620 - \$810]
		Total	\$4673 [\$4009 - \$5614]	\$6541 [\$5849 - \$7580]

	<i>Appointments (Median [IQR])</i>	Medical	1 [1 - 3]	2 [2 - 3]
		Hand Therapy	5 [3 - 6]	2 [2 - 3]
Laceration	<i>Cost (Median [IQR])</i>	n	1	1
		ED	\$424	\$313
		IP	\$4,858	\$3,075
		OP	\$310	\$230
		Total	\$5,592	\$3,618
	<i>Appointments (Median [IQR])</i>	Medical	1	1
		Hand Therapy	1	0
All cases	<i>Cost (Median [IQR])</i>	n	191	35
		ED	\$428 [\$304 - \$659]	\$497 [\$392 - \$689]
		IP	\$3254 [\$2480 - \$4781]	\$3597 [\$2903 - \$5443]
		OP	\$770 [\$545 - \$1085]	\$620 [\$390 - \$1005]
		Total	\$4508 [\$3993 - \$6172]	\$5057 [\$3957 - \$6730]
	<i>Appointments (Median [IQR])</i>	Medical	2 [1 - 3]	2 [1 - 3]
		Hand Therapy	4 [2 - 6]	2 [1 - 3]

Abr: ED: Emergency Department; IP: inpatient; OP: Outpatient

Table 5.2 Simplified and Detailed Mechanism of Injury

Simplified Mechanism	Detailed Mechanism	n	Total Cost
<i>Bite</i>		4	\$35,303
	Dog	3	\$31,460
	Human	1	\$3,843
<i>Crush</i>		25	\$123,117
	Assault	1	\$3,899
	Brick	1	\$3,973
	Car Door	3	\$11,335
	Door	6	\$22,105
	Furniture	2	\$10,928
	Machine	8	\$51,321
	Metal	3	\$13,578
	Power Tool	1	\$5,977
<i>Direct Blow</i>		24	\$119,250
	Punched Ground	2	\$10,345
	Punched Person	5	\$33,905
	Punched Tree	1	\$3,274
	Punched Wall	12	\$52,573
	Power Tool Kick Back	3	\$14,222
	Unspecified	1	\$4,932
<i>Fall</i>		12	\$60,134
	Fall from height	2	\$9,953
	FOOSH	6	\$29,152
	ETOH	1	\$7,301
	Mechanical Fall	3	\$13,727
<i>Laceration</i>		100	\$561,904
	Glass	26	\$137,214
	Knife	23	\$139,563
	Machine	3	\$13,571
	Metal	17	\$87,744
	Self-harm	4	\$25,360
	Power Tool	24	\$139,459
	Ceramic	3	\$18,993

<i>Puncture</i>		5	\$24,480
	Metal	2	\$13,694
	Power Tool	3	\$10,786
<i>Sport</i>		55	\$275,295
	Australian Rules Football	13	\$60,778
	Basketball	2	\$7,432
	Bicycle	6	\$32,271
	Cricket	2	\$7,174
	Football	4	\$23,345
	Hockey	2	\$8,496
	Horse Riding	1	\$4,437
	Hurling	1	\$5,263
	Motorbike	3	\$15,072
	Netball	3	\$16,313
	Rugby	4	\$16,817
	Sailing	1	\$4,862
	Skateboard	1	\$3,450
	Soccer	4	\$17,584
	Squash	1	\$10,445
	Tennis	1	\$3,140
	Volleyball	1	\$5,167
	Wrestling	1	\$7,239
	Gym	4	\$26,012
<i>Innocuous</i>	Unspecified	1	\$5,122
<i>Total</i>		226	\$1,204,606

Abr: ETOH: Ethyl Alcohol related fall; FOOSH: Fall on Outstretched Hand

Table 5.3 Demographic Details of Included Cases

Presentations		226	
Surgeries		232	
Gender	Male, n (%)	183	81.00%
	Female, n (%)	43	19.00%
Age	Median years [IQR]	31.6	[24.8 - 42.9]
Hand Dominance	Left, n (%)	21	90.71%
	Right, n (%)	205	9.29%
Hand injured	Dominant, n (%)	104	46.02%
	Non-dominant, n(%)	121	53.54%
	Bilateral, n (%)	1	0.44%
Smoker	Yes, n (%)	44	19.47%
Occupation	Manager and Administrator, n (%)	5	2.21%
	Professional, n (%)	32	14.16%
	Associate Professional, n (%)	22	9.73%
	Tradesperson and related persons, n (%)	36	15.93%
	Clerical, sales and service workers, n (%)	35	15.49%
	Production and transport workers, n (%)	4	1.77%
	Labourers and Related Workers, n (%)	42	18.58%
	Students, n (%)	13	5.75%
	Retired, n (%)	12	5.31%
	Unemployed, n (%)	11	4.87%
	Not stated, n (%)	14	6.19%
Simplified Mechanism of injury	Bite, n (%)	4	1.77%
	Crush, n (%)	25	11.06%
	Direct Blow, n, (%)	24	10.62%
	Fall, n (%)	12	5.31%
	Laceration, n (%)	100	44.25%
	Innocuous n (%)	1	0.44%
	Puncture, n (%)	5	2.21%
	Sport, n (%)	55	24.34%
Day of injury to ED presentation (Days)	Mean (95% CI)	0.83	[0.49; 1.16]

Table 5.4 Zone of Injury for Muscle/Tendon Injuries

Location	Structure	No zone specified	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI
Thumb	FPL	5	1	1				
	FPB	1						
	APB	2						
	EPL	7		4	3			
	EPB	2			1			
Index	FDS	1		2	1			
Finger	FDP	1	2	2	1			
	EDC	5	2	1	1			
	EI	2						
Middle	FDS	1		2	2			
Finger	FDP	2		2	2			
	EDC	4		1	1			1
Ring	FPS				1			
Finger	FDP	1			1			
	EDC	4	2					
Little	FDS			4	1		1	
Finger	FDP		1	5	2		1	
	EDC	5	3			1	1	
	EDM	2				1		
	ADM				1			
Wrist	FCR	1						
	FCU	4						
	PL	2						

Abr: FPL: Flexor Pollicis Longus; FPB: Flexor Pollicis Brevis; APB: Abductor Pollicis Brevis; EPL: Extensor Pollicis Longus; EPB: Extensor Pollicis Brevis; FDS: Flexor Digitorum Superficialis; FDP: Flexor Digitorum Profundus; EDC: Extensor Digitorum Communis; EI: Extensor Indicis; EDM: Extensor Digiti Minimi; ADM: Abductor Digiti Minimi; FCR: Flexor Carpi Radialis; FCU: Flexor Carpi Ulnaris; PL: Palmaris Longus

Table 5.5 Regression Results using Cost as the Criterion

Predictor	<i>b</i>	<i>b</i> 95% CI [LL, UL]	<i>beta</i>	<i>beta</i> 95% CI [LL, UL]	<i>sr</i> ²	<i>sr</i> ² 95% CI [LL, UL]	<i>r</i>	Fit
(Intercept)	5222.35*	[4014.90, 6429.81]						
Delayed presentation	-75.01	[-194.53, 44.50]	-0.08	[-0.22, 0.05]	.01	[-.01, .03]	-.09	
Age	5.08	[-18.15, 28.30]	0.03	[-0.10, 0.16]	.00	[-.01, .01]	.04	
Gender	-7.01	[-786.93, 772.91]	-0.00	[-0.13, 0.13]	.00	[-.00, .00]	.01	
								<i>R</i> ² = .009 95% CI [.00,.03]

Note. A significant *b*-weight indicates the beta-weight and semi-partial correlation are also significant. *b* represents unstandardized regression weights. *beta* indicates the standardized regression weights. *sr*² represents the semi-partial correlation squared. *r* represents the zero-order correlation. *LL* and *UL* indicate the lower and upper limits of a confidence interval, respectively.

* indicates $p < .05$. ** indicates $p < .01$.

Abr: DOI: Date of Injury; ED: Emergency Department

5.4.10 Manuscript III Figures

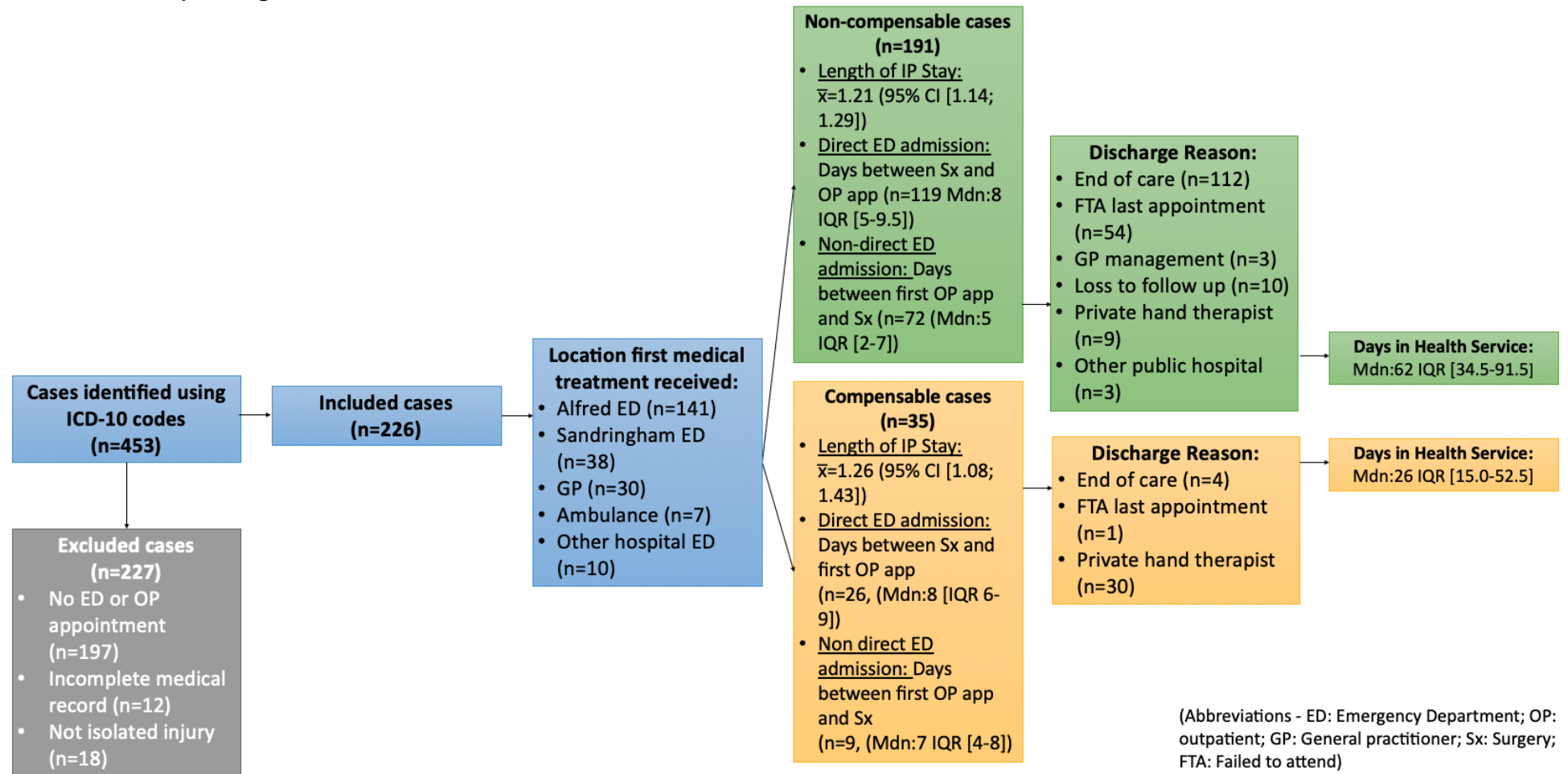


Figure 5.1 Patient Care Journey

5.4.11 Manuscript III Appendices

Appendix 5.1 ICD-10 Codes used for Case Identification

ICD-10 Code	Diagnosis Description
S62.63	Fracture of distal phalanx
S66.2	Injury of extensor muscle and tendon of thumb at wrist and hand level
S62.61	Fracture of proximal phalanx
S62.62	Fracture of middle phalanx
S62.32	Fracture of shaft of other metacarpal bone(s)
S62.52	Fracture of distal phalanx of thumb
S64.4	Injury of digital nerve of other finger
S62.21	Fracture of base of first metacarpal bone
S66.8	Injury of other muscles and tendons at wrist and hand level
S66.3	Injury of extensor muscle and tendon of other finger at wrist and hand level
S62.12	Fracture of triquetral bone of wrist
S62.31	Fracture of base of other metacarpal bone(s)
S62.33	Fracture of neck of other metacarpal bone(s)
S62.0	Fracture of navicular [scaphoid] bone of hand
S64.0	Injury of ulnar nerve at wrist and hand level
S62.51	Fracture of proximal phalanx of thumb
S62.14	Fracture of trapezium bone
S64.3	Injury of digital nerve of thumb
S64.2	Injury of radial nerve at wrist and hand level
S62.34	Fracture of head of other metacarpal bone(s)
S62.30	Fracture of other metacarpal bone(s), part unspecified
S66.1	Injury of flexor muscle and tendon of other finger at wrist and hand level
S64.1	Injury of median nerve at wrist and hand level
S62.16	Fracture of capitate bone
S66.0	Injury of long flexor muscle and tendon of thumb at wrist and hand level
S62.50	Fracture of thumb, part unspecified
S62.17	Fracture of hamate bone
S62.60	Fracture of phalanx, part unspecified
S64.8	Injury of other nerves at wrist and hand level
S62.11	Fracture of lunate bone of wrist
S66.9	Injury of unspecified muscle and tendon at wrist and hand level
S62.22	Fracture of shaft of first metacarpal bone
S64.9	Injury of unspecified nerve at wrist and hand level

Appendix 5.2 Included and Excluded Cost Components

Cost Location	Included Cost Components
Emergency Department Costs	Allied Health Emergency Department (including medical) Imaging Pathology Pharmacy
Inpatient Costs	Allied Health Imaging Medical (non-surgical) Medical (surgical) Other Pathology Pharmacy Theatre Ward/Nursing
Outpatient Costs	Hand Therapy (Occupational Therapy / Physiotherapy) (Unit cost price (2015) \$80) Speciality Medical Services (Plastic Surgery or Orthopaedics) (2015-unit cost price \$230)
Excluded cost components	
Cost Type	Excluded Cost Components
Indirect costs	Costs due to loss of productivity (e.g. paid or unpaid work), child-care, transport or other out-of-pocket costs were not included in our cost estimates. As the study setting was restricted to one-public health network, costs associated with resources used prior to clinical presentation (e.g. ambulance, other public hospital ED presentation, general practitioner [GP] consultation) or after presentation (e.g. private inpatient admission, additional private surgical management, or private medical or allied health outpatient management) are also not included.

5.5 Impacts of the Study

Journal Metrics: To be determined once accepted for publication.

This paper was presented to the Victorian Division of the Australian Hand Therapy Association (AHTA) which led to discussions amongst members highlighting the need for more detailed recording of objective measures (such as range of motion and pain); patient-reported outcomes (such as the Patient-Reported Wrist and Hand Evaluation); and information relating to the patient's occupation and time off work to allow for an estimation of the costs associated with loss of productivity. This paper was also presented at the AHTA national conference as an invited speaker and as an ePoster at my profession's peak international conference.

Invited Speaker

Robinson, L. S. (2018). Costs and epidemiology of acute hand and wrist injuries. Australian Hand Therapy Association National Congress, 19th – 21st October, Melbourne Australia.

Conferences:

Robinson, L. S., & O'Brien, L. (2019). Costs, epidemiology and post-operative resource use for surgically managed acute hand injuries [ePoster]. 14th IFSSH & 11th IFSHT Triennial Congress with combined FESSH Congress, 17th – 21st June, Berlin, Germany.

5.6 Chapter Summary

Building on the findings presented in Chapter 4, this retrospective file audit aimed to provide an estimate of the direct costs associated with emergency department, surgical and post-operative resource use. A total of 226 patients, with 232 surgeries were included in the cost-of-illness analysis.

Key Findings:

- Surgically managed hand and wrist injuries contribute to significant expenditure (approximately \$1.2 million per year) at one Australian public health network.
- The median cost per injury for non-compensable cases (n=191) was \$4,508 [IQR \$3,993 – \$6,172] and \$5057 [IQR \$3,957 – \$6,730] for compensable cases (n=35).
- The mean inpatient length of stay for non-compensable cases was 1.21 days (95% CI [1.14; 1.29] and 1.26 days (95% CI [1.08; 1.43]) for compensable cases.
- The typical profile for individuals who required surgery for an acute hand or wrist injury was a male (81%) aged between 25- and 34-years (median: 31.6 years [IQR 24.8 – 42.9]).
- A total of 6.6% of patients re-presented to the emergency department following their surgery.
- Twenty-eight per cent (n=54) of non-compensable patients ended their care within the health network by failing to attend their scheduled outpatient appointment. Also, 34% (n=77) of non-compensable and compensable patients failed to attend more than one of their appointments during the patient pathway within the health network.
- Inpatient costs (\$889,045) accounted for the highest proportion of total health care costs (73.8%), followed by outpatient (\$187,540; 15.6%) and emergency department (\$128,021; 10.6%) costs.
- No significant correlation was found between cost and delayed presentation, age or gender; however, it must be acknowledged that this may be a result of a Type II error as no power calculation was performed.
- Further research using rigorous data collection methods are required to establish epidemiological data and national estimates of cost burden.

The next chapter presents a cost-of-illness study which investigates the economic implications of hand and wrist injuries that were sustained as a result of participation during sport or exercise from the perspective of one Australian public health service (Alfred Health). It aims to estimate all direct costs that were accrued within Alfred Health from resources used in the emergency department, inpatient (if required) and outpatient settings. In addition, we aimed to illustrate the demographic profile, patient care

journey of this population and also identify the sport and exercise activities that lead to the most significant burden within the study setting.

5.7 References

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Chapter 6

Profile and cost of sport and exercise-related hand and wrist injuries with Emergency Department presentation

6.1 Chapter Introduction

Chapter 5 presented a cost-of-illness study that estimated the direct costs associated with an emergency department presentation, surgical intervention and consequent postoperative resources for individuals presenting with a hand or wrist injury at one Australian public health service. We found that these injuries result in yearly costs of approximately \$1.2 million at this health service and that the median cost for non-compensable injury cases was \$4,508 [IQR \$3,957 – \$6,730] and \$5057 [IQR \$3,957 – \$6,730] for compensable cases. We also found that the typical patient requiring surgical intervention was male (81%) and aged between 25 and 34 years (median 31.6 years [IQR 24.8 – 439]). We observed that 28% of non-compensable patients ended their patient care journey within the health service by failing to attend their scheduled outpatient appointment. Also, we observed that 34% of non-compensable and compensable patients failed to attend at least one of their appointments during their patient care journey, and therefore, identified a key driver of potentially avoidable direct cost burden.

Expanding on from the findings presented in Chapter 4, which identified that sport and exercise were a causative factor in approximately 16% of hand and wrist injury presentations to the emergency department, we sought to understand the direct cost burden experienced as a result of emergency department, inpatient and outpatient resource use for these injuries from a health-system perspective.

6.2 Chapter Aims

This chapter presents a cost-analysis from one Australian public hospital health service which estimates the economic implications of hand and wrist injuries sustained as a result of participation in sport or exercise. We calculated all direct costs accrued within the health service from resources used in the emergency department, inpatient and outpatient settings. We also describe the demographic profile of

the individuals who sustained these injuries, their patient care journeys, and also identify the sport and exercise activities that led to the most significant cost burden.

6.3 Chapter Contents

The manuscript that forms this chapter is currently under review for consideration for publication in the *Journal of Science and Medicine in Sport*. The proposed citation of this manuscript is:

Robinson, L. S., Brown, T. & O'Brien, L. (2019, under review). Profile and cost-analysis of sport and physical activity related hand and wrist injuries with Emergency Department presentation. *Journal of Science and Medicine in Sport*.

Date submitted: 26/09/2019

6.4 Manuscript IV

Manuscript IV, as it appears in this chapter, is presented in the format that was required for consideration of publication in the *Journal of Science and Medicine in Sport*.

6.4.1 Abstract

Objectives Injuries to the hand and wrist from sport and exercise are common and costly. This cost-of-illness analysis was performed with the purpose of estimating the economic implications of hand and wrist injuries that were sustained as a result of participation during sport or exercise at one Australian public hospital health service.

Design Descriptive Epidemiological Study - Audit

Methods Using ICD-10 diagnostic codes and electronic billing records, 778 potential cases for inclusion in this study were identified. Electronic medical records were screened and reviewed to extract demographic and patient care journey data. Costs from the perspective of the health care service were calculated from resource use in the emergency, inpatient and outpatient settings.

Results 692 individuals, (n=761 individual zone of injuries), were included. Australian Rules Football (ARF) was the largest contributor to injuries (20.2%) followed by riding bicycles (15.9%). The total cost of all injuries was \$790,325, with a median cost per case of \$278 [IQR \$210 - \$282] in the Emergency Department (n=692), \$3,328 [IQR \$2,242 - \$6,441] in the inpatient setting (n=76) and \$630 [IQR \$460 - \$870] in the outpatient setting (n=244).

Conclusions Hand and wrist injuries sustained from sport and exercise contribute to a significant financial burden on the healthcare system. Injury prevention programs may mitigate the observed injury trends. Further research is needed on the cost-effectiveness, and cost-benefit of an on-call allied health advanced practitioner hand therapist in Emergency departments to assist in the triage and timely treatment of injuries that can be conservatively managed.

Practical implications

- Injury prevention programs should be considered as potential avenues to decrease the economic burden associated with avoidable hand and wrist injuries sustained from participation in sport and exercise.
- Targeted strategies to reduce the number of failed to attend appointments should be considered within practice settings to decrease avoidable expenditure.
- An on-call allied health advanced practitioner hand therapist in Emergency departments may be able to assist in the triage and timely diagnosis and treatment of injuries that can be conservatively managed which has the potential to reduce cost burden and enhance the patient care journey.

6.4.2 Introduction

Sport is one of the defining cultural pastimes and interests in Australia. The broader benefits of sport are increasingly acknowledged by governments, businesses and communities^{1,2} with estimates of participation rates within the Australian population varying from 28-40% for organised physical activity and 60-70% for non-organised physical activity³. Sport is an effective means for combating the rising rates of obesity and chronic illness, crime rates, as well as improving levels of physical and mental health^{4,5}. Despite these health and social benefits, organised and non-organised sport or exercise also has

the potential to cause serious injury at a significant cost to both the individual, their family and broader society⁶.

In Australia, it is estimated that annually one in seventeen sport-playing individuals sustain an injury that is significant enough to miss a game or training, leave the field of play, or seek medical or first aid treatment⁷. In 2011-12 36,000 people aged 15 years and older were hospitalised as the result of an injury while playing sport and spent a total of 79,000 days in hospital⁶. In addition to the impact on the individual (i.e. pain, discomfort, physical impairment, loss of productivity), sports injuries place a heavy burden on Australian society with costs upwards of \$2 billion dollars each year⁸.

While injuries to the shoulder and knee receive much attention, approximately 25% of sports injuries involve the hand or wrist⁹. Furthermore, 20% of sports-related fractures are sustained in the hand or wrist, second only to the knee/lower leg (23%)⁶. In Australia, no published evidence currently exists that examines the epidemiology, costs, and medical care resource consumption for sports-related acute hand and wrist injuries due to the absence of a national systematic patient data repository. Accurate information regarding costs and resources used in the provision of healthcare is essential to policymakers, funders and health service managers for planning and resource distribution¹⁰.

This cost-of-illness analysis was performed with the purpose of estimating the economic implications of hand and wrist injuries that were sustained as a result of participation during sport or exercise at one Australian public hospital health service. Specifically, we aimed to:

1. estimate the costs associated with resource use following a sport or exercise-related hand or wrist injury from the perspective of the health care service; and
2. illustrate the demographic profile, patient care journey, and resources used by this patient population.

6.4.3 Methods

The target population for this cost-of-illness analysis was patients of any age who required an Emergency Department (ED) presentation within the study setting for an acute hand or wrist injury sustained while engaged in sport or exercise.

Using ICD-10 diagnostic codes involving the hand or wrist (refer Appendix A) 5,028 patients from electronic billing records presenting to either the Alfred or Sandringham hospital EDs from July 1st, 2014 to June 30th, 2015 were identified¹¹. The listed mechanism of injury contained within the electronic billing records were screened to identify patients who had presented with injuries that were as a result of participation in a sport (which may have been in a formal, informal or training setting) or an exercise activity (defined as a “planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness” (p.129)¹². For example, cases that were reported to occur from walking were excluded as it was not considered exercise using this definition; however, cases that occurred from jogging or running were included. This secondary analysis resulted in 778 potential cases for inclusion in this study. The full electronic medical record of each case identified in the screening process was reviewed to ensure the following selection criteria were met (1) the injury was the result of participation in a sport or exercise, (2) the injury was sustained to the hand and/or wrist, (3) the hand and/or wrist injury was the primary reason for presentation to the ED, and (4) sufficient detail was contained in the medical record to allow for extraction and analysis purposes. Using data extracted from the electronic medical records, we assigned a primary injury type as either (1) fracture, (2) joint injury, (3) laceration, (4) combination injury, (5) soft tissue injury, or (6) tendon injury.

The study setting was Alfred Health, one of Australia’s major health services, has three hospital campuses (two with emergency departments), as well as several outpatient clinics and a range of community services. The Alfred Hospital is a 680-bed major tertiary referral teaching hospital that is a major provider of specialist state-wide services to residents of Victoria that has about 65,000 ED visits per year. The Sandringham Hospital is a 100-bed medium tertiary referral teaching hospital and has about 34,000 ED visits per year. The health service is responsible for serving approximately 700,000 residents

within the state of Victoria, owing to its specialised health services. Ethics was approved by Alfred Health (233/16) and Monash University (CF16/2268 – 20160001119).

We used an incidence-based approach for our cost-analysis, where we estimated the lifetime costs of a condition from its onset to its disappearance (in this instance, the completion of treatment in the study setting), to estimate the cost burden over a determined period of time¹³. Medical costs were estimated from the perspective of Alfred Health and were calculated for all resources used during ED presentations, inpatient surgical procedures, and outpatient appointments (refer Appendix B for included cost components). As traditional with this method, morbidity and mortality were not considered¹³.

Indirect costs due to loss of productivity (e.g. paid or unpaid work), child-care, transport or other out-of-pocket costs are not included in our cost estimates. As the study setting was restricted to one public health network, costs associated with resources used prior to presentation (e.g. ambulance, other hospital ED presentation, general practitioner (GP) consultation) or after treatment within the study setting (e.g. private inpatient admission, additional private surgical management, or private medical or allied health outpatient management) were also not included.

Details relating to costs incurred from resource use in the ED and inpatient settings were extracted from hospital billing records that are collected for the health service's clinical, admissions and financial records systems. These cost estimates were not adjusted (0% discount rate) and are presented as billed/recorded during the data collection period. All outpatient resource use (e.g. medical, nursing and therapy appointments) was extracted from electronic medical records, with costs calculated using unit cost prices (2015) (refer Appendix B). The total cost of each individual case was estimated by summing all publicly funded resources used during the episode of care within the study setting.

Demographic data (e.g. age, occupation, hand dominance), injury details (e.g. sport or exercise that resulted in injury, location of injury, hand injured), inpatient length of stay (LOS), patient care journey (e.g. general practitioner [GP] appointments prior to ED presentation, outpatient discharge destination) and outpatient resource use (e.g. number of medical, hand therapy (HT), physiotherapy (PT)

or failure to attend (FTA) appointments) were extracted from electronic medical records. Where the individual's primary work occupation was reported, it was classified using the Australian Standard Classification of Occupations (ASCO)¹⁴.

Where appropriate, similar sport or exercise types were grouped together for analysis. For example, injuries sustained while using skateboards, scooters or rollerblades were combined into one category. Similarly, injury types were grouped together for analysis. For example, volar-plate or collateral ligament injuries of the finger with/without avulsion fractures were classified as joint injuries, while both tendinous and bony mallet injuries were classified as a tendon injury.

Normality of data was assessed before analysis. Descriptive statistics were used to report epidemiological, demographic and cost data. A biostatistician checked the data analysis procedures to ensure the accuracy of reported findings. All reported costs are presented in 2015 Australian Dollars (AUD). Data analysis was performed using R studio and Microsoft Excel.

6.4.4 Results

A total of 692 patients, with a total of 761 individual zones of injuries (ZOI), who attended an ED within Alfred Health with an acute hand or wrist injury as a result of sport or exercise were eligible for inclusion in this study. This represents approximately 14% of all hand and wrist injury ED presentations during the data collection period¹¹. Eighty-six cases were excluded following a full review of electronic medical records as they did not have a clear sport/exercise related cause of injury (n=58); the injury was not sustained to the hand or wrist (n=10); the hand or wrist injury was not the primary reason for presentation to the ED (n=11); or there was insufficient information reported in the medical record to allow for adequate data extraction and analysis (n=14) (refer Fig 1). Demographic data are reported in Table 6.1.

A total of nineteen different sport and exercise categorises associated with injuries were observed (refer Table 6.1). Australian Rules Football (ARF) was found to be the most significant contributor to injuries (20.2%), followed by riding a bicycle (15.9%), basketball (11.8%) and soccer (known in European countries as football) (9.4%).

