# Process Matters:
# The Effects Of Process Variables On Patient Outcomes In Musculoskeletal Care Pathways

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# Abstract

In New Zealand and globally, the burden of pain, disability, and related healthcare costs due to musculoskeletal conditions is increasing. Researchers and clinicians have endeavoured to tackle this growing issue through various diagnostic and treatment-focused management strategies. Given the limited success of existing assessment and treatment methods, there has been a recent shift among clinicians, researchers and funders towards promoting value-based care for musculoskeletal conditions. This approach enhances efficiency and incentivises better patient outcomes by emphasising the importance of care processes. Consequently, value-based care presents an opportunity to investigate how individual processes experienced by patients during their rehabilitation, known as process variables, impact outcomes for musculoskeletal patients within New Zealand's care pathways. However, there appears to be limited evidence and understanding in the existing literature regarding the role of process variables and their impact on patient outcomes. To address this gap, this thesis primarily aims to investigate how process variables affect patient outcomes in musculoskeletal care pathways. A series of three studies was developed and are presented in this thesis.

In the first study, to better understand what a process variable is within a musculoskeletal care pathway, a nominal group technique (a consensus-based approach) was employed among New Zealand experts in the management of care pathways. The operational definition clarified that a process variable is a modifiable factor, within a pathway, that can be measured and when changing it may lead to different operational or patient outcomes.

In the second study, a focus group approach was used to explore patient perspectives on process variables in musculoskeletal care pathways, aiming to identify what patients consider important during their rehabilitation journey. Several process variables were identified, including the timeliness of treatment, the order of care, the coordination of care delivery, quantifying progress, equity of access, and patient navigation. Four themes emerged from the reflexive thematic analysis: 1) process matters, 2) how quantifying progress facilitates patient engagement, 3) the benefits of equitable access of care, and 4) recovery is made easier with navigation.

In the third study, an observational cohort study retrospectively examined a database of patients with musculoskeletal injuries receiving care within musculoskeletal rehabilitation care pathways. Quantile linear regressions were utilised to analyse the associations between process variables and the outcome measures reported by

patients at discharge. Significant associations with varying degrees of effect were found between process variables and patient outcomes in some surgical and non-surgical musculoskeletal care pathways.

Collectively, the findings demonstrate that process variables can significantly influence patient outcomes in musculoskeletal care pathways, both positively and negatively. Therefore, this thesis urges clinicians, funders, health system planners, researchers and educators to prioritise the identification, measurement, and utilisation of process variables within musculoskeletal care pathways to enhance patient outcomes.

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# Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements) nor used artificial intelligence tools or generative artificial intelligence tools (unless it is clearly stated, and referenced, along with the purpose of use), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Daniel Harvey 27/11/2025

# Co-Authored Works

Peer-reviewed papers from the research

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# Declaration of Collaboration

Chapter 5 includes data that was extracted collaboratively from the Careway database with Mr. Joel Collett for his Honours project. Mr Joel Collett used the same knee data as I did for his respective research question. The subsequent processing and analysis of this data were carried out independently. The agreement outlining this arrangement is provided in Appendix 8.

# Ethics Approval

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# List of Abbreviations

| | |
|---|---|
| ACC | Accident Compensation Corporation |
| ACL | Anterior cruciate ligament |
| AUTEC: | Auckland University of Technology Ethics Committee |
| CPR | Clinical prediction rules |
| EBPG | Evidence-based practice guidelines |
| ECP | Escalated care pathways |
| GP | General practitioner |
| ICP-MSK | Musculoskeletal integrated care pathways |
| MCID | Minimal clinically important difference |
| MSK | Musculoskeletal |
| QI | Quality improvement |
| RCT | Randomised controlled trial |
| RQ1 | Research question one |
| RQ2 | Research question two |
| RQ3 | Research question three |
| UK | United Kingdom |
| USA | United States of America |
| VBC | Value-based care |
| vNGT | Virtual nominal group technique |

# Chapter 1: Thesis overview

This chapter provides the relevant background to the present research. It outlines the issue of increasing disability and related healthcare costs due to musculoskeletal conditions in New Zealand and globally. The chapter then examines New Zealand's public health and health insurance systems, as well as previous approaches to managing musculoskeletal conditions. Next, there is an introduction to value-based care and the significance of process within healthcare systems. Finally, the rationale and importance of this research are explained, along with the aims of the thesis.

## 1.1 The problem - musculoskeletal pain and disability

A healthy musculoskeletal (MSK) system is vital for human function and quality of life. MSK pain and disability are leading causes of poor health and high economic costs worldwide. In 2019, the global prevalence of MSK disorders reached 1.71 billion people, and cost over $380 billion in the United States of America (USA) alone (Blyth et al., 2019; Briggs et al., 2018; Cieza et al., 2021). MSK conditions, including soft tissue injuries and chronic pain disorders, are the most significant contributors to global years lived with disability and the largest demand for lifelong rehabilitation (Nguyen et al., 2024). The prevalence and impact of MSK conditions are expected to keep rising, as most painful MSK issues are connected to ageing, the presence of non-communicable diseases (e.g., obesity, metabolic disorders), and reduced activity levels (Briggs et al., 2018; Williams et al., 2018).

In New Zealand, MSK conditions represent a significant health issue, with prevalence among the adult population ranging from 40% to 66.7% (Bossley & Miles, 2009; Taylor, 2005; Tregonning & Bossley, 2011). These conditions significantly increase healthcare costs and are estimated to account for 16.2% of the total expenditure on non-communicable diseases, as well as nearly 10% of overall health spending (Blakely et al., 2019). The New Zealand indigenous Māori population experiences a higher rate of MSK pain, increased pain-related disability, and lower quality of life compared to the non-Māori population (Antunovich et al., 2024; Bowden et al., 2025; Ingham et al., 2025). MSK conditions also affect the workforce, accounting for over 30% of the overall disability due to work-related injuries and illnesses, and result in approximately 15,000 disability-adjusted life years lost annually (WorkSafe New Zealand, 2022).

To improve patient outcomes, researchers have concentrated on enhancing diagnosis and implementing diagnosis-informed individual treatment strategies for MSK conditions (Croft, Altman, et al., 2015; Tousignant-Laflamme et al., 2017; van Smeden et al., 2021). Unfortunately, the emphasis on diagnostics, including the frequent use of low-value imaging, has probably contributed to increased resource use and costs for MSK disorders (Croft, Dinant, et al., 2015; George et al., 2020; Kjelle et al., 2024; Severijns et al., 2024). Likewise, personalised and evidence-based treatments for specific MSK conditions aimed at improving patient outcomes and reducing costs have not resulted in significant improvements in disability or overall patient health (Croft et al., 2024; Fourney et al., 2011; James et al., 2018; Mafi et al., 2013; Tousignant-Laflamme et al., 2017).

An alternative approach to enhancing patient outcomes involves investigating how clinical factors identified during assessments may predict these outcomes. Examples of clinical factors include the patient's age, specific findings of orthopaedic special tests, or symptom reproduction during clinical tests. These factors can be grouped to create clinical prediction rules (CPRs) (Childs & Cleland, 2006). Although CPRs have been successfully developed for ankle and knee fractures (Bachmann et al., 2004; Bachmann et al., 2003), few have been established for MSK pain conditions, with most only explored in preliminary studies (Cook, 2008; Stanton et al., 2010). There have been limited randomised controlled trials validating the effectiveness of CPRs, leading to criticism that they lack generalisability and do not reliably predict clinical diagnoses or outcomes (Cook, 2008; Patel et al., 2013; Tousignant-Laflamme et al., 2017).

Other clinical initiatives aimed at improving patient outcomes include adopting the biopsychosocial model and implementing evidence-based practice guidelines (EBPGs). The biopsychosocial model is one of the main frameworks for patient-centred health improvement, promoting a more holistic and contextual understanding of patients and their health status (Card, 2023; Engel, 1981). Although the biopsychosocial model is over 40 years old, the evidence supporting its effectiveness in improving outcomes for MSK pain conditions remains unconvincing when compared against certain other treatments or usual care (Booth et al., 2017; Smart, 2023).

EBPGs are systematically developed recommendations designed to optimise patient management by synthesising the best available research evidence and clinical expertise (Institute of Medicine Committee on Standards for Developing Trustworthy Clinical Practice, 2011; Veras et al., 2016). Recent concerns about the harms linked to opioid medications, along with limited evidence for the effectiveness of specific MSK surgical procedures, have shifted EBPG recommendations towards non-operative and

non-pharmaceutical management of MSK conditions (Lin et al., 2020; Zadro et al., 2019). Despite their user-friendliness, several workplace and clinician barriers hinder the integration of EBPGs into clinical practice (Fullen et al., 2023). A recent review found that very few studies demonstrate the effectiveness of implementing EBPGs in allied healthcare settings (Goorts et al., 2021).

A recent scoping review also suggests that evidence-based practice and shared decision-making can enhance patient outcomes and yield a return on investment for healthcare systems (Connor et al., 2023). In Connor's study, most evidence-based practice initiatives were situated in the USA, primarily within acute care settings (>90%). Evidence-based practices were implemented across various systems, including infectious disease (n=113), cardiac (n=72), pulmonary (n=62), MSK (n=61) and gastrointestinal/genitourinary systems (n=53). The majority of evidence-based practices included some aspect of infection prevention (n=175), followed by cardiac care (n=62), falls (n=40), and hospital-acquired pressure injuries (n=39). Rehabilitation care (n=3) had the fewest evidence-based practices implemented. Whilst the present research provides some support for evidence-based practice involving the MSK system, there is a clear need for further evaluation of the effectiveness of specific MSK EBPGs in the non-acute or MSK rehabilitation settings (Connor et al., 2023).

## 1.2 Healthcare systems in New Zealand

In New Zealand, healthcare for MSK conditions is delivered through two central systems: the universal public health system; and the Accident Compensation Corporation (ACC) services (see Figure 1). Health New Zealand is the government organisation that manages the public health system including all public hospitals, specialist services, as well as primary and community care within designated districts (Ashton & Tenbensel, 2012; Ditzel et al., 2006; Health New Zealand., 2022). The central government funds public healthcare through general taxation. It covers care for non-MSK conditions and chronic, non-accident-related MSK conditions, such as osteoarthritis and inflammatory or rheumatic diseases. Patients in New Zealand do not pay for hospital and outpatient public health services; however, there are long waiting lists for surgery, community-based MSK rehabilitation, and outpatient physiotherapy, all requiring a referral from a general practitioner (GP) (Baxter et al., 2020; Hill et al., 2023). Patients can also opt to fund their supplementary healthcare privately through private health insurance or personal funds (Bowden et al., 2025).

The ACC was established in 1974 and is a New Zealand Crown entity responsible for managing the country's accident compensation scheme. This scheme expanded on the previous national workers' compensation scheme, by also covering non-work, motor vehicle and sports-related accidents (Bismark & Paterson, 2006). A key change with the creation of the ACC was the removal of the right to pursue civil claims for damages for personal injury, making ACC the first no-fault insurance system worldwide (Rai & Devaiah, 2019). The scheme distributes the financial burden of personal injuries across the community, regardless of fault, and embodies a moral and ethical duty for the injured to access rehabilitative care (Bismark & Paterson, 2006; Rai & Devaiah, 2019; Woodhouse, 1967).