The patient care journey for all cases can be seen in Figure 6.1. The mean days between the date of injury (DOI) and presentation to the ED was 1.14 [95% CI 0.82 – 1.46]. A total of seven patients re-presented to the ED following their initial presentation during their episode of care.

Seventy-five (27.9%) participants who were referred and attended for further management within Alfred Health (n=243) received a different diagnosis by the specialist medical team to that documented in the ED (e.g. a missed fracture, incorrect interpretation of imaging, or substantially different anatomical location of zone of injury). When considering health profession and clinician training, registrars (who have at least two years medical training) and interns (during their twelve-month internship following graduation) were most likely to provide a primary diagnosis in the ED that was later corrected by the specialist medical team (35% and 33% of all referrals to a specialist medical team respectively). Approximately 8% of patients saw a physiotherapist as their primary consultant within the ED, with 62% of these cases being referred on for specialist opinion (either a surgeon or hand therapist within Alfred Health or for private follow-up).

The location of all individual ZOI (n=761) can be seen in Figure 6.2. It should be noted that this includes all 692 cases, therefore, there is a risk that some cases may have a different diagnosis to that stated in the ED. Globally, most injuries were sustained to the little finger (n=154) and/or the wrist (n=150). When considering the 243 patients who attended one or more specialist outpatient appointments (medical or therapy), and had a confirmed diagnosis provided by a specialist, the most common primary type of injury was a fracture (n=150), followed by a joint injury (n=58) or tendon injury (n=19) (refer Table S1).

For cases that required and attended outpatient appointments (n=243), the median number of appointments with a surgeon (or Registrar/Resident Medical Officer) was 2 [IQR 1 – 3] (refer Table S1). Injuries that required surgical intervention resulted in a higher median number of medical appointments (n=73; Mdn: 2 [IQR 2 – 4]) then conservatively managed injuries (n=170; Mdn: 1 [IQR 1 – 2]).

The median number of therapy appointments delivered at the hospital by a hand therapist or physiotherapist for all injuries was 2 [IQR 0 – 4] (refer Table S1). Injuries that were surgically managed required a higher median number of therapy appointments (n=76; Mdn: 4 [IQR 1.25 – 6]) than conservatively managed injuries (n=167; Mdn: 2 [IQR 0 – 3]). It should be noted, however, that it is common practice for physiotherapists in the study setting to refer fractures externally for private follow-up which has the potential to lead to a skewed representation of the data results. For fractures that were managed by a hospital-based hand therapist (n=83), the median number of appointments was 3 [IQR 2-5].

The combined total cost for treatment of all cases (n=692) within Alfred Health was \$790,325 (refer Table S2). Inpatient costs contributed the highest portion of total cost (n= 76; \$354,984; 45%) followed by ED costs (n=692; \$239,611; 30%) and outpatient costs (n=264; \$195,730; 25%). The median cost per case for each treatment location was \$278 [IQR \$210 - \$282] in the ED (n=692), \$3,328 [IQR \$2,242 - \$6,416] in the inpatient setting (n=76) and \$630 [IQR \$460 - \$870] in the outpatient setting (n=244). The median costs of treatment location for each sport and exercise category can be seen in Table S2.

Injuries sustained from riding a bicycle (n=110) led to the largest overall costs (\$173,076) and the highest ED and outpatient costs. Injuries sustained while playing ARF (n=140) led to the second-largest overall costs (\$161,538) and also the most cost accrued in the inpatient setting. Table S3 reports the median costs of each sport and exercise categories in regard to patient care journey.

6.4.5 Discussion

Profile and cost data relating to acute hand and wrist injuries sustained as a result of sport and exercise in the Australian Healthcare system have been absent from the empirical literature to date. This study shows that these injuries represent approximately 14% of all hand and wrist injury ED presentations at one Australian hospital network in one financial year¹¹. These injuries cost over AU\$790,000 of direct healthcare costs within the one health network.

Male patients (74%) were disproportionately represented among the study sample. This finding, however, is not uncommon in the international literature for upper extremity injuries sustained from participation in sport or exercise such as soccer^{15, 16}, basketball^{16, 17}, volleyball¹⁶, or running¹⁶. Further, in a study that investigated the epidemiology of sport-related hand fractures (n=1,430) that 86% of observed cases were male⁴. This finding may be partially explained by the fact that in general Australian males aged between 15-17 years and 18-24 years have higher participation rates in sport and physical activity than females (85% and 70%; 76% and 67% respectively)¹⁸. However, the difference between participation rates between individuals aged between 25-34, which contains the median age of our included cases (Mdn: 25 years [IQR 16 – 33.75 years]), is negligible. Our finding that only 9% of cases were aged over 45 years is consistent with the decrease in participation trends observed in Australia¹⁸ and highlights the fact that individuals who sustain a sport or exercise-related hand or wrist injury are likely to be engaged in higher education or at the beginning of their economically productive years.

Australian Rules Football (ARF), a unique code of football widely played only in Australia, was the leading cause of injury for included cases. The sport, which is full contact, involves a mix of physical endurance (four 20-minute quarters), high speed running, frequent changes of direction, jumping, sudden and forceful collisions, aggressive tackling as well as kicking and ball-handling skills^{19, 20}. Owing to its distinctive rules and physical demands, the sport exposes players to both unique and uncommon injuries compared to those sustained in other football codes (i.e. gridiron football played in the United States and Canada or Gaelic football play in the Republic of Ireland).

Published evidence pertaining to all injuries sustained playing ARF at a community level estimate that upper limb injuries account for between 13-33.9% of all ARF injuries^{19, 20} and hand and wrist account for approximately 8% of all injuries²¹. Further, hand fractures are the second most frequent injury, behind concussion²². Our finding that they account for one in five sport or exercise-related injuries at Alfred Health at the cost of AU\$167,538 may have implications for potential health promotion, sports-safety or injury prevention strategies. This includes, but is not limited to, regulations surrounding ground conditions, and education or formal implementation of safety practices at a grassroots and amateur levels to ensure that the risk of injuries related to tackling and marking (i.e. catching the ball) are

minimised. Further, strategies that aim to reduce the risk of misdiagnosis and exposure to further, such as the availability of health professionals trained in acute hand trauma^{19,23}, should also be considered.

Injuries sustained from riding bicycles (n=110) were the costliest mechanism of injury for cases included in this study, resulting in AU\$167,538 of healthcare costs within the study setting. Causes included being struck by a car and environmental causes (e.g. potholes, road conditions, weather). This may have implications for potential health promotions strategies such as protected bike lanes or road safety campaigns²⁴; however, research into their efficacy and cost-effectiveness is required.

A key finding of this study was the high percentage of cases that were discharged from the health service due to failing to attend (FTA) their final appointment (22% of all cases (n=268); 22% of surgically managed cases (n=76); and 11% of conservatively managed cases (n=167)). Further, a third of cases (33%) had at least one or more recorded FTA during their patient care journey within Alfred Health. While at the higher end, this finding falls within the previously published FTA outpatient appointment data estimates²⁵. Beyond the financial costs that FTA incur, they can also lead to inefficient use of facilities with unnecessary delays in the waiting times to assess or review other patients which can lead to poorer clinical outcomes²⁶.

Another key finding of this study was that 27.9% (n=75) of patients who were referred and attended for further management within Alfred Health (n=243) received a different diagnosis by the specialist medical team than what was provided in the ED. Thirty-one cases had missed or incorrect interpretation of medical imaging results, 33 had misdiagnosis/missed injuries, and 11 reported the incorrect anatomical location of the injury. This finding may be explained by the lack of available imaging, resources or clinician knowledge at the time of ED presentation. This observation is not uncommon. One retrospective audit of all misdiagnosed injuries in an ED in the United Kingdom found 953 diagnostic errors in 934 patients over a four year period²⁷. However, the total attendance was not reported, so a percentage of the total number of attendees cannot be established.

Similar research found that 7.8% of paediatric hand fractures were missed or misdiagnosed²⁸, and 6.1% of injuries of the wrist were misdiagnosed as a sprained wrist²⁹. The common finding of these studies was that many of the errors were made by residents or young physicians, which is reflected in our findings that registrars and interns were most likely to report an inaccurate primary diagnosis in the ED. An alternative strategy to attempt to reduce the number of misdiagnosed or missed upper extremity injuries may be an on-call allied health advanced practitioner hand therapist in the ED to assist in the triage and timely treatment of injuries that can be conservatively managed, such as dislocations, closed mallet injuries, and undisplaced fractures.

There are several limitations that must be considered in the context of this investigation. First, caution must be taken when generalising the findings to the Australian population as data was collected from a single-centre in the state of Victoria. For example, the finding that ARF was the sport leading to the most injuries is likely due to its popularity in Victoria. It is likely that if a similar study was conducted in other states of Australia (e.g. New South Wales where Rugby League/Union is the most popular form of football), findings would differ. Second, although we present the costs accumulated by Alfred Health, we did not include indirect costs that occur due to loss of productivity (estimated to be between 64.5-68% of total costs)³⁰, other costs borne by the individuals themselves or the costs that may have been incurred at other health services outside of the study setting. To present a complete estimate of the burden of these injuries, studies from the societal perspective (which include medical, morbidity, mortality, transportation and non-medical costs) are recommended¹³. Additionally, we did not capture costs that occurred prior to ED presentation (e.g. GP) or after (e.g. privately funded practitioners). Finally, it is likely that our cost calculations are underestimates due to factors such as cost-shifting, data entry error, or other miscellaneous causes. In an attempt to decrease underestimation, outliers were closely inspected alongside medical records to determine if under- or over-costing had likely occurred (e.g. the number of resources used compared with cost estimate available).

Despite these limitations, our study had several notable strengths. First, we had a large database of ED presentations collected over a one-year period that allowed for a detailed analysis. Second, we have addressed an important void in literature both in Australia and internationally regarding the

demographics, costs and outpatient resources associated with hand and wrist injuries sustained from sport or exercise.

6.4.6 Conclusions

Acute hand and wrist injuries sustained from sport and exercise have the potential to contribute a significant burden on the Australian public health system. Our study has shown that these injuries result in substantial direct health care costs at one urban healthcare network over one year.

6.4.7 Acknowledgements

The authors would like to thank Mehmet Özmen, Manager of the Statistical Consulting Service, Monash University, for his expert assistance with our data analysis and Danielle Willis, Manager of Costing Services, Alfred Hospital, for her expert assistance with data collection.

Conflict of Interest Statement

The authors have no conflict of interest to declare.

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6.4.8 Manuscript IV Figures

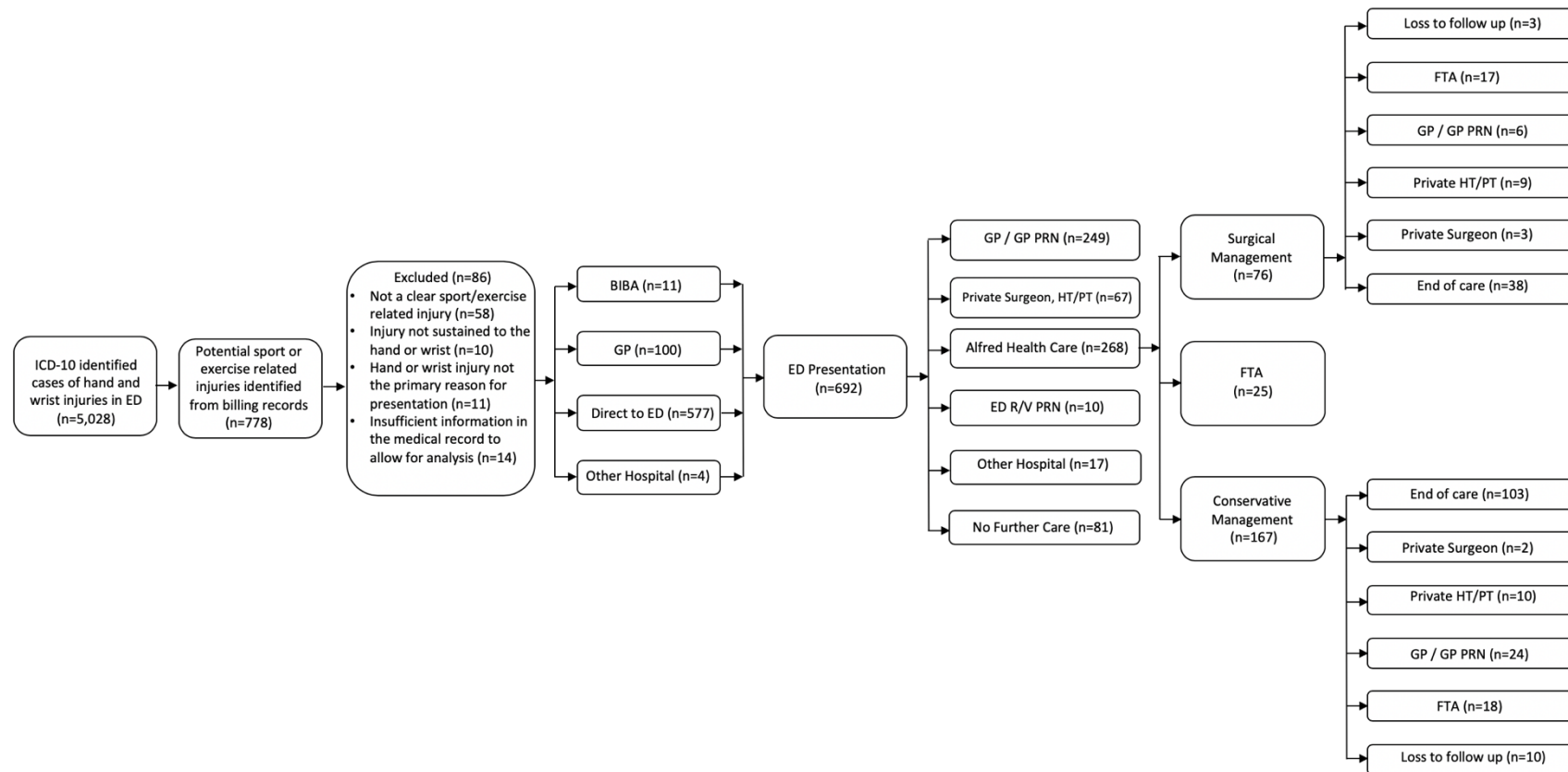


Figure 6.1 Patient Pathway

Abv: BIBA: brought in by ambulance; GP: general practitioner; ED: emergency department; PRN: per registered need; HT: hand therapist; PT: physiotherapist; R/V: review; FTA: failed to attend

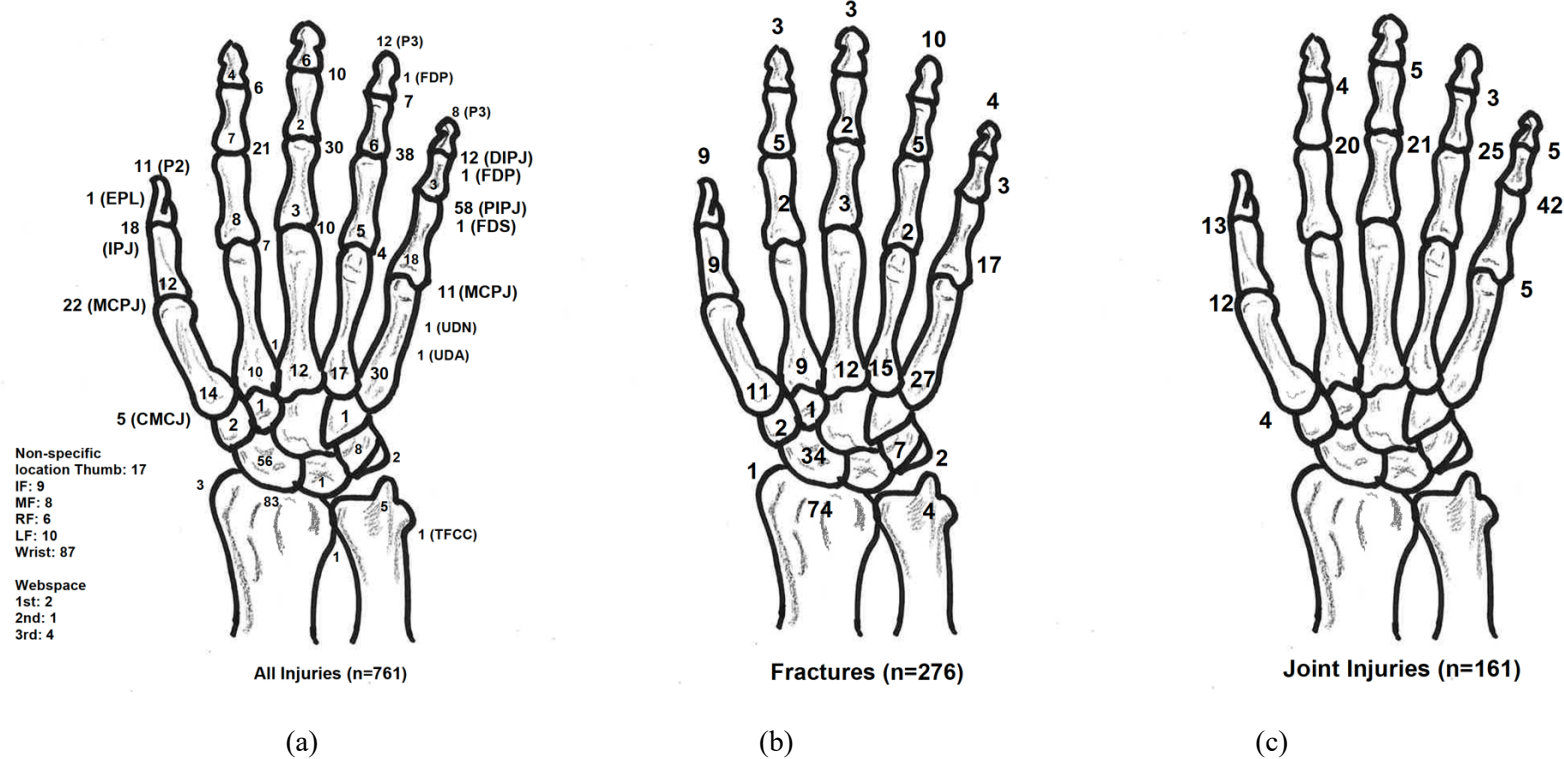


Figure 6.2 Injury Location (a) All Injuries; (b) Fractures; (c) Joint Injuries

Abv: IF: index finger; MF: middle finger; RF: ring finger; LF little finger; CMCJ: carpometacarpal joint; MCPJ: metacarpophalangeal joint; IPJ: interphalangeal joint; EPL: extensor pollicis longus; FDP: flexor digitorum profundus; P1: proximal phalanx; P2: middle phalanx; P3: distal phalanx; DIPJ: distal interphalangeal joint; PIPJ: proximal interphalangeal joint; FDS: flexor digitorum superficialis; UDN: ulna digital nerve; UDA: ulna digital artery; TFCC: triangular fibrocartilage complex

6.4.9 Manuscript IV Tables

Table 6.1 Demographics of Included Cases

		n=	
<i>Presentations</i>		692	
<i>Individual zone of injury</i>		761	
<i>Age (years)</i>	Median [IQR]	25	[16-33.75]
		<i>n=</i>	<i>%</i>
<i>Gender</i>	Male	511	73.8%
	Female	181	26.2%
<i>Hand Dominance</i>	Left	32	4.6%
	Right	360	52.0%
	Not Stated	300	43.4%
<i>Hand Injured</i>	Left	360	52.0%
	Right	328	47.4%
	Bilateral	4	0.6%
<i>Mechanism of injury</i>	Athletics/Gymnastics/Dancing	22	3.2%
	Australian Rules Football	140	20.2%
	Ball Sport (Unspecified)	10	1.4%
	Baseball/Softball	6	0.9%
	Basketball	82	11.8%
	Bicycle	110	15.9%
	Cricket	38	5.5%
	Golf	3	0.4%
	Hiking/Horse Riding	4	0.6%
	Hockey/Ice Hockey	14	2.0%
	Martial Arts/Boxing	18	2.6%
	Netball	57	8.2%
	Racquet Sports	7	1.0%
	Rugby	24	3.5%
	Skateboard/Scooter/Rollerblading	52	7.5%
	Snow Sport	18	2.6%
	Soccer	65	9.4%
	Volleyball	5	0.7%
	Water Sports	17	2.5%

<i>Occupation</i>	Clerical and Administrative Workers	42	6.1%
	Community and Personal Service Workers	36	5.2%
	Labourers	7	1.0%
	Machinery Operators and Drivers	2	0.3%
	Managers	40	5.8%
	Not stated	185	26.7%
	Professionals	76	11.0%
	Retired	5	0.7%
	Sales Workers	22	3.2%
	Student	219	31.6%
	Technicians and Trades Workers	52	7.5%
	Unemployed	6	0.9%

6.4.10 Manuscript IV Supplementary Documents

Appendix S6.1 Outpatient Medical and Therapy (Hand Therapy/Physiotherapy) Resource Use for Cases that had Specialist Care within the Study Setting (n=243)

		Medical Appointments		Therapy Appointments	
Injury Type	n=	Median	IQR	Median	IQR
Fracture	150	2	[1.0 - 3.0]	2	[0.0 - 3.0]
Joint Injury	58	1	[1.0 - 1.0]	3	[2.0 - 5.0]
Laceration	4	1	[1.0 - 1.0]	0.5	[0.0 - 1.0]
Combination injury	7	2	[1.5 - 2.5]	2	[1.5 - 4.0]
Soft Tissue Injury	5	1	[1.0 - 1.0]	0	[0.0 - 1.0]
Tendon Injury	19	1	[1.0 - 1.0]	4	[2.5 - 6.0]
<i>All injuries</i>	243	2	[1.0 - 3.0]	2	[0.0 - 4.0]

N.B. Excludes cases that only received outpatient orthotic appointments (n=1)

Appendix S6.2 Cost by Treatment Location

Sport/Exercise	ED Costs				IP Costs				OP Costs				Total Cost
	n=	Median	IQR	Total Cost	n=	Median	IQR	Total Cost	n=	Median	IQR	Total Cost	
Athletics/Gymnastics/Dancing	22	\$248	[\$210 - \$315]	\$7,718	1	\$356	-	\$356	6	\$620	[\$620 - \$1,013]	\$4,130	\$12,204
Australian Rules Football	140	\$331	[\$207 - \$371]	\$46,284	18	\$3,861	[\$3,122 - \$6,607]	\$91,934	40	\$690	[\$470 - \$923]	\$17,880	\$167,538
Ball Sport (Unspecified)	10	\$306	[\$237 - \$346]	\$2,914	-	-	-	-	3	\$390	[\$390 - \$470]	\$1,330	\$4,244
Baseball/Softball	6	\$241	[\$204 - \$284]	\$1,448	-	-	-	-	1	\$390		\$390	\$1,838
Basketball	82	\$262	[\$206 - \$337]	\$24,496	6	\$3,117	[\$2,258 - \$3,660]	\$19,348	22	\$510	[\$463 - \$7,110]	\$14,900	\$58,743
Bicycle	110	\$351	[\$250 - \$556]	\$52,872	16	\$3,329	[\$2,427 - \$7,420]	\$81,114	46	\$660	[\$410 - \$1,115]	\$39,090	\$173,076
Cricket	38	\$241	[\$189 - \$321]	\$10,976	4	\$2,806	[\$2,578 - \$3,759]	\$14,125	15	\$390	[\$390 - \$705]	\$8,350	\$33,450
Golf	3	\$227	[\$201 - \$632]	\$1,439	-	-	-	-	-	-	-	-	\$1,909
Hiking/Horse Riding	4	\$301	[\$207 - \$499]	\$1,623	2	\$2,363	[\$1,917 - \$2,808]	\$4,725	-	-	-	-	\$6,348
Hockey/Ice Hockey	14	\$273	[\$221 - \$390]	\$4,895	3	\$2,741	[\$2,676 - \$3,204]	\$9,020	5	\$620	[\$390 - \$710]	\$2,890	\$16,804
Martial Arts/Boxing	18	\$253	[\$205 - \$331]	\$4,765	2	\$4,521	[\$3,944 - \$5,099]	\$9,043	5	\$550	[\$470 - \$820]	\$4,380	\$18,188
Netball	57	\$264	[\$193 - \$360]	\$17,821	5	\$4,021	[\$2,241 - \$7,079]	\$23,156	21	\$630	[\$460 - \$850]	\$15,410	\$56,387
Racquet Sports	7	\$225	[\$174 - \$335]	\$3,103	1	\$7,786	-	\$7,786	1	\$710	-	\$710	\$11,759
Rugby	24	\$263	[\$226 - \$352]	\$7,579	4	\$3,175	[\$3,010 - \$4,940]	\$19,101	11	\$550	[\$460 - \$695]	\$6,220	\$32,900
Skateboard/Scooter/Rollerblading	52	\$270	[\$193 - \$365]	\$15,313	4	\$4,615	[\$1,712 - \$7,748]	\$19,376	24	\$690	[\$460 - \$1,098]	\$21,730	\$56,419
Snow Sport	18	\$300	[\$238 - \$488]	\$7,127	4	\$3,778	[\$2,855 - \$7,653]	\$26,918	11	\$1,020	[\$850 - \$1,835]	\$20,750	\$54,795
Soccer	65	\$290	[\$207 - \$425]	\$21,838	4	\$3,597	[\$2,695 - \$6,711]	\$23,239	29	\$630	[\$460 - \$920]	\$20,820	\$65,897
Volleyball	5	\$263	[\$197 - \$315]	\$1,305	-	-	-	-	-	-	-	-	\$1,305
Water Sports	17	\$272	[\$211 - \$299]	\$6,095	2	\$2,872	[\$2,398 - \$3,345]	\$5,743	4	\$490	[\$370 - \$473]	\$1,650	\$13,489
<i>All</i>	692	\$278	[\$210 - \$382]	\$239,611	76	\$3,328	[\$2,242 - \$6,416]	\$354,984	244	\$630	[\$460 - \$920]	\$195,730	\$790,325

Appendix S6.3 Cost by Patient Pathway

Sport/Exercise	ED			ED + IP			ED + IP + OP			ED + OP		
	n=	Median	IQR	n=	Median	IQR	n=	Median	IQR	n=	Median	IQR
Athletics/Gymnastics/Dancing	16	\$236	[\$183-\$275]	-	-	-	1	\$2,295	-	5	\$936	[\$698 - \$1,868]
Australian Rules Football	100	\$246	[\$203 - \$351]	-	-	-	18	\$5,288	[\$4,310 - \$7,907]	22	\$776	[\$671 - \$1,002]
Ball Sport (Unspecified)	7	\$295	[\$243 - \$336]	-	-	-	-	-	-	3	\$707	[\$662 - \$806]
Baseball/Softball	5	\$276	[\$233 - \$288]	-	-	-	-	-	-	1	\$584	-
Basketball	60	\$355	[\$205 - \$331]	-	-	-	6	\$4,533	[\$4,516 - \$5,352]	16	\$735	[\$638 - \$853]
Bicycle	63	\$301	[\$240 - \$413]	1	\$2,763	-	15	\$6,782	[\$3,923 - \$9,421]	31	\$1,075	[\$793 - \$1,379]
Cricket	23	\$210	[\$167 - 278]	-	-	-	4	\$3,848	[\$3,714 - \$4,944]	11	\$707	[\$625 -\$836]
Golf	2	\$632	[\$429 - \$834]	-	-	-	-	-	-	1	\$645	-
Hiking/Horse Riding	1	\$130	-	-	-	-	2	\$3,975	[\$3,669 - \$4,281]	1	\$1,459	-
Hockey/Ice Hockey	8	\$240	[\$188 - \$300]	1	\$4,092	-	2	\$4,117	[\$3,823 - \$4,410]	3	\$753	[\$691 - \$871]
Martial Arts/Boxing	11	\$234	[\$182 - \$308]	-	-	-	2	\$5,600	[\$4,925 - \$6,274]	5	\$795	[\$709 - \$818]
Netball	36	\$238	[\$181 -\$319]	-	-	-	5	\$4,028	[\$3,756 - \$8,529]	16	\$927	[\$706 - \$1085]
Racquet Sports	6	\$207	[\$166 - \$233]	-	-	-	1	\$10,215	-	-	-	-
Rugby	13	\$260	[\$219 - \$369]	-	-	-	4	\$3,975	[\$3751 - \$5,857]	7	\$946	[\$784 - \$989]
Skateboard/Scooter/Rollerblading	28	\$263	[\$202 - \$360]	-	-	-	4	\$6,677	[\$3,007 - \$10,731]	20	\$875	[\$748 - \$1,190]
Snow Sport	7	\$235	[\$216 - \$418]	-	-	-	4	\$5,048	[\$4,686 - \$9,543]	7	\$1,401	[\$1,033 - \$1,685]
Soccer	36	\$246	[\$186 - \$363]	-	-	-	4	\$5,224	[\$4,443 - \$8,323]	25	\$931	[\$707 - \$1,198]
Volleyball	5	\$263	[\$197 - \$315]	-	-	-	-	-	-	-	-	-
Water Sports	13	\$251	[\$211 - \$284]	-	-	-	2	\$3,627	[\$3,125 - \$4,130]	2	\$689	[\$689 - \$690]
All injuries	440	\$253	[\$199 - \$347]	2	\$3,667	[\$3,428 - \$3,760]	74	\$4,727	[\$3,847 - \$8,206]	176	\$857	[\$697 - \$1,149]

6.4.11 Manuscript IV Appendices

Appendix 6.1 ICD-10 Codes used for Case Identification

ICD-10 Code	Description
S609	Superficial injury of wrist and hand, unspecified
S619	Open wound of wrist and hand part, part unspecified
S628	Fracture of other and unspecified parts of wrist and hand
S6300	Dislocation of wrist, part unspecified
S6310	Dislocation of finger, part unspecified
S6350	Sprain and strain of wrist, part unspecified
S637	Sprain and strain of other and unspecified parts of hand
S649	Injury of unspecified nerve at wrist and hand level
S659	Injury of unspecified blood vessel at wrist and hand level
S669	Injury of unspecified muscle and tendon at wrist and hand level
S678	Crushing injury of other and unspecified parts of wrist and hand
S684	Traumatic amputation of hand at wrist level
S689	Traumatic amputation of wrist and hand, level unspecified
S697	Multiple injuries of wrist and hand
S698	Other specified injuries of wrist and hand
S699	Unspecified injury of wrist and hand

Appendix 6.2 Included Cost Components

Cost Location	Included Cost Components
Emergency Department Costs	Allied Health Emergency Department (including medical) Imaging Pathology Pharmacy
Inpatient Costs	Allied Health Imaging Medical (non-surgical) Medical (surgical) Other Pathology Pharmacy Theatre Ward/Nursing
Outpatient Costs	Hand Therapy (Occupational Therapy / Physiotherapy) (Unit cost price (2015) \$80) Speciality Medical Services (Plastic Surgery or Orthopaedics) (Unit cost price (2015) \$280)

6.5 Impacts of the Study

Journal Metrics: To be determined once accepted for publication.

This paper was presented at the Australian Hand Therapy Association's national conference (invited speaker), as an ePoster at my profession's peak international conference, and as a poster at the Monash University Faculty of Medicine, Nursing and Health Sciences research festival.

Invited Speaker

Robinson, L. S. (2018). Costs and epidemiology of acute hand and wrist injuries. Australian Hand Therapy Association National Conference, 19th – 21st October, Melbourne Australia.

Conferences:

Robinson, L. S., & O'Brien, L. (2019). Costs and epidemiology of sport related acute hand injuries [ePoster]. 14th IFSSH & 11th IFSHT Triennial Congress with combined FESSH Congress, 17th – 21st June, Berlin, Germany.

Accepted abstract:

Robinson, L. S., & O'Brien, L. (2020). Costs and profile of sport and exercise-related acute hand and wrist injuries [Oral Presentation]. 12th Asian Pacific Federation of Societies for Surgery of the Hand and the 8th Asian Pacific Federation of Societies of Hand Therapists Congress, 11th – 14th March, Melbourne, Australia.

6.6 Chapter Summary

Expanding on the findings presented in Chapter 4, this retrospective file audit aimed to estimate the direct healthcare costs incurred at one Australian public hospital health service for hand and wrist injuries that were sustained as a result of participation in sport or exercise. A total of 692 patients, with 761 individual zones of injury were included in the cost-of-illness analysis.

Key Findings:

- Hand and wrist injuries caused by sport or exercise were found to cost \$790,325 at one Australian public health network.
- These injuries accounted for approximately 14% of all hand and wrist injuries that presented to the emergency department during the data collection period.
- The median age of patients presenting with these injuries was 25 years [IQR 16 – 33.75], with males accounting for 74% of all cases.
- Australian Rules Football was found to be the largest contributor to injuries (20.2%), followed by bicycle related injuries (11.8%), and soccer (9.4%).
- Inpatient costs contributed to the highest portion of total cost (n=76; \$354,984; 45%), followed by emergency department costs (n=692; \$239,611; 30%) and outpatient costs (n=264; \$195,730; 25%).
- Approximately, 28% of patients who were referred for further management within the study setting (n=243) received a different diagnosis by the specialist medical team to that documented in the emergency department.
- Twenty-two per cent that required care in the study setting following an emergency department presentation were discharged from the health service due to failing to attend their final appointment.
- One-third of cases were found to have failed to attend at least one or more appointments during their patient pathway.

This investigation concluded that further research is required to establish epidemiological data and national estimates of cost burden. It suggested that misdiagnosis in the emergency department, failed to attend rates and bicycle injuries may be an area where costs could be minimised. The findings of this investigation provide preliminary support for the trial of an on-call advanced hand therapy practitioner in the emergency department to reduce inaccurate diagnosis and begin early treatment; and to consider health promotion strategies to reduce avoidable injuries.

The next chapter presents the findings of a pilot prospective longitudinal cost-of-illness study which sought to test the feasibility of this method for accurately quantifying the total burden of acute hand and wrist injuries. We aimed to measure direct, indirect and intangible costs at three timepoints during the first-year following injury in an attempt to identify the specific key drivers of individual and societal burden.

6.7 References

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Chapter 7

Is it feasible to accurately capture the cost of acute hand and wrist injuries from the individual and societal perspective?

7.1 Chapter Introduction

Chapter 6 presented a cost-of-illness study which investigated the economic implications of hand and wrist injuries that were sustained as a result of participation during sport or exercise. We found that these injuries result in approximately \$790,000 worth of direct costs in one year at one Australian public health network for individuals who presented via the emergency department. We also found that males and those aged in their economically productive years were most likely to present with a sport or exercise-related hand or wrist injury and that Australian Rules Football was the most common activity. Further, it was observed that nearly one-third of patients who were referred for further management within the study setting received a different diagnosis by the specialist medical team to that documented in the emergency department, and one-third of patients failed to attend at least one or more appointments during their patient care journey.

Whilst the direct cost-of-illness or injury is relatively simple to estimate using existing records, indirect and intangible costs are more challenging to measure, meaning the full scale of the economic burden reported for hand and wrist injuries is likely to be underestimated. The only way to accurately quantify the economic burden of injury over the first year is to prospectively follow people with newly acquired injuries using repeated, valid, and comprehensive measures of cost. These types of studies, however, are known to be resource-intensive and challenging to execute, especially the recruitment and retention of a representative sample of participants. For example, a feasibility study that aimed to track long term functional and quality of life outcomes of burns patients found that only one in four eligible patients participated in the study, attrition rates were high, and no superior mode of administration was identified¹.

In this pilot study, we aimed to test the feasibility of a burden of injury study for wrist/hand fractures, tendon injuries and nerve injuries. We aimed to capture direct, indirect and intangible costs at three timepoints in the first-year post injury in order to identify the specific key drivers of individual and societal burden.

7.2 Chapter Aims

This chapter aims to present the findings of the pilot study, in which we set out to survey participants at six-weeks, twelve-weeks and six-months in an attempt to accurately estimate the burden experienced at an individual and societal level. It presents preliminary findings from the limited data (the result of low participant recruitment and retention), highlights the difficulties encountered during the conduct of the investigation, and makes recommendations for increasing the feasibility of conducting similar research in the future.

7.3 Chapter Contents

The manuscript that forms this chapter is currently under review for consideration for publication in the *Hand Therapy* journal. The proposed citation of this manuscript is:

Robinson, L. S., Brown, T., & O'Brien, L. (2019, under review). Is capturing the cost acute fractures, tendon and nerve injuries of the hand and wrist from the individual and societal perspective feasible?

7.4 Manuscript V

Manuscript V, as it appears in this chapter, is presented in the format that was required for consideration for publication in *Hand Therapy*.

7.4.1 Abstract

Introduction:

Given the high incidence of hand and wrist injuries, they are exceptionally costly to the economy. This pilot study was performed with the purpose of establishing the feasibility of the study protocol and

providing a preliminary estimate of the individual and societal economic implications that result from sustaining an acute fracture, tendon or nerve injury to the hand or wrist.

Methods:

A pilot longitudinal cohort design with baseline measures of injury type and severity, and repeated measures of disability, cost, and activity limitations and participation restrictions at six-weeks, three-months and six-months was selected to test study feasibility. We aimed to compare total burden between three common acute hand or wrist injury groups (fractures, tendon and nerve injuries) with participants recruited from two-public health care services.

Results:

A total of 206 patients consented to participate in this study, representing 54% of those invited to participate. The retention rates were 18% at six-weeks, 2.4% at twelve-weeks, and 0.004% at six-months following injury. From the limited data collected at six-weeks, it was noted that nearly half of the patients reported a decrease in usual financial income, 14% reported absenteeism, and 62% reported presenteeism.

Discussion:

The study findings highlight the difficulties of completing longitudinal survey research investigating individual and societal burden with this population. Future research should be carefully designed to encourage participation and retention by considering the time burden placed on the participants within and across selected survey time points, providing participants with incentives to participate, and highlighting the relevance and real-world applications of the findings.

7.4.2 Introduction

Hands and wrists were the third most commonly injured body part in US workplace injury data,² and the largest category of work-related injuries in Australia.³ Given their high incidence, these injuries are astonishingly costly to the economy. In the US, cost of injury data collected via the Centres for Disease Control and Prevention WISQARS™ (Web-based Injury Statistics Query and Reporting System) indicated that wrist and hand fractures alone cost the economy more than 6 Billion US dollars in 2010, with work loss costs comprising 78% of total costs.⁴ Similarly, a Dutch population-based study found that, given the volume of injuries sustained annually, hand and wrist injuries ranked first in the order of most expensive injury group, ahead of knee, hip, and skull-brain injuries.⁵ This was due to

impacts on work productivity, especially in males aged between 20 and 65 years, and healthcare costs in women aged over 65.

In Australia, evidence on the scale of the economic burden of acute hand and wrist at an individual, community or societal level is currently limited to work-related injuries⁶. Therefore, there is a poor understanding of how the specific factors associated with these injuries (such as poorly managed pain, lack of social or workplace support, late presentation to specialist facilities, misdiagnosis by primary health care providers, and sub-optimal treatment and rehabilitation⁷⁻⁹) and the systems in place outside of the workers compensation system to manage these contribute to or mitigate this burden.

The economic burden of a disease or injury is described as the sum of all costs associated with the condition that would not be incurred if that disease did not exist^{10, 11} and is calculated by totalling direct, indirect, and intangible costs¹²⁻¹⁵. Direct medical costs relate to diagnostics and the actual treatment provided in response to the injury and can include surgery, inpatient admission, medications, imaging, and postoperative care^{14, 15}. Direct non-medical costs are costs and resources used in connection with the health service but are not health sector costs (e.g. transport to and from a medical facility). Indirect costs most commonly relate to productivity losses due to morbidity and mortality and can be borne by the individual, family, society or the employer^{11, 14, 15}.

These costs are due to work absences resulting in foregone productivity (referred to as absenteeism), reduced work capacity due to impairment related to their condition (presenteeism), and unpaid productivity which involves reduced possibilities of performing usual activities at home such as housework or caring for family members due to illness or disease^{10, 11, 16-18}. Indirect costs are often harder to calculate than direct costs as it is difficult to measure productivity when considering presenteeism or unpaid roles objectively or with certainty. Intangible costs consider burden beyond the monetary costs of goods and services and include other sequelae that reflect decreased enjoyment of life because of illness. Such costs are associated with functional limitations, pain, psychological distress, and decreased social interaction¹⁹.

Information about cost burden and the resources used in the design, implementation, and provision of healthcare²⁰, is of interest to policymakers for resource allocation and cost-minimisation. However, such an analysis has not been completed for hand and wrist injuries in Australia. This study focuses on individuals presenting with acute fractures, tendon and nerves injuries of the hand and wrist at two Australian public health services to provide insight into the direct and intangible costs experienced from an individual patient perspective and the indirect costs experienced from an individual patient and societal perspective. In addition, it seeks to identify the specific drivers of individual and societal economic burden.

7.4.3 Aims

This pilot study was performed with the purpose of establishing the feasibility of the study protocol (including recruitment and retention of a representative sample) and providing a preliminary estimate of the individual and societal economic implications that result from sustaining an acute fracture, tendon or nerve injury to the hand or wrist.

Specifically, we aimed to:

- Evaluate methods for collecting data regarding direct and intangible costs experienced at an individual patient perspective in an acute hand/wrist injury population in Australia
- Provide a preliminary estimate of profile of costs incurred by injury type: either fractures; tendon or nerve injuries;
- Identify the specific key drivers of economic and individual, family and social burden.

It was hypothesised that impacts on participation are more pronounced and prolonged for people with tendon injuries than those with fractures or nerve injuries, and that burden of disease is, therefore, higher for this group.

7.4.4 Methods

Design

A pilot longitudinal cohort design with baseline measures of injury type and severity, and repeated measures of disability, cost, and activity limitations and participation restrictions at six-weeks, three-months and six-months was selected to test study feasibility and potentially allow for a comparison of total burden estimates between three common acute hand or wrist injury groups (fractures, tendon and nerve injuries).

Target population and subgroups

As we sought to compare the individual and societal costs, level of disability, and the activity limitations and participation restrictions between hand and wrist fractures, tendon and nerve injuries, three subgroups were targeted during participant recruitment. Patients from two major metropolitan hospitals in Melbourne, Australia who met the inclusion criteria of: (1) having a clinical diagnosis of an acute hand or wrist fracture, nerve, or tendon injury; (2) were of working age (18-65 years); (3) were able to participate in completing a survey (no serious mental health, cognitive or linguistic impairment that would impact on participation); and (4) were not experiencing other serious disorders or injuries that might confound the experience of their acute hand or wrist injury, were identified by their treating therapist during their first outpatient specialist appointment within the study settings.

An invitation to discuss information relating to the study was offered to eligible participants by the treating hand therapist. Written consent was obtained after a full explanation of nature and scope of the study by the first author (LR) prior to the commencement of data collection. Data collection occurred between July 2016 and December 2017. Ethical approval was granted by Alfred Health (422/13), Monash Health (LNR/16/MonH/18) and Monash University (CF14/197).

Setting and location

The Alfred Hospital (a campus of Alfred Health) is a 680-bed tertiary referral teaching hospital that is a major provider of specialist state-wide services (e.g. burns, trauma) to residents of Victoria. The Emergency Department (ED) has about 65,000 visits per year.²¹ The Dandenong Hospital (a campus of

Monash Health) is a 573-bed tertiary referral teaching hospital that is a provider of general and specialist services to the people of Dandenong and surrounding areas. The ED has about 70,000 visits per year²².

Study perspective

We used a prospective, incidence-based approach to costing illness, where we estimated the lifetime costs of a condition from its onset until its disappearance to quantify the economic burden over a determined period^{11, 23}. Direct and intangible costs were estimated from the perspective of the individual patients, while indirect costs due to lost productivity were estimated from the individual patient and societal perspective⁹.

Data collection

Participants were offered the opportunity to complete online, paper-based or telephone surveys at six-weeks, three-months and six-months following injury. The surveys consisted of:

- A demographic form which included age, gender, marital status, education, employment status prior to injury, current employment status (hours worked in previous week, ANZCO code for type of work performed²⁴) number of children, number of persons dependent on family income, compensation status, and job stability measures (number of full-time jobs in past five years, total years at current job, and total years with current employer);
- An injury description form which included the location of the injury, type of injury, the time from injury to presentation at hospital, and injury mechanism;
- The Patient-Rated Wrist and Hand Evaluation (PRWHE)²⁵, which contains 15 items: five of which evaluate pain (intensity and frequency) and 10 evaluate function (specific activities and usual activities). The pain subscale is calculated by summing the five items, while the functional score is calculated by the sum of the ten items divided by two. A score of 100 is reflective of a significant impact, whereas a score of zero reflective of no impact. Information from the PRWHE can be used to determine the magnitude of wrist or hand-related disability at one point in time;
- The SF-36, short form of the Health Status measure, which is a comprehensive multidimensional measurement of health status concepts. The scales include a physical functioning scale, two scales that distinguish between role limitations because of 'physical health' or 'mental health', a

social functioning scale, a mental health scale, and a vitality and general health perception scale²⁶; and

- The Short Form of Health and Labour Questionnaire (SF-H&L) which has three modules covering absence from paid employment, productivity loss without absence from paid employment, and impediments to paid or unpaid employment.²⁷

All instruments were selected based on validity and reliability, sensitivity to detect changes over time, appropriate normative data, time and literacy levels required for completion, self-report, and relevance to workplace productivity²⁸⁻³².

Data analysis

All data were checked for normality and, if skewed, presented as a Median (Mdn) and Interquartile Range [IQR]. Descriptive statistics were used to report demographic data, injury types, direct health care costs (health service use and out of pocket expenses) productivity costs (time off work, as well as time in alternative duties) indirect costs (such as paying others to perform roles/duties usually done by the injured person) and impacts on family and social participation. Multiple linear regression modelling was proposed for prediction of costs and duration of disability/productivity impairment, and we planned to use latent growth curve analysis to see if changes in one variable result in changes to others over the first six months post-injury. Cost data are presented in Australian dollars (AUD). Data analysis was performed using R studio³³ and Microsoft Excel³⁴.

7.4.5 Results

A total of 382 participants were invited to participate in this study with 206 providing content to participate (54%) over the eighteen-month data collection period. Of this group, only 37 participants (18%) completed their six-week survey, and only five participants (2.4%) completed their twelve-week survey and one participant (0.004%) their six-month survey (refer Figure 7.1). The surveys that were completed at twelve-weeks and six-months were further complicated by a large portion of missing data in many of the sections meaning comparisons between time points was not feasible.

The demographic details of the initial sample and the thirty-seven participants who completed the six-weeks post-injury survey can be viewed in Table 7.1. The median age of participants was 32 years [IQR 26-60 years] with the majority of respondents being male (68%). Regarding injury type, 33 participants had sustained a fracture, with tendon injuries (n=3) and nerve injuries (n=1) largely absent from completed responses. More than half of the injuries were sustained to a finger (57%), with the dominant hand most commonly affected. The median number of specialist medical and hand therapy appointments attended (as reported by respondents at six-weeks following injury) was four [IQR 3-5] and three [IQR 2-4] respectively.

Despite the majority of patients identifying as being covered by either universal healthcare (73%) or insurance-based compensation systems (8%), both of which cover medical and therapy costs, all participants reported out-of-pocket medical costs associated with their injury at a median cost of \$75 [IQR \$40-\$200]. Prior to their injury, 92% of participants reported that they were working either full-time, part-time or casually. At six-weeks following injury, 14% of participants who were working prior to their injury reported they were forced to take a temporary absence from work, with one participant losing their employment role held before injury. Of the participants who reported loss of income from lost penalty rates, commissions or other forms of additional income (n=17) the median financial deficit six-weeks following injury was \$1000 [IQR \$100 - \$2500]. Also, nearly half of participants (n=14) reported needing to accommodate for expenditure on tasks that were usually performed independently before injury (e.g. home maintenance, lawn mowing) at a median cost of \$150 [IQR \$100-\$275] when this occurred.

PRWHE Scores

At six-weeks, the median PRWHE score for all participants was 39.5 [IQR 25.5-53.5] which is suggestive of a moderate impact. The median scores of the pain and function subscales (both out of a possible score of 50) were 15 [IQR 10-26] and 21 [IQR 14-29.5] respectively. No comparison between six-weeks and twelve weeks and six-months was possible.

SF-36 Scores

The mean scores of the subscales of the SF-36 following the scoring guidelines proposed by Ware and Sherbourne (1992)²⁶ are presented in Table 7.2. It was observed that role limitations due to physical problems (mean: 16.2 SD 28.4) was the most noted impact on health status, which when compared to the norm for healthy Australians (both genders) (mean: 79.7 SD 35.1), indicates that our sample observed significant impact on the ability to complete their normal roles³⁵. The mean summary measures of physical health (physical components summary) and mental health (mental component summary), calculated as proposed by Ware and Gandek (1998)³², were 62.1 (SD 10.6) and 57.2 (SD 16.8) respectively. This indicates that these injuries appear to have a slightly greater impact on mental health than physical health.

SF-H&L Findings

Responses to the SF-H&L questionnaire revealed that of participants who identified as remaining in a paid employment role six-weeks following injury (n=32), six participants were unable to perform any work in the two-week period before completing the survey. Of the participants who were able to work in the two-week period prior to completing the survey (n=26), 62% reported that their work was hindered as a direct result of their hand or wrist injury. The most common experiences were needing to work at a slower pace (n=8 often/always), putting off some of their regular work tasks (n=6 often/always), and needing other people to complete routine work tasks (n=6 often/always). Details relating to annual or weekly income were largely absent in the completed survey responses indicating a preference of participants not to disclose such information.

All participants who reported that they were unable to work (n=6) did not provide income data, and therefore, an estimate of indirect costs was not feasible. The median number of hours spent in a one-week period on household work (e.g. preparing meals, cleaning the house, washing clothes), shopping (e.g. daily groceries), odd jobs (e.g. house repairs, gardening), specific activities for or with own children (e.g. providing care, providing transport) and providing care for a person other than a child (e.g. spouse, parent, or other) and frequency of reported impact is presented in Table 7.3. The frequency of participants

seeking assistance with household work, the source of assistance and the median number of weekly hours of assistance are presented in Table 7.4.

7.4.6 Discussion

Although this investigation provides some insight in to the individual and societal cost burden experienced at six-weeks following a hand or wrist injury by a small group of participants, the findings are limited and confounded by several limitations. While we demonstrated an acceptable level of recruitment of those invited to participate (54%), retention of those who had consented in the days following injury and adherence of completing the six-week (17%), the twelve-week (2.4%) and six-month (0.004%) post-injury surveys were extremely low. This outcome was observed despite providing recruited participants with the option of how they would like to complete the surveys (e.g. online, paper-based, telephone) and method of reminder notices (e.g. email, text messages, telephone messages).

Increasingly lower participation rates in epidemiological studies have been observed over the last forty years³⁶, with even steeper declines observed in more recent years³⁷. Such observations have been noted and documented by government agencies³⁸, academic researchers³⁹ and for-profit companies⁴⁰. Commonly reported reasons for this decline in participation include the ‘over surveyed’ effect, where there is increasing number of requests to participate in various research and consumer surveys³⁶; the decrease in societal volunteerism, which has been found to parallel participation in survey research⁴¹; the growing disillusionment with science and scientific studies⁴²; and the increasingly complex nature and demands of research studies and their perceived time burden³⁶. It is, therefore, plausible to suggest that some or all of these factors could have contributed to the results observed.

When considering why people choose to participate in survey research, three main factors have been suggested. These being altruism (e.g. furthers some purpose important to the respondent or fulfilling a social obligation), survey related reasons (e.g. respondent is interested in the survey topic or find the interviewer appealing) and egoistic reasons (e.g. respondents ‘like it’ or are motivated by money)⁴³. Groves et al⁴⁴ proposes a leverage-salience theory to describe the decision to participate in survey research. The theory suggests that a decision is made resulting from multiple considerations, some of

which are survey specific (e.g. topic and sponsorship), some person-specific (e.g. privacy concerns), and others being specific to the respondent's social and physical environment⁴⁵. It is postulated that a combination of these factors may have resulted in the low retention and adherence rate observed in this study.

As participants received no compensation for their time to complete the surveys, one potential consideration for future researchers is to have some form of incentive available for participants to encourage retention^{46, 47}. Further, as participants were asked to provide potentially sensitive information relating to income, despite assurances of confidentiality, some privacy concerns may have led to non-participation and/or omission of these requested details. Finally, it is suggested that the retention rates observed may be the result of the first data collection occurring at six-weeks following a hand or wrist injury, a time that is well into recovery for most uncomplicated injuries.

It was anticipated that the impacts on participation would be more pronounced and prolonged for people with tendon injuries than those with fractures or nerve injuries, and that burden of disease would be higher for this group. Owing to the extremely low response and retention rate of participants who consented to participate in conjunction with low numbers of participants outside the fracture subgroup, this assumption was not able to be formally tested. Therefore, more research that reflects the considerations as mentioned above for this type of study design is required.

Overall, the reported individual cost burden experienced by individuals with acute hand and wrist injuries at six-weeks following injury should be considered preliminary given the limited response rate following recruitment. The findings do, however, suggest that the individual burden experienced from these injuries could be substantial and have the potential to impact the individual in terms of loss of income, out-of-pocket expenses, and impaired role performance, health and well-being. Based on these limited findings, the role of a hand therapist in providing occupation-based interventions that consider the unique individual's roles and responsibilities^{48, 49}, could be viewed as one method that may reduce the individual burden experienced. However, a well-designed economic evaluation that considers the cost-benefit is required to validate this proposal.

The findings of PRWHE total scores in this investigation at six-weeks (mean 41.7 SD 20.5) are comparable to a previously published study where the PRWHE was administered for various hand and wrist pathologies at the same timepoint (mean 43.28 SD 23.61)⁵⁰. This suggests that the burden experienced by the limited participants in this study appear a somewhat accurate representation.

Finally, these injuries have the potential to lead to significant impacts and productivity costs for employers at a societal level as the majority of respondents who were at work four to six-weeks after their injury were not performing tasks at their normal capacity as the result of their injury. This supports the notion that these injuries contribute to societal burden via absenteeism (i.e. absence from the work setting) and presenteeism (i.e. when the individual is present at the work setting, but performance is likely impacted owing to a health condition⁵¹). However, the true scale of this cost burden in remains largely unknown.

Limitations and Future Research

Our study must be considered in the context of several limitations. First, it likely that the cost estimates presented in the study could be either under- or over-estimated as is typical when surveying participants about the cost burden encountered as a result of injury or disease. Second, the study setting was restricted to two Australian public healthcare services in Victoria. It possible that the recruitment, retention and cost burden observed in this study may not be generalisable to the broader Australian population. Finally, we recruited participants soon after their injury, generally in their first outpatient appointment. It is possible that recruiting participants closer to the first survey time point (i.e. six-weeks after injury) may have led to a higher retention rate due to the recency of discussing the research project, its aims and its real real-world applications.

Future research should be carefully designed to encourage participation and retention by considering the time burden placed on the participants within and across selected survey time points, providing participants with incentives to participate, and highlighting the relevance and real-world applications of the findings at the point of recruitment and potentially again at the time of survey

completion. Also, researchers should consider conducting such research from a national perspective to allow for the broader generalisation of results.

7.4.7 Conclusion

The study findings highlight the difficulties of completing longitudinal survey research investigating individual and societal burden with this population. While limited findings were achieved in this investigation, the insights observed into the possible individual and societal burden resulting from fractures, tendon and nerve injuries of the hand or wrist warrants the need for further studies.