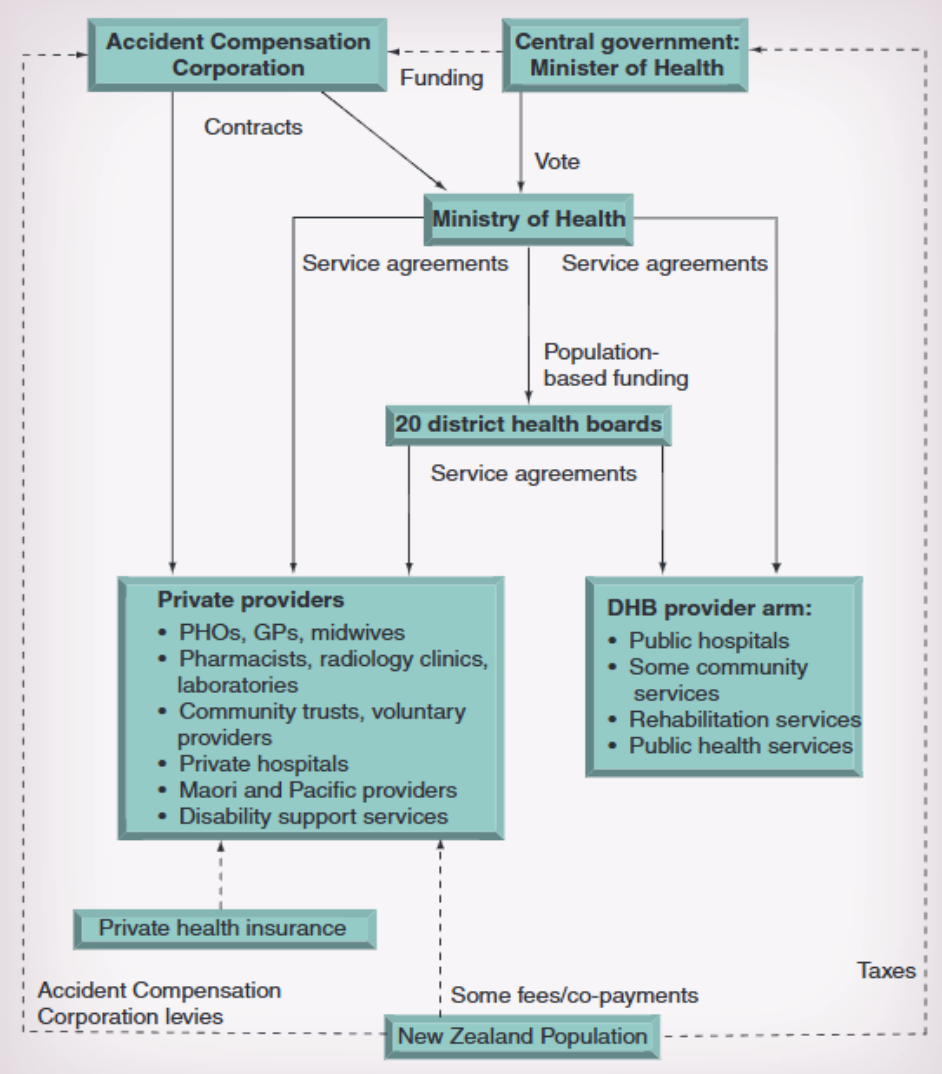


*Figure 1 Structure of the New Zealand Health and Disability System (Ashton & Tenbensel, 2012)*

### 1.2.1 Accident Compensation Corporation scheme

ACC is a 24-hour, 365-day no-fault scheme that covers everyone who is personally injured in an accident in New Zealand, including overseas visitors, children, beneficiaries, students, unemployed people, and retired people (Accident Compensation Corporation, 2022a). An accident by definition is a “specific event or a series of events, that involves the application of a force (including gravity), or resistance, external to the human body; or involves the sudden movement or twisting of the body to avoid a force (including gravity), or resistance, external to the body” (Accident Compensation Act, 2001, pp. Section 25, part A, i-iii). The scheme also covers gradual process work injuries, serious injuries and disabilities, mental injuries resulting from a physical injury, sexual abuse, dental injuries, injuries that cause death, and (following legislative changes in 2005) injuries resulting from medical and healthcare treatment (Accident Compensation Corporation, 2022a; Bismark & Paterson, 2006). The ACC scheme is funded through general government taxation, together with an employer and earner’s levy. The earner’s levy is a flat rate and is currently set at $1.67 per $100 of the earner’s taxable income (see Figure 2).

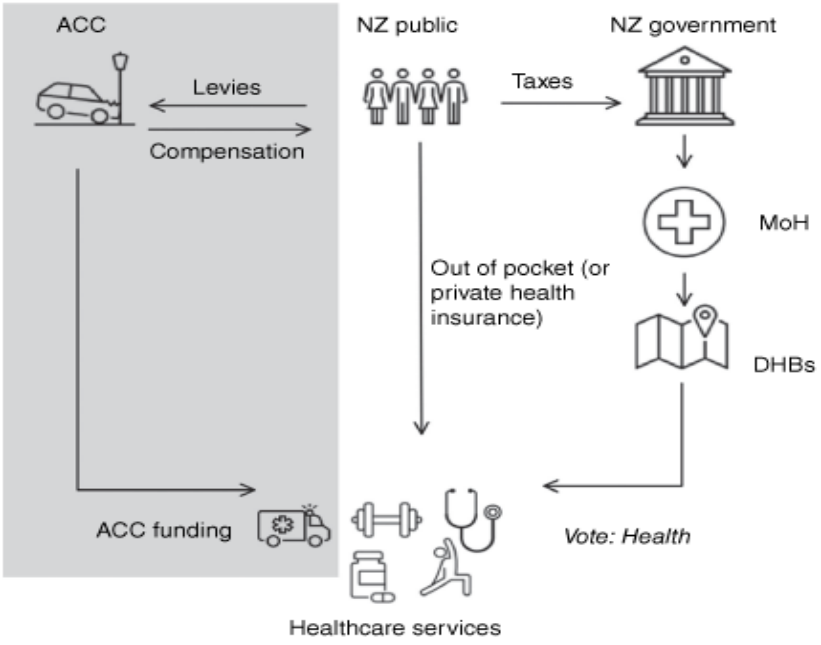


*Figure 2 The Accident Compensation Corporation system within the New Zealand healthcare structure (Hill et al., 2023)*

The fixed award schedule guarantees that ACC claimants with comparable disabilities receive uniform compensation. Entitlements cover treatment and rehabilitation costs,

pharmaceuticals, disability aids, childcare, home modifications, transport costs, and vocational retraining. ACC claimants can claim compensation for lost earnings, including weekly compensation of 80% of the claimant's earnings at the time of injury, up to a set maximum. Claimants are entitled to lump-sum compensation—a one-off payment of up to NZ$100,000 – to compensate for permanent impairment resulting from a personal injury, alongside any other ACC entitlements. Finally, in the case of accidental death, claimants receive support for dependents in the form of a funeral grant and a survivor's grant paid to surviving spouses and children under age 18 (Accident Compensation Corporation, 2021a, 2021b, 2022c, 2022d; Bismark & Paterson, 2006). The ACC scheme's administrative costs are low (<10%), and the process of making an ACC claim and having it accepted is seamless compared to other insurance schemes worldwide (Bismark & Paterson, 2006).

The ACC insurance scheme funds workers' compensation and treatment costs for most accident-related MSK conditions in New Zealand. Analysing ACC claim data of tendon and ligament injuries from 2010 to 2016, it was found that knee and shoulder tendon and ligament injury claims were the most common and costly sites of injury (Clark et al., 2020). During this period, there were over 281,000 knee and 371,000 shoulder injury claims in a country with fewer than 5 million people, resulting in costs of $423 million and $569 million, respectively. Treatment costs increased by 28% for knee and by 36% for shoulder conditions over those six years. Low back pain in New Zealand is another costly MSK condition. In 2012-13, a total of $326.8 million was spent, with 34% of costs through ACC and 66% through the public health system. However, these low back pain cost estimates (from 10 years ago) do not include indirect costs, such as loss of income and productivity, which were estimated to be significantly higher, at approximately $2.6 billion per year (Baxter et al., 2020; National Health Committee, 2015).

Despite this high expenditure on rehabilitation, levels of MSK pain and disability among New Zealanders do not seem to be decreasing. The prevalence of chronic pain and disability in New Zealand continues to increase, with one in five adults and high school students currently reporting a persistent pain condition, many of which are MSK conditions (Farrant et al., 2023; Ministry of Health, 2021; Moore & Davies, 2018). This rate has increased from one in six (16.9 %) adults reporting chronic pain in 2011 (Dominick et al., 2011).

### 1.2.2 Current Accident Compensation Corporation management of musculoskeletal injuries

Currently, ACC claimants often encounter a fragmented system of care after their injury. They can directly access assessment, treatment, and rehabilitation via their GPs and various ACC private treatment providers (physiotherapists, osteopaths, chiropractors, and others). However, treatment providers frequently operate independently, leading to poorly coordinated care (Accident Compensation Corporation, 2009, 2019). Private ACC providers, working in the private healthcare sector, often charge a co-payment for consultations on top of the ACC-funded component of the care, and meeting those additional costs for treatment can be a barrier to people accessing care for MSK injuries (Baxter et al., 2020; Reid et al., 2021) (see Figure 2).

ACC funds healthcare services for accepted claims for MSK conditions through both public and private healthcare systems (see Figures 1 & 2). The ACC finances service agreement contracts with Health New Zealand to deliver care in specific district hospitals and outpatient settings for eligible ACC patients. Additionally, ACC has service agreement contracts with private healthcare providers to deliver fully funded, specialised social, vocational and pain management rehabilitation services in the primary care and community rehabilitation settings (Accident Compensation Corporation, 2025a, 2025b).

Equity in the access to care for people with MSK injuries, and in particular for indigenous Māori, has been a priority for New Zealand governments over the past two decades (King, 2001; Reid & Larmer, 2007). Māori people have, on average, lower incomes and life expectancy, along with poorer educational and health outcomes, and face barriers to accessing healthcare compared to non-Māori people (Ajwani et al., 2003; Bowden et al., 2025; Ingham et al., 2025). One of ACC's strategic goals is to improve the outcomes for Māori claimants and ensure they have access to culturally and clinically appropriate healthcare (Accident Compensation Corporation, 2022e, 2025d). Currently, Māori represent 24% of all active serious ACC claim injuries despite representing only 16% of the general population. A recent large cross-sectional survey of Māori found that 32.6% were unable to contact a GP due to cost. Socioeconomic challenges were prevalent, with nearly a quarter reporting they borrowed from family or friends to meet daily living costs, and over a third economised on fresh food produce to save money (Ingham et al., 2025). It has been found that Māori are also underrepresented in lodging ACC claims relative to their proportion of the population (Accident Compensation Corporation, 2022e).

In summary, the healthcare costs and ACC claims data of MSK conditions continue to grow, especially for shoulder, knee, and lower back injuries in New Zealand. There is an urgent need for culturally responsive, coordinated and targeted healthcare systems to reduce the incidence and improve the clinical outcomes of MSK injuries (Accident Compensation Corporation, 2019, 2022e; Baxter et al., 2020; Clark et al., 2020; Reid et al., 2021).

### 1.2.3 Value-based care

Due to the apparent limited effectiveness of MSK assessment and management approaches, there has been a recent shift among insurers and researchers toward incentivising value-based care (VBC) for MSK conditions. VBC enhances efficiencies and provides incentives for improving patient outcomes by focusing on the value of the care provided rather than the volume of services (Cook et al., 2021; Lentz et al., 2020; Traeger et al., 2019). VBC encompasses care that is patient-centred and guideline-concordant, considers patient perspectives, and routinely captures patient outcome measures (Cook et al., 2021). VBC considers the timing of care, mode of access, and order of treatment, as well as ensuring unwanted care escalation or unnecessary imaging or treatment interventions (Gleadhill et al., 2023; Lentz et al., 2020). This focus on VBC has emerged intuitively, without research, through a lens of reimagining what best-practice care should look like for the patient. It could be argued that the shift toward VBC is an attempt to improve processes so that each patient receives the relevant care at the right time, by the right provider (Cook et al., 2021; Health Foundation, 2013). However, healthcare systems are often not designed to support this value-based approach to MSK care, facing numerous barriers, including the lack of time for consultations, workforce pressures, funding constraints, and the incentivised fee-for-service model (Traeger et al., 2019). Despite this growing interest in VBC, there appears to be a lack of research investigating a process-oriented approach in the MSK healthcare field (Connor et al., 2023; Goorts et al., 2021).

### 1.2.4 Escalated Care Pathways

In response to the increasing surgical and rehabilitation costs associated with ACC shoulder, knee and low back injuries, along with the inequity of access to healthcare for Māori claimants, ACC instigated its first VBC pilot for MSK conditions, the Escalated Care Pathways (ECP), in 2019 (Accident Compensation Corporation, 2019, 2022g).