7.4.8 Acknowledgements

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Conflict of Interest Statement

The authors have no conflict of interest to declare

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7.4.9 Manuscript V Tables

Table 7.1 Demographics of Participants at Entry and on Completion of Six-Week Measures

		Participants who consented to participate		Participants who completed six-week survey	
		n		n	
			206		37
		n	%	n	%
Gender	<i>Male</i>	159	77%	25	68%
	<i>Female</i>	41	20%	12	32%
	<i>Not stated</i>	6	3%		
Age	<i>Median years [IQR]</i>	30	[25 – 38.25]	32	[26 – 60]
Location of injury	<i>Finger</i>	80	39%	22	59%
	<i>Hand</i>	103	50%	10	27%
	<i>Wrist</i>	11	5%	5	14%
	<i>Missing</i>	12	6%		
Type of injury	<i>Fracture</i>	177	86%	33	89%
	<i>Tendon</i>	11	5%	3	8%
	<i>Nerve</i>	2	1%	1	3%
	<i>Missing</i>	11	5%		
Side of injured hand	<i>Left</i>	80	39%	16	43%

	<i>Right</i>	114	55%	20	54%
	<i>Missing</i>	12	6%	1	3%
Injured dominant hand	<i>Yes</i>			21	57%
Number of days between injury and presentation to ED	<i>Median days [IQR]</i>			1	[0 – 2]
Mechanism	<i>Bite</i>			1	3%
	<i>Crush</i>			4	11%
	<i>Fall / FOOSH</i>			6	16%
	<i>Laceration (knife, blade)</i>			2	5%
	<i>Not stated</i>			2	5%
	<i>Power tool</i>			1	3%
	<i>Punch / Altercation</i>			6	16%
	<i>Sport (inc. bicycle)</i>			15	41%
Marital Status	<i>Divorced</i>			1	3%
	<i>In a relationship</i>			1	3%
	<i>Married / Long term cohabitation</i>			23	62%
	<i>Relationship</i>			1	3%
	<i>Single</i>			11	30%
Education	<i>Bachelor's degree</i>			5	14%
	<i>Certificate III/IV</i>			3	8%
	<i>Diploma / Advanced Diploma</i>			11	30%
	<i>Graduate Diploma / Graduate Certificate</i>			2	5%

	<i>Post Graduate Degree</i>	5	14%
	<i>Year 10</i>	1	3%
	<i>Year 11 or below (inc. Cert I/II)</i>	3	8%
	<i>Year 12 / VCE or equivalent</i>	7	19%
Employment Status (prior to injury)	<i>Employed, Casual</i>	6	16%
	<i>Employed, Full-time</i>	25	68%
	<i>Employed, Part-time</i>	3	8%
	<i>Not in labour force</i>	2	5%
	<i>Unemployed, Looking for full time work</i>	1	3%
Employment Status (six-weeks post injury)	<i>Employed, Casual</i>	6	16%
	<i>Employed, Full-time</i>	21	57%
	<i>Employed, Part-time</i>	1	3%
	<i>Employed, temporarily away from work</i>	5	14%
	<i>Not in labour force</i>	2	5%
	<i>Unemployed, Looking for full time work</i>	2	5%
Occupation	<i>Clerical and Administrative Workers</i>	3	8%
	<i>Community and Personal Service Workers</i>	2	5%
	<i>Managers</i>	9	24%
	<i>Not in the labour force</i>	4	11%
	<i>Professionals</i>	10	27%
	<i>Sales Workers</i>	3	8%

	<i>Technicians and Trade Workers</i>	6	16%
Number of Full-time positions in last five years	<i>No Full-time position</i>	6	16%
	<i>One Full-time position</i>	15	41%
	<i>Two Full-time positions</i>	10	27%
	<i>Three Full-time positions</i>	4	11%
	<i>More than four Full time Positions</i>	2	5%
Number of years with current employer (n=33)	<i>Median [IQR]</i>	2	[1-7.75]
Children	<i>Participants with children</i>	14	38%
	<i>Mean number of children (SD)</i>	3	1.3
Number of dependents on income	<i>No dependents</i>	15	41%
	<i>One dependent</i>	12	32%
	<i>Two dependents</i>	3	8%
	<i>Three dependents</i>	5	14%
	<i>Four dependents</i>	2	5%
Funding type	<i>Private</i>	6	16%
	<i>Public</i>	27	73%
	<i>Reciprocal health agreement</i>	1	3%
	<i>TAC</i>	1	3%
	<i>WorkCover</i>	2	5%

Table 7.2 Mean Scores and Standard Deviations of SF-36 Subscales

Subscale	Items	Mean	SD
Physical functioning	10	77.7	10.9
Role functioning/physical	4	16.2	28.4
Role functioning/emotional	3	41.4	40.3
Energy/fatigue	4	53.1	17.9
Emotional well-being	5	62.9	19.9
Social functioning	2	74.8	20.2
Pain	2	62.7	22.9
General health	5	67.4	18.8

Table 7.3 Hours Spent in Weekly Tasks and Reported Impact from Injury (SF-H&L) at Six Weeks

	<i>(no. of responses)</i>	<i>Median hours (IQR) spent in previous week (no. of responses reporting time spent)</i>	<i>% reported impact from injury</i>
Household work	(n=37)	10 (IQR 4 – 20) (n=37)	70%
Going shopping	(n=36)	2.5 (IQR 2 – 45) (n=36)	56%
Odd jobs	(n=37)	2 (IQR 0 – 2) (n=37)	65%
Specific activities with children	(n=37)	20 (IQR 10 – 35.25) (n=10)	30%
Carer role	(n=37)	5 (IQR 2.25 – 8) (n=11)	24%

Table 7.4 Source and Hours of Assistance in Household Work (SF-H&L) at Six Weeks

	<i>No. of responses who reported assistance</i>	<i>Median hours (IQR) of assistance</i>
Family	(n=16)	6.5 (IQR 2 – 10.25)
Neighbour/volunteer	(n=1)	18 (IQR 18 – 18)
Paid home help	(n=4)	2.75 (IQR 1.59. 12.62)
Other	(n=0)	

7.4.10 Manuscript V Figures

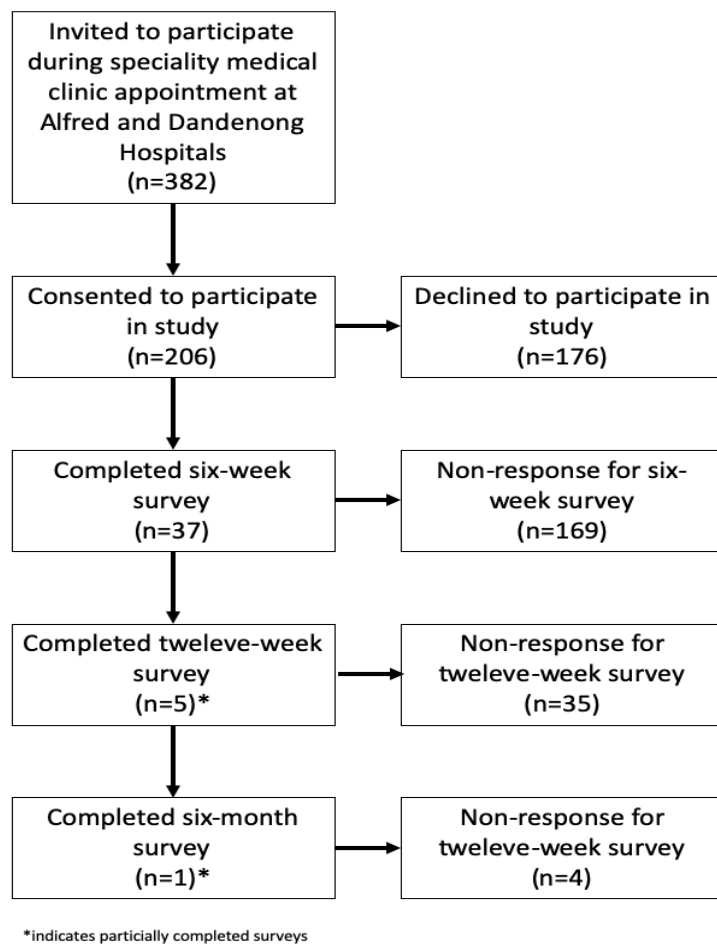


Figure 7.1 Participant, Recruitment, Retention, and Survey Completion

7.5 Impacts of the Study

Journal Metrics: To be determined once accepted for publication.

It is intended that this manuscript be submitted for presentation at the next national Australian Hand Therapy Association (AHTA) conference and at my profession's peak international conference.

7.6 Chapter Summary

Expanding on the findings of the previous chapters of this thesis, this prospective longitudinal cost-of-illness pilot study aimed to provide an estimate of the direct and intangible costs experienced from an individual patient perspective and the indirect costs experienced from an individual patient and societal perspective following a fracture, nerve or tendon injury of the hand or wrist. Unfortunately, owing to poor retention rates of recruited participants, results from this study are limited mainly to data collected six-weeks after injury for thirty-seven participants; however, some insights into the possible cost burden were observed.

Key Findings:

- All participants who completed the survey at six-weeks following injury (n=37) reported direct medical costs experienced from an individual perspective at a median cost of \$75 [IQR \$40 – \$200].
- Nearly half (46%) of participants reported loss of financial income from usually received penalty rates, commissions or other forms of income at a median cost of \$1,000 [IQR \$100 – \$2,500].
- Of the participants working before their injury, 14% were forced to take a temporary absence from work (i.e. absenteeism), while 62% of those working in the prior two-weeks of completing their six-week survey reported their injury was hindering work performance (i.e. presenteeism).
- Role limitations due to physical problems were found to be the most significant impact on health and well-being as measured by the SF-36 (mean 16.2, SD 28.4).

- The conduct of the longitudinal cohort study designed in this investigation was found to be non-feasible due to low retention and adherence rates of participants who consented in the days initially following injury;
- Possible reasons for low retention and adherence rates include:
 - A lack of incentive to participate (i.e. no monetary gift or similar);
 - The ‘over-surveyed’ effect that is commonly being observed in modern research;
 - Potential privacy concerns, despite assurances regarding data collection and storage methods, regarding sensitive personal financial income data; and
 - The first data collection timepoint at six weeks is a time that is well into recovery for most uncomplicated injuries and, therefore, the relevance of the survey material may be viewed as unnecessary.
- Consideration of reasons that promote and hinder participant recruitment, retention and adherence need to be strongly considered in future research designs that investigate the individual and societal burden of these injuries from a prospective, incidence-based approach.

The next chapter presents a qualitative study which builds on evidence concerning the burden experienced from the individual perspective after an acute hand or wrist injury, by conducting semi-structured interviews with twelve participants.

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Chapter 8

Workplace, family and social participation following acute hand injury

8.1 Chapter Introduction

Chapter 7 presented the findings of a pilot longitudinal cost-of-illness cohort study that was performed with the purpose of establishing the feasibility of the study protocol (including recruitment and retention of a representative sample) and providing a preliminary estimate of the individual and societal economic implications that result from sustaining an acute fracture, tendon or nerve injury. The study findings highlighted the difficulties of completing longitudinal survey research into individual and societal burden with this population. Possible reasons as to why this design was not feasible included a lack of incentive to complete surveys, the perceived intrusiveness of questions regarding income (which some may see as potentially sensitive information), and the timing of first survey at six-weeks following injury – a time that is well into the recovery for most uncomplicated injuries.

Despite the poor retention of recruited participants, and results being limited to the data from a small sample (n=37) at six-weeks after injury, we were able to present some insights into the possible individual and societal cost burden. We found that nearly half of the participants who completed the survey reported a decrease in their normal financial income from loss of penalty rates, commissions or other forms of additional income at a median deficit of \$1000 (IQR \$100 – \$2,500) in the first six weeks. Also, we found that both absenteeism and presenteeism appear to be key contributors to societal burden of acute hand and wrist injuries and that both physical and mental health remain impacted at six-weeks following injury.

Expanding on these findings, this chapter presents the results of a qualitative investigation that used semi-structured interviews and content analysis to understand the perceived individual burden as a result of a hand or wrist injury especially on workplace, family and social participation.

8.2 Chapter Aims

This chapter aims to capture the individual's experience of the burden experienced as a result of an acute hand and/or wrist injury. It presents a deep exploration of family and social impacts, as well as the experience of lost productivity. It also identifies the injured person's perceptions of the key drivers of individual, family and societal burden experienced as a result of their injury.

8.3 Chapter Contents

The manuscript contained within this chapter is currently under review for consideration for publication in the *Journal of Hand Therapy*. The proposed citation of this manuscript is:

Robinson, L. S., Robinson, A., & O'Brien, L. (2019, under review). Workplace, Family and Social Participation following acute hand injury. *Journal of Hand Therapy*.

8.4 Manuscript VI

Manuscript VI, as it appears in this chapter, is presented in the format that was required for consideration for publication in the *Journal of Hand Therapy*.

8.4.1 Abstract

Study Design: Qualitative descriptive

Introduction: Hand and wrist injuries are common and costly. They have potential to lead to significant burden by preventing occupational engagement and can be a source of stress, disruption to daily life and can greatly change the ability to perform life roles satisfactorily and successfully.

Purpose of this study: To understand the perceived burden as a result of injury that encompasses family, social impacts, and lost productivity for individuals with hand and/or wrist injuries.

Methods: Twelve adults with acute hand and/or wrist-injury were interviewed. The transcribed text was analysed using manifest and latent content analysis.

Results: The perceived burden of injury in the context of family, social impacts and lost productivity were discussed in terms of consequences and adaption in daily life, the perceived costs associated with injury, impact of lost productivity and health-care system experiences.

Conclusions: The findings suggest that engagement in daily occupations, participation in usual roles and emotional and physical health are perceived to contribute the most burden after hand/wrist injury.

Clinical indications: Therapists are encouraged to consider using conceptual models alongside formal and informal assessment to ensure a holistic and client-centred approach to decreasing burden.

Level of Evidence: Not applicable.

8.4.2 Introduction

Hands, which are recognised as being a key component in defining us as humans, play an immense and integral role in our vocational, avocational, and social functioning¹. Not only do they provide us with independence, competence, and a sense of identity, they also give us a means of productivity, employability, and expression². Given such significance in our everyday occupations, individuals with acute hand and/or wrist injuries are likely to experience significant occupational performance issues, activity limitations and participation restrictions at a significant cost to themselves, their family and to society^{3,4}. This paper reports the findings from a qualitative study exploring patient perspectives of the burden of an acute hand and/or wrist injury in the context of work, family and social participation.

8.4.3 Background

Injuries sustained to the hand and/or wrist are common and have been estimated to account for between 5-30% of all emergency department (ED) presentations⁵⁻⁷. While most people with uncomplicated injuries will recover full function, some require a long period of recovery and rehabilitation, and a proportion faces the potential of a long-term disability. Regardless of the severity of an injury, it is commonly accepted that most patients will, for a period, experience impacts leading to issues with occupational performance⁸.

Occupations, which can be divided into self-care, productivity and leisure, have been defined as groups of activities and tasks that are part of everyday life⁹. Changes in the involvement or engagement in meaningful or regular occupations, and therefore changes in occupational performance (the result of the dynamic and interwoven relationship between the person, the environment and the occupation), has the potential to affect an individual's health and well-being and how they structure and give meaning to their life⁹. Therefore, an acute hand and/or wrist injury that prevents occupational engagement can be a source of stress and disruption to daily life and can greatly change the ability to perform life roles satisfactorily and successfully¹⁰.

8.4.4 Purpose of the study

The aim of this qualitative study is to explore the experience of burden as a result of an acute hand and/or wrist injury in the context of work, family and social participation. Specifically, we aimed to:

1. understand the perceived burden as a result of injury that encompasses family, social impacts, and lost productivity – including both absenteeism (i.e. absent from the work setting) and presenteeism (i.e. when the individual is present at the work setting but performance is likely impacted owing to a health condition¹¹ – in people with hand or wrist injuries; and
2. identify injured persons' perceptions of the key drivers of economic and family/social burden following an acute hand or wrist injury.

8.4.5 Methods

Design and participants

A qualitative descriptive method using an inductive approach was used to achieve a deeper understanding of how individuals perceive the burden of their hand injury in the context of their workplace, home and social environments. Twelve adult patients with hand injuries who had attended hand therapy services at Alfred Hospital, a major metropolitan trauma hospital, within the previous year were included in the study. Participants were purposefully sampled to ensure a diverse representation of experiences including type of injury, socioeconomic background, age, gender and work status. The inclusion criteria were: an existing clinical diagnosis of an acute hand or wrist injury

sustained in the past twelve months, able to participate in an interview (no serious mental health, cognitive or linguistic impairment that would impact on participation), and not experiencing other serious disorders or injuries that might confound the experience of their acute hand or wrist injuries.

Data collection commenced in September 2014 and was completed in January 2016. The sample size (n=12) was determined by data saturation, where no new categories or themes emerged after coding the last two interviews. Participant demographics and injury descriptions are presented in Table 8.1.

Procedure and ethical considerations

Therapists working within the hand therapy department at Alfred Hospital provided potentially eligible participants with an explanatory statement outlining the project and sought permission for the first author to contact them. An explanation of the project was provided over the telephone or at the clinic by the first author, emphasising the voluntary nature of the study, and an interview time was set for those who agreed to participate. Written consent was obtained prior to conducting the interview. All participants were informed of the data analysis process and were assured of anonymity in presented findings. Ethical approval was granted by Alfred Health (442/13) and Monash University (CF14/197).

All interviews were performed and recorded by the first author, in a quiet conference room or over the telephone and lasted between 30 and 75 minutes. The interviews commenced with restatement of the purpose of the study. A semi-structured interview schedule designed specifically for this study was used to guide the interviews (refer Appendix 1). The recorded interviews were transcribed verbatim by the first author.

Data analysis

Conventional content analysis methods with an inductive approach was selected as the most appropriate method for analyzing the data. The text and audio recordings were analyzed using manifest (which focuses on the surface structural meaning presented in the message) and latent

(which focuses on the deep structural meaning or underlying meaning conveyed in the message) content analysis¹². A detailed description of the data analysis methodology used is presented in Figure 8.1. The first and second authors carried out the first reading and thereafter compared and discussed their impressions of the text and completed steps one to four depicted in Figure 8.1.

8.4.6 Results

The following analysis focuses on the perceived burden experienced as a result of an acute hand or wrist injury with a specific focus on the workplace, home and social environments. Discussion is structured around three themes: consequences and adaption in daily life; the perceived costs associated with injury and health-care system experiences.

Consequences and adaptation in daily life

Engagement in occupations that occur in the workplace, home or during leisure and social contexts was experienced as restricted or limited as a result of the acute hand or wrist injury. As each participant's circumstances were unique, the duration of the consequences, which ranged from weeks to months, and the need for assistance and adaption varied. Despite the differences in roles, time use and interests, common descriptions were that positive relationships with family, friends and employers contributed to positive attitudes surrounding recovery. The ability to adapt to challenges was highlighted and practice and experience of one-handed self-discovered techniques led to increased confidence and competence in challenging tasks. The consequences and areas in daily life that were significantly impacted, limited or required adaption were classified by the authors as changes in occupational performance or occupational patterns; shift in roles; and impact on physical and emotional health.

Changing occupational performance and patterns

Three common narratives that were discussed by all participants was that '*day to day activities*' were significantly impacted in the first few weeks to months following injury; the notion of being '*sidelined*' where life appeared to be in '*limbo*'; participation was restricted or not possible; and that engagement in many meaningful occupations and socialisation was heavily curtailed by the

inability to drive a car. This was evident with all participants discussing difficulties of varying extremes.

“I couldn’t believe how much impact a hand injury has on your day to day, just your activities, your survival, everything you do. It has an enormous impact.” P1

“I wasn’t able to do anything... I couldn’t drive, I couldn’t lift weights, I couldn’t do anything... one of my hobbies is that I play some video games and I couldn’t do that either... it sidelines, it sidelined me from everything... everything is affected by your hand. Everything that you do. There are some things you can’t [do] and there are some things that you do with difficulty.” P5

“I find that the hand injury is far more impacting on your lifestyle and on your capacity to participate and do things. It has been much more pervasive than say a sprained ankle or I have had an arthroscopy and things like that. It does impact you a lot more because it impairs you in most facets of life.” P12

“My activities took a bit of a sideline... I had to put everything on hold... it put everything to a bit of a standstill.” P9

When discussing experiences of completing self-care tasks relating to personal care, participants reported that they generally needed more time than usual (e.g. showering, hair washing, dressing); assistance from a partner or significant other (e.g. cutting up food, assistance with setting up materials to complete a task); paying for assistance (e.g. hair wash/blow dry) or adapting the way they completed tasks (e.g. wearing different clothing to normal). However, competence with completing self-care tasks was seen to increase with time and practice using the non-injured hand. When completing domestic activities of daily living, participants discussed similar requirements of increased time required, adaption or assistance, however, they also noted avoidance of some tasks all together. Many participants discussed their reliance on others to complete heavy domestic tasks (e.g. vacuuming) or those that involved water (e.g. washing the dishes) when they were instructed to keep dressings/casts/orthoses dry. In addition, participants reported an increased reliance on buying prepared meals (‘take away’) in lieu of being able to complete usual cooking tasks. Table 8.2 presents commonly reported occupations that were impacted as a result of participants’ hand and wrist injuries.

“Every task I did was modified... things like washing my hair, I had to double bag my hand, so it didn’t get wet. I wouldn’t get the wound wet, or get the finger wet... it was not an easy time to do things, but you realise just how good your left arm becomes at doing tasks and fine motor skills... they really do improve quite quickly.” P1

“I couldn’t obviously pull my weight as easily in terms of cleaning around the flat. In terms of, with my girlfriend, I couldn’t really uphold my end of the bargain, you know vacuuming and that sort of thing that we do. We sort of share the domestic duties. So, I did what I could, but it wasn’t feasible a lot of the time.” P6

The participants described a variety of common experiences in limitations or challenges observed in their productivity. These included difficulties such as using a computer (*Typing an email... I would probably say about 25% longer [to type]*” P1), completing manual handling tasks, or handwriting. A common reflection was that when participants were able to participate in their normal roles, productive output and satisfaction with work completed decreased in the initial stages of recovery.

“I am basically doing the same thing, but it is taking me longer and I have got to find other ways... I am right handed, to work a syringe you have to teach your left hand how to do it... so I can do everything, or almost... I am slower and clumsier, and yeah it takes longer to do the same job.” P8.

Many participants revealed that they were unable to engage in their usual or preferred leisure occupations. While some adapted or sought new opportunities, many found they were limited or struggled to substitute new leisure interests into their revised daily routine. Nearly all interviewed reported that they were unable to participate in their usual sporting or physical activity interests and identified this as a significant burden resulting from their hand or wrist injury.

“The fact that I was still able to run around has been really good, but if I hadn’t been able to exercise at all I probably would have found it more frustrating.” P3

“I couldn’t go to the gym, couldn’t play golf, couldn’t play footy... I couldn’t do anything... I go to the gym now and it is sort of like, I can’t really do any of the stuff I used to do. Like bench press, or lifting dumbbells, well heavy dumbbells, you know. I am very restricted in what I can do at the gym.” P4

“It’s like when you can’t work and you can’t do the number one hobby you want to do [basketball], and you are a bit lazy anyway, you aren’t really motivated to go out of the way to do extra things.” P7

All participants noted a decreased participation in social activities at some point during their recovery. This was particularly evident in the early phase of healing due to pain, the inability to drive, and lowered mood or self-confidence (e.g. limited clothing options, appearance of finger/orthosis).

“I didn’t do the usual amount of socialising in the initial stages. Mainly because you are uncomfortable with your finger. In the acute phase it is just that uncomfortable really that you just... I wouldn’t say that you are a sad sack, but you are just not yourself... We are quite regular socialisers and so I probably think we really cut that back for at least the first fortnight and we didn’t do as much as that for about four to six weeks in total” P1.

“I think I just sort of retreated a bit, sort of physically... I didn’t want to... it is almost like you don’t want to be out and about in ways... so you really need to spend a bit more time at home.” P12

Shift in roles

The narratives revealed that the consequences of an acute hand or wrist injury led to a shift in usual roles. As we purposively recruited a diverse representation of participants, the types of roles discussed varied (refer Table 8.1).

When discussing the role as partner, significant other or carer, participants discussed a transference of the usual tasks that were completed as part of their daily routine. Tasks included: provision of childcare; domestic tasks, such as cleaning, gardening, and cooking; providing income for cost-of-living expenses; and providing transport for dependents. Some participants reported a strong or complete dependency on other family members to fulfil their usual roles, however, reported that this did not always have a perceived negative effect on the relationship beyond stress or inconvenience.

“Basically, the normal workload that I would carry as a wife and a mother was probably reduced to about 20%.” P1

“When I had my arm in plaster and I was reliant on my mother for care, for myself and my son, I did find it extremely frustrating.” P9

“It put heaps of pressure on my girlfriend as I wasn’t available... I wasn’t able to help around the house... I wasn’t working... my girlfriend was the only income and she [had] to do everything around the house... it put a lot of pressure on her.” P5

Interviewees who discussed their role as worker and were absent from employment for a period of time following injury, commonly reported that their employer was required to reallocate tasks to another employee (absenteeism). Participants who returned to work in the first few weeks reported experiencing reduced productivity compared to their usual performance and also required alterations or modification of tasks (presenteeism). A similar experience was reported by the participant who identified as a student. Two participants (P7, P11) reported that their employers were required to hire an additional employee to ensure that productivity was maintained during their absence. One participant (P5), lost their job role as a worker, as they were not able to work due to their injury impacting on their ability to perform required tasks.

“So we got, we’ve got a couple of workers now, but I could’ve done some admin work or drafting all that kind of stuff, but in terms of, I haven’t physically worked in three months or whatever, and yet I can do some crane work and maybe a little bit of welding and stuff like that, but not worth the risk of falling off, you know in terms of OH&S.” P7

“I was replaced while I was, while I was out. [My] job’s not available anymore.” P5

Impact on emotional and physical health

All participants noted unexpected effects on their emotional and physical health as a direct result of their hand or wrist injury. While various effects and magnitudes were discussed, common experiences were observed.

Emotional reactions, which were prominent throughout the narratives, that participants connected to their injury included frustration, stress/anxiety, questioning of self-worth, impact on self-confidence, depression or noted mood changes. Frustration was an emotional impact that was voiced by all participants and was frequently discussed in the context of forced changes to occupations and roles and/or a sense of an unknown future outcome. Those who were able to adapt to changes or challenges in their usual routine and find new occupations or ways to fill time appeared less likely to experience significant impacts on emotional health beyond frustration or anxiety relating to reinjury or final outcome. A protective factor discussed by several participants was access to emotional support from family, friends and employers, as well as advice and guidance from health-care professionals who understood the consequences of their injury.

“I did feel frustrated because I am not good at sitting around doing much... I am a bit of [a], I’ve got to achieve X amount of things per day... And because I set myself quite high achievement levels, I think I felt quite high levels of frustration.” P1

“I felt bloody frustrated. Really, really frustrated, as I am a really independent person. So not being able to do the normal things to contribute to the household was a little bit challenging.” P2

“I became really depressed for a long time, for the three months, I think it was pretty tough... it was a real mental struggle more than financial, I mean outside of having to pay rent and bills and stuff and not working, as far as the injury goes, it was more of a mental cost than a monetary one.” P5

*“It was a downer. Not being able to work or play sport is f***ing depressing. I am not actually depressed, well maybe, I don’t know, but it is just tough getting out of bed and I have got to spend eight hours a day not doing anything. I can do some things, just not the things I want to do.” P7*

“The main stress for me as soon as I did it, was going to be my work situation. Obviously, I can’t do my job with a broken hand. It is the one thing that you don’t want to break. But my boss was very understanding. He could have very easily not been supportive. And then I would have struggled to pay my rent. And I would have had to dip into my savings to cover my rent and that sort of thing. So, the fact my boss was supportive when he didn’t have to be, and had no right to be, meant that it wasn’t a stressful experience really.” P6

“I did find I was getting stressed because I was trying to find things to do. I would try them, and I couldn’t do them, or I could do them and I was restricted in how I did them.” P11

“I want it to fully recover and get movement in that joint. But I guess right now I am in a bit of mourning of how my finger was to how my finger is currently. I guess it has impacted on my mood... No one wants to feel like they are incapable, or incompetent or useless you know.” P9

In addition to emotional impacts on health and well-being, participants described effects on their physical health. This included pain (which impacted all interviewed), decreased fitness/deconditioning, reduction in energy levels, disrupted sleep, weight gain and secondary health issues.

“I ended up putting on a lot of weight because of it. I wasn’t able to go anywhere or do anything.” P5
“[Not going] to the gym has had a big backlash [because] my core literally has weakened and has caused me a lot of back problems... I would have to grab my bedhead for support to move. I’ve found a lot of hip issues from it.” P10

Perceived costs associated with injury

The perceived costs associated with injury for some participants included descriptions of *monetary costs* that resulted in financial implications, while the majority of participants highlighted *non-monetary costs* which were discussed in terms of emotional impacts and temporal inconveniences.

Monetary costs

While most participants reported that they did not experience significant financial impacts, several common areas where costs were present were identified in the text. These included parking costs to attend hospital appointments (a major source of expenditure for most participants), additional petrol costs, loss of wages from absenteeism (including the use of unpaid or paid leave), forfeiting of overtime benefits, *“forced earlier than expected retirement”* (P8) and loss of employment (P5). Several participants reported that their savings were significantly affected by their injury, while two participants required financial assistance from welfare payments (i.e. Centrelink) while recovering from their injury (P5, P7).

An additional source of financial cost experienced by several participants, albeit not directly related to themselves, was when a significant other provided support and/or assistance during the course of recovery (e.g. post-operative assistance, transport to appointments) and was required to take a period of leave from their own employment.

“He had to not work those days cause... my son goes to school in another town... [it] may have resulted in some upsets in his work environment.” P9

“I haven’t been able to save any money, but Centrelink give enough to pay bills.” P7

Non-monetary costs

Participants commonly identified non-monetary costs associated with their injury, with the most frequently discussed being linked to frustration, stress or time. Frustration was discussed as a cost factor in the context of lack of occupational opportunities and a decrease in productivity and was the most common identified non-monetary cost. Stress was often discussed in the context of loss of wages or relating to welfare or income insurance applications (P11), or when discussing entitlements, especially when there was resistance or lack of understanding from employers. The concept of loss of time being perceived as a cost was spoken about in the context of waiting for medical appointments, missing work or leisure opportunities, or needing to complete exercises.

“My time cost is hugely affected.” P10

Health care system experiences

An unanticipated theme that surfaced was the participants’ uneven experiences with the health care system. While many participants praised the free care they received from the public healthcare system and the individual healthcare professionals who provided their care (i.e. *positive perceptions in service delivery*), many described their perceptions of gaps in service delivery during their patient experience. A lack of post-injury information (e.g. not being made aware of the rehabilitation process or likely outcome) and not always having a ‘*holistic*’ approach were expressed as significant limitations in service delivery.

Gaps in service delivery

The lack of a holistic approach or lack of post-injury information was discussed in terms of a lack of clarity or distinction between what you “*should be doing, and what you shouldn’t be doing*” (P11), with the latter being more prominent in discussions with healthcare professionals. This presented as having implications in the participation in leisure activities as well as employment.

“The doctor wrote a medical certificate for a month, which was a bit of a shock for me... I was hoping to reduce that down, but that didn’t eventuate.” P1

The participant who lost their job stated:

“I probably actually could have gone back to work too, so I mean, it’s hard to, it is really hard to bring the two things together from a hospital perspective where they’re liable for what happens and there is, they have to perform in a certain way... I feel like there is a limited understanding of what people are actually able to do and how much it affects them... I think that there is a real disconnect between rehab and real life.” P5

8.4.7 Discussion

This study describes the experience of burden resulting from an acute hand and/or wrist injury on workplace, home, and social participation. We found variable effects on engagement in daily occupations, participation in usual roles, and emotional and physical health. Typically, in the early stages of recovery, participants reported challenges in many aspects of day to day life, highlighting a significant perceived change in occupational performance. This observation confirms the dynamic interaction between the person (in this case an individual who has sustained an acute hand and/or wrist injury), their environments and their occupations in shaping occupational performance⁹. It is commonly accepted that performance of meaningful everyday occupations is an important part of everyday life with withdrawal or changes in these occupation patterns significantly impacting self-perceived health and wellbeing⁴. This supports our finding of emotional impacts on health and wellbeing that ranged from frustration to depression.

Despite the identified perceived burden resulting from reduced participation, participants also described several protective factors that mitigated the overall impact of injury. These included

positive relationships with family, supports and employers, gaining proficiency in one-handed techniques, and the ability to adapt to changes in usual occupational patterns and roles to align with current occupational performance. In addition to protective factors, participants also discussed gaps in service delivery that may have inadvertently contributed to the burden experienced. The most frequently discussed were a lack of post-injury education (e.g. what to expect following surgery, in rehabilitation and likely recovery) and not always receiving what they perceived to be holistic or individualised care. The latter was illustrated by an emphasis being placed on what a patient ‘should not be doing’ and not focusing on what they *can* be doing.