ECP is an ACC programme where treatment providers were invited to design and implement innovative care pathways to manage specific MSK conditions and improve access to care (Accident Compensation Corporation, 2019). ACC's goal is that each ECP patient will experience more timely access to surgery and rehabilitation, as appropriate to each individual, with a coordinated wraparound service that meets all their recovery needs and reduces the risk of re-injury (Accident Compensation Corporation, 2019) (see Figure 3). This includes an interdisciplinary team of physiotherapists, orthopaedic surgeons and allied health professionals assessing and working with the patient to achieve an effective rehabilitation outcome.

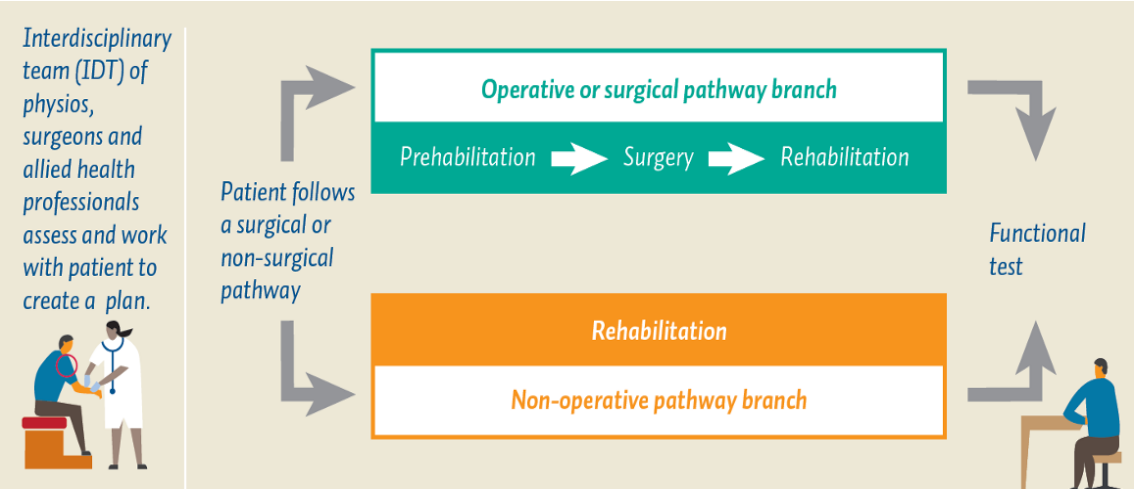


*Figure 3 Core elements of an Escalated Care Pathway (Accident Compensation Corporation, 2023)*

The origins of the ECP can be traced back to 2015 when ACC engaged the health sector on the Elective Services Pathways Programme (ESPP). This ESSP was not approved for delivery; therefore, ACC partnered with a treatment provider group in Christchurch, New Zealand, in 2017 to test an interdisciplinary pathway approach for treating Anterior Cruciate Ligament (ACL) ruptures. The success of the trial paved the way for ACC to re-engage with the market to co-design and test an interdisciplinary pathway for patients with moderately complex knee, shoulder, and lower back injuries (Accident Compensation Corporation, 2023).

One example of an ECP is Careway, a consortium that delivers surgical and non-operative care pathways across the Auckland and Northland regions of the upper North Island, New Zealand (Accident Compensation Corporation, 2019; Reid et al., 2021). In Careway, patients follow an integrated, personalised, and coordinated plan that moves

them smoothly from injury to recovery, with the intent of providing ‘the right treatment at the right time’ (Accident Compensation Corporation, 2019; Reid et al., 2021). Patients must meet an exit criterion of a limb symmetry index of ≥90% on strength testing compared to the uninjured limb; a minimal clinically important difference in patient-reported outcome measures; returning to work; and reaching functional independence. ACC describes this ECP pilot as a substantial improvement over the previous fragmented ACC business-as-usual system, characterised by long delays and a lack of collaboration among treatment providers (Accident Compensation Corporation, 2022g).

## 1.3 Process in healthcare

Process is the sum of all actions that make up healthcare. Processes have previously been classified into two categories: technical processes, which refer to how care is delivered; and interpersonal processes, which include the manner in which care is delivered (Donabedian, 1980; Donabedian, 1988). Donabedian is regarded as the foremost author on process in healthcare and designed a framework model to evaluate the quality of care within a healthcare system by examining the three categories of structure, process, and outcomes (Donabedian, 1988). Donabedian believed that within healthcare systems, all three categories are closely interconnected, with structure influencing process, which in turn impacts outcomes (Donabedian, 1988, 2005). There is some agreement among authors that for a healthcare system or care pathway to achieve effective patient outcomes, it is necessary to have processes in place that facilitate the movement of patients in a timely and well-organised manner (Health Foundation, 2013; Kreindler, 2017; Showell et al., 2012). Donabedian opined that measuring process is critical, as it encompasses all individual aspects of healthcare delivery and reflects the overall quality of care in the healthcare system (Donabedian, 1988, 2005). What is unclear, however, is whether pertinent individual variables within the healthcare delivery process can be both identified and measured, and what influence they may have on patient outcomes. Hence, the ECP offers an opportunity to investigate how individual processes, henceforth referred to as process variables, impact MSK patient outcomes in New Zealand care pathways.

## 1.4 The rationale and significance of the present research

The burden of MSK pain and disability continues to increase in New Zealand and worldwide, despite efforts from researchers, funders, and clinicians. The growing body

of research highlights the importance of process in healthcare outcomes. Although there is interest in and recognition of the significance of process, there is no explicit agreement on how a process variable is defined in the literature. Moreover, it has not been sufficiently studied to determine whether process variables can impact outcomes for individual patients with specific MSK conditions. With respect to modifiable process variables, gaining a clearer understanding of how these variables relate to patient outcomes will help guide future decisions about the design and implementation of healthcare pathways for patients with MSK conditions.

## 1.5 The aim and research questions of the research

The overall objective of this research was to explore whether process variables in healthcare systems or MSK care pathways influence patient outcomes. To achieve this aim, the following research questions were considered and addressed:

1) What is the operational definition of a process variable within a healthcare system or MSK care pathway?
2) What process variables do patients consider ‘matter’ or ‘are important’ in their MSK rehabilitation journey?
3) Do process variables influence patient outcomes in ACC ECP (Careway) MSK care pathways?

## 1.6 Thesis outline

This thesis comprises six chapters that describe the three studies undertaken to answer the research questions outlined above (see Figure 4). The specific aims of each chapter are detailed below.


*Figure 4 Graphical overview of the research studies included in the thesis*

Chapter 1 explains the problem, provides context for the research, and outlines the increasing burden of MSK pain and disability. It describes the unique New Zealand healthcare system, including the public sector and ACC's roles in managing MSK conditions. The chapter details the current ACC standard care for MSK injuries and introduces VBC. It also covers the ACC ECP for targeted MSK conditions and summarises the healthcare process.

Chapter 2 offers a narrative review of process variables in business and healthcare settings. It discusses the theoretical basis for process variables in healthcare, reviews industrial processes and research on quality improvement, and concludes with an examination of how these variables impact MSK patients, supported by evidence.

Chapter 3 describes the findings from a New Zealand nominal group technique study used to reach a consensus on a process variable and addresses research question one (RQ1): What is the operational definition of a process variable within a healthcare system or MSK care pathway?

Chapter 4 outlines the findings of a qualitative research study exploring patient perspectives on process variables in MSK care pathways in New Zealand. It addresses research question two (RQ2): What process variables do patients consider ‘matter’ or ‘are important’ in their MSK rehabilitation journey?

Chapter 5 addresses research question three (RQ3): Do process variables influence patient outcomes in MSK care pathways? It outlines a quantitative retrospective cohort observational study examining the links between process variables and patient outcomes in New Zealand MSK care pathways.

The final Chapter 6 of this thesis offers an overview and discussion of the key findings. It also explores the research's implications, including its strengths and limitations, and suggests directions for future research related to this work.

# Chapter 2: A review of process variables

This thesis aims to explore whether process variables in healthcare systems or MSK care pathways influence patient outcomes. A preliminary scoping review of the literature revealed a lack of empirical studies that specifically examined the effects of process variables on patient outcomes. Hence, a systematic approach was used to gain insight into the research topic, and studies were included if they reported research findings (both primary studies and systematic reviews) investigating the impact of process variables on MSK patient outcomes.

The search terms ‘healthcare’ AND ’process variables‘ AND ‘patient outcomes’ AND ‘musculoskeletal’ were used to identify potentially relevant articles. Articles were included if they were available in English and specifically examined the effects of process variables on MSK patient outcomes between January 2010 and July 2025. The databases MEDLINE (via EBSCO), CINAHL Complete (via EBSCO), and Scopus were selected, resulting in 89 articles identified through the literature search. Eight duplicate citations were removed from the search results. The remaining 81 titles and abstracts were screened by the primary researcher for relevance to the inclusion criteria.

This search did not find any studies that had examined how process variables affect MSK patient outcomes. However, it identified research that provided some understanding of the process within the healthcare system, albeit with a lack of clarity regarding the process variables themselves. Therefore, a narrative review guided by an interpretivist theoretical framework was chosen to explore process variables in-depth (Ferrari, 2015; McGrath et al., 2021).

The narrative review starts by outlining the theoretical understanding of process variables, initially exploring processes in the industrial manufacturing sector and their relevance to healthcare. The manufacturing industry is seen as the origin of research into process versus outcomes, owing to its characteristics of systematic process analysis, measurable outputs, and efficiency and effectiveness (Castro & Faria Araújo, 2020). The review examines research on quality improvement in the health sector. Key papers and their reference lists were searched to identify and critically analyse the fundamental theoretical foundations of process variables in health care. Finally, the review assessed how potential process variables may influence MSK patients.

## 2.1 Learnings and research from the industrial sector

Over the past century, revolutionary thinking about industrial processes has significantly improved the quality and efficiency of manufacturing industrial products (Castro & Faria Araújo, 2020; Smith, 2001; Young et al., 2004). Over the past two decades, considerable interest has arisen in these processes from the industrial and manufacturing sectors, as well as in their potential applications in healthcare settings. From a business standpoint, an industrial manufacturing organisation aims to boost productivity through system simplification and continual improvement (Li & Carayon, 2021; Singh & Singh, 2009). It has been suggested that applying lessons from the industrial sector to healthcare systems has the potential to improve processes, control quality of care delivery, reduce waiting times, and enhance the working environment – all leading to better patient care and outcomes (Sikka et al., 2015; Young et al., 2004).

There are many established industrial processes and business management frameworks. One that has been applied to many popular topics in healthcare economics is ‘lean thinking’. Lean thinking was developed and implemented by the Toyota company in Japan in the 1950s to manufacture large volumes of high-quality motor vehicles in a safe and timely manner (NEJM Catalyst, 2018). Lean thinking focuses on meeting a customer’s needs productively while minimising waste and flow obstruction (Womack & Jones, 1996; Young et al., 2004). The healthcare sector faces similar organisational challenges, including patient volume, timeliness, safety, and quality of care, making lean thinking a popular approach in redesigning complex health systems (Ben-Tovim et al., 2008; NEJM Catalyst, 2018). Examples of potential improvements after applying lean thinking to healthcare include the reduction in clinical delays, minimising repeated clinical encounters, decreasing errors by health professionals or administrators, and eliminating inappropriate medical or health procedures (Young et al., 2004).

Six Sigma is a widely used industrial process developed by Motorola in the late 1970s to enhance quality and performance. The term ‘sigma’ refers to the statistical standard deviation from the mean in a normal distribution, serving as a system to assess quality and generate measurable results (Young et al., 2004). Six Sigma aims to identify and eliminate sources of errors within a system. For it to be effective, accurate data, clearly defined goals, and consensus on what constitutes a defect are essential (Liberatore, 2013; Young et al., 2004). In healthcare, implementing Six Sigma would require robust information technology processes to measure and monitor ongoing improvement efforts (Burton, 2016). Without digital health data within healthcare pathways, Six Sigma might only be practical in settings with high and standardised throughput, like

computer-generated prescriptions (Young et al., 2004). Its limited adoption in healthcare is partly due to the considerable time, costs and training needed for implementation. It has been suggested that Six Sigma may be better suited for whole-system improvements and redesigns rather than targeting individual process variables (Benedetto, 2003).