The findings in this study revealed several important areas for clinical consideration for therapists treating patients with acute hand and/or wrist injuries, particularly when working in fast-paced, time-limited settings. To ensure ‘*holistic*’ client-centred care, therapists are encouraged to consider contextualising the nature of a patient’s injury with a particular focus on the individual’s usual occupational patterns and roles. This can be achieved by using a conceptual model of practice or an appropriate frame of reference grounded in occupational therapy, such as the Canadian Model of Occupational Performance and Engagement (CMOP-E)⁹. This model considers occupational performance as the result of the dynamic and ongoing relationship between the ‘person’ (comprising of physical, cognitive and affective domains) with spirituality at its core; their ‘occupations’ (self-care, productivity and leisure); and their environments (physical, social, cultural and institutional) in which they live, work, play and participate. It is suggested that use of a model or framework, like the CMOP-E can assist therapists in identifying where misalignment exists between these domains and highlights areas that require further assessment and intervention¹⁶. In addition, use of an outcome measure such as the Canadian Occupational Performance Measure (COPM)¹³, the self-administered Role Checklist (RC)¹⁴ or Occupational Self-Assessment (OSA)¹⁵ may help facilitate holistic and client-centred care by identifying problematic areas in daily occupations and encourage occupation-based interventions that focus on what the client can do, rather than what they should not do¹⁶. Owing to the time constraints frequently observed in many clinics, an informal screening assessment that considers similar concepts to the COPM could be considered. Given the RC and OSA are self-administered, they could be completed before or after a treatment session.

Most participants in this study accepted dependence on others, particularly in the early stages of recovery, to compensate for changes in occupational and role performance. Support from a spouse, family, or friend are considered to be key factors in facilitating recovery after a physical trauma¹⁷⁻¹⁹, and can help develop independence and motivation²⁰. A lack of support, which also includes that from employers, may therefore present as a potential indicator for impacts on emotional health and could be an area for therapists to consider in the initial data gathering stages of patient contact and to revisit in the earlier stages of recovery. In addition, it is suggested that therapists periodically discuss emotional health with patients and ensure referrals to relevant services are made in the context of depression like symptoms²¹.

Methodological considerations

When conducting research using a qualitative design, findings should strive to be as trustworthy as possible²². This requires authors to establish credibility, dependability, confirmability and transferability²³. In this investigation, we used purposive sampling to recruit participants to provide many different perspectives of the perceived burden of an acute hand and/or wrist injury in the context of workplace, home, leisure and social environments. Although the interviews varied in length, all interviews were rich in detail. To establish dependability, two authors independently read the transcribed interviews and engaged in in-depth discussions as a means to achieve an appropriate interpretation. The collaboration between researchers with significant clinical experience of hand therapy (HT) (LR > 4 years) and minimal experience (AR < one-year HT, > 5 years in the field of neurology) reinforced the awareness of preunderstanding in an attempt to reduce the influence it could have had on analysis. To further establish dependability, quotations from the transcribed interviews are presented to demonstrate the interpretation process to the reader. Confirmability was ensured by constantly confirming and clarifying responses during the interviews. While the transferability of the manifest findings of this study may be limited to individuals with acute hand and/or wrist injuries that received their care within the public health system within Australia, findings may also be applicable to patients seen in other settings and locations. In addition, the latent findings may also be transferable

to other patient groups experiencing burden in the context of workplace, home, leisure and social environments due to other acute or chronic upper limb conditions.

8.4.8 Conclusion

This study allows a deeper understanding of how patients with acute hand and/or wrist injuries perceive burden in the context of work, social and family participation. The findings suggest that impacts on engagement in daily occupations, participation in usual roles, and emotional and physical health are perceived as the most common contributors to the experience of burden resulting from hand and wrist injury. Health professionals who specialise in hand therapy are encouraged to embrace a holistic approach, which includes assessing the patient's occupational roles and patterns as well as support structures to gain the information required to mitigate burden and promote positive adaptation and coping. Further research is needed to quantify the burden of acute hand and/or wrist injuries in the context of work, social and family participation and should consider using objective measures at various timepoints to truly capture the full burden experienced. Such research should ensure a sample size with appropriate stratification of patient groups that can be generalised to the wider patient population.

8.4.9 Acknowledgements

The authors would like to thank the participants who donated their time to provide us with their experiences. The authors would also like to the hand therapy department at the Alfred Hospital for their assistance with participant recruitment.

Conflict of Interest Statement

The authors have no conflict of interest to declare

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8.4.10 Manuscript VI Tables

Table 8.1 Participant Demographics and Injury Details

Participant	Gender	Age	Injury	Mechanism	Surgical management (Y/N)	Dominant hand injured (Y/N)	Occupation
P1	F	41	Right index finger open distal phalanx fracture	Crushed with hockey stick	Y	Y	Receptionist
P2	F	31	Right scaphoid fracture	Basketball	N	Y	Media
P3	M	23	Right little finger middle phalanx fracture	Australian Rules Football	N	Y	Student
P4	M	25	Right little finger PIPJ dislocation	Australian Rules Football	Y	Y	Hospitality
P5	M	30	Right FPL, UDN, UDA Zone I and II 100% laceration	Laceration from broken wine glass	Y	Y	Courier and Personal Trainer
P6	M	27	Left ring finger metacarpal fracture	Rugby	Y	N	Physiotherapist
P7	M	26	Right thumb UCL injury	Basketball	Y	Y	Boilermaker
P8	M	63	Right index finger FDS repair	Cattle bolt gun	Y	Y	Farmer
P9	F	39	Light ring finger mallet injury	Altercation	Y	Y	Mother (young son) / looking for work
P10	F	55	Right middle finger mallet injury	Pulling up socks	N	Y	Hospitality
P11	M	42	Right middle finger proximal phalanx fracture	Crushed in sailing equipment	Y	Y	Theatre technician
P12	F	64	Right thumb MCPJ avulsion fracture	Fall from bike	N	Y	Carer of husband

Table 8.2 Commonly Reported Occupations Impacted by Hand or Wrist Injury

<i>Occupational domain</i>	<i>Commonly affected occupations</i>
Self-Care	<ul style="list-style-type: none">• Dressing (e.g. buttons), showering (e.g. washing hair) cutting nails, using cutlery (e.g. cutting up food)• House cleaning (e.g. vacuuming, washing dishes), cooking, gardening, looking after pets• Driving
Productivity	<ul style="list-style-type: none">• Computer tasks (e.g. typing, using a mouse), handwriting, moderate to heavy lifting/manual handling, driving
Leisure	<ul style="list-style-type: none">• Sport/gym/physical activity, socialising, video games, attending social or family events

8.4.11 Manuscript VI Figures

<p>Content analysis: a careful, systematic and detailed interpretation and examination of particular material that contains narratives and/or observations in an attempt to identify patterns, themes, assumptions and meanings.</p> <p>Three approaches to qualitative content analysis:</p> <ul style="list-style-type: none"> • <i>Conventional content analysis:</i> generally used when the study design aims to describe a phenomenon where existing theory or research literature on the phenomenon is limited. • <i>Directed content analysis:</i> existing theory or prior research exists about a phenomenon that is incomplete or would benefit from further description. The aim is to validate or extend conceptually a theoretical framework or theory. • <i>Summative content analysis:</i> identifies and quantifies certain words or content in text with the purpose of understanding the contextual use of words or content. The aim is to explore usage, and not attempt to infer meaning.
<p>Unit of analysis: the major entity that is being analysed in the study. It is the 'what' or 'who' that is being studied.</p>
<p>Data collection: by written or verbal questions, or by observations, and transforms the collected data into written text</p>
<p>Data analysis: can use <i>manifest analysis</i> (surface structure – "What has been said?") or <i>latent analysis</i> (deep structure – "What intended to be said?" in isolation or combined. Both types deal with interpretation, however, they may vary in depth and level of abstraction.</p>

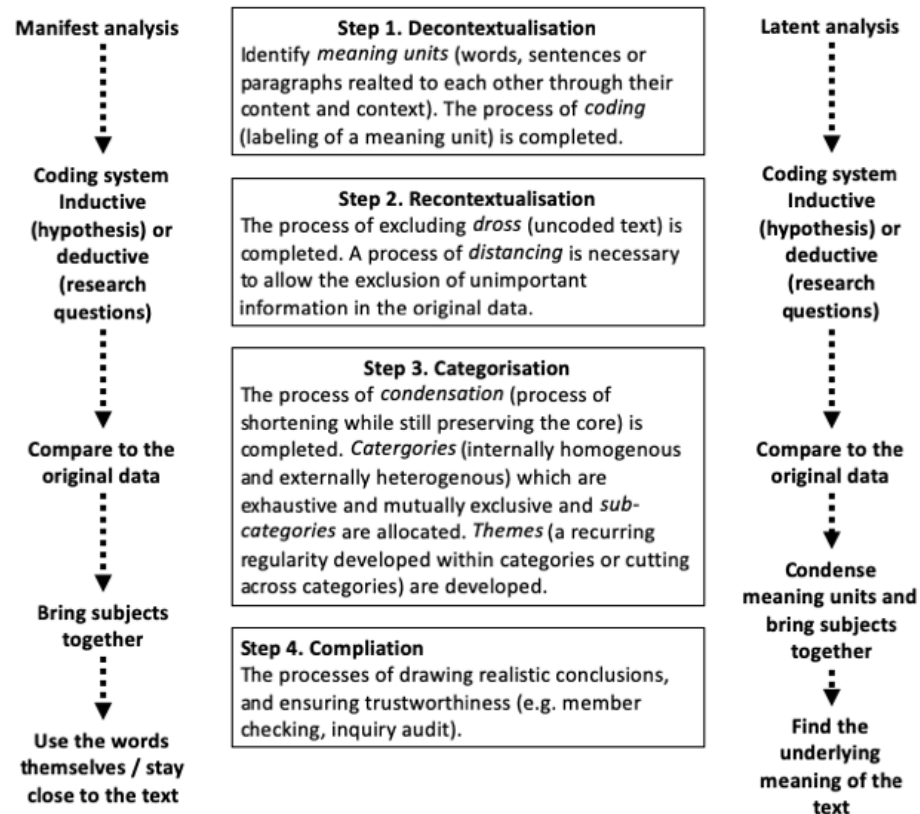


Figure 8.1 Content Analysis Methodology Flowchart

Adapted from Bengtsson,²⁴; Graneheim & Lundman,²³; Hsieh & Shannon,²⁵; Lune & Berg,²⁶; and Neuendorf.²⁷

8.4.12 Manuscript VI Appendices

Appendix 8.1 Semi-Structured Interview Guide

Questions:

- 1 Regarding your recent hand or wrist injury:
 - How did it happen?
 - Did you seek treatment straight away, or did it take you some time to get it assessed?
 - Were you given a clear diagnosis by the first health professional you saw?
 - Does any form of insurance cover your injury?
 - 2 Were you in paid employment (or job seeking) at the time of your injury?
 - If working, what impact has your injury had on the ability to do your usual job?
 - Are there some tasks you were/are unable to do because of your injury? If so, who did/does these?
 - Are there tasks that are taking you longer to do, or you are doing with lower quality than usual?
 - Are you working the same hours as you did before your injury?
 - Are you able to get time off for medical/therapy appointments?
 - Is this paid or unpaid time off?
 - Has this affected your ability to do penalty, shift, higher duties or overtime work?
 - Has your usual pay changed at all as a result of your injury?
 - If looking for work:
 - Has this affected your ability to look for work?
 - Are you receiving any form of income support?
 - 3 How has your injury affected your ability to take care of yourself?
 - Have you needed assistance in completing these activities?
 - If so, who is assisting you and are there any associated costs with getting someone else to do them?
 - 4 How has your injury affected your participation in your usual family responsibilities?
 - Have you had to change or miss out on any usual family activities/responsibilities?
 - Have you had to get help (either paid or unpaid) with family duties you would usually do?
 - Have you needed more support from your partner or other family members?
 - 5 How has your injury affected your participation in activities outside of work or family (e.g. sports, hobbies, volunteering, community activities)?
 - 6 Has your injury affected your participation in social activities?
 - Are there any things that you have missed out on?
 - Are there any things that you have avoided?
 - 7 Having an injury or health condition can be associated with hidden costs such as:
 - Paying others to do things that you would usually do (e.g. mowing lawns)
 - Using taxis (if unable to drive)
 - Transport and parking costs when attending appointments
 - Medical appointments
 - Pharmacy related costs
 - Can you think of any examples of hidden costs that related to your injury?
 - 8 Are there any other comments you would like to make about the impact of this injury on any impact of your day-to-day life?
-

8.5 Impacts of the Study

Journal Metrics: To be determined once accepted for presentation.

It is intended that this manuscript be submitted as an abstract for consideration of an oral presentation at the national Australian Hand Therapy Association (AHTA) conference 2020 and at my profession's peak international conference scheduled in 2022.

8.6 Chapter Summary

Building on the limited findings presented in Chapter 7, this qualitative study aimed to explore the burden experienced as a result of an acute hand and/or wrist injury in the context of work, family and social participation from an individual perspective. A total of 12 patients were interviewed using semi-structured interviews and the data analysed using manifest and latent content analysis.

Key Findings:

- In terms of experienced burden in the context of work, family and social participation, three key themes emerged:
 - the consequences and adaption in daily life;
 - the perceived costs associated with injury; and
 - uneven healthcare system experiences.
- Common narratives that were discussed by participants included:
 - '*day to day activities*' were significantly impacted in the first few weeks to months following injury;
 - the notion of being '*sidelined*' where life appeared to be in '*limbo*';
 - participation was restricted or not possible owing to the injury;
 - engagement in many meaningful occupations and socialisation was heavily curtailed by the inability to drive a car;
 - usual productivity and leisure activities were significantly impacted in the first few weeks to months following injury;

- for some there is a need for significant or complete dependency on other family members to fulfil their usual roles;
- frustration and pain are commonly observed emotional and physical impacts of these injuries;
- non-monetary costs are more noticeable than monetary costs; and
- a lack of post-injury information (e.g. not being made aware of the rehabilitation process or likely outcome) and not always having a '*holistic*' approach were expressed as significant limitations in service delivery.

This study concluded that impacts on engagement in daily occupations, participation in usual roles, and impacts on emotional and physical health are perceived as the most common contributors to the experience of individual burden resulting from hand or wrist injuries. Further, the results of this study encourage the need for hand therapists to employ a holistic approach which includes assessing the patient's occupational roles and patterns, their current support structures (i.e. family, friends, manager/boss), and considers occupation-based interventions to mitigate burden, promote positive adaptation and coping, and reduce client perceptions of gaps in service delivery.

The next chapter, the last of the publication chapters in this thesis, presents a viewpoint article which was written in response to my personal reflections encountered during the early interviews conducted in the investigation that forms this chapter. It proposes a duality of focus when providing treatment for hand and wrist injuries in an attempt to provide holistic, client-centred care which can reduce burden (i.e. indirect and intangible costs) and promote health and well-being.

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Chapter 9

Embracing an occupational perspective: Occupation-based interventions in hand therapy practice

9.1 Chapter Introduction

Chapter 8 presented a qualitative investigation which explored the experience of burden as a result of an acute hand and/or wrist injury in the context of work, family and social participation. We found that impacts on engagement in daily occupations, participation in usual roles, and emotional and physical health were perceived as the most common contributors to the experience of burden resulting from hand and wrist injury.

As I conducted the early interviews of this investigation, I was surprised to find that several participants felt as though there was a lack of holistic care that was provided to them from both the medical and hand therapy teams. One particular comment made by a young male participant with a tendon injury who lost two jobs (personal trainer and courier) really struck me:

“I feel like there is a limited understanding of what people are actually able to do and how much it affects them... I think that there is a real disconnect between rehab and real life.”

He also reported that the information regarding his injury, as provided by his hand therapist, had led to a fear of rupture due to the emphasis placed on what he could *not* do, and an absence of what he could *safely* do. As a result of this type of communication and focus, he reported that he had encountered symptoms of depression owing to the forced changes in his normal occupational patterns (i.e. in his normal productivity roles and leisure occupations). When considering his injury and his role as a personal trainer, potentially exploring modified work duties (i.e. communicating instructions to his clients rather than active demonstration) may have resulted in a completely different outcome for this client.

I found that this experience was not isolated to one participant, with several participants reporting that they had their restrictions discussed in the context of ensuring the protection of body structures and functions, especially during the early healing phase, and not addressing occupational performance issues with their own individual habits and roles. This would, in turn, present significant implications in the participation of leisure activities as well as employment for those interviewed. This notion of a narrow focus on body structure and function, rather than a holistic occupation-based approach that considers the unique occupational identity and patterns that each individual possesses, laid the foundation of the ideas presented in the viewpoint article that forms the contents of this chapter.

9.2 Viewpoint Aims

This viewpoint article poses the question “*as the profession of occupational therapy moves to reassert its philosophical foundations of the intrinsic relationship between occupation, health and wellbeing*”, should hand therapists endeavour to focus more on embracing an occupational perspective and incorporate interventions that are grounded in the key principles of the profession?” The article acknowledges the importance of a structure-specific approach to manage hand impairments; however, it challenges therapists to avoid neglecting the person attached to the hand in order to reduce the burden (i.e. indirect and intangible costs) experienced by our clients.

9.3 Chapter Contents

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9.4 Manuscript VII

Manuscript VII, as it appears in this chapter, is presented in the format that was required for publication in the *Australian Occupational Therapy Journal*.

9.4.1 Abstract

Occupational therapists practicing in the field of hand therapy have been inclined to follow a reductionist biomedical approach to clinical practice that focuses primarily on body structures and functions. As a result, the intrinsic relationship between occupation, health and wellbeing is often overlooked resulting in interventions that are provider-centered and authoritarian in nature. Although the importance of a structure-specific approach to manage hand impairments is recognised, therapists must avoid neglecting the person attached to the hand by fixating on specific anatomical structures. To ensure holistic and client-centred practice, a move towards occupation-based hand therapy that utilises occupation-based intervention is proposed. By employing an appropriate theoretical practice model, such as the Canadian Model of Occupational Performance and Engagement (CMOP-E), it is possible that actions can be taken to reduce the mechanistic default tendency in hand therapy clinical practice and embrace an occupational perspective of health.

9.4.2 Introduction

The founding philosophies of occupational therapy and the medical model have had an uneasy relationship for more than sixty years. In the late 20th century, a paradigm shift occurred within the discipline from the deeply ingrained medical model, which resulted in the creation of practice-based theories of occupation, and models of occupational therapy across the globe ¹. This paradigmatic shift was a direct challenge to the previous practice models and frameworks that stemmed from level of impairment and disability rather than the client's perspective of participation in daily activities and occupations.

Although embracing theory as part of practice is important for the growth and evolution of occupational therapy, its implementation remains a challenge for many therapists. As the profession moves to reassert our philosophical foundations of the intrinsic relationship between occupation, health and wellbeing ², should hand therapists endeavour to focus more on embracing an occupational perspective and incorporate interventions that are grounded in the key principles of the profession?

9.4.3 The challenge for hand therapy: Duality of focus

Hand therapy differs from other occupational therapy specialisations because it merges occupational therapy and physiotherapy practice approaches to treatment. Despite most hand therapists having graduated with an occupational therapy degree ³ with training in the use of occupation-based interventions, clinical hand therapy practice is perceived to be closer to that of physiotherapy. This is highlighted by the focus regularly placed on exercise prescription and application of physical agent modalities in preference to a dual focus that also includes enabling clients through the use of occupation.

The hand therapy field has been inclined to follow a reductionist biomedical approach to clinical practice that focuses primarily on body structures and functions ^{4,5}. The biomechanical paradigm, which is often applied in hand therapy practice, assumes that humans operate like machines, and is provider-centred and directive in nature. It utilises objective measures (such as range of motion) to quantify improvements in impairment. Such an approach sees the therapist in control of both the treatment process and also determining and defining the measures of success. As a result, the client is expected to adhere with therapist-generated instructions, and to derive satisfaction from improvement in objective measures. Consequently, successful treatment is viewed as improvement in range of motion or strength, and not achievement of client-centred goals or a successful return to meaningful occupations. In this context, the practice of hand therapy would appear not to be client-centred. Although the importance of a structure-specific approach to manage hand impairments is recognised in the early acute phases of an injury to protect healing structures, therapists must avoid

neglecting the unique occupational needs of each individual by fixating on specific anatomical structures and failing to acknowledge clients as occupational beings. As such, contraindicated occupations that could compromise recovery and outcome in the early stages of healing should be modified or limited by the therapist. However, the therapist should discuss with the client the reasons for (and importance of) these restrictions, as well as suitable occupations that can be safely performed. They should also commence a dialogue that frames return to meaningful occupation as the overall collaborative rehabilitation goal.

Despite the occupational therapy profession's desire for the increased use of occupation as a treatment modality ^{6,7}, a paucity of research investigating occupation-based hand therapy interventions exists ⁸. This is in contrast with many other currently used standard impairment-based interventions. A recent examination of the frequency of the International Classification of Functioning, Disability and Health (ICF) domains included in 788 hand therapy specific articles found significantly less emphasis was placed on activities, participation and environmental factors of individuals with hand injuries compared to body function and structure components ⁵. This study confirms the deeply entrenched reductionist focus to the provision of hand therapy treatment, which contextualises its service provision approaches largely on reducing deficits in physical function without taking clients' occupational perspectives into consideration.

While a large majority of occupational therapists who practice hand therapy acknowledge the value and client-centred nature of occupation-based interventions, few are incorporating them into their daily clinical practice ^{7,9}. Commonly cited reasons are lack of time, cost containment measures, reliance on protocols, and a lack of understanding of occupation-based interventions ^{7,9}. In order to embrace an occupational perspective on health and implement interventions that are grounded in the key principles of the profession, hand therapists must incorporate a duality of focus. This should recognise the benefits of existing evidence-based methods (e.g., prescriptive exercise programs and physical agent modalities) as well as occupation as a therapeutic mechanism.

9.4.4 Theoretical and practice models: A prompt to occupation-based intervention

In order to avoid reinforcing the primacy of diagnosis over person, therapists are encouraged to contextualise the nature of an injury with a particular focus on the individual's occupational performance and interaction within their daily living environments ⁴. By employing a conceptual model of practice or an appropriate frame of reference grounded in occupational therapy theory, actions can be taken to reduce the mechanistic default tendency in clinical practice and encourage the use of occupation-based interventions.

The Canadian Model of Occupational Performance and Engagement (CMOP-E) contends that occupational performance is the result of the dynamic ongoing relationship between the 'person' (comprising physical, cognitive and affective domains) with spirituality at its core; their 'occupations' (self-care, productivity and leisure); and their environments (physical, social, cultural and institutional) in which they live, work, play, and travel ¹. It is proposed that when these domains are balanced, occupational performance is optimised. In the instance where a misalignment exists between these domains, the need for assessment and consequent intervention is highlighted to the therapist.

By actively using a practice model like the CMOP-E, occupational therapists are encouraged to parallel the medical model by considering objective changes in range of motion or subjective changes in pain (person; physical) as outcomes of intervention. Where it diverges from the medical model is its focus on encouraging therapists to consider activities of daily living (occupation: self-care, productivity and leisure) as prompts for producing occupation-based interventions that consider the demands faced outside the clinical setting (environment). By placing spirituality at the core of the 'person', therapists are reminded that impairment in occupational performance is personally defined and experienced. This promotes the use of interventions that are client-centred and occupation-based.

In the case of acute or chronic hand injuries, therapists need to identify and evaluate barriers that may challenge the competence and ability of clients to carry out their chosen occupations and, as

a result, develop occupation-based interventions to eliminate or ameliorate barriers. Use of a functional outcome measure, such as the Canadian Occupational Performance Measure (COPM), can facilitate client-centred, occupation-based intervention to address barriers and challenges identified by the client, whilst also providing evidence of efficacy ^{1, 10}.

An alternative method for eliciting a client's perspective on their occupational performance is the use of an occupational profile. A process within the Occupational Therapy Practice Framework – third edition ¹¹, an occupational profile aims to develop a summary of a client's occupational history and experiences, patterns of daily living, interests, values, habits, and needs. By using both formal interview techniques and casual conversation, information is gathered to understand what is currently important and meaningful to the client (i.e., what they want and need to do) and to identify past experiences and interests that may assist in the understanding of current issues or barriers. From the information collected, the client is encouraged to identify priorities and desired targeted outcomes that will lead to engagement in occupations that support participation in life. Using this client-centred approach, therapists are able to collaboratively design occupation-based interventions. By valuing and respecting client input, the occupational profile aims to foster client involvement and efficiently guide interventions.

9.4.5 Occupation-based interventions

Participation in daily occupations enables a person's state of health and wellbeing ¹². Withdrawing, changing, or restricting engagement in personally meaningful occupations as a result of functional performance deficits can have a significant impact on a person's health, happiness and life-satisfaction. The effects of activity limitations and participation restrictions have the potential to influence physiological states of the body. In order to maintain the intrinsic relationship between occupation, health and wellbeing, the personality and needs of the person need to be matched with environments or situations that enable them to remain engaged, interested and challenged ¹².

The concept of occupation-based hand therapy is described as a treatment approach that balances the value of occupation as a therapeutic mechanism and the value of maintaining sound

biomechanical principles ¹³. This client-centred approach prioritises engagement in occupations and uses occupation-based interventions that focus on both subjective and objective aspects of performance without ignoring the biomechanical frame of reference or the benefits of existing evidence-based methods. It promotes the use of occupation as a means, where occupation acts as the therapeutic change agent to remediate impaired abilities ¹⁴. It recognises that, although it is imperative to treat hand impairments within structure-specific limits, therapists should not become so fixated on specific anatomical structures that they neglect an individual's occupational needs and participation issues.

By using an occupation-based approach to clinical practice, therapists can assist clients to maintain a positive connection to important roles, responsibilities, habits, and daily activities that have been disrupted by their injury. They can motivate clients using occupation as an ends by demonstrating the link between rehabilitation and a return to meaningful occupations that includes self-care, work, education, sleep/rest, play, leisure, and social participation ^{14, 15}.

The evidence for the effectiveness of occupation-based intervention has been well established in various occupational therapy practice contexts, ranging from mental health to paediatrics for several decades. In contrast, the emergence of evidence for its use in the hand therapy practice arena has only appeared over the last decade ^{8, 9}.

One randomised control trial investigated the effectiveness of occupation-based intervention versus traditional therapeutic exercises in the management of hand injuries ¹⁶. Its findings indicated that the use of occupation simulations for individuals with acute or chronic hand injuries resulted in statistically significant higher levels of improvement in patient-rated outcome measures as well as pinch, grip, and range of motion compared to those who underwent traditional exercise-based treatment. Two case studies that investigated the use of occupation-based intervention in the management of shoulder adhesive capsulitis and lupus-related arthritis documented a decrease in pain, improved range of motion ¹⁷ and improved self-ratings of occupational performance ¹⁵. The use of orthotic interventions to promote occupation in two case studies documented that orthoses that were

designed, constructed, and monitored collaboratively with the client promoted physical and emotional wellbeing by enabling valued activity, client-engagement, and participation^{10, 18}.

In spite of the current scarcity of research for the effectiveness of occupation-based interventions in hand therapy, the significant body of research available that has been conducted in physical rehabilitation settings in other occupational therapy practice areas should be considered. Common outcomes reported include pain, function, participation, activities of daily living, range of motion, and quality of movement.

9.4.6 Conclusion

To embrace our identity as occupational therapists specialising in hand therapy, more therapists need to join those already incorporating a firmly cemented duality of focus that includes an occupation-based intervention approach. Further research into the efficacy of occupation-based hand therapy interventions, and their appropriate timing with respect to healing structures is required. By using an appropriate theoretical model, such as the CMOP-E, in conjunction with patient-centred outcome measure, such as the COPM, to guide occupation-based hand therapy practice, therapists can reassert the philosophical foundations of the intrinsic relationship between occupation, health and wellbeing and minimise their reliance solely on mechanistic, reductionistic approaches to care.

9.5 Additional Commentary

This viewpoint article, that provided a discussion surrounding the use of occupational-based interventions to decrease the sole focus of body structures and functions when treating hand and wrist injuries, encourages therapists working in the speciality of hand therapy to embrace an occupational perspective when providing interventions with clients. Such a perspective may have the potential to reduce the severity of indirect and intangible costs faced by individual who sustain these injuries. A well-designed economic analysis, which compares the use and non-use of occupation-based interventions and measures direct, indirect and intangible costs associated with these injuries, could validate the efficacy and cost-effectiveness of such interventions. However, as discussed in Chapter 7, the feasibility in conducting a prospective study such as this has proven to be difficult with this patient population.

9.6 Impacts of the Study

Journal Metrics:

Impact Factor (2015): 1.404

Article Influence (2015): 0.377

Eigenfactor (2015): 0.001480

Source-Normalised Impact Per Paper (SNIP) (2015): 1.036

SCImago Journal Rank (SKR) (2015): 0.590

This paper has been cited in high impact journals including *Hand Therapy*, *Australian Occupational Therapy Journal*, *The Open Journal of Occupational Therapy* and the *South African Journal of Occupational Therapy*. Further, it was the third highest cited article in the *Australian Occupational Therapy Journal* in 2018.

9.7 Chapter Summary

Originating from my personal reflections during the conduct of the semi-structured interviews for the qualitative investigation presented in Chapter 8, this viewpoint article presents a call to action

to hand therapists to avoid neglecting the person attached to the hand by fixating on specific anatomical structures. It argues for adopting a duality of focus which considers both the body structures and functions related to the presenting injury or condition and the unique occupational being attached to the hand in order to reduce the burden experienced by our clients (i.e. indirect and intangible costs).