Another industrial process method is called Kaizen, a Japanese term that signifies continual improvement, derived from the words ‘kai’ (change) and ‘zen’ (for the better). It aims to implement standardised and efficient operations by eliminating waste, compartmentalisation and self-importance (Abuzied, 2022; Chotaliya & Mehta, 2022; Singh & Singh, 2009). A research study employed a qualitative analysis of Swedish hospital employees' suggestions for system improvement to perceived problems using the Kaizen approach (Mazzocato et al., 2016). The authors used content analysis to categorise the suggestions into the following categories: type of situation (proactive or reactive) triggering an action; type of process addressed (technical/administrative, support and clinical); complexity level (simple or complex); and type of outcomes aimed for (operational or sociotechnical). Compliance with the Kaizen template was calculated, and the results demonstrated that 72% of the improvement suggestions were reactions to a perceived problem. Most of the Kaizen documents addressed simple situations and focused on operational outcomes (Mazzocato et al., 2016). The authors concluded that clinicians have an opportunity to fully understand and implement Kaizen practices to innovate and overcome complex clinical care processes.

An example of a well-established industrial process regularly used in healthcare is the Theory of Constraints. This theory states that all systems have blockages or barriers and that the more complex a system or production line, the more likely a bottleneck will occur (Bacelar-Silva et al., 2022; Young et al., 2004). In the healthcare sector, bottlenecks frequently occur in the emergency department and orthopaedic and surgical pathways, where large numbers of complex patients present and often exceed system capacity (Ben-Tovim et al., 2008; Health Foundation, 2013). According to the Theory of Constraints, identifying and addressing major roadblocks is essential to improving patient flow through a system. Process changes targeting non-constraint steps may not enhance the efficiency of a system as a whole and can only advance patients more quickly to encounter the same bottleneck further along in the recovery pathway (Kreindler, 2017; Showell et al., 2012).

Several methods for improving processes in the industrial sector can be adapted to enhance quality and outputs in the healthcare sector. The following section discusses the application of quality improvement in healthcare.

## 2.2 Research on quality improvement in the healthcare sector

In healthcare, the term ‘flow’ describes the movement of patients across staff, departments and organisations along a care pathway. Flow is not about the ’what‘ of clinical care decisions but about the ‘how’, ‘where’, ‘when’ and ‘who’ of delivering care. It has been argued that improving patient flow requires a whole-systems approach, aligning a target population with appropriate healthcare capacity through a process free of constraints (Kreindler, 2017). It is also suggested that focusing on a patient’s journey across the entire care continuum enables organisations to move beyond fragmented process initiatives towards a more comprehensive approach to identifying constraints and managing patient flow (Health Foundation, 2013; James & Savitz, 2011; Kreindler, 2017).

Healthcare systems are complex, and redesigns often generate high political expectations as well as high costs (Locock, 2003). The previously described industrial process methodologies emphasise the concept of a system as a multifaceted interaction of individual processes (Health Foundation, 2013; Kreindler, 2017; Li & Carayon, 2021; Singh & Singh, 2009; Young et al., 2004). The goal for any system using a continuous improvement approach is to eliminate unnecessary process variations and processes that don’t add value (Kaplan & Porter, 2011; NEJM Catalyst, 2018). For a healthcare system to be timely, efficient, and effective for the patient, it is necessary to have processes in place that are measurable and facilitate the flow of patients through identified bottlenecks (Health Foundation, 2013; Kreindler, 2017; Showell et al., 2012; Young et al., 2004). Achieving this requires a coherent system-level strategic approach and the participation and contribution from all users of the system, including patients, clinicians, managers, funders, and other key stakeholders (James & Savitz, 2011; Kreindler, 2017; Young et al., 2004).

Over the past 20 years, there has been considerable interest in applying business process or quality improvement (QI) methodologies to health care to deliver high-quality care at a lower cost (Boak et al., 2017). These various QI approaches aim to improve processes, boost efficiencies, and reduce waste and costs (Institute of Medicine (USA) Committee on Quality of Health Care in America, 2001). Healthcare organisations have traditionally struggled to implement business operational management strategies to meet the ever-growing patient health care needs and requirements (Zanotto et al., 2021). QI has been described as a naturally preventative strategy, which achieves most of its cost savings by improving care at the front end,

thereby avoiding downstream failures and their associated cost blowouts (Connor et al., 2023; James & Savitz, 2011). Theoretically, QI methodologies are thought to improve the processes of care and patient experiences within a health system or care pathway by influencing process variables. While a QI process can bring about opportunities for system-wide efficiency and productivity, it can be a labour-intensive, time-consuming and costly process for a particular healthcare organisation (Young et al., 2004).

A systematic review was conducted by Nicolay et al. (2012) to identify and assess the application and effectiveness of various QI methodologies in the field of surgery. The search yielded 1,595 articles, with 34 articles meeting the inclusion criteria after consensus from two independent investigators. Of the 34 studies, nine studies described continuous quality improvement strategies, five using Six Sigma, five employing total quality management (TQM), five utilising plan-do-study-act (PDSA) or plan-do-check-act (PDCA) cycles, five applying statistical process control (SPC) or statistical quality control (SQC), four adopting lean thinking, and one using Six Sigma. The researchers found that 20 of the studies were undertaken in the USA. The most common aims of the QI initiatives were to reduce complications or improve outcomes (n=11), decrease infections (n=7), and minimise theatre delays (n=7). Only one randomised controlled trial was identified. The authors reported that QI methodologies from the manufacturing industry can significantly improve surgical care, such as reducing infection rates and increasing operating room efficiency. However, they concluded that the evidence from the review was of suboptimal quality, and that rigorous randomised multicentre studies were needed to establish more substantial evidence for QI approaches in surgery and other healthcare areas (Nicolay et al., 2012).

A recent study by Wyles et al. (2021) aimed to enhance institutional value-based patient care processes, improve provider collaboration, and establish continuous process improvement mechanisms for primary total hip arthroplasties (THA) and total knee arthroplasties (TKA) by creating a perioperative orthopaedic surgical home within a USA healthcare system (Wyles et al., 2021). A multidisciplinary team was tasked with applying lean thinking methodology to identify inefficiencies and care gaps in managing THA and TKA over 12 months, and to implement solutions for these issues and potential process enhancements. During the pre-operative phase, 17 innovations were introduced, including the elimination of unnecessary testing and standardisation of care delivery. In the intraoperative phase, 19 innovations were adopted, including standardising care and reducing unnecessary radiological and narcotic use. Post-

operatively, 12 innovations were implemented, including same-day physiotherapy for all patients and optimising post-operative pain management protocols. The results were notable, with the average hospital length of stay decreasing from 2.7 to 2.2 days ($P < .001$), and the proportion of patients discharged to a skilled nursing facility dropping from 24% to 17% ($P = .008$). The number of patients receiving physiotherapy on the day of surgery increased from 10% to 100% ($P < .001$). Additionally, the annual volume of THA and TKA surgeries grew by 11.4%. The reductions in hospital stay and the surge in surgical volume generated combined yearly savings of $2.5 million across the nine participating orthopaedic surgeons (Wyles et al., 2021).

In a recent systematic review, the outcomes of managing healthcare services using the theory of constraints (TOC) were analysed (Bacelar-Silva et al., 2022). The authors aimed to provide an overview of TOC implementations in healthcare services and their effects. The review aimed to address five key questions:

- What are the outcomes of applying TOC in healthcare services?
- How widespread is TOC in healthcare so far (e.g., primary care or hospitals, public or private practice)?
- Are there common problems – also known as undesirable effects (UDEs) in TOC application– faced by healthcare services?
- Has TOC been able to address all of them?
- What methods and tools are commonly used to apply TOC in healthcare services?

The authors identified 42 TOC implementations (cases), all of which reportedly resulted in positive outcomes, both tangible and intangible. Most cases occurred in hospital settings, primarily in Emergency and Orthopaedic departments, with 28 of 42 cases occurring in the USA or the United Kingdom (UK). The two main improvements were in productivity (98%; n=41) in the timeliness of care (83%; n=35), with significant improvements observed in mean patient waiting times (50%), reduced patient length of stay (38%), improved operating room productivity (43%), and increased mean throughput (34%). Other positive results from the TOC cases included enhancements in quality of care (48%; n=20), financial outcomes for funders (29%; n=12), and staff satisfaction (29%; n=12). According to the findings, a typical TOC implementation in healthcare occurred in the Accident and Emergency department of a UK public hospital. The most common problems affecting healthcare services involved in this systematic review were insufficient productivity (31%; n=9), inadequate timeliness of care (21%; n=6), financial issues (21%; n=6), and quality of care concerns (18%; n=5). The most frequently reported method was the Five Focusing Steps (5FS), accounting

for 76% of implementations (n = 32). The authors noted that most TOC recommendations and changes showed almost immediate results and required little to no additional cost to implement. This evidence supports TOC as a practical, solution-focused approach for enhancing quality and efficiency in healthcare delivery; however, further research is needed in the MSK field (Bacelar-Silva et al., 2022).

## 2.3 Process variables in the health sector

A clear definition of what constitutes a process variable in the health sector has not previously been established. Some authors described process variables as factors within a health system that precede the assignment of a treatment and therefore have the potential to influence or affect the patient outcome by interacting with the treatment variable (Baron & Kenny, 1986; Morse et al., 1994). However, this description has not been widely adopted or agreed upon. Nonetheless, it appears that there is some agreement that process variables play a significant role in healthcare systems and may influence outcomes (Mainz, 2003; Morse et al., 1994; Oostendorp et al., 2020).

Whilst the influence of a process variable within an MSK care pathway is likely affected by the healthcare setting, the patient context, and other environmental confounding variables, there seems to be general agreement that a process variable is separate from the structural factors of a healthcare system, including the physical facilities and organisational management systems (Cook et al., 2023; Jesus & Hoenig, 2015; Skivington et al., 2021) (see Figure 5).

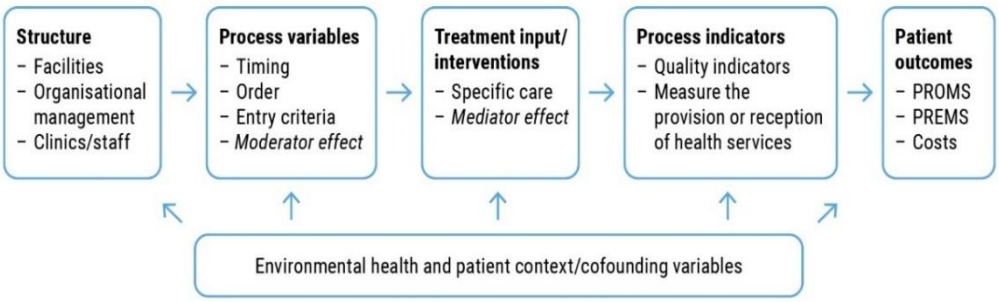


*Figure 5 Process variables within a musculoskeletal healthcare system (Adapted from Donabedian, 2005, and Jesus & Hoenig, 2015)*

As shown in Figure 5, a process variable could include the timing, the order of care received, or the entry criteria for patients entering the healthcare pathway. A process variable may precede the specific treatment or management delivered to the patient. Process indicators are used to measure the provision or receipt of health services, such as the number of physiotherapy sessions received, the cost of treatment, and the duration of care delivery (Sand-Svartrud et al., 2022). A process indicator does not directly influence patient outcomes but instead acts as a measure of the quality of the health services provided within that healthcare pathway. Patient-reported outcome measures (PROMs) and patient-reported experience measures (PREMs) quantify patient outcomes and experiences and are considered measures of patient outcomes following treatment (Jesus & Hoenig, 2015; Sand-Svartrud et al., 2022).

In theory, a process variable in a care pathway can act as a moderator (see Figure 6) and influence an outcome (Baron & Kenny, 1986; Fairchild & MacKinnon, 2009). Moderator variables affect the strength and/or direction of the relationship between a predictor and an outcome by enhancing, reducing or changing the influence of the predictor (Fairchild & MacKinnon, 2009). While process variables have the potential to alter the patient's trajectory, they are separate from a treatment input or specific care intervention that may indeed have a mediating effect on patient outcomes (Baron & Kenny, 1986; Fairchild & MacKinnon, 2009; Hancock & Kent, 2022; Wu & Zumbo, 2008).

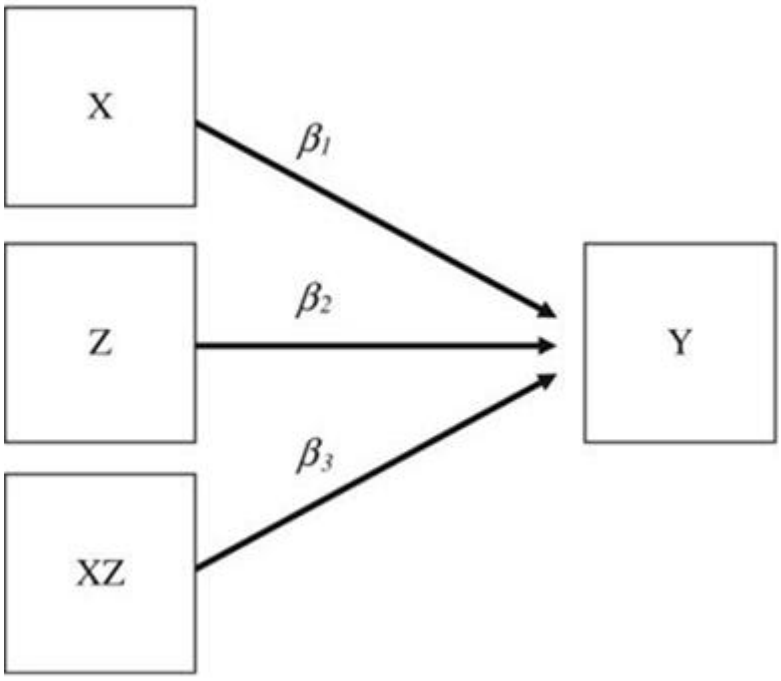

*Figure 6 Conceptual path diagram for the moderation effect (Fairchild & MacKinnon, 2009)*

*β1* = effect of X (independent variable) on Y (dependent variable)

In contrast, a mediator (see Figure 7) is a causal model that explains the ‘why‘ and ’how‘ a cause-and-effect relationship occurs between two variables (Baron & Kenny, 1986; Wu & Zumbo, 2008). An example is how a treatment intervention for a patient in a care pathway results in an immediate improvement in a physical impairment, as measured by a joint range of motion.

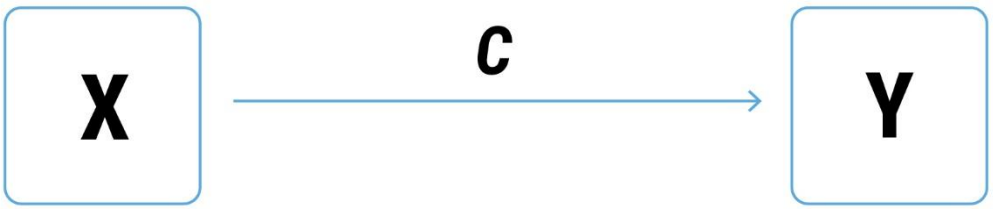


*Figure 7 Conceptual path diagram for the mediation effect (Wu & Zumbo, 2008)*

c = causal effect of X (independent variable) on Y (dependent variable)

Conceptually, a process variable serves as a moderator. When describing its effect, one can plot its influence on a path analysis, with each process variable moderating the patient’s care pathway toward their recovery and desired outcome (Lleras, 2005). Paths are not linear; therefore, an alluvial plot (see Figure 8) may better reflect the role and function of a process variable. An alluvial plot was initially developed to map and represent changes in network structure over time. It consists of horizontal axes representing different categorical variables, with stacked bars representing the values of each variable (Rosvall & Bergstrom, 2010). In healthcare, an alluvial plot functions as a flow chart that represents patterns, trends and significant changes in the categorical health data of a person within a system over time (Munévar, 2021). For example, suppose a patient encounters a specific type of treatment delay (such as a ‘mild’ or ‘moderate’ delay) in accessing treatment (left side of Figure 8). This delay influences their trajectory toward a specific path or outcome (on the right side of Figure

8). Theoretically, this effect cannot be reversed (Munévar, 2021; Rosvall & Bergstrom, 2010).


*Figure 8 Conceptual path diagram for a process variable moderator* (delay in treatment*) (Adapted from Munévar, 2021)*

Some authors have considered the role of process variables in managing health conditions and attempted to design care pathways that incorporate identified process variables, which have been demonstrated or considered likely to improve patient outcomes. One example of a proposed health care model with clearly embedded process variables is the post-acute (PAC) rehabilitation quality framework (Jesus & Hoenig, 2015). This framework aims to enhance the quality of care that acute rehabilitation patients receive following a stroke by employing an evidence-based care approach while acknowledging the importance of the relationships among structure, process, and outcomes. Jesus and Hoenig (2015) considered five patient care processes in their framework: guidelines, individualisation, amount and timing, coordination of care, and specific interventions (see Figure 9). The framework provides a conceptual model of how different patient care processes interact with structure,

environmental context, patients' values, and outcomes, within a healthcare system (Donabedian, 2005; Jesus & Hoenig, 2015).

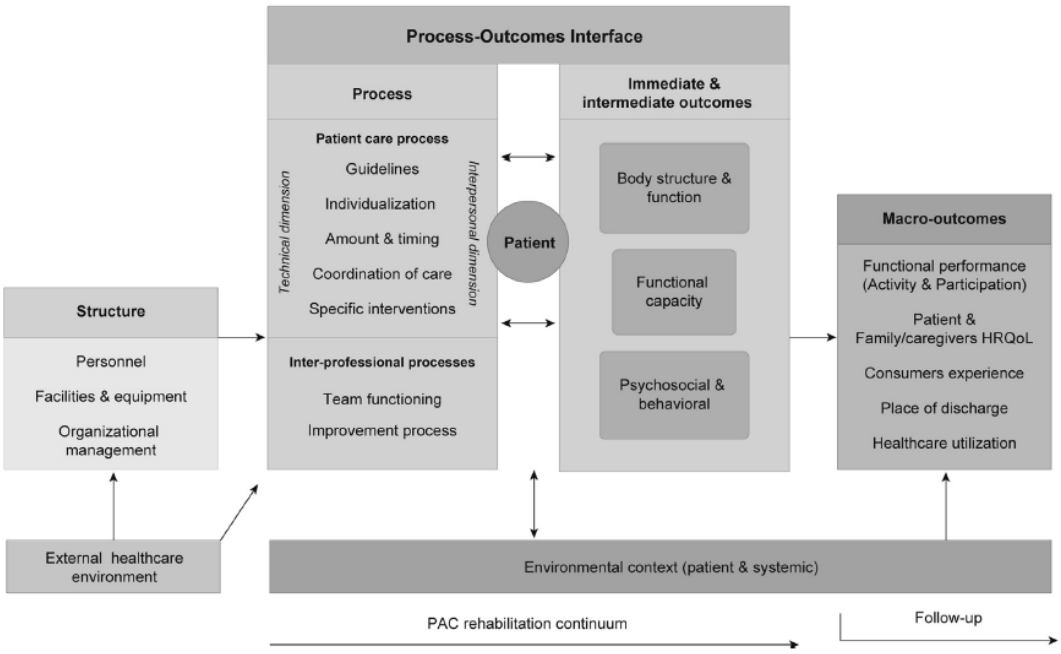


*Figure 9 Post-acute rehabilitation quality framework (Jesus & Hoenig, 2015)*

Many of the process variables considered in the PAC-rehabilitation model are also relevant to the MSK field. For example, several evidence-based practice guidelines (EBPG) for the management and care of patients with MSK problems have been developed and published (Accident Compensation Corporation, 2004a, 2004b; Fullen et al., 2023; Lin et al., 2020). Such EBPGs have been proposed as the panacea for the growing burden of MSK conditions; however, implementing EBPGs within care pathways is acknowledged as challenging (Childs et al., 2015; Fourney et al., 2011; Koes et al., 2010). The realisation of EBPGs is limited by several issues, including contextual differences (where the guidelines developed in one setting may not be suitable in another healthcare system), organisational aspects (organisations being reluctant to adopt new care models), and human factors (clinicians unwilling to change their current practice) (Fullen et al., 2023). Additionally, clinicians may not have the time, resources or the necessary clinical skills to apply EBPG with patients (Scurlock-Evans et al., 2014).

Another variable considered in the PAC model of care that is relevant to the MSK field is ‘individualisation’. In this context, the term refers to providing care that is meaningful

and aligns with the patient's preferences and values. Individualisation underpins patient-centred care in MSK healthcare systems (Lin et al., 2020). Similarly, the variable 'coordination of care' could help MSK patients achieve a smoother transition and a better outcome trajectory. The coordination of care for a patient within an MSK care pathway involves synchronising both clinical inputs and the professional communication the patient receives across all their care interfaces (Oostendorp et al., 2020).

The variable 'amount and timing' of care is widely recognised as a crucial factor that can influence patient outcomes in MSK healthcare (Jesus & Hoenig, 2015; Mainz, 2003). Some systematic reviews have identified adverse effects from delays in receiving physiotherapy treatment for MSK conditions (Deslauriers et al., 2021; Ojha et al., 2016). Deslauriers and colleagues reviewed 16 studies, which had varying quality and found that waiting for outpatient physiotherapy negatively affected pain, disability, quality of life, and psychological symptoms in patients with MSK disorders. The review also revealed evidence of increased healthcare utilisation and costs for patients who experienced longer waits before accessing outpatient physiotherapy services (Deslauriers et al., 2021).

An earlier systematic review (Ojha et al., 2016) examined the timing of physiotherapy initiation for nonsurgical management of MSK disorders and its impact on patient outcomes. This review included 14 studies, primarily focusing on patients with low back pain. For spinal pain, low-quality evidence indicated that early versus delayed physiotherapy was associated with lower costs and reduced frequency of opioid prescriptions, advanced imaging and surgeries, without compromising outcomes important to patients (Ojha et al., 2016). In most studies, delayed physiotherapy meant waiting at least one month longer, while early access was deemed as 14 days or less after injury. The review did not detail the reasons for the delays. One subgroup analysis revealed improved disability levels in individuals who received early physiotherapy in an occupational health setting. Although the authors noted that the quality of the studies was low, they concluded that the available evidence suggests early physiotherapy may reduce health utilisation costs without affecting outcomes (Ojha et al., 2016).

## 2.4 Process variables and their impact in the healthcare sector

To date, it appears that very little research has directly investigated process variables in healthcare settings and their impact on patient outcomes. Morse et al. (1994) examined the process variables that moderated and mediated treatment effects in a cohort of homeless people with mental illness. In this study, treatment outcomes were measured by the number of days in stable housing and by patient satisfaction. The authors did not identify any significant moderator variables (Morse et al., 1994).

Sand-Svartrud et al. (2022) investigated process indicators in an extensive (n=239) high-quality, multicentre, prospective cohort study of adults with rheumatic and musculoskeletal diseases. The primary aim of this study was to consider associations between the quality of rehabilitation and the subsequent clinical outcomes (Sand-Svartrud et al., 2022). Process indicators that had been previously validated were included as measures of the provision or receipt of health services, and scores were rated as pass rates (Johansen et al., 2019). The process indicators encompassed the domains of initial assessment, patient participation, individual goal setting, individual follow-up, and coordination across levels of healthcare. The authors reported that they did not observe any statistically significant associations among process indicators across the various domains of care and outcomes. Based on this finding, they suggested that other phenomena, such as process variables, might explain the improvements in patient outcomes.

In a prospective observational outpatient study, several factors were found to influence treatment outcomes (Deutscher et al., 2009). Patient characteristics, such as age, gender and the type of MSK condition, play a role, as do treatment processes, including patient compliance with exercises and the specific interventions used. Deutscher and colleagues (Deutscher et al., 2009) found that patient adherence to the prescribed home exercise programme, along with the application of therapeutic exercise and manual therapy, is associated with better outcomes. In contrast, specific interventions for some MSK condition types were associated with poorer outcomes, as was being female.

## 2.4.1 Process variables that may influence musculoskeletal patient outcomes

Although there is no consensus on the definition of a process variable, several studies (including primary and systematic reviews) have examined factors widely regarded as process variables. The following sections outline that research and the variables studied.