The next chapter presents an integrated discussion that summarises the main findings of the investigations included in this thesis. The implications of these findings in relation to the individual and societal burden of acute hand and wrist injuries and future clinical and research considerations will be presented using the adapted version of the Injury Outcome Framework relating specifically to acute hand and wrist injuries.

9.8 References

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Chapter 10

Integrated discussion

10.1 Introduction

In this thesis, several studies investigating the individual, community and societal burden of acute hand and wrist injuries were conducted. The methodology of each study varied to allow for a comprehensive investigation of the impact and cost burden experienced as a result of these injuries from different perspectives.

In this chapter, the original key research questions, and supplementary questions are revisited, and a discussion of the overall findings from the investigations that comprise Chapters 3 to 8 of this thesis is presented. The chapter is organised around the components of the Injury Outcome Framework (IOF)¹, which I have adapted and related specifically to acute hand and wrist injuries (refer Figure 10.1). A discussion of the limitations in existing knowledge about this topic and those related to this thesis will be explored. Finally, the implications for further research and concluding statements on how this research affects the wider community will be presented.

10.2 Revisiting the Research Questions

The research questions, and supplementary questions, that were posed in Chapter 2 are presented in Table 10.1, along with the key findings of each investigation and the IOF domain and level of impact investigated. Common themes are explored further in section 10.2 using the adapted version of IOF to present the cost of acute hand and wrist injuries (refer Figure 10.1).

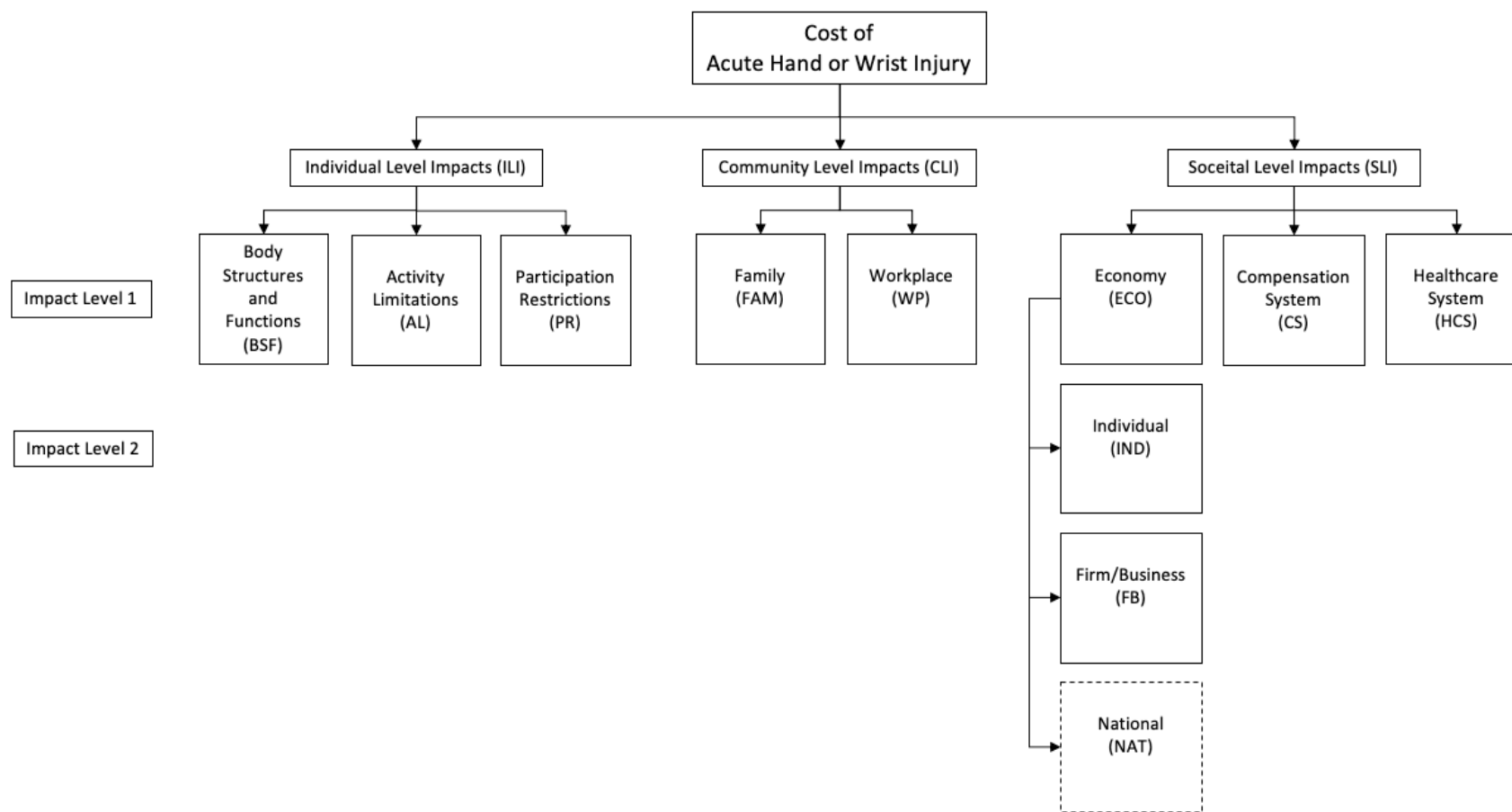


Figure 10.1 Adapted Injury Outcome Framework (IOF) for Acute Hand and Wrist Injuries

Adapted from the Injury Outcome Framework (IOF)¹
 (N.b. - - - indicates national estimates outside of Australia were presented)

Table 10.1 Key and Supplementary Research Questions and Key Findings

Key Research Question	Supplementary Research Question	Key Findings	IOF Domain: Impact Level(s)
1. In international literature, what are the reported direct, indirect and intangible costs of acute hand and wrist injuries?		From a systematic review of the direct, indirect and intangible costs of acute hand and wrist injuries, it was found that:	
		<ul style="list-style-type: none"> The median total cost per case of all injury types using a cost-of-illness methodology was US\$6,951 (IQR \$3,357-\$22,274). 	SLI: E, FB, NAT
		<ul style="list-style-type: none"> The median total cost per case of all injury types using a health economic evaluation methodology was US\$8,297 (IQR \$3,858-\$33,939). 	SLI: E, FB, NAT
		<ul style="list-style-type: none"> Indirect costs represented a large portion of total cost in cost-of-illness studies [64.5% (IQR 50.75-88.25)] and health economic evaluations [68% (IQR 49.25-73.5)]. 	SLI: E, FB
		<ul style="list-style-type: none"> Only one study used the findings of outcome measures to quantify a financial figure of intangible cost (QALYs was found to be 82% of total estimated cost). 	SLI: E, IND
	What analytical tools and methodologies have been used to measure direct, indirect and intangible costs associated with acute hand and wrist injuries?	<ul style="list-style-type: none"> The methodology used to derive direct, indirect and intangibles costs differs markedly across published studies (cost-of-illness n=14; cost-effectiveness analysis n=5; cost-benefit analysis n=1; cost-utility analysis n=1). 	SLI: E, FB, NAT
		<ul style="list-style-type: none"> The majority of studies were conducted from a health system perspective (n=19). 	SLI: E, FB
		<ul style="list-style-type: none"> The human capital approach was the most commonly used method for estimating indirect costs. 	SLI: E, FB
		<ul style="list-style-type: none"> Intangible costs were calculated using the EQ-5D (n=3), the DASH (n=3), the SF-36 (n=1), the quickDASH (n=1), the DHI (n=1) and the Rosén and Lundborg scoring system. 	SLI: E, FB, IND
	What cost components are included when estimating the direct, indirect and intangible costs of acute hand and wrist injuries?	<ul style="list-style-type: none"> All studies reported direct medical costs resulting from inpatient or outpatient service use, however, few studies included specific outpatient resource. 	SLI: HCS
		<ul style="list-style-type: none"> Loss of productivity was the most common measure of indirect cost, with some studies also including sickness/injury benefits. 	SLI: E, FB
		<ul style="list-style-type: none"> Occupational therapy and physiotherapy services were found to contribute to as little as 0.01% of total cost but have the potential to 	SLI: E, HCS

		play a large role in reducing indirect costs by addressing individual and workplace-related factors that impact return to work timeframes.	
2. What are the total direct costs associated with resource use in the Emergency Departments of one Australian public health service for individuals presenting with a hand or wrist injury?		<p>From a retrospective review of billing records of 10,024 consecutive patients who presented to Alfred Health with an acute hand or wrist injury between July 1st, 2014 and June 30th, 2016, it was found that:</p> <ul style="list-style-type: none"> These injuries contribute a significant cost of approximately \$2 million per year at one Australian public health network. SLI: E, FB The mean cost per presentation was \$383 in 2014-15 and \$407 in 2015-16. Fractures of the wrist and hand accounted for the largest portion of total costs (38%, \$1.5 million over two years). SLI: E, FB 	SLI: E, FB
	What is the demographic profile of this patient population at this health service?	<ul style="list-style-type: none"> Acute hand and wrist injuries account for approximately 5.4% of all yearly emergency department presentations within one Australian public health service. SLI: E, HCS Males were more likely to present with these injuries than females (62% of presentations). SLI: E, HCS The mean age of individuals presenting was 36 years, with those aged between 25-34 years accounting for the largest proportion of presentations (27%). SLI: E, HCS Individuals were most likely to present with an open wound to the hand or wrist (34%) or a fracture of the hand or wrist (29%). SLI: E, HCS Lacerations from miscellaneous objects, knives or glass were the most common mechanism for presentation (31%). SLI: E, HCS 	SLI: E, FB
	Has there been an increase in the direct costs associated with resource use in this patient population between two financial years at this health service?	<ul style="list-style-type: none"> No statistically significant increase in cost was noted between the two financial year periods. SLI: E, HCS An increase in sport related presentations was noted in May and August (which may be explained by the beginning and ending of common sporting competition seasons in Victoria), and an increase in lacerations were noted in October (which may be explained by the increase of do-it-yourself projects that are frequently commenced during this time). SLI: E, HCS 	
	Has there been an increase in the number of individuals	<ul style="list-style-type: none"> There was no statistically significant change in the numbers of presentations between the two financial years periods. SLI: E, HCS 	

	presenting with hand and wrist injuries between two financial years at this health service?	<ul style="list-style-type: none"> The differences between the proportions of presentations of each of the ICD-10 categories between the two financial year period was negligible. 	SLI: E, HCS
3.	What are the total direct costs associated with resource use for individuals requiring surgical intervention and outpatient follow-up following an emergency department presentation for an acute hand or wrist injury at one Australian public hospital health service?	<p>From a retrospective review of medical records of billing records of 226 patients who received surgical interventions for an acute hand or wrist injury after presenting to an emergency department at Alfred Health between July 1st, 2014 and June 30th, 2015, it was found that:</p> <ul style="list-style-type: none"> The total cost of all injuries was \$1,204,606. The median cost per injury for non-compensable cases (n=191) was \$4,508 [IQR \$3,993 - \$6,172] and \$5057 [IQR \$3957 - \$6730] for compensable cases (n=35). Inpatient costs (\$889,045) accounted for the highest portion of costs (73.8%), followed by outpatient (\$187,540; 15.6%) and emergency department (\$128,021; 10.6%) costs. Sport (n=45) was found to be the most frequent cause of isolated fracture at a combined cost of \$230,490 (Mdn: \$4295 IQR [\$3852 - \$5595]) with Australian Rules Football being the most frequent cause (n=12; Mdn \$4295 [IQR \$3581 - \$5878]). 	<p>SLI: E, FB</p> <p>SLI: E, FB</p> <p>SLI: E, FB, HCS</p> <p>SLI: E, FB, HCS</p>
	What is the demographic profile and patient care journey of this patient population at this health service?	<ul style="list-style-type: none"> These injuries accounted for approximately 5% of all hand and wrist injury-related emergency department presentations during the investigated financial year period. Males were most likely to present with an injury that required surgical intervention (81%) than females. The median age of individuals presenting was 31.6 years, with those aged between 25-34 years accounting for the largest group of clinical presentations (37.1%). The most common classifications of occupation were laborers (18.6%) and tradespersons (15.9%). The mean length of stay for non-compensable cases was 1.21 (95% CI [1.14; 1.29]) days and 1.26 (95% CI [1.08; 1.43]) for compensable cases. 	<p>SLI: E, HCS</p> <p>SLI: E, HCS</p> <p>SLI: E, HCS</p> <p>SLI: E, FB</p> <p>SLI: E, HCS</p> <p>SLI: E, HCS</p>

	<ul style="list-style-type: none"> The median length of days within the health services was 62 days [IQR 34.5 – 91.5] for non-compensable cases and 26 days [IQR 15.0 – 52.5] for compensable cases. Fractures (n=136) were the most common injury type requiring surgical interventions. The most common simplified mechanism of injury for all cases was laceration (n=100; 44.3%) followed by sport (n=55; 24.3%). 	SLI: E, HCS SLI: E, HCS
What post-operative medical and specialist hand therapy resources are used by this patient population at this health service?	<ul style="list-style-type: none"> The median number of post-operative appointments with a surgeon (or Registrar/Resident Medical Officer) was 2 [IQR 1 – 3] for both compensable and non-compensable cases. The median number of hand therapy (HT) appointments delivered at the hospital for non-compensable cases and compensable cases was 4 [IQR 2 – 6] and 2 [IQR 1 – 3] respectively. Fifty-nine percent of non-compensable cases completed their care within the setting, 28% (n=54) ended their care by failing to attend (FTA) their scheduled outpatient appointment. When considering both non-compensable and compensable cases, 34% (n=77) FTA ≥ 1 appointment during their patient pathway with a combined total of 114 FTAs recorded. 	SLI: E, HCS SLI: E, HCS SLI: E, HCS
What demographic variables, if any, are significantly associated with direct costs?	<ul style="list-style-type: none"> A multiple linear regression found no significant predictors of cost ($R^2=0.008$, $F(3,222)=0.63$, $p=0.59$). No statistically significant correlations between the variables of cost and delayed presentation ($r(224)=0.09$, $p=0.19$), age ($r(224)=0.04$, $p=0.54$) or gender ($r(224)=0.01$, $p=0.86$) were found. 	SLI: E, HCS SLI: E, FB SLI: E, FB
4. What are the total direct costs associated with resource use for individuals that require treatment for a hand or wrist injury sustained as a result of participation in sport or exercise at	<p>From a retrospective review of medical records of billing records of 692 patients who presented to an emergency department at Alfred Health between July 1st, 2014 and June 30th, 2015, with an acute hand or wrist injury sustained from participation in sport or exercise, it was found that:</p> <ul style="list-style-type: none"> The total cost of all injuries was \$790,325. Inpatient costs contributed the highest portion of total cost (n= 76; \$354,984; 45%) followed by emergency department costs (n=692; \$239,611; 30%) and outpatient costs (n=264; \$195,730; 25%). The median cost per case for each treatment location was \$278 [IQR \$210 - \$282] in the ED (n=692), \$3,328 [IQR \$2,242 - 	SLI: E, FB SLI: E, FB, HCS

one Australian public hospital service?

\$6,416] in the inpatient setting (n=76) and \$630 [IQR \$460 - \$870] in the outpatient setting (n=244).

SLI: E, FB, HCS

What is the demographic profile and patient care journey of this patient population at this health service?

- These injuries represent approximately 14% of all hand and wrist injury emergency department presentations within Alfred Health during the investigated financial year period.
- Males were most like to present with these injuries (74%) than females.
- The median age of individuals presenting was 25 years [IQR 16 – 33.75].
- The most common classifications of occupations (excluding records not stated) were students (31.6%) and professionals (11%).
- Injuries sustained to the little finger (n=154) and/or the wrist (n=150) were most common.
- ARF was the most common mechanism of injury (20.2%), followed by riding a bicycle (15.9%), basketball (11.8%) and soccer (9.4%).

SLI: E, HCS

SLI: E, HCS

SLI: E, HCS

SLI: E, HCS

SLI: E, HCS

How much medical and specialist hand therapy resources are used by this patient population at this health service?

- For cases that required and attended outpatient appointments (n=243), the median number of appointments with a surgeon (or Registrar/Resident Medical Officer) was 2 [IQR 1 – 3].
- Injuries that required surgical intervention resulted in a higher median number of medical appointments (n=73; Mdn: 2 [IQR 2 – 4]) than conservatively managed injuries (n=170; Mdn: 1 [IQR 1 – 2]).
- The median number of therapy appointments delivered at the hospital by a hand therapist or physiotherapist for all injuries was 2 [IQR 0 – 4].
- For fractures that were managed by a hospital-based hand therapist (n=83), the median number of appointments was 3 [IQR 2-5].
- Injuries that were surgically managed required a higher median number of therapy appointments (n=76; Mdn: 4 [IQR 1.25 – 6]) than conservatively managed injuries (n=167; Mdn: 2 [IQR 0 – 3]).

SLI: E, HCS

SLI: E, HCS

SLI: E, HCS

SLI: E, HCS

SLI: E, HCS

SLI: E, HCS

ILI, AL, PR

What are the major costs associated with hand fractures, tendon and nerve injuries?

What are the specific key drivers of economic and individual, family and social burden?

Can a prediction of total cost of injury be made by a model that includes duration of disability and productivity impairment?

- This subsequent question could not be answered with certainty due to the low retention and adherence rate of survey completion.
- This subsequent question could not be answered with certainty due to the low retention and completion rate of survey completion.
- A cost prediction model was not possible due to the low numbers of participants recruited with tendon and nerve injuries, in addition to challenges associated with participant retention.

6. What do individuals with an acute hand or wrist injury perceive as the most important impacts of experience burden of injury?

From qualitative interviews of twelve patients who had sustained an acute hand or wrist injury, it was found that:

- The perceived burden of injury in the context of family, social impacts and lost productivity were discussed in terms of consequences and adaptation in daily life, the perceived costs associated with injury, the impact of lost productivity and healthcare system experiences.
- The findings suggested that engagement in daily occupations, participation in usual roles, and emotional and physical health were perceived to contribute to the most burden after an acute hand or wrist injury.

ILI: BSF, AL, PR

CLI: FAM, WP

10.3 Individual, Community and Societal Burden of Acute Hand and Wrist Injuries

As described in Chapter 1, the Injury Outcome Framework (IOF)¹ can be used to describe known impacts of injury across the individual, community and societal domains. Impact, as per the IOF, is defined as the “consequences of change in physical, psychological, economic or other circumstances that could be directly or indirectly attributed to injury”^{1p589}. To discuss the major findings of the investigations that form this thesis, the term ‘impact’ includes direct (economic), indirect (economic) and intangible (physical, psychological) cost burden.

As the publications within this thesis attempted to investigate the individual, community and societal burden experienced as a result of an acute hand and wrist injury, a discussion of the major findings of the studies that form Chapters 3 to 8 will be linked to the most appropriate Domain and Impact Level 1 of an adapted version of the IOF which relates specifically to hand and wrist injuries (refer Figure 10.1). Also, a discussion of implications for future research and implications for practice will be explored in each domain when appropriate.

10.3.1 Individual level impacts

Impacts at the individual level refer to those that are directly experienced by an injured person. As discussed in Chapter 1, the Impact Level 1 terms within this domain of the IOF were developed from the International Classification of Functioning, Disability and Health (ICF)². Therefore, the definitions proposed by the World Health Organization are considered when discussing the results of this thesis in this domain.

10.3.1.1 Body structures and functions

The World Health Organization³ defines the dimension of Body Function as the “physiological functions of the body system (including psychological functions”^{p.12} and Body Structures as “anatomical parts of the body such as organs, limbs and their components”^{p.12}.

Findings of the systematic review that forms Chapter 3 of this thesis demonstrates that the EQ-5D, which has subjective measures of pain/discomfort and anxiety/depression⁴, and the VAS pain scale, which measures pain intensity out of a score of 100⁵, are the most frequently used measures to determine impact on body structures and functions in cost-of-illness and health economic evaluations relating to hand and wrist injuries. The studies included in the review discussed specific impacts on hand and wrist structures and functions in the context of intangible costs. These included pain⁶⁻⁹, chronic regional pain syndrome (CRPS)^{6,8}, functional limitations/decreased range of motions (ROM)⁹⁻¹¹, cold sensitivity⁷, clumsiness⁷, infection^{8,11}, non-union⁸, and anxiety and depression⁹.

Expanding on these findings, the pilot, prospective longitudinal cost-of-illness study presented in Chapter 7 found that at six weeks following an acute fracture, nerve or tendon injury to the hand or wrist when compared to SF-36 norms of healthy Australians, most people experience significant physical and mental health burden. Further, we found that the median score of Patient-Rated Wrist and Hand Evaluation (PRWHE)¹² for the pain subscale at six weeks was 15 [IQR 10 – 26]. Although limited by the small sample size (n=37), and the fact that these measures were only completed at one time point, our findings suggest that pain and impacts on physical and mental health should be viewed as a key consideration when attempting to estimate the intangible cost burden of these injuries.

This finding is further supported in our qualitative investigation (Chapter 8) which revealed impacts on body structures and functions that were linked to pain, frustration, decreased fitness or deconditioning, disrupted sleep, weight gain and reduced energy levels as a direct result of a hand or wrist injury. These impacts were reported to be most prevalent in the first three months following injury followed by a resolution as the injury stabilised. This suggests that data collection pertaining to intangible costs appears most important in the early phase of recovery.

Based on these integrated findings, it is suggested that when attempting to capture the individual intangible costs that occur from impacts on structures and functions, researchers should carefully consider the selection of both patient-reported and researcher administered outcome

measures in the context of the target population to ensure a complete and comprehensive insight into experienced burden.

Further, in order to quantify the economic impact of changes in body structures and functions for these injuries, future studies should consider calculating these intangible costs as a monetary estimate to present a true dollar value. While conflicting views on whether this practice has a place in cost-of-illness studies¹³, I believe that by not considering intangible costs, results produced would underestimate the total burden cost endured by the individual. One suggested method to achieve this would be to compare the quality of life of patients with a hand or wrist injury with the general population in order to assign a monetary value to the loss of health in terms of Quality-Adjusted Life Years (QALYs)¹⁴. This could be performed using the EQ-5D which produces a utility score which can be compared to normative data¹⁵.

The findings relating to body structures and functions from the investigations that form this thesis are similar to those in existing literature which do not consider or include cost data. In their prospective study which followed patients with acute traumatic hand injury from one week to one year following injury, Gustafsson and Ahlström¹⁶ reported that 67% (n=91) of participants had some form of limitation when performing physical activities due to pain or hand impairment. In addition to physical changes in body structures and functions, they found that 36% of participants had medium to high levels of trauma related distress and 10% had signs of mood disorder one-year following injury.

In line with the findings in Chapter 8, the authors conclude that, in most cases, pain and signs of depression or anxiety (reported as statistically significant changes in symptoms between weeks one to two and three months) were most likely to decrease in the first three-months following injury. Interestingly, they also reported that there were no statistically significant changes in pain or psychological symptoms between three-months and one-year highlighting the need for early assessment and intervention. While psychological impacts are being increasingly investigated in the context of traumatic or mutilating hand and wrist injury¹⁷⁻¹⁹, a lack of research relating to acute hand

and wrist injuries with a focus on cost burden continues to exist. Therefore, this should be viewed as a priority area in this field of research.

The integrated findings of this thesis regarding the cost burden experienced from changes in body structures and functions have several implications for practice. In addition to monitoring changes in physical body structures and function (e.g. pain, ROM), it is proposed that it is important for therapists to recognise and monitor changes in mental health and psychological functioning. By identifying and addressing these impacts early, there is a potential for reducing intangible and direct costs, however, further research is needed to validate this claim.

Further, it is proposed that early assessment and intervention, which could be provided by an on-call hand therapist in the emergency department, is one method to reduce overall cost (e.g. direct, indirect and intangible costs) by reducing secondary issues associated with injury and ensuring timely and accurate diagnosis and treatment. While preliminary findings presented in Chapters 4 and 6 support this proposal, further research such as a well-designed economic evaluation incorporating cost-effectiveness and cost-benefit methodologies is indicated.

10.3.1.2 Activity

The World Health Organization³ defines the dimension of activity as the “execution of a task or action by an individual”^{p.12}. Deficits of performance in this dimension are referred to as activity limitations and involve domains such as mobility, self-care and domestic tasks.

Findings from the systematic review presented in Chapter 3 demonstrate that the most frequently used measures in cost-of-illness studies and health economic evaluations that measure activity limitations are the Disability of the Arm Shoulder and Hand (DASH) and the EuroQol (EQ-5D). Interestingly, most of the included studies in the review did not discuss specific activity limitations experienced by participants, instead presenting total scores of patient-reported outcome measures to provide insight into intangible costs. The exceptions were Thorsén and colleagues

(2012)⁷ and Trybus and colleagues (2006)¹¹ who reported that 71% (n=176) and 58.8% (n=170) of participants reported specific activities limited by their hand or wrist injury respectively.

One common finding of included studies in the review was that when injury severity was measured (frequently measured by the Hand Injury Severity Score - HISS²⁰), an increase was correlated with a noted impact of activity limitations. Therefore, the inclusion of the HISS within future cost-of-illness studies could be beneficial to help determine costs associated with activity limitations and allow for stratification of included participants when completing cost analysis. However, this presents a challenge within the study settings used in this thesis (i.e. Alfred and Monash Health) as this is not routinely collected data and would require significant organisational change.

The qualitative study presented in Chapter 8 found that ‘day to day’ activities were significantly impacted in the first few weeks to months following injury. Commonly reported difficulties included those in the domains of self-care (dressing, hygiene related tasks, house cleaning, cooking, and driving), productivity (computer tasks, handwriting, manual handling) and leisure activities (sport, gym). Building on these findings the prospective study (Chapter 7) found that at six weeks post injury 43.2% of respondents required assistance from family members at a median of 6.5 hours per week thus suggesting a significant impact on the ability to perform normal activities was experienced.

While these integrated findings demonstrate the potential impact of activity limitations, caution must be taken when attempting to generalise the findings. They may, however, be used to help guide future researchers with assessment selection in larger scale cost-of-illness or economical evaluations to allow for a comprehensive estimate of intangible cost burden. Alternatively, these findings could provide preliminary data for the creation of a patient-reported outcome measure that is specifically designed to capture the burden of hand and wrist injuries as currently no such tool exists.

Published literature discussing the course of acute hand and wrist injuries relating to performance of daily activities is limited and commonly presents a specific hand or wrist injury diagnosis (e.g. nerve injury)²¹. This may be due to the tendency to include outcomes that focus purely on return to work and/or function at an impairment level, such as pain, grip strength or sensibility (e.g. body structures and functions). Meiners and colleagues²² report that two years after nerve injury, patients reported minor problems in performing daily activities (such as self-care), but significant problems in performing leisure activities. In contrast, Chan and Spencer²³, who followed hand patients with non-specific acute hand or wrist injury for one-year, found that all participants were still experiencing lasting limitations in the use of their hands during daily activities. While a growing number of published studies reporting the burden of activity limitations exist, this continues to be a domain that requires further investigation and consensus on how to best quantify its associated cost burden. This further supports the notion that a patient-reported outcome measure that is specifically designed to capture the intangible cost burden of hand and wrist injuries is warranted.

The findings presented in this thesis regarding the burden experienced from activity limitations have several implications for practice. First, the findings suggest that we need to focus on enabling engagement in activities that are meaningful for the individual, which would in turn have the potential to reduce individual burden experienced. This recommendation was presented and published as a viewpoint article presented in Chapter 9. Further, we should ensure that the education provided to our patients provides guidance for safely completing daily activities to avoid limitations and intangible cost burden experienced.

10.3.1.3 Participation

The World Health Organization³ defines the dimension of participation as the “involvement in a life situation”^{p.12}. Deficits in this dimension are referenced as participation restrictions that commonly occur in the areas of employment, education and social environments².

Findings from the systematic review presented in Chapter 3 highlight the minimal focus on estimating the cost burden of participation restrictions as a result of a hand or wrist injury. Non-

participation in work was the primary measure of participation restriction, which is consistent with similar research for other health conditions²⁴⁻²⁷, and was reported under indirect costs. While the overall finding was that these costs accounted for 64.5% of total costs in included cost-of-illness studies, and 68% for health economic evaluations, no included study used a “willingness to pay” method (refer 1.3.3.2.1.2) which may have provided a greater insight and cost estimate of perceived or actual impacts on participation. Further, there are no published investigations on the impacts of participation in non-paid work roles (e.g. carer of a dependent, family member or other).

At an individual impact level, Trybus and colleagues¹¹ demonstrated a statistically significant association ($p < 0.001$) between permanent loss of hand function and return to pre-injury activity or profession supporting the notion that more severe injuries result in greater costs as a result of participation restrictions. Further, Holmberg²⁸ reported that beyond pain, work function was perceived as the greatest impact as a result of a digit/thumb replant ($n=24$) or amputation ($n=6$). These findings are congruent with published literature excluded from the systematic review.

When considering non-specific hand and wrist injuries, Gustafsson and Ahlström¹⁶ reported that 59% of patients were on sick leave for less than three months, 25% between three months and one year, 13% one-year post accident. These findings indicate that the majority of work-related loss of productivity is experienced in the first three months following an acute hand or wrist injury. This assumption is supported in our qualitative study (Chapter 8) in which participants reported that the greatest impact on work participation was in the immediate period following injury and was largely dictated by health professional recommendation and support received from employers.