**Timeliness**

Timeliness in the emergency department has been described as reducing wait times and possibly harmful delays for both those who receive and those who provide care (Handel et al., 2011). In the MSK field, timeliness refers to the delay between recognising a patient's need for care and the actual start of treatment (Harder & Chu, 2020). The timeliness of care appears to be a vital process variable within healthcare systems. Brennan et al. (2015) conducted a retrospective analysis (n=328) of electronic health data to evaluate outpatient care following total knee arthroplasty (TKA). Patients in that study completed patient-reported outcome measures (PROMs) at each visit through a web-based clinical outcomes electronic database integrated into the clinic's practice management system (Brennan et al., 2015). These authors reported that variables related to the process of providing outpatient care accounted for the variability in clinical outcomes after TKA. They observed that a shorter interval between inpatient discharge and the start of outpatient clinic-based physical therapy was associated with reduced pain and improved function after outpatient rehabilitation. Specifically, each day sooner that outpatient physiotherapy was initiated after discharge reduced pain intensity, as measured by the numeric pain rating scale (NPRS), by 0.062 points (95% CI: 0.039, 0.085, $p < 0.001$). Similarly, the score on the Knee Outcome Survey Score of Activities of Daily Living (KOOS) at discharge decreased by 0.50 points (95% CI: 0.32, 0.68, $p < 0.001$) for each day of delay before starting outpatient treatment, indicating higher disability. Although these results were statistically significant, they did not seem to reach the minimal clinically important difference for TKA (Beiene et al., 2023). Interestingly, Brennan et al. (2015) reported that a longer duration in the outpatient rehabilitation period was significantly associated with less pain and better function following TKA (Brennan et al., 2015).

The findings of Brennan et al. appear to contrast with those of a recent retrospective analysis of over 9,000 accepted workers' compensation claims for low back pain in Australia, which investigated the relationship between the timing of physiotherapy commencement and the duration of work disability (Mekonnen et al., 2025).

Counterintuitively, these authors found that the shortest disability duration was observed among patients who did not see a physiotherapist (median 4.1 weeks). The authors postulated that this result may be because some workers received physiotherapy treatment outside workers' compensation systems, even before filing or having their claims accepted. Another interpretation of this finding is that their database included claims involving injuries of lesser severity, many of which may have resolved naturally without the need for physiotherapy. Additionally, patients with higher self-efficacy may have self-managed their low back pain and not needed physiotherapy treatment (Mekonnen et al., 2025).

While this finding was unexpected, timeliness was associated with treatment delay among patients who did see a physiotherapist. The median duration of work disability was associated with the timing of physiotherapy initiation. Timing ranged from 8.0 weeks for those who received treatment (≤7 days after injury onset) to 34.7 weeks for those who were delayed by more than 30 days. Compared to physiotherapy provided in ≤7 days after onset of injury, there was an increased likelihood of longer disability duration for those who received treatment within 8-14 days (37.0%; time ratio [TR] 1.37; 95% CI 1.23-1.52), 15-30 days (119%; TR 2.19; 95% CI 1.96-2.44), versus more than >30 days (315%; TR 4.51; 95% CI 4.06-5.02) (Mekonnen et al., 2025). These findings demonstrate that initiatives promoting timely initiation of physiotherapy after low back injury have the potential to reduce future work-related disability.

A recent systematic review and meta-analysis of randomised controlled trials (RCTs) investigating the effect of physiotherapy timing on patient-reported outcomes in individuals with acute low back pain was conducted by McDevitt et al. Seven RCTs were included in the meta-analysis. Random effects meta-analysis comparing early physiotherapy to non-physiotherapy care for acute low back pain indicated a significant reduction in pain (standard mean difference [SMD] = 0.43, 95% confidence interval [CI]: -0.69 to -0.17) and disability (SMD = 0.36, 95% CI: -0.57 to -0.16) in the short term. When results were pooled, a small effect (SMD = 0.43, 95% CI: −0.69 to −0.17) was found in favour of early physiotherapy for short-term pain. Pooled results demonstrated a small effect (SMD = 0.36, 95% CI: −0.57 to −0.16) that favoured early physiotherapy for short-term disability. Early physiotherapy compared to delayed physiotherapy did not result in a statistically significant improvement in short-term pain (SMD = -0.24, 95% CI: -0.52 to 0.04), short term disability (SMD = 0.28, 95% CI: -0.56 to 0.01), or long-term pain (SMD = 0.21, 95% CI: -0.15 to 0.57), or long term disability (SMD = 0.14, 95% CI: -0.15 to 0.42) (McDevitt et al., 2023). This systematic review highlights that early physiotherapy versus non-physiotherapy care is associated with

statistically significant reductions in short-term pain and disability (up to 6 weeks) with small effect sizes.

A narrative review by Campbell et al. (2022) examined the current evidence on the effects of timing physiotherapy treatment on MSK injury outcomes, focusing on the potential benefits of early versus typical or delayed commencement of physiotherapy treatment. The narrative review aimed to explore the existing evidence evaluating the effects of the timing of physiotherapy treatment delivery on patient outcomes in military-specific environments, as well as the potential impacts of the treatment on personnel health, organisational costs, and the operational effectiveness of military forces. The review included evidence from four systematic reviews, with the majority focusing on back or neck pain and using retrospective cohort studies. Based on their review, the authors reported that there was no clear evidence of longer-term benefits (beyond 3-6 months) of early physiotherapy treatment for MSK injuries. However, they did report that a small number of primary studies (four, all conducted in a military context) demonstrated positive outcomes associated with early access to physiotherapy care (Campbell et al., 2022). Campbell and co-authors concluded that the findings of these systematic reviews indicate low-quality evidence supporting the use of early physiotherapy treatment to reduce total health service utilisation costs, particularly for patients treated in these military settings. Specifically, early treatment (within 14-30 days) expedited early physical and functional recovery following MSK injury and was associated with longer-term mental well-being benefits (Campbell et al., 2022).

A New Zealand study by Gregg et al. (2022) considered the results of treatment for clients with persistent leg-dominant low back pain caused by a new accident (Gregg et al., 2022). The authors aimed to determine the association between potential predictive factors and clinically relevant outcomes. This was an observational study (n=256) of patients with low back pain referred to a large treatment supplier, which ran over 24 months. A range of clinical variables were studied, including job demand (sedentary to medium versus heavy to very heavy) and work status (working, limited, or not working), along with validated measures of pain (Numeric Pain Rating Score: NPRS), function (Oswestry Disability Index: ODI) and disability (World Health Organisation Disability Assessment: WHODAS 2.0). These measures were taken at initial assessment, discharge, and at 12 months post-discharge. Multivariate logistic regression was used to examine the relationships between potential predictive variables and clinical outcomes. The group reported a 3.3-point improvement in mean NPRS and a 21.6-point improvement in mean ODI score. Eighty-one per cent of patients returned to their full pre-injury employment hours by the end of the intervention, and an additional 12.9% returned to work on partial hours or with modified duties. The analysis of

predictive factors indicated that completing the OREBRO PROM questionnaire was positively associated with improvements in pain, function, and disability outcome measures. Job demand (sedentary to medium) was predictive of good functional outcomes (ODI), and injury duration (days from injury to entry into the treatment programme) was predictive of improvements in pain, function, and disability. While several factors appear to be associated with patient outcomes in this study, the process variable of timeliness from the accident/injury date to entry into the treatment programme was found to be significantly associated with patient outcomes (Gregg et al., 2022).

Timeliness has been explored in non-MSK conditions. Paddock et al. (2017) performed a large retrospective cohort study (n=339,966) of veterans in the USA who received inpatient and outpatient care for substance use disorders (SUD). These authors examined the process variables of treatment initiation, treatment engagement, SUD-related psychosocial treatment, and SUD-related psychotherapy in relation to 12- and 24-month mortality rates using logistic regression analysis. The overall mortality rates were 3% (at 12 months) and 6% (at 24 months) for this cohort of clients. The authors reported that early treatment initiation (within 14 days) and engagement (two SUD therapy sessions in 30 days) were associated with significantly lower mortality risk in SUD patients. Interestingly, they did not find associations between improved outcomes and specific therapy treatment interventions. This evidence suggests that improvements in timeliness for this SUD population should be prioritised to enhance outcomes and provides further support for the importance of timeliness in healthcare (Paddock et al., 2017).

**Entry criteria**

Entry criteria are the characteristics of a patient that make them eligible for enrolment into a care pathway. Defined entry criteria enable healthcare systems to be designed to match patient needs with the resource capacity of the care pathway, ensuring a better flow for patients (Health Foundation, 2013; Kreindler, 2017; Showell et al., 2012). In a published report on a routine health system improvement, McGonigle and McGeoch (2020) described an initiative to improve equity, timeliness, and access to MSK physiotherapy services in New Zealand. Changes to the pre-existing MSK and orthopaedic care pathway included a simplified referral process for GPs, clear entry and exclusion criteria, and the option for patients to select a contracted physiotherapy clinic near their location, rather than having to attend a hospital department for treatment. The authors reported that these changes were developed using an iterative process and utilised a clinical QI approach.

The findings from the 12-month evaluation indicated that changes in processes led to 75% of referrals being accepted for physiotherapy, and the acceptance rate increased over time as GPs became more familiar with the entry and eligibility criteria. The authors concluded that improvements in public healthcare physiotherapy delivery were achieved in terms of equity of access, timeliness, and the effective delivery of MSK and orthopaedic physiotherapy services in the community, due to process changes within the current system. Rigorous entry criteria were identified as a key process variable associated with improved patient outcomes in this study (McGonigle & McGeoch, 2020).

The previously described study of New Zealand patients with persistent leg-dominant low back pain utilised strict inclusion criteria (Gregg et al., 2022). These criteria included having at least one of the following: an OREBRO questionnaire score of greater than 50; a provisional diagnosis of lumbar radiculopathy; reduced work hours/duties or not working due to the injury; not progressing or recovering from usual primary care treatment; and/or uncertainty regarding the diagnosis. Having process variables, such as a robust entry criterion, will ensure that patients enter a care pathway not only with specific injuries or conditions that require interventions, but also with identified barriers that a targeted care pathway can address. In this example, patients who have been identified as having obstacles to returning to work (OREBRO score >50 and reduced hours/duties due to the back injury) are matched with a care package that will enable them to regain function via a new recovery trajectory. Based on the evidence from these two studies, entry criteria as a process variable can improve access to necessary treatment and match patients with identified barriers to packages of care that facilitate their recovery.

**Order of care**

The order of care refers to the sequence of treatment interventions that patients receive for a specific condition. The choice and arrangement of suitable interventions are determined by patient preferences, accessibility, socioeconomic factors, injury severity, and the clinician’s assessment of the patient’s needs (Kearney et al., 2017). In an extensive retrospective analysis (n=60,730) of an insurance scheme, undertaken by Garcia et al. (2021), participants with patellofemoral knee pain were analysed to determine whether adherence to a stepped care approach led to favourable outcomes. Stepped care models encourage triage, with higher-risk, higher-cost treatment options reserved for cases that have failed to respond to lower-cost, lower-risk treatments. In a stepped care model, patients with a known condition first received evidence-based, lower-cost and lower-risk treatment in a stepwise approach (Garcia et al., 2021). For

example, patients with patellofemoral pain received, in step one, self-management education (i.e., home exercise programmes, activity modification), assurance that most painful conditions resolve with time, low-risk non-invasive procedures, and non-opioid pain medication as needed. In step two, patients were referred to specialty services, including physical therapy, chiropractic care, orthopaedic surgery, pain medicine clinics, and more aggressive nonopioid pain management strategies, as well as corticosteroid injections. Step three included the addition of opioid prescriptions, as well as the use of interdisciplinary pain rehabilitation teams, advanced pain medicine diagnostics and interventions, or a multidisciplinary pain service. Patients were recommended to start with step one care within 30 days of diagnosis and could not proceed to step two until at least 30 days had passed since the diagnosis.

The authors reported that for patients seeking additional care, providing lower-risk interventions earlier, before higher-risk interventions, led to reduced knee pain recurrence and significant cost savings over the following two years. The 30-day threshold for early care decisions appears essential, as the benefit decreased when initial care decisions occurred beyond the 60-day post-diagnosis mark. This study shows that the sequence of care, in this case through a stepped care model, and the timeliness of care both improved patient outcomes and lowered costs (Garcia et al., 2021).

### 2.4.2 Research investigating the patient's perspective on process during their musculoskeletal rehabilitation

Several studies have investigated patients' perspectives of MSK care they have received. An early study (May, 2001) investigated patient satisfaction (including the process of care received) in the MSK setting. This qualitative study of 34 patients with back pain utilised semi-structured interviews to examine which aspects of physiotherapy care the patients considered important. The authors reported that patients' needs were related not only to the outcome of care, but also to the quality of the care process. Themes related to the structure and process of physiotherapy care, including short waiting times, accessibility, and sufficient time with the therapist, were deemed necessary from the patient's perspective (May, 2001).

These findings were supported by those of a qualitative study that used a nominal group technique to explore the characteristics of good and bad experiences in private practice physiotherapy from the patients' perspectives (n=26) (Potter et al., 2003) . Potter and colleagues reported that timeliness and accessibility to services were

factors that influenced patients' decisions about whether their experience of private practice physiotherapy was good or bad. Further support for this finding is provided by a qualitative study that included patients with acute and chronic MSK conditions (Hills & Kitchen, 2007). In this study, patients' views on satisfaction with outpatient physiotherapy were explored during focus group discussions. One of the four themes identified as contributing to patient satisfaction was ‘treatment process’, specifically, issues relating to accessibility and long waiting lists for care. Hills and colleagues reported that these process variables appear to influence both positively and negatively the patients’ experiences during their journey through health care systems.

In 2016, O’Keeffe et al. conducted a qualitative systematic review and meta-analysis of studies investigating factors influencing patient-therapist interactions in MSK physiotherapy. They reported that organisational and environmental aspects of physiotherapy were key themes, with patients generally dissatisfied about a lack of organisation regarding the timing of appointments, delays in gaining appointments, and the availability of appropriate resources and facilities (O'Keeffe et al., 2016). Inadequate care processes can also lead to poor patient satisfaction and experiences. From the same study, it was found that clinicians’ interpersonal/communication skills, as well as individualised patient-centred care, influenced patient-therapist interactions in MSK physiotherapy. Clinicians' soft skills in the MSK healthcare system can build therapeutic relationships, encourage patient engagement, and impact patient outcomes in a culturally responsive manner (O'Keeffe et al., 2016). Clearly, patients value these relational aspects when receiving MSK healthcare; however, the extent to which these non-structural process variables influence patient outcomes is unknown.

Research has investigated which aspects of patient experience are linked to clinical effectiveness and patient safety outcomes. Doyle, Lennox, and Bell (2013) systematically reviewed the research to determine what evidence is available on the links among patient experience, clinical effectiveness, and patient safety outcomes. The review included hospital and primary care settings and a wide range of disease conditions, including cancer, cardiac, diabetes, pulmonary, chronic pain and MSK conditions. Their results showed that a positive patient experience in healthcare was consistently associated with good patient safety and clinical effectiveness across a wide range of disease areas, study designs, settings, population groups, and outcome measures. The authors discussed relational or functional aspects of the patient experience. Relational elements refer to the interpersonal interactions between the patient and the healthcare provider, such as empathy, respect, and the building of mutual trust. Functional aspects relate to basic expectations about how care is delivered, such as attention to physical needs, clean and safe environments, and

processes of care, including timeliness, effective coordination among professionals, and continuity of care (Doyle et al., 2013). This review highlights the importance of patients' functional aspects of care in contributing to a positive patient experience and clinical effectiveness in healthcare.

A recent overview of reviews (both systematic and scoping reviews) has examined studies investigating both the functional and relational aspects of care for patients with MSK disorders (Chi-Lun-Chiao et al., 2020). Thirty reviews were included (18 systematic and 12 scoping reviews). Relational elements were identified and reported in 29 reviews, and functional components were identified and reported in 25 reviews. Chi-Lun-Chiao and colleagues reported that their review identified common themes among patients regarding what they considered essential to their healthcare experience. These included the application of individualised, tailored treatment delivered on time, continuity during transitions among different healthcare settings, physical accessibility to healthcare sites, and coordination within the interdisciplinary healthcare team (Chi-Lun-Chiao et al., 2020).

### 2.4.3 Summary

The evidence discussed in this chapter provides the background for the current understanding of process variables, identifies knowledge gaps, and outlines the current state of the literature. This current narrative review began with insights from research in the industrial manufacturing sector and its applications to the health sector. The theoretical foundation for process variables within healthcare systems is described. A review of research on business quality improvement methods in the healthcare sector highlights the importance of process in enhancing efficiencies and outcomes. The findings have prompted consideration of the role of process variables in influencing patient health outcomes.

The review emphasised the fundamental understanding of process variables and our current absence of an up-to-date definition of what a process variable is within the health sector. The potential influence and significance of process variables on healthcare systems have been explored. The review thoroughly examined factors widely regarded as process variables and the research findings supporting their impact on MSK patient outcomes. Additionally, patient perspectives on the care process during MSK rehabilitation have been comprehensively assessed and considered. The review of process variables in MSK patients revealed a significant gap in our

understanding of what process variables are and how they affect patient outcomes, which will be addressed in the subsequent chapters of this thesis.

A current, clear definition of a process variable within the MSK healthcare sector is needed. Reaching consensus on this definition will serve as a foundation for studies examining how process variables affect MSK patient outcomes. Evidence suggests that process variables in MSK healthcare may influence the patient experience, satisfaction, and outcomes. However, the patient's perspective on these process variables in existing MSK healthcare systems remains unknown. Further research should identify which process variables are crucial for MSK patients to achieve their goals and functional outcomes. Additionally, the direct impact of process variables on patient outcomes in the MSK sector has not yet been robustly quantified. Studies are needed to determine whether process variables affect patient trajectories and, consequently, lead to improved care and better functional outcomes. The increasing burden of pain and disability from MSK injuries and conditions continues across New Zealand and worldwide, with process variables representing a promising avenue to address this issue. The subsequent chapters will outline a series of interconnected, sequential research studies aimed at addressing current gaps in our understanding of process variables.

# Chapter 3: A consensus-based agreement on a definition of a process variable: findings from a New Zealand nominal group technique study

## Reference

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## Preface

The following chapter presents the findings from a nominal group technique used to reach a consensus on defining a process variable. As outlined in Chapters 1 and 2, process is vital in the health sector; however, there remains no definition of a process variable within a healthcare system or MSK care pathway.

The study presented in this chapter prioritises developing a detailed description of a process variable using a panel of experts with clinical and management experience in MSK care pathways in New Zealand.

The findings from this study are crucial to the thesis because they establish a clear definition of a process variable. Since the present research aims to explore the impact of process variables on patient outcomes in MSK care pathways, this represents the first step toward a deeper understanding of these variables. This chapter will address RQ1: What is the operational definition of a process variable within a healthcare system or MSK care pathway?

## Abstract

### Background

Musculoskeletal pain and disability are leading causes of reduced health and significant economic costs worldwide. Individualised, and evidence-based treatment approaches for specific musculoskeletal conditions aimed at improving patient outcomes and costs have not been successful. Recently authors have suggested that the ‘process’ of how care is implemented within a health system needs to be considered as an influencer on patient outcomes. With the rising prevalence of musculoskeletal conditions and the burgeoning costs associated with their treatment, it seems timely that new research focusing on process variables and their influence on patients with musculoskeletal conditions is explored. Before such studies can take place, a modern definition of a process variable within a musculoskeletal care pathway is needed to anchor future research endeavours. Therefore, the aim of this study was to establish a consensus-based definition of a process variable within a musculoskeletal care pathway, based on a New Zealand setting.

### Methods

This study used a virtual nominal group technique and took place in July 2023 using a Microsoft Teams platform. A nominal group technique employs a structured approach to generate information and solutions to problems that can then be prioritised through group discussion and consensus. It is unique because it allows expert participants to explore using in-depth inquiry, areas previously unidentified or not yet investigated. There was an inclusion criterion, and the participants completed pre-work before the two-hour five stage virtual meeting. The Auckland University of Technology Ethics Committee (AUTEC) approved this study (AUTEC 23/94).

### Results

The study included eight participants (five male, three female) who had extensive experience with the New Zealand ACC insurance scheme and the design, implementation, and administration of musculoskeletal care pathways. The consensus definition was ‘A health process variable is any modifiable factor in a health process or pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome’.

## Conclusion

This study of New Zealand-based experts has formed a consensus-based agreement for a definition of a process variable in a musculoskeletal care pathway. This is an important first step in developing our understanding of process variables, and further research is needed to establish the link between process variables and their influence on the outcomes of patients with musculoskeletal conditions.

## Keywords

Process variables, Healthcare, Musculoskeletal conditions, Nominal group technique, Care pathway

## Background

Musculoskeletal (MSK) health is essential for human function and quality of life (Briggs et al., 2021). MSK-related pain and disability are leading causes of reduced health and significant economic costs worldwide (Aasdahl et al., 2021; Briggs et al., 2018; James et al., 2018; Maselli et al., 2022; Meisingset et al., 2020). In 2019, MSK conditions comprised 17% of global years lived with disability (YLDs) (Blyth et al., 2019). The prevalence and impact of MSK conditions will continue to rise, as most painful MSK conditions are associated with an increase in age, other comorbidities (i.e., obesity, diabetes), and reduced activity levels (Briggs et al., 2021; James et al., 2018; Vos et al., 2020).

To improve MSK patient outcomes, researchers and clinicians have historically focused on improving diagnosis and on the implementation of diagnosis-informed individual treatment approaches for MSK conditions (Accident Compensation Corporation, 2003, 2004a; Tousignant-Laflamme et al., 2017; Whalen et al., 2019). Unfortunately, the focus on diagnostics has contributed to the increasing resource utilization for MSK conditions and does not appear to have improved outcomes (George et al., 2020). Similarly, individualised, and evidence-based treatment approaches for specific MSK conditions aimed at improving patient outcomes and costs have not led to any dramatic improvement in disability levels or patient outcomes (Fourney et al., 2011; James et al., 2018; Mafi et al., 2013; Tousignant-Laflamme et al., 2017). These failed attempts to influence patient outcomes have led to some researchers suggesting that elements other than diagnosis and clinical factors may have a greater effect on outcomes (Cook & Decary, 2020; Croft, Altman, et al., 2015; Croft, Dinant, et al., 2015).

It has been suggested that the ‘process’ of how care is implemented within a health system needs to be considered as an influencer on patient outcomes (Cook et al., 2021; Kreindler, 2017). It is thought that health systems that have processes in place that facilitate the movement of patients through a care pathway in a timely and organised manner will more likely have better results (Health Foundation, 2013; Kreindler, 2017; Showell et al., 2012; Young et al., 2004). There has been a recent focus on strengthening and improving the MSK care pathway and health systems worldwide to match the unmet need for the rehabilitation of musculoskeletal conditions (Lentz et al., 2020; Traeger et al., 2019).

A process variable within a health system or care pathway was first described as a factor that precedes the assignment of a treatment and has the potential to influence or affect the patient outcome by interacting with the treatment variable (Baron & Kenny,

1986; Morse et al., 1994). An example could be time taken for a patient to first receive an assessment or treatment. Brennan et al. (2015) performed a retrospective analysis (n = 328) of electronic health data to evaluate outpatient care following total knee arthroplasty (TKA) and reported that variables related to the process of providing outpatient care were significant predictors of clinical outcomes following TKA. It was found that fewer days between discharge as an inpatient to the initiation of outpatient clinic-based physical therapy was significantly correlated with lower pain and higher functional levels at the completion of outpatient rehabilitation (Brennan et al., 2015). Other than the work of Brennan and colleagues, there is limited research investigating process variables within MSK care pathways. Furthermore, there also does not appear to be agreement of what variables should be considered process variables in a health care setting (Mainz, 2003).

Currently, health care systems around the world use different approaches to manage the growing burden of musculoskeletal conditions and disorders (Briggs et al., 2021; Garcia et al., 2021; World Health Organisation, 2022). In New Zealand, most MSK accidents and injuries are covered and managed by the ‘no fault’ Accident Compensation Corporation (ACC) scheme that allows claimants access to a range of compensation and rehabilitation entitlements (Bismark & Paterson, 2006; Foley, 2008; Woodhouse, 1967). There has been a recent focus by ACC on redesigning and implementing new treatment pathways with enhanced processes in an attempt to improve patient outcomes (Accident Compensation Corporation, 2022g; Reid et al., 2021). In 2020, the ACC rolled out the Escalated Care Pathway (ECP), in which patients follow an integrated and coordinated system designed to provide the right treatment at the right time and to move them smoothly from injury through to recovery (Accident Compensation Corporation, 2022g).