Expanding on these findings, the pilot study presented in Chapter 7 found that at six weeks post injury, 14% of participants who were working prior to their injury reported they were forced to take a temporary absence from work. Further, respondents reported that their work role and carer role were hindered as a direct result of their injury (62% and 24% respectively). While the findings provide preliminary data on the cost burden associated with paid and unpaid productivity roles,

further research is warranted in order to present a comprehensive and representative cost estimate of participation restriction in these domains.

While cost burden associated with restrictions in social participation is only partially explored within this thesis, it is suggested that this is a domain for careful consideration in future research. Chan and Spencer²³, in their investigation of pain following acute hand injury, report that degree of social participation was found to be negatively correlated with pain ($r = -0.739$). This finding suggests that individuals with marked pain in the early stages of recovery may be experiencing significant intangible costs, however, this is largely unexplored. The need for sharper focus on this cost consideration is further emphasised by the findings reported in Chapter 8 which observed that all interviewed participants experienced a decrease in social activities at some point during their recovery. This was particularly evident during in the early phases of healing with links made between pain, the inability to drive, mood and self-confidence.

The integrated findings presented in this thesis regarding the burden experienced from participation restrictions have several implications for practice. First, therapists should consider how they can best facilitate participation in paid and non-paid roles early in the therapy process in an attempt to reduce both intangible and indirect costs of these injuries. Further, therapists should demonstrate an increased awareness of social participation in the early phases of therapy and attempt to address apparent issues to support health and wellbeing, thus minimising intangible costs.

10.3.2 Community level impacts

In the domain of community level impacts, the IOF considers the impact an injury has on family, carers (of injured individuals) and the workplace. Although not a primary focus of this thesis, several trends relating to these impact levels were observed due to the research questions and associated methodology chosen.

Analysis of findings of the pilot longitudinal study (Chapter 7) and qualitative investigation (Chapter 8), while restricted to the perceived impacts from the perspective of the individuals surveyed

and interviewed, demonstrated noticeable impacts at the family, carer, and workplace level. While some insights can be taken from these findings that can direct future research and practice considerations, it should be recognised that they do not truly represent the impact that these injuries have at a community level and any consequent burden that may result.

10.3.2.1 Family

According to the IOF, the impact at family level involves the demands, psychological experiences and effects an injury has on relationships. Analysis of the interviews completed in Chapter 8 revealed that participants perceived an increase in demands they placed on family members for transport (e.g. to and from medical appointments), providing care for dependants, and assistance with personal care (e.g. cutting nails) and domestic tasks (e.g. cooking and housework) in the initial weeks following injury.

Further, some participants revealed that family members were required to take time off work to provide transport or assistance following the injury. These types of absences have the potential to result in burden for both the family member (e.g. loss of wages) and society (e.g. loss of productivity). This presents as an important consideration when attempting to estimate total cost burden. Building on these findings, the pilot study presented in Chapter 7 found that 43% of participants required assistance from their family to complete normal household work, indicating another consideration in the cost calculation. These integrated findings demonstrate the need to consider the impact of these injuries on the family of the injured individual in order to present a truly comprehensive cost burden of these injuries.

One proposed way of capturing family related costs that occur due to injury is to include the number of days that a family member missed work as a direct result of the demands resulting from an injury. Majowicz and colleagues²⁹, in their study of the cost burden of gastroenteritis in Canada, included work days missed by a family member or significant other in their model used to estimate total burden of disease. Based on their model, which included approximately 29,000 people (23,000 with gastroenteritis and 6,000 ‘caregivers’), a total of 93,000 days of paid employment were missed at

a cost of CAD \$8.3 million (73% of total cost-of-illness) per 100,000 population. Considering the days missed by a family member or significant other, the authors reported a predicted mean of 6,016 work days missed per 100,000 population. This reflects 6% of all work days missed by patients and family members combined and demonstrates the importance of including this cost variable when attempting to provide an accurate estimate of indirect cost burden.

Another method for capturing these costs is a community-based cost analysis which uses a household surveillance system that allows for surveying of a target population. In their investigation of the economic burden of unintentional injuries, Thanh and colleagues³⁰ surveyed 30 clusters (population size 23,807) in a province of Vietnam to identify their incidence and cost burden. From the surveyed population, they reported 1,740 non-fatal injuries in the 12-months data collection period and analysed costs that occurred at a household level, which included loss of relatives' time. They estimated that missed work by family members equated to 7% of total costs (i.e. direct and indirect costs). While this approach could provide important data to estimate cost burden of acute hand and wrist injuries in Australia, the absence of such a surveillance system (and the resulting need for significant research resources) makes this method currently non-feasible. The poor retention rate of participants observed in Chapter 7 further suggests that such research in Australia with this population is likely to be problematic.

The integrated findings presented in this thesis regarding the burden experienced from the family perspective, while limited, have several implications for practice. As our findings suggested the cost burden is most likely going to impact the family in the first few weeks to months following injury, therapists should encourage independence in activities of daily living as soon as possible to decrease the burden observed. Further, depending on the unique circumstances of each client, services such as home help (i.e. assistance with cleaning) should be considered if family burden in the initial stages of recovery is noted.

10.3.2.2 Carers

According to the IOF, the impact at a carer level is the experience on primary caregivers. No investigations conducted within this thesis reported results relating to the burden borne by primary

carers, but rather family members who provided short-term ad-hoc care. This observation is not unique to this thesis, as data relating to primary care giver cost for individuals with acute hand and wrist injuries is absent in currently published literature. It is postulated that this is due to the temporary nature of these injuries, with the impact on primary caregivers predicted to be rare or minimal, particularly in the absence of other pre-morbid pathology. This is in contrast to injuries such as an acquired brain injury (ABI) or spinal cord injury, where a growing body of work investigating such burden is available owing to the significant care demands.³¹⁻³⁴ For hand and wrist injuries, however, it is likely that this is not a commonly observed impact, and therefore represents no or very minimal cost burden.

10.3.2.3 Workplace

The IOF defines the domain of workplace as the processes, practice and perceptions of the employer and co-workers involved in return to work after an injury. Analysis of the findings from interviews conducted in the qualitative investigation (Chapter 8) highlights that interviewees who discussed their role as a worker and were absent from employment for some time following injury, commonly reported that employers were required to reallocate tasks to another employee owing to absenteeism. Further, participants who returned to work in the first few weeks following injury reported reduced productivity (presenteeism) which can have a significant impact on the process and practices of the workplace.

These findings were also reflective in Chapter 7's pilot, prospective longitudinal cost-of-illness cohort study in which 14% of participants reported absenteeism and 62% reported presenteeism. Using the SF-H&L questionnaire, this investigation found that the most common impacts of presenteeism included the need to work at a slower pace and other people needing to complete routine work tasks.

While some of the potential impacts in the workplace have been highlighted, concrete economic cost estimates are not feasible from the investigations included in this thesis. Therefore, to provide an accurate economic analysis of the burden that these injuries place on the workplace,

further research is warranted. Considerations when completing such research should include the ‘ripple effects’ that presenteeism can produce for co-workers such as emotional distress, physical injury and even termination of employment³⁵.

The integrated findings presented in this thesis regarding the burden experienced from the workplace perspective, while limited, have several implications for practice. As we observed that these injuries appear to have noted impacts on the workplace, it is recommended that therapists incorporate a dialogue within their treatment sessions to ensure that both the individual and employer expectations are managed. This could reduce the burden observed by both parties and result in planning or accommodations which would reduce the impacts of presenteeism.

10.3.3 Societal level impacts

In the domain of societal level impacts, the IOF considers the impact an injury has on the economy, the healthcare system, and associated compensation systems. Owing to the lack of a clear distinction in the IOF between impacts observed in the economy and healthcare system, for the purposes of this discussion, and my adapted version of the IOF, all financial costs (i.e. medical costs) experienced by a healthcare service will be discussed as an impact on the economy. Findings relating to the patient demographics of those presenting with these injuries and resource used within the healthcare service will be discussed as an impact on the healthcare system.

10.3.3.1 Economy

The impact an injury has on the economy can occur at two levels, a macro-economic level, which impacts society as a whole, or a micro-economic level, which impacts households/individuals, firms/businesses and the government³⁶. The investigations included in this thesis were focused at the micro-economic level, with a particular focus at an individual (e.g. patient) and firm (e.g. Alfred Health) perspective.

10.3.3.2 Individual perspective

Findings of the economic costs of hand and wrist injuries from an individual perspective (which considers both direct and indirect costs) in this thesis are included in the pilot study presented in Chapter 7 and the qualitative interviews conducted in Chapter 8. In Chapter 7, we found several areas in which participants experienced individual direct and indirect cost burden. Despite having universal healthcare and insurance-based compensation systems in Australia which cover medical and therapy costs, out-of-pocket costs were reported by all participants surveyed (median \$75 [IQR \$40 – \$200]). Further, close to half of the sample reported both a loss of income from lost penalty rates, commissions or other forms of additional income (median deficit \$1000 [IQR \$100 – \$2500]) and the need to pay for tasks that were normally performed independently pre-injury (median \$150 [IQR \$100 – \$275]).

Expanding on these findings, in Chapter 8 we found that while most participants reported that they did not experience significant financial impacts, some common financial costs associated with injury were noted. These included parking costs to attend hospital appointments, additional expenditure above normal spending relating to transportation (e.g. petrol) and cooking (e.g. take away), loss of wages, and forfeiting of overtime benefits.

While these findings are difficult to generalise to the wider population owing to the small sample sizes (n=37; n=12) and geographical location (metropolitan Melbourne), they can be used to inform the selection of appropriate measures for future research of individual cost burden. For example, we did not include measures that captured the financial cost due to additional transportation, parking or cooking in the pilot study and therefore potentially neglected sources of significant individual cost burden. This again supports the need for a patient reported outcome measure that is specifically designed to capture individual cost burden encompassing direct, indirect and intangible costs.

Alternatively, future researchers could consider the use of a cost diary to measure individual direct and indirect costs encountered as a result of these injuries. This alternative method, which

involves completing a pre-populated booklet which contains instructions and an example has observed a 68% completion rate for individuals with fibromyalgia and chronic lower back pain³⁷. However, it should be noted that our experiences of participant retention in our pilot study (Chapter 7) with an acute injury, rather than a chronic condition, demonstrates difficulties in capturing such data with this population. Therefore, future researchers should consider providing incentives (i.e. financial) and ensure they highlight the relevance and real-world applications of completing such research.

10.3.3.3 Firm/business perspective

While limited conclusions can be drawn about the individual economic impacts of acute hand and wrist injuries, the manuscripts that form Chapter 3 to 6 of this thesis present detailed insight into the economic impact experienced from a firm/business perspective.

The systematic review presented in Chapter 3 found that indirect costs, resulting from loss of productivity, accounted for approximately 64.5-68% of total cost expenditure. Similar figures for indirect costs have been reported in cost-of-illness studies investigating conditions such as lower back pain³⁸, rheumatoid arthritis³⁹, and traumatic brain injury⁴⁰, although there is some variation with indirect costs reported to be as low as 10% of total cost in some evaluations (e.g. lower back pain^{41,42}). This is not surprising given the different methodologies and costing parameters used to provide cost estimates. This highlights the need for clear and accurate descriptions of adopted methodology so that readers can contextualise and interpret results. This could be achieved by ensuring the use of the Consolidated Health Economic Evaluation Reporting Standards (CHEERS)⁴³ statement for future studies that investigate indirect cost burden resulting from acute hand and wrist injuries.

The finding that indirect costs are major cost drivers for acute hand and wrist injuries highlights the need for further research into interventions that promote early return to productivity roles. The finding in the systematic review that occupational therapy and physiotherapy services contribute as little as 0.01% of the total cost, is surprising given their potential to play an important role in reducing indirect costs and consequent overall cost burden by addressing individual and workplace factors to enable earlier return to work⁴⁴. To measure the impact of focused work

interventions for acute hand therapy patients, future researchers could consider a well-designed economic evaluation that compares this with current standard practice.

The findings presented in Chapters 4 to 6 of this thesis have provided insight into the direct medical cost of acute hand and wrist injuries from a healthcare service perspective in Australia. In Chapter 4, we established that these injuries account for approximately \$2 million per year of direct medical costs in one health service's emergency departments alone.

In Chapter 5, we found that when these injuries require surgery, the combined cost at one health service for emergency department presentations, surgical intervention and outpatient resources was \$1.2 million per year. Using the findings of our systematic review (Chapter 3) in which direct costs associated with hand and wrist injuries accounted for one-third of total costs, it could be roughly estimated that the acute hand and wrist injuries requiring surgery at this one health care network could contribute to a societal burden of around \$3.6 million per year in indirect costs.

However, in order to present credible societal cost burden estimates, a prospective cost-of-illness study that captures both direct medical costs encountered within the healthcare system and indirect costs using the human capital approach (e.g. multiplying the duration of time unable to fulfil working role by the amount they would normally earn^{45,46}) is proposed as the pilot, prospective longitudinal cost-of-illness design presented in Chapter 7 was not feasible using the methods trialled. A better method might be weekly phone calls to participants to record the amount of days they were absent from work, thus reducing the time burden placed on individuals to complete regular surveys.

In Chapter 6, it was established that injuries sustained as a result of sport or exercise account for approximately \$790,000 worth of yearly direct medical costs within one health network. Further, it was found that injuries sustained from riding bicycles led the highest total cost burden (\$173,076) followed by ARF (\$161,538). Beyond highlighting the costs which these specific sport injuries place on the already stretched healthcare system, these results have provided insight into areas in which

health promotion strategies, such as protected bike lanes or road safety campaigns, could be evaluated as part of future cost-effectiveness or cost-benefit investigations.

Although the findings of the investigations conducted within this thesis provide some insight into the potential magnitude of the economic costs that acute hand and wrist injuries have on the Australian economy from a healthcare system perspective, the findings are largely limited by the absence of a national injury surveillance system. In an attempt to address this barrier, future researchers could consider using a cost-of-illness approach with a cross section of Australian health services in an attempt to calculate a more comprehensive national direct cost estimate of these injuries.

10.3.4 Healthcare system

For the purposes of this discussion, the impact that acute hand and wrist injuries have on the healthcare system in the adapted IOF relates to the demands placed on the healthcare system (e.g. Alfred Health) in regard to resource use. In addition, it relates to findings regarding the profile of individuals who require treatment and intervention for these injuries, an area that has been previously limited to workplace compensation data in Australia.

10.3.4.1 Health service use

Analysis of results from the investigations conducted within Chapters 4 to 6 of this thesis demonstrate several key insights into the health service use of individuals with acute hand and wrist injuries and have identified key drivers of direct cost within a healthcare service (e.g. Alfred Health). Further, these investigations have confirmed the difficulty of capturing all direct costs encountered by patients with acute hand and wrist injuries, as the patient care journeys in these investigations demonstrate resource use by participants prior to and after their care provided in the public hospital setting.

The investigation conducted in Chapter 4 revealed that acute hand and wrist injuries are associated with over 5% of all emergency department visits within one public health network (Alfred

Health). While this finding is significantly less than the estimated 10-30% proposed in international literature^{6,47,48}, it adds to the limited knowledge that these injuries account for 16% of all new injuries in Australia⁴⁹ and that they form the largest category of work-related injuries⁵⁰.

In Chapter 6, we discovered that 27.9% (n=75) of patients who were referred and attended for further management within Alfred Health (n=243) for a sport or exercise-related injury received a different diagnosis by the specialist medical team than what was provided in the emergency department. A suggested method to reduce the number of misdiagnosed or missed upper extremity injuries may be an on-call allied health advanced practitioner hand therapist in the emergency department to assist in the triage and timely treatment of injuries that can be conservatively managed, such as dislocations, closed mallet injuries, and undisplaced fractures. A similar approach has been observed in the management of musculoskeletal injuries by physiotherapists with the available evidence suggesting they may be more cost-effective than medical providers in managing low urgency conditions in the emergency department⁵¹. However, in order to test the feasibility and outcomes of an on-call allied health advanced practitioner hand therapist in the emergency department, researchers would need to conduct a well-designed economic evaluation which employs both incorporating cost-effectiveness and cost-benefit methodologies.

The cost-of-illness studies that investigated the cost and resource use for surgically managed injuries (Chapter 5) and sport and exercise-related injuries (Chapter 6) both confirm that inpatient costs as a result of surgical intervention are the key driver of total cost within the healthcare service. While surgery can be unavoidable for some acute hand and wrist injuries, the resources used within the inpatient setting could be seen as a possible area for cost-minimisation in an attempt to reduce total direct costs. However, the margin for reduction is hypothesised to be minimal and, therefore, may not warrant researchers and administrators time and resources.

In contrast, one area that this thesis has identified that warrants further attention for reducing healthcare system direct costs are the rates of patients failing to attend appointments. In both cost-of-illness studies conducted in Chapters 5 and 6, we found rates of 28.2% and 22% respectively of

patients failing to attend their final scheduled appointment. Additionally, we found a high percentage of patients failing to attend one or more appointments during the patient care journey (34% and 33%). In the cost-of-illness study that investigated the cost and resource use for surgically managed injuries (Chapter 5) alone, the observed number of failed to attend appointments resulted in approximately \$20,000 of additional costs to the healthcare service in a one-year period. These integrated findings suggest the need for the implementation of cost saving measures. Research focusing on reducing non-attendance in outpatient physical therapy settings has primarily focused on the effects of reminders (e.g. text messages⁵²⁻⁵⁴ and telephone reminders⁵⁴). Such methods have demonstrated some effectiveness for reducing non-attendance, however, motivational effects remain underexamined in published literature for this patient population.

In a study investigating reasons for failing to attend appointments in the outpatient client setting that surveyed 204 patients in Ireland, Roberts and colleagues (2011)⁵² found that the most common reason for not attending was simply forgetting (28%). Interestingly, of those surveyed 47% reported they would be willing to pay a fee on booking that could be refunded on attending their appointment. While this may be an extreme and unpopular measure, it may have the potential to reduce observed rates and therefore costs and, therefore, could be considered by future researchers. Further, while Taylor and colleagues⁵³ conclude that text-reminders can reduce non-attendance in physical therapy outpatient clinics, they also identified that both age and whether the scheduled appointment was an initial or review appointment were independent predictors of non-attendance. Consideration of such factors, combined with patient and public involvement in the review and potential redesign of outpatient service appointment scheduling⁵⁶, are areas which should be considered by future researchers, managers and public health services when addressing non-attendance with this patient population.

10.3.4.1.1 Demographic profile

The investigations conducted within this thesis provides insight into the typical demographic and injury profile of individuals who are most likely to present to the emergency department with an acute hand or wrist injury and go on to require medical and hand therapy interventions. Considering the

results of the investigations that form Chapters 4 to 7, it can be observed that within the healthcare services where the research took place:

- Males are more likely to present with acute hand and wrist injuries than females (62% of all emergency department presentations; 74% of all sport and exercise-related presentations; 77% of recruited participants in pilot study) and require surgical intervention (81%);
- Individuals aged between 25-34 years are most likely to present to the emergency department for an acute hand or wrist injury (27%), require surgical intervention (37.1%) or sustain their injury from participation in sport or exercise (29.4%);
- Open wounds to the hand or wrist (i.e. laceration) are the most likely cause for both emergency department presentations (34%) and surgical intervention (44.3%);
- ARF was the most likely mechanism leading to a sport or exercise-related hand or wrist injury (20.2%); and
- Students and professionals were more likely to present with an acute hand or wrist injury from participation in sport or exercise (42.6%) while labourers and tradespersons (34.5%) were more likely to sustain injuries that require surgical intervention.

While caution must be taken when generalising these results to the wider Australian population as the results were restricted to one or two public health service(s), the findings that males and those aged in their economically productive years are more likely to sustain acute hand and wrist injuries align with previously published international literature^{47,53}.

It is proposed that these findings have applications in terms of determining where to best target the resources required in the design, implementation, and provision of healthcare, as well as health promotion strategies to minimise the costs associated with these injuries (e.g. awareness campaigns for the safe operation of power tools^{54,55} or protective equipment worn in sport⁵⁶). Also, the findings have provided insight about the population that future cost-of-illness studies should ideally target and consider when designing research methodology and the limitations they will need to

consider (i.e. males aged between 25 and 34 years are likely to be difficult to retain for survey-based research).

10.3.4.2 Compensation system

For the purposes of this discussion, the impact that acute hand and wrist injuries have on the compensation system in the adapted version of the IOF which specifically relates to acute hand and wrist injuries considers the demands that have been placed on WorkCover and the TAC.

Findings relating to this impact level are limited to the cost-of-illness study presented in Chapter 5 which found that patients who required surgery and were funded by work or transport insurance, resulted in a median cost of \$5057 within the study setting. It was also found that when compared to non-compensable patients, they required the same median number of post-operative appointments with a surgeon, however, observed less hand therapy appointments within the health service.

Such findings demonstrate the difficulty in truly providing comprehensive cost estimates from a range of perspectives owing to the cost-shifting nature of healthcare in Australia where patients receive care from multiple sources (e.g. general practitioner, private hand therapist or other healthcare professional, private surgeon) and receive treatment or imaging outside of the chosen cost perspective. In order to combat this, future researchers should ensure they provide a clear and accurate descriptions of adopted methodology for the intended audience to be able to contextualise and interpret results.

10.4 Limitations of this Thesis

This thesis employed a variety of methodologies to answer the proposed research questions relating to the individual, community and societal burden of acute hand and wrist injuries. Some of these methodologies, however, present with some inherent limitations.

The systematic review in Chapter 3, for example, was limited to databases for medical publications reported in English and neglected other databases and sources (i.e. economic databases, thesis and dissertations) limiting the possibilities of additional relevant publications. The cost-of-illness study that investigated emergency department presentations (Chapter 4) which was limited to one health network and was dependent on the accuracy of the records used to estimate direct costs, which can be prone to variations in coding and reporting. The cost-of-illness studies that investigated the cost and resource use for surgically managed injuries (Chapter 5) and sport and exercise-related injuries (Chapter 6) were both limited to one health network and were largely dependent on the accuracy of both cost and medical record notes, which can vary depending on the quality and accuracy of the file notes. The pilot, prospective longitudinal cost-of-illness cohort study (Chapter 7) was particularly difficult to conduct due to low participant retention and is likely prone to over- or under estimates provided by participants who completed the survey at six-weeks. Further, this investigation did not consider patient and public involvement in the design of data collection methods. This limitation may explain the low retention rate of participants who consented to participate. Finally, the results of the qualitative investigation (Chapter 8) cannot be generalised to the Australian population as they are limited by the geographical location from which the participants were recruited, and the fact that all participants were native English speakers.

Limitations with relation to each individual investigation are discussed in more detail within the chapters of each respective manuscript.

This chapter summarised the results of the studies that make up this thesis. It has presented the findings of the specific research questions posed in Chapter 2, in addition to contextualising the findings of Chapters 3 to 8 using an adapted version of the IOF which specifically relates to acute hand and wrist injuries. The following chapter, the final in this thesis, summarises the original contribution this research has made to the knowledge on individual, community and societal burden of acute hand and wrist injuries and also makes recommendations for future research in this topic area.

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Chapter 11

Conclusion

In this thesis, I aimed to explore the individual, community and societal burden following acute hand and wrist injuries. Using various methodologies, I have established that these injuries have the potential to lead to substantial costs and impacts for the individual patient, their families, their employers and work colleagues, the public health system, and broader society. Further, I have provided much needed epidemiological data on the demographic profile, resource use, and key drivers of cost for individuals who present to the emergency department having sustained an acute hand or wrist injury.

Original contributions this work has made to the knowledge and understanding of the individual, community and societal burden following acute hand and wrist injuries

Research on the individual, community and societal burden of acute hand and wrist injuries is notably lacking in published literature, even though these injuries can account for between 5 and 30% of all emergency department presentations. I therefore set out to collect and publish data relating the cost burden, impact, and epidemiology of acute hand and wrist injuries for both Australian and international audiences.

The original contributions and importance this research have made to the understanding of the burden of these injuries have been acknowledged by both the section editor and a reviewer for the *Emergency Medicine Australasia* journal who reviewed the manuscript presented in Chapter 4 titled *Description and cost-analysis of emergency department attendances for hand and wrist injuries*. Specifically, they acknowledged:

“There appears to be a gap in the Australian literature around this and it would provide useful information to health administrators.”

Section Editor – Emergency Medicine Australasia

“Epidemiology studies are necessary to inform us of the burden and costs of hand and wrist injuries in order to facilitate research and interventions to minimise injury and costs... This study does bring attention to the significance and cost of hand and wrist injury presentations”.

Reviewer 3 – Emergency Medicine Australasia

Further, the research that I have completed within this thesis has resulted in the opportunity to present my findings as an invited speaker at two hand therapy conferences (Australian Hand Therapy Association (AHTA) National Conference and the Asian Pacific Federation of Societies for Surgery of the Hand (APFSSH) / Asia Pacific Federation of Societies of Hand Therapy (APFSHT) combined congress). In their invitation letter, the APFSHT scientific committee commented:

“We are honoured to invite you to present an invited presentation at the 8APFSHT. This is recognising your expertise in health economics within hand therapy.”

Kath Dalton – on behalf of the APFSHT scientific committee

It is hoped that the research completed within this thesis has provided empirical evidence for the support of further investigations and trials of additional resources for the management of acute hand and wrist injuries. One suggested method to reduce cost of individual, community and societal burden of these injuries is having an on-call allied health advanced practitioner hand therapist in emergency departments with high volumes of hand and wrist injuries. This role could assist in the triage, accurate diagnosis, and timely treatment of injuries that can be conservatively managed. Additionally, it is hoped that the cost and epidemiological data presented within this thesis can be used by clinicians and researchers working in the field of hand therapy to leverage funding for future research efforts.

Future research directions and practice implications

The key implications arising from this thesis are that allied health professionals working in hand therapy can have an important role to play in both researching and potentially reducing the burden of acute hand and wrist injuries at the individual, community and societal levels.

At this point, we do not have sufficient evidence to generate precise national cost burden estimates observed at the individual, community and societal level in Australia. Although the findings of our systematic review conducted in Chapter 3 suggest that indirect costs account for between 64.4-68% of total cost expenditure, the pilot study conducted in Chapter 7 demonstrates the difficulties of capturing such estimates in Australia with this patient population. Therefore, future researchers are encouraged to dedicate their efforts on designing study protocols that consider methods that not only accurately capture indirect cost estimates, but also encourage participant buy-in. Such methods should include patient and public involvement whereby patient and public partners act as consultants in the design and review of qualitative interview schedules and questionnaires relating to burden. Further, these partners can also assist in disseminating findings to lay parties and highlight the importance and relevance of this research area with the aim of leading to increased patient buy-in and participant retention.

While the findings of this thesis have provided some insight into the burden experienced at individual, community and societal levels, they are limited by the perspectives adopted (i.e. healthcare system) in the absence of a national surveillance system. Further, the geographical location of the study settings used in this collection of research means that caution needs to be taken when attempting to generalise the findings to the Australian population. Future researchers are encouraged to consider large scale cost-of-illness studies conducted within various healthcare services across Australia to enable a more comprehensive estimate of the total national cost burden. Further, it is suggested that the adapted version of the IOF presented in Chapter 10, which relates specifically to acute hand and wrist injuries, be considered in the design process to ensure a complete inclusion of cost considerations. This is also applicable to future researchers looking to conduct studies in other countries that lack a national surveillance system.

Although the outcome measures used in this thesis have allowed for insight into the intangible costs encountered at the individual level, the integrated findings of this thesis suggest the need for the development of a patient-reported outcome measure that is specially designed for the population presenting with an acute hand or wrist injury. It is suggested that our findings mapped to the individual level impacts in the adapted version of the IOF may be used by future researchers to help guide its conception.

The findings of this thesis have several implications for clinical practice that should be considered by therapists in an attempt to reduce the burden experienced by our patients, their families and broader society. First, in addition to monitoring changes in physical body structures and function, it is essential that we recognise and monitor changes in mental health and psychological functioning. Second, we need to focus on enabling engagement in activities that are meaningful for the individual in order to align the rehabilitation we provide with the ‘real world’ of our patients. Third, we should consider how to best facilitate participation in paid and non-paid roles early in the therapy process for the benefit of both the individual and broader society. Finally, we should demonstrate an increased awareness of social participation in the early phases of therapy and attempt to address the apparent issues to support health and wellbeing.

I believe that by therapists identifying and addressing such impacts early in the therapy process, there is a significant potential for reducing costs experienced at individual, community and societal levels leading to better outcomes for all.

Appendices

12.1 Appendix 1 – Ethics approvals

Project	Approval Date and number		
	Monash SCERH	Alfred Hospital Ethics Committee	Monash Health Hospital Human Research Ethics Committee
Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review	Ethics not required		
Description and cost-analysis of emergency department attendances for hand and wrist injuries	CF16/2268 - 2016001119; 30 June 2016	233/16; 15 June 2016	N/A
Cost-analysis, epidemiology and post-operative resource use for surgically managed acute hand and wrist injuries with emergency department presentation	CF16/2268 - 2016001119; 30 June 2016	233/16; 15 June 2016	N/A
Profile and cost-analysis of sport and physical activity related hand and wrist injuries with Emergency Department presentation	CF16/2268 - 2016001119; 30 June 2016	233/16; 15 June 2016	N/A
Is capturing the cost acute fractures, tendon and nerve injuries of the hand and wrist from the individual and societal perspective feasible	CF14/197; 21 January 2014	422/13; 7 November 2013	16082L; 17 March 2016
Workplace, Family and Social Participation following acute hand injury	CF14/197; 21 January 2014	422/13; 7 November 2013	16082L; 17 March 2016
Embracing an occupational perspective: Occupation-based interventions in hand therapy practice	Ethics not required		



MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Confirmation of Registration

This is to certify that the project below is now registered with the Monash University Human Research Ethics Committee under the Memorandum of Agreement with the Alfred Health HREC.