With the rising prevalence of MSK conditions and the burgeoning costs associated with their treatment, it seems timely that new research focusing on process variables and their influence on patients with MSK conditions is explored. Before such studies can take place, a modern definition of a process variable within an MSK care pathway is needed to anchor future research endeavours. Knowing what a process variable is within a health care system will enable research that explores the influence of such variables on patient experiences, outcomes, and costs. Therefore, the aim of this study was to establish a consensus-based definition of a process variable within an MSK care pathway.

# Methods

## Study design

This study used a virtual nominal group technique (vNGT) and took place in July 2023 using a Microsoft Teams (Microsoft Corporation, 2017) platform. A nominal group technique (NGT) employs a structured approach to generate information and solutions to problems that can then be prioritised through group discussion (Potter et al., 2004). It obtains qualitative information from target groups that are closely associated with a problem area. An NGT is unique because it allows participants to explore using in-depth inquiry areas previously unidentified or not yet investigated (Van de Ven & Delbecq, 1972). It uses collaborative discussion of immediately formed individual viewpoints and allows minority perspectives to be equally heard before reaching a group consensus (Khurshid et al., 2023; Potter et al., 2004). An NGT can be carried out face to face or online (virtual NGT) and is seen as a time efficient, cost effective and efficient decision making approach (Khurshid et al., 2023; McMillan et al., 2014; Potter et al., 2004). The Auckland University Technology Ethics Committee (AUTEC) approved this study (AUTEC 23/94) and it was conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013).

## Participant inclusion criteria and selection

For inclusion in this study, participants needed to have recognised expertise and considerable experience (> 10 years) in the design, administration, management and/or clinical delivery of MSK care pathways in New Zealand and/or overseas. Participants were purposively recruited from the database of providers and administrators from Careway, an ACC ECP provider of MSK care based in the upper North Island of New Zealand. An independent administrator employed by Careway contacted potential participants with information about the study to reduce researcher bias or coercion. Additionally, an advertisement about the vNGT study inviting suitable participants was placed on the social media platforms LinkedIn and Facebook by the primary researcher.

The recommended size of an NGT group is five to nine participants (Potter et al., 2004).Ten participants initially applied to be included, of which eight of the applicants met the inclusion criteria and gave written informed consent to participate in the vNGT.

## Study procedure

### *Prework*

Two weeks prior to the vNGT, participants were given information about the process and asked to consider the question “What is the operational definition of a process variable within a musculoskeletal care pathway or health system?” Participants were encouraged to enter their definition and examples of process variables into a shared Google document prior to the vNGT to help them prepare to generate a range of thoughts and to facilitate the sharing of ideas in the group discussion stages of the vNGT.

### *vNGT*

A two-hour vNGT was conducted via Microsoft Teams. The moderator was the primary author who has extensive experience in the design and delivery of services in MSK care pathways. A vNGT followed the five-stage protocol of Potter et al. (2004) and was previously described by Cook et al. (2023). In summary, the stages included:

1. A welcome and introduction of the participants to each other and an explanation of the purpose and procedure of the vNGT workshop.

2. The question (as detailed above) was restated to the participants, and they were given time to add to the shared Google document that they had previously been given access to. During this stage, all participants were asked not to consult or discuss with each other.

3. Next, each participant introduced their initial definition and examples of factors they considered to be process variables that they had contributed to the Google document (Table 1). This document was shared on the screen so that all participants could see the list in real time. No debate or discussion occurred during this stage; however, participants were encouraged to modify their own contribution to the Google document as they listened to other participants if they so wished.

*Table 1*

*Participant background and initial process variable definitions*

| Participant | Background | Initial process variable definition |
|---|---|---|
| One (non-clinical background) | Physiotherapy business owner/manager 13 years. Health contracts manager 3 years. Health regional manager 2 years. Chief technology officer/founder health business 3 years. | In the context of a care pathway or health system, a process variable can be operationally defined as a measurable or observable factor that relates to the delivery of healthcare services or the implementation of a care pathway. It refers to a specific aspect or element of the healthcare process that can be quantified, monitored, or assessed to evaluate the performance, quality, or effectiveness of the system. |
| Two (clinical background) | Physiotherapist. Over 18 years' experience based primarily in the public health system. Roles include professional leadership, allied health unit manager, physiotherapy manager, clinical coordinator of community rehabilitation and MSK expert & project facilitator. | A variable that is any structured procedure (generally aimed at enhancing service, improving outcome and/or enhancing cost to benefit) that while receiving a health-related intervention that can influence the outcome of said intervention. |
| Three (clinical background) | Physiotherapist. Over 22 years of clinical practice, 11 years clinical lead of a specialist orthopaedic spine pathway. Currently physiotherapy consultant and advanced practice and clinical development lead. | An interdependent factor in a clinical care pathway that creates variability in a process measure, moderating one or more clinical and operational outcomes. |
| Four (non-clinical background) | Over 10 years' experience in operations, engagement and communications within education and healthcare sectors across the UK and NZ, including leading system and process improvements, change management, strategy implementation and delivery. | A change to the current pathway and process which aims to improve current way of doing things including information technology systems to make positive change in the patients' life and enable efficiencies in providers' setting (included operational processes for administration teams). |
| Five (non-clinical background) | Over 15 years' experience in health management and operations including chief operating officer, strategic | A health process variable is any modifiable factor in a health process or pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome. |

| | | |
|---|---|---|
| | programme manager and services manager. | |
| Six (non-clinical background) | Experienced executive with over 30 years in NZ public and private healthcare systems across funding and operational delivery including Director of Elective Services, General Manager of Cardiac and Cancer services, member of expert panels nationally for; population funding, healthcare design and pricing, CEO of clinician-led healthcare company. | A range of processes and inputs that are used to engage, treat, and enable a patient along their pathway to recovery. These are clinical/psychosocial and are modifiable by those engaged in that patients care and return to function including by the patient and their family and employer. |
| Seven (clinical background) | Physiotherapist. Over 14 years clinical experience working within inpatient and outpatient hospital services, private musculoskeletal practice, and community-based rehabilitation. 8 years' experience as a health researcher. Product Owner to support the design and implementation of Integrated Care Pathways at ACC. | Process factors that are end to end and modifiable across a pathway and are independent of structure and funding and effect outcomes. |
| Eight (clinical background) | Physiotherapist. Clinical practice for 4 years. ACC employee including clinical advisor, team leader, and product manager for 14 years. Product Manager of Health Initiatives at ACC. | Identified factors that might impact processes and outcomes (not necessarily modifiable). |

4. Once all participants had spoken, group discussion was encouraged so that participants could seek explanations or further details about any ideas that were produced during the sharing ideas stage. The moderator ensured that all participants were able to contribute to the discussion and that too much time was not spent on any one idea. Participants were encouraged to suggest new items for discussion or thoughts on how to combine ideas to enhance individual definitions. The use of the Microsoft Teams chat function was also encouraged for participants to discuss mutual ideas or conflicts directly with other participants. Each participant “owned” their individual definition and only edited their definition if they agreed to a change suggested by other participants. Following the method of Cook et al. (2023), participants were given two days following the completion of the vNGT online session to modify or delete their own contributions and to suggest edits to other definitions (Table 2). This additional time allowed participants to collect their thoughts and refine their definitions individually (Cook et al., 2023).

5. The final stage of the vNGT was to allow the participants to ‘rank order’ the definitions generated in the previous stage (Table 2). Participants were emailed a link to a Qualtrics survey form that included a ranking function. This form included all seven definitions, and participants could identify their order of preference from their top choice (rank number 1) to bottom choice (rank number 7).

*Table 2*

*Final process variable definitions*

| **Participant** | **Final process variable definition** |
|---|---|
| One | A process variable is a specific measure which can be quantified and tracked that affects the outcome of healthcare service delivery. Process variables are often associated with the identification and management of bottlenecks or constraints within a system. |
| Two | A health-related process variable is a process that has an impact on any part of the patient's journey, it is interdependent with the patient and other processes, it is modifiable, measurable, and generally patient centric. One should always consider the effect of modification and change of a process variable on the overall outcomes for the patient. |
| Three | An interdependent factor in a clinical care pathway that creates variability in a process measure, moderating one or more clinical and operational outcomes. |
| Four | A health process variable are patient-centric interdependent and modifiable factors that impact current processes and pathways to enhance and improve patient, provider and community engagement and create a change in the system that will have a sustainable impact now and in the future. This includes removing access barriers, improving funding structures, operational efficiencies, technology/systems integration (including real-time information sharing, data exchange, collection), and engagement initiatives. |
| Five | A health process variable is any modifiable factor in a health process or pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome. |
| Six | A range of processes and inputs that are used to engage, treat, and enable a patient along their pathway to recovery. These are clinical/psychosocial and are modifiable by those engaged in that patients care and return to function including by the patient and their family and employer. |
| Seven/Eight | Process variables are modifiable aspects of the end-to-end patient care pathway that can influence a patient outcome. |

## Results

### Participant characteristics

The vNGT included eight participants (five male, three female) with a mixture of non-clinical (two had system design and two had business development backgrounds) and clinical (four were physiotherapists) backgrounds. All participants had extensive experience with the New Zealand ACC insurance scheme and the design, implementation, and administration of MSK care pathways.

### Stage two findings

Each of the eight participants generated an initial definition of a process variable during stage two of the vNGT. Additionally, all participants provided examples of what they considered to be process variables (Table 1).
During the group discussion phase, the participants actively shared thoughts and opinions on process variables, and they were allowed to craft their final individual definitions. The final process variable definition for three participants was unchanged from their initial iteration. At the end of this stage of the vNGT, there were seven definitions (two participants agreed to combine ideas to form a single definition (Table 2).

### Final definition

The rank ordering and voting process needed a clear winner (at least one standard deviation mean score over the next best score) from the seven definitions. Definitions five and seven both ranked highly, being placed in the top three by all participants. Once all participants had voted, the final definition had two standard deviation mean scores over the second placed definition and was defined from participant number five.

> *"A health process variable is any modifiable factor in a health process or pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome".*

## Discussion

The aim of the study was to form a consensus-based agreement on a definition of a process variable within an MSK care pathway. The NGT method was used instead of other methods because the NGT allowed for a collaborative environment between study participants with open and interactive debate and discussion (Potter et al., 2004). The vNGT is not a time-demanding method, and it allows expert participants with opinions on process variables to come together virtually and discuss differing viewpoints before exploring mutual solutions in real time (Harvey & Holmes, 2012;

Humphrey-Murto et al., 2023). The NGT method facilitated an exploratory inquiry into this previously undefined area of health care and led to a clear consensus being formed via the ranking process (Van de Ven & Delbecq, 1972). The final definition identifies that a process variable is any single modifiable factor in a health process or MSK care pathway that can influence patient or operational outcomes.

The participants provided examples of process variables in MSK care pathways during stage two of the vNGT. There was agreement between participants with common examples of process variables, including timeliness and access to care, referral criteria and the measurement of patient outcome measures. The examples of process variables provided by the participants appeared to reflect the participant's background. The clinically orientated participants focused on the operational flow of patients through an MSK care pathway including the entry and exit criteria, clinical roles, and responsibilities and the timing of assessment/treatment. It is believed that the patient's flow and seamless navigation of a care pathway can influence downstream outcomes (Health Foundation, 2013; Kreindler, 2017; Showell et al., 2012). The non-clinical participants gave examples of process variables that were related more to the design and implementation of the MSK care pathway, including information technology integration, pricing models, coordination of care, key performance indicators and the digital enablement of patients/clinicians. It is thought that the processes of care that rehabilitation patients experience can be enhanced with the integration of digital technologies and artificial intelligence applications by healthcare organisations (Alsobhi et al., 2022; Davenport & Kalakota, 2019).

The group discussion stage of the vNGT gave the participants the opportunity to hear alternate viewpoints, pursue areas of agreement and seek further explanation from each other (Potter et al., 2004). At the start of the group discussion, most participants agreed that process variables can be measured or quantified and that they influence patient outcomes. Collaborative discussion occurred, and it was agreed among the group that there are interdependent factors or components of an MSK care pathway, such as information technology processes, environmental/ funding