Project Number	CF16/2268 - 2016001119		
Project Title	Direct Costs and Epidemiology of Acute Hand and Wrist Injuries: A Single-centre Retrospective Study		
Chief Investigator	Dr Lisa O'Brien		
Date Approved:	30 June 2016	Valid until:	30 June 2021

Terms:

1. Registration is valid whilst you hold a position at Monash University and approval at the primary HREC is current.
2. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
3. **End of project:** Notification should be provided at the conclusion of the project. MUHREC should also be notified if the project is discontinued before the expected date of completion.
4. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to the project in accordance with *The Australian Code for the Responsible Conduct of Research*.



Professor Nip Thomson
Chair, MUHREC

cc: Mr Luke Robinson

Human Ethics Office

Monash University
Room 111, Chancellery Building E
24 Sports Walk, Clayton Campus, Wellington Rd, Clayton VIC 3800, Australia
Telephone +61 3 9905 5490 Facsimile +61 3 9905 3831
Email muhrec@monash.edu <http://intranet.monash.edu.au/researchadmin/human/index.php>
ABN 12 377 614 012 CRICOS Provider #00008C



ETHICS COMMITTEE CERTIFICATE OF APPROVAL

This is to certify that

Project No: 233/16

Project Title: Direct Costs and Epidemiology of Acute Hand and Wrist Injuries: A Single-centre Retrospective Study

Principal Researcher: Dr Lisa O'Brien

*was considered for Low Risk Review and **APPROVED** on 12/05/2016*

It is the Principal Researcher's responsibility to ensure that all researchers associated with this project are aware of the conditions of approval and which documents have been approved.

The Principal Researcher is required to notify the Secretary of the Ethics Committee, via amendment or report, of

- Any significant change to the project and the reason for that change, including an indication of ethical implications (if any);
- Serious adverse effects on participants and the action taken to address those effects;
- Any other unforeseen events or unexpected developments that merit notification;
- The inability of the Principal Researcher to continue in that role, or any other change in research personnel involved in the project;
- A delay of more than 12 months in the commencement of the project; and,
- Termination or closure of the project.

Additionally, the Principal Researcher is required to submit

- A Final Report on completion of the project.

Approval covers the project as described in the application (including any modifications made prior to approval). Low Risk projects are subject to audit and ethical approval may be withdrawn if the project deviates from that proposed and approved.

SPECIAL CONDITIONS

None

SIGNED:



**Professor John J. McNeil
Chair, Ethics Committee**

Please quote project number and title in all correspondence



MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

This is to certify that the project below has been approved by the Monash University Human Research Ethics Committee under the Memorandum of Agreement with The Alfred HREC

Project Number: CF14/197 - 2014000044
Project Title: Workplace, family, and social participation following acute hand injury
Chief Investigator: Dr Lisa O'Brien
Approved: From: 21 January 2014 to 21 January 2019

Terms of approval - Failure to comply with the terms below is in breach of your approval and the Australian Code for the Responsible Conduct of Research.

1. Approval is only valid whilst you hold a position at Monash University and approval at the primary HREC is current.
2. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
3. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
4. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.



Professor Nip Thomson
Chair, MUHREC

cc: Assoc Prof Terry Haines; Assoc Prof Natasha Lannin

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ABN 12 377 614 012 CRICOS Provider #00008C



ETHICS COMMITTEE CERTIFICATE OF APPROVAL

This is to certify that

Project No: 422/13

Project Title: Workplace, family, and social participation following acute hand injury

Principal Researcher: Dr Lisa O'Brien

Project Proposal: Section 1.14b of Module One (Version 2 amended 16-Oct-2013)

Participant Information and Consent Form Version 2 dated: 16-Oct-2013

*was considered by the Ethics Committee on **24-Oct-2013**, meets the requirements of the National Statement on Ethical Conduct in Human Research (2007) and was **APPROVED** on **7-Nov-2013***

It is the Principal Researcher's responsibility to ensure that all researchers associated with this project are aware of the conditions of approval and which documents have been approved.

The Principal Researcher is required to notify the Secretary of the Ethics Committee, via amendment or progress report, of

- Any significant change to the project and the reason for that change, including an indication of ethical implications (if any);
- Serious adverse effects on participants and the action taken to address those effects;
- Any other unforeseen events or unexpected developments that merit notification;
- The inability of the Principal Researcher to continue in that role, or any other change in research personnel involved in the project;
- Any expiry of the insurance coverage provided with respect to sponsored clinical trials and proof of re-insurance;
- A delay of more than 12 months in the commencement of the project; and,
- Termination or closure of the project.

Additionally, the Principal Researcher is required to submit

- A Progress Report on the anniversary of approval and on completion of the project (*forms to be provided*);

The Ethics Committee may conduct an audit at any time.

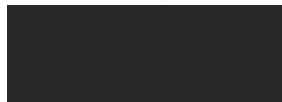
All research subject to the Alfred Hospital Ethics Committee review must be conducted in accordance with the National Statement on Ethical Conduct in Human Research (2007).

The Alfred Hospital Ethics Committee is a properly constituted Human Research Ethics Committee in accordance with the National Statement on Ethical Conduct in Human Research (2007).

SPECIAL CONDITIONS

None

SIGNED:



**R Frew
Secretary, Ethics Committee**

Please quote project number and title in all correspondence

17 March 2016

Dr Lisa O'Brien
Occupational Therapy
Allied Health Research Unit
Kingston Centre
Cheltenham Vic 3192

Dear Dr O'Brien

Study title: Workplace, Family and Social Participation Following Acute Hand Injury
NMA Reference Number: LNR/16/MonH/18
Monash Health HREC Ref: 16082L

The Monash Health HREC Low Risk Review Panel reviewed the above application and are also satisfied that the responses to our correspondence of 23 February 2016 have been sufficiently addressed.

The HREC approved the above application on the basis of the information provided in the application form, protocol and supporting documentation.

This reviewing HREC is accredited by the Consultative Council for Human Research Ethics under the single ethical review system.

Approval

The HREC and Site Specific Authorisation approval is from the date of this letter.

Approval is given in accordance with the research conforming to the *National Health and Medical Research Council Act 1992* and the *National Statement on Ethical Conduct in Human Research (2007)*. The HREC has ethically approved this research according to the Memorandum of Understanding between the Consultative Council and the participating organisations conducting the research.

Approval is given for this research project to be conducted at the following sites and campuses:

- Monash Health –
 - Monash Medical Centre, Clayton
 - Dandenong Hospital

You must comply with the following conditions:

The Principal Investigator is required to notify the Research Support Services, Monash Health of the following:

1. Any change in protocol and the reason for that change together with an indication of ethical implications (if any)
2. Serious or unexpected adverse effects of project on subjects and steps taken to deal with them
3. Any unforeseen events that might affect continued ethical acceptability of the project
4. Any expiry of the insurance coverage provided in respect of sponsored trials

12.2 Appendix 2 – Participant information and consent form



Participant Information Sheet/Consent Form

Non-Interventional Study - *Adult providing own consent*

Title	Workplace, family, and social participation following acute hand injury
Protocol Number	1
Principal Investigator	Dr Lisa O'Brien
Associate Investigator(s)	Luke Robinson, A/Prof Terry Haines
Location	The Alfred

Part 1 What does my participation involve?

There are 2 parts to this study, and you are invited to participate in both parts.

Participation in Part 1 of this project will involve:

- being interviewed about the effects your hand or wrist injury has had on your social and family life and your ability to work and participate in other things that are important to you. This can take place in person or over the phone, is not expected to take more than 20- 30 minutes, and will be audio-taped

Participation in Part 2 of this project will involve:

- answering some questions about your injury, work, and family responsibilities at the time of your injury, and at 4 time-points during the following year.

1 Introduction

You are invited to take part in this research project: Workplace, family, and social participation following acute hand injury. This is because you have recently attended our Emergency/ Trauma service after sustaining a wrist or hand injury. The research project is aiming to fully understand the impact of hand and wrist injuries on people's family, social life, and work. There are 2 parts to this study, and you are invited to participate in both parts.

This Participant Information Sheet/Consent Form tells you about the research project. Knowing what is involved will help you decide if you want to take part in the research.

Please read this information carefully. Ask questions about anything that you don't understand or want to know more about. Before deciding whether or not to take part, you might want to talk about it with a relative, friend or local doctor.

Participation in this research is voluntary. If you don't wish to take part, you don't have to. You will receive the best possible care whether or not you take part.

If you decide you want to take part in the research project, you will be asked to sign the consent section. By signing it you are telling us that you:

- Understand what you have read
- Consent to take part in the research project
- Consent to the tests and research that are described
- Consent to the use of your personal and health information as described.

You will be given a copy of this Participant Information and Consent Form to keep.

2 What is the purpose of this research?

Hand injuries are common and costly. In Australia, there is a lot of data about hand injuries that happen at work, but not a lot is known about the impact of injuries that happen outside work, or how injuries affect people's lives in the first year afterwards. This research project is aiming to fully understand the impact of hand and wrist injuries on people's family, social life, and ability to work.

The results of this research will be used by the researcher Luke Robinson toward his Doctor of Philosophy degree.

3 What does participation in this research involve?

If you decide to participate in this project, the lead researcher will ensure you sign a consent form before commencing.

- If you decide to participate in Part 1, you will be interviewed about your injury, and how it has affected your day-to-day life. The interview can be done in person at The Alfred, or over the phone, and will be audio-taped.
- If you decide to participate in Part 2, you will be asked to fill in a form about your current injury, work, and family situation. At six weeks after your injury, you will be sent 4 brief surveys to complete. These surveys will be repeated at three months, six months and one year. They can be completed as paper surveys (via return post), or you may choose to complete these on-line (via a secure web link) or telephone. They will ask about pain, whether and how much you are working, your overall health, and how well you can do daily living activities. We will also ask you how many medical or therapy appointments you attended.

This research project has been designed to make sure the researchers interpret the results in a fair and appropriate way and avoids study doctors or participants jumping to conclusions.

There are no costs associated with participating in this research project, and you will be provided with a \$20 gift voucher to thank you for your participation in part 1 of this study.

4 Other relevant information about the research project

We plan to interview 10-12 people for Part 1 of the study.

For Part 2, we hope to survey around 400 people from Alfred Health and Monash Health.

5 Do I have to take part in this research project?

Participation in any research project is voluntary. If you do not wish to take part, you do not have to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage.

Your decision whether to take part or not to take part, or to take part and then withdraw, will not affect your routine treatment, your relationship with those treating you or your relationship with The Alfred.

6 What are the possible benefits of taking part?

There will be no clear benefit to you from your participation in this research, although you will be given a \$20 gift voucher to thank you for your time if you complete either Part 1 or 2, (\$40 if you participate in both)

7 What are the possible risks and disadvantages of taking part?

If you become upset or distressed as a result of your participation in the research, the study doctor will be able to arrange for counselling or other appropriate support. Any counselling or support will be provided by qualified staff who are not members of the research project team. This counselling will be provided free of charge.

8 What if I withdraw from the research project?

If you decide to take part and later change your mind, you are free to withdraw from the project at any time. If you do decide to withdraw, your personal data will also be withdrawn from the research database. Your decision whether to take part or not, or to take part and then withdraw, will not affect your relationship with the researchers or The Alfred Hospital and will not compromise the quality of your care.

Part 2 How is the research project being conducted?

9 What will happen to information about me?

By signing the consent form you consent to the study doctor collecting and using personal information about you for the research project. Any information obtained in connection with this research project that can identify you will remain confidential. If you participate in Part 1, the audio file and transcript of your interview will be stored on a password-protected computer that can only be accessed by the researchers. The transcription will be done by a company that specialises in medical reports, and they will ensure strict confidentiality of your information. For Part 2, all information will be coded and stored in a locked filing cabinet (for paper-based surveys) or entered into a password-protected computer database (phone and computer-based surveys). Your information will only be used for the purpose of this research project and it will only be disclosed with your permission, except as required by law.

It is anticipated that the results of this research project will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified.

In accordance with relevant Australian and/or Victorian privacy and other relevant laws, you have the right to request access to the information collected and stored by the research team about you. You

also have the right to request that any information with which you disagree be corrected. Please contact the research team member named at the end of this document if you would like to access your information.

Any information obtained for the purpose of this research project that can identify you will be treated as confidential and securely stored. It will be disclosed only with your permission, or as required by law.

10 Complaints and compensation

If you suffer any injuries or complications as a result of this research project, you should contact the study team as soon as possible and you will be assisted with arranging appropriate medical treatment. If you are eligible for Medicare, you can receive any medical treatment required to treat the injury or complication, free of charge, as a public patient in any Australian public hospital.

11 Who is organising and funding the research?

This research project is being conducted by Dr Lisa O'Brien with a seeding grant from Monash University.

11 Who has reviewed the research project?

All research in Australia involving humans is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this research project have been approved by the HREC of Alfred Health. This project will be carried out according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect the interests of people who agree to participate in human research studies.

12 Further information and who to contact

The person you may need to contact will depend on the nature of your query. If you want any further information concerning this project or if you have any medical problems which may be related to your involvement in the project (for example, any side effects), you can contact

Name: Dr Lisa O'Brien
Role: Principal Researcher & Quality Coordinator, Occupational Therapy
Telephone: 9076 3230 or email: l.obrien@alfred.org.au

Or

Name: Associate Professor Natasha Lannin
Role: Research Coordinator, Occupational Therapy
Telephone: 9076 3526

For complaints:

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about being a research participant in general, then you may contact:

Name: Ms Emily Bingle
Position: Research Governance Officer,
Office of Ethics & Research Governance, The Alfred
Telephone: 9076 3619

You will need to tell Ms Bingle the following Alfred Health project number: **422/13**

Consent Form - *Adult providing own consent*

Title	Workplace, family, and social participation following acute hand injury
Protocol Number	1
Principal Investigator	Dr Lisa O'Brien
Associate Investigator(s)	Luke Robinson, A/Prof Terry Haines
Location	The Alfred

Declaration by Participant

I have read the Participant Information Sheet, or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research described in the Participant Information Sheet.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in:

- ☐ Part 1
- ☐ Part 2

of this research project as described and understand that I am free to withdraw at any time during the project without affecting my future health care.

I understand that I will be given a signed copy of this document to keep.

Name of Participant (please print)	_____
Signature	_____ Date _____

Declaration by Study Doctor/Senior Researcher[†]

I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Name of Study Doctor/ Senior Researcher [†] (please print)	_____
Signature	_____ Date _____

[†] A senior member of the research team must provide the explanation of, and information concerning, the research project.

Note: All parties signing the consent section must date their own signature

12.3 Appendix 3 – Successful competitive grant/scholarship applications



ABN 72 874 453 636
PO Box 5111
WEST BUSSELTON WA 6280
T: +61 8 9755 0416
E: info@ahta.com.au
www.ahta.com.au

Attention: Luke Robinson
luke.s.robinson@gmail.com (home)
luke.robinson@monash.edu (work)

18 November, 2017

Dear Luke,

Thank you for your application, 'Epidemiology And Costs Of Sports Related Acute Hand Injuries: A Retrospective Analysis Of Two Emergency Departments In Australia'. The research committee would like to thank you for your submission and feel that the proposed research is of high quality and clinically relevant to Hand Therapy in Australia.

We are delighted to award you up to \$7,000 from the AHTA research grant program/scholarship

We will allocate half of the funds initially and will release the second half of the funds when the project has reached its halfway point. We will need to receive a breakdown of funds used and once you are at halfway we would be really grateful if we can use your numbers achieved to project the remaining funds that will be needed. The funding will allow for 167 hours of research assistant time for your project, allowing an estimated 1002 cases to be reviewed. If you do not end up needing this many hours, we can evaluate this at the halfway stage, and allocate you with funds as appropriate to meet your needs, up to the value of \$7K.

Based on the timelines you have provided we would anticipate a progress report in February 2018 to ascertain if the project has reached the halfway point.

Please note that by accepting this grant, you are required to fulfil the obligations of an AHTA grant recipient outlined in the "Guidelines for AHTA research grant program/scholarship" document, included below:

9. OBLIGATIONS OF GRANT RECIPIENTS

(i) Payment of grants will be in two instalments. The first instalment will be paid shortly after notification of the success of the application. The second instalment will be provided upon completion of an interim progress report half way through the project timeline. At the completion of the project any unused funds must be returned to the AHTA. Equipment purchased to complete the project may be kept by the successful applicant/organisation.

(ii) Interim project report. An interim project report is required at the half way point identified in the submitted timeline. An update on the status of the project is required to determine continuation of funding (*appendix 5f).

12.4 Appendix 4 – Awards received during candidature



SPAHC 3MT People's Choice Winner 2019

IS AWARDED TO

Luke Robinson

FOR

Competing against other graduate research students in a Three Minute Thesis competition, showcasing their research and building their academic communication skills.

Tuesday 28th May 2019

School of Primary and Allied Health Care



Associate Professor Lisa OBrien
Director of Research



Professor Terry Haines
Head of School

12.5 Appendix 5 – Invited speaker invitations received during candidature



Thursday 26th July 2018

Mr Luke Robinson
Monash University
Level 4, Building G
Peninsula Campus McMahon's Road
Frankston VIC 3199

Via email: luke.robinson@monash.edu

Dear Luke,

On behalf of the 2018 Australian Hand Therapy Association (AHTA) National Conference organising committee, I am delighted to formally invite you to present at the AHTA 2018 National Conference. The conference is being held at Crown Melbourne from the 19th – 21st October 2018.

As previously discussed with the committee, we would like you to present a 25 minute presentation on Sunday 21st October 2018. Details of your presentation are as follows:

Presentation Title: Costs and epidemiology of acute hand and wrist injuries

Presentation Date: Sunday 21st October 2018

Session Time: 10.55am – 1.00pm

Presentation Time: 11:45am – 12.10pm

Room: Promenade Ballroom

In addition to your presentation, the conference committee is pleased to accept the following submissions for poster presentations:

Orthotic management of fixed flexion deformity of the proximal interphalangeal joint following traumatic injury: A systematic review

Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review

Presenters are asked to erect their posters by morning tea on the first day of the conference, Friday 19th October 2018. Poster boards will be available for use in the exhibition area, where all catering breaks will take place. Posters will be exhibited for the duration of the conference and can be collected after morning tea on Sunday 21st October 2018.

A scheduled poster session will take place on Saturday 20th October 2018, during the second half of the lunch break from 1.30 – 2.00pm. The committee has asked that poster presenters please stand next to their posters during this session to answer any questions from delegates and judges.

2018 AHTA National Conference
c/ YRD Event Management
PO Box 717,
Indooroopilly
Australia

Phone: (07) 3368 2422
Fax: (07) 3368 2433
E-Mail: ahta@yrd.com.au

Dear Luke,

As you have received from the conference secretariat of the APFSSH-APFSHT 2020, we are honoured to invite you to present an **invited presentation** at the 8APFSHT.

This is recognising your expertise in health economics within hand therapy. Given the large international audience and your free paper abstract submission, we were wondering whether you could customise a presentation to cover some of the differentials in costs for acute hand injuries? This could be Australian in context but have scope to include generalisation with the international cohort.

As you are aware, this triennial congress will be held at the Melbourne Convention Centre from the 11th - 14th of March 2020. We are working hard to showcase the diversity and talent within the Asia-Pacific region with sessions for clinical intervention, innovative research and practice management. There is no funding for presenters as the funding available is channelled into supporting attendance for surgeon and therapists from developing nations within the Asia Pacific region, as well as securing the few keynote speakers across both congresses. All sessions will be open to all attendees with 4 -5 concurrent streams between surgery and therapy occurring continuously across the four days.

The invited presentation would be 8 minutes in length (not including question time). Further details of your presentation day will be forthcoming prior to the end of the year. Additionally, you will receive an email from the conference secretariat requesting submission of an abstract purely for program printing purposes.

We trust you are happy to accept this offer and look forward to hearing your thoughts shortly.

Please don't hesitate to contact for any further information or questions:

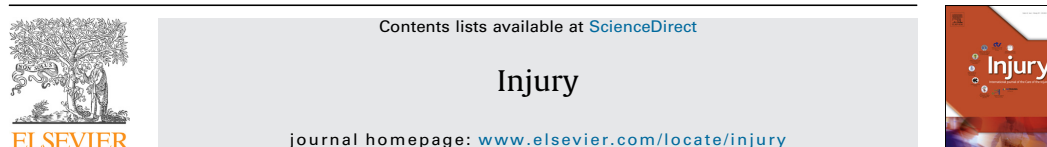
Warm Regards

Kath Dalton, on behalf of 8APFSHT scientific committee



12.6 Appendix 6 – Cover pages of peer reviewed publications arising from this thesis

Injury, Int. J. Care Injured 47 (2016) 2614–2626



Review

Direct, indirect and intangible costs of acute hand and wrist injuries: A systematic review



Luke Steven Robinson, BOccTherapy (Hons)^{a,*}, Mitchell Sarkies, BAppScPhysio^b,
Ted Brown, PhD, MSc, MPA, BScOT (Hons), GCHPE, OT(C), OTR^a,
Lisa O'Brien, PhD, B App Sc OT, M Clin Sc (Hand & Upper Limb Rehab), Grap Dip Ergo^a

^a Department of Occupational Therapy, Monash University, Melbourne, Victoria, Australia

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ARTICLE INFO

Article history:
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Keywords:
Hand injury
Wrist injury
Cost of illness
Health care costs
Efficiency
Health expenditures

ABSTRACT

Background: Injuries sustained to the hand and wrist are common, accounting for 20% of all emergency presentations. The economic burden of these injuries, comprised of direct (medical expenses incurred), indirect (value of lost productivity) and intangible costs, can be extensive and rise sharply with the increase of severity.

Objective: This paper systematically reviews cost-of-illness studies and health economic evaluations of acute hand and wrist injuries with a particular focus on direct, indirect and intangible costs. It aims to provide economic cost estimates of burden and discuss the cost components used in international literature.

Materials and methods: A search of cost-of-illness studies and health economic evaluations of acute hand and wrist injuries in various databases was conducted. Data extracted for each included study were: design, population, intervention, and estimates and measurement methodologies of direct, indirect and intangible costs. Reported costs were converted into US-dollars using historical exchange rates and then adjusted into 2015 US-dollars using an inflation calculator.

Results: The search yielded 764 studies, of which 21 met the inclusion criteria. Twelve studies were cost-of-illness studies, and seven were health economic evaluations. The methodology used to derive direct, indirect and intangible costs differed markedly across all studies. Indirect costs represented a large portion of total cost in both cost-of-illness studies [64.5% (IQR 50.75–88.25)] and health economic evaluations [68% (IQR 49.25–73.5)]. The median total cost per case of all injury types was US\$6951 (IQR \$3357–\$22,274) for cost-of-illness studies and US\$8297 (IQR \$3858–\$33,939) for health economic evaluations. Few studies reported intangible cost data associated with acute hand and wrist injuries.

Conclusions: Several studies have attempted to estimate the direct, indirect and intangible costs associated with acute hand and wrist injuries in various countries using heterogeneous methodologies. Estimates of the economic costs of different acute hand and wrist injuries varied greatly depending on the study methodology, however, by any standards, these injuries should be considered a substantial burden on the individual and society. Further research using standardised methodologies could provide guidance to relevant policy makers on how to best distribute limited resources by identifying the major disorders and exposures resulting in the largest burden.

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Contents

Introduction	2615
Cost-of-illness (COI) studies	2615

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ORIGINAL RESEARCH

Description and cost-analysis of emergency department attendances for hand and wrist injuries

Luke S ROBINSON ^{1,2} and Lisa O'BRIEN ¹¹Department of Occupational Therapy, Monash University, Melbourne, Victoria, Australia, and ²Department of Occupational Therapy, Alfred Health, Melbourne, Victoria, Australia

Abstract

Background: Injuries to the hand and wrist are estimated to account for between 10% and 30% of all ED presentations. The economic burden placed on the healthcare system can be extensive and rise sharply with increase in injury severity.

Objectives: This cost-analysis was performed with the aim of estimating the economic implications of ED attendances for hand and wrist injuries from the perspective of one Australian public health network.

Methods: Data from two EDs were retrieved from the electronic billing records of one large health network across two financial year periods (2014–2015 and 2015–2016) using ICD-10 codes. All costs that resulted from the treatment of any acute hand or wrist injury across the 2 year period were calculated and are presented by age, sex, injury type and mechanism of injury.

Results: A total of 10 024 individuals presented to the two EDs in the 2 year period, accounting for approximately 5.4% of all presentations. The most common presentations were males (62.2%), people aged 25–34 years (26.9%) and lacerations (31.2%). The total cost in the 2 year study period was \$3 959 535.38 (\$1 923 852.38 in 2014–2015; \$2 035 683.00 in 2015–2016). The mean cost per presentation was \$383 (95% CI [\$373, \$393]) in

2014–2015 and \$407 (95% CI [\$394, \$421]) in 2015–2016.

Conclusions: Acute hand and wrist injuries contribute to a significant volume of ED presentations each year in one Australian public health network leading to significant expenditure and health resources. Further research into how to best utilise resources and reduce avoidable injuries should be priority areas to reduce the cost of these injuries to the healthcare system and society.

Key words: cost-analysis, hand injury, healthcare cost, health expenditure, wrist injury.

Introduction

Injuries to the hand and wrist are common, with reports suggesting that they account for between 10% and 30% of all ED presentations,^{1–3} and typically affect young and economically productive populations.^{1,4} Although most uncomplicated injuries will recover fully, accurate assessment and treatment are vital as mismanagement can result in delayed recovery and potential long-term disability at a significant cost to the individual, healthcare system and society.^{3–7}

The administration of the Australian healthcare system is complex, involving all three levels of government in addition to other stakeholders that include private

Key findings

- Acute hand and wrist injuries contribute to a significant volume of ED presentations each year at one Australian public health network (approximately 5.4% of all ED presentations).
- They contribute significant costs (approximately \$2 million per year) at one Australian public health network.
- Further research into how to best utilise resources (e.g. advanced hand therapist practitioner) and reduce avoidable injuries should be seen as priority areas to reduce the cost of these injuries to the healthcare system and society.

and public service providers.⁸ The Australian government has a responsibility for the tax-funded universal public health insurance scheme, Medicare, which involves subsidising medical services, such as public ED funding, and providing some funding for private health networks.⁹ However, the private sector is largely funded by premiums paid by households (e.g. private health insurance or the Victorian Transport Accident Commission [TAC] levy that funds treatment for individuals with injuries because of road trauma) and employers (e.g. WorkCover insurance which provides a compensation system for individuals injured at work).

Public hospitals are funded by the state, territory and Australian governments, but are managed by state and territory governments, whereas

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Accepted 11 January 2019

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Viewpoint

Embracing an occupational perspective: Occupation-based interventions in hand therapy practice

Luke S. Robinson,¹ Ted Brown¹ and Lisa O'Brien^{1,2}

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KEY WORDS *client-centred practice, information gathering and collaborative goal setting, musculoskeletal/hand therapy, occupational performance, occupational therapy theory and models.*

Introduction

The founding philosophies of occupational therapy and the medical model have had an uneasy relationship for more than 60 years. In the late 20th century, a paradigm shift occurred within the discipline from the deeply ingrained medical model, which resulted in the creation of practice-based theories of occupation and models of occupational therapy across the globe (Townsend & Polatajko, 2013). This paradigmatic shift was a direct challenge to the previous practice models and frameworks that stemmed from level of impairment and disability rather than the client's perspective of participation in daily activities and occupations.

Although embracing theory as part of practice is important for the growth and evolution of occupational therapy, its implementation remains a challenge for many therapists. As the profession moves to reassert our philosophical foundations of the intrinsic relationship between occupation, health and wellbeing (Wilcock, 2006), should hand therapists endeavour to focus more on embracing an occupational perspective and

incorporate interventions that are grounded in the key principles of the profession?

The challenge for hand therapy: Duality of focus

Hand therapy differs from other occupational therapy specialisations because it merges occupational therapy and physiotherapy practice approaches to treatment. Despite most hand therapists having graduated with an occupational therapy degree (Dimick *et al.*, 2009) with training in the use of occupation-based interventions, clinical hand therapy practice is perceived to be closer to that of physiotherapy. This is highlighted by the focus regularly placed on exercise prescription and application of physical agent modalities in preference to a dual focus that also includes enabling clients through the use of occupation.

The hand therapy field has been inclined to follow a reductionist biomedical approach to clinical practice that focuses primarily on body structures and functions (Fitzpatrick & Presnell, 2004; Rose, Kasch, Aaron & Stegink-Jansen, 2011). The biomechanical paradigm, which is often applied in hand therapy practice, assumes that humans operate like machines, and is provider-centred and directive in nature. It utilises objective measures (such as range of motion) to quantify improvements in impairment. Such an approach sees the therapist in control of both the treatment process and also determining and defining the measures of success. As a result, the client is expected to adhere with therapist-generated instructions, and to derive satisfaction from improvement in objective measures. Consequently, successful treatment is viewed as improvement in range of motion or strength, and not achievement of client-centred goals or a successful return to meaningful occupations. In this context, the practice of hand therapy would appear not to be client-centred. Although the importance of a structure-specific approach to manage hand impairments is recognised in the early acute phases of an injury to protect healing structures, therapists must avoid neglecting the unique occupational needs of each individual by fixating on specific anatomical structures and failing to

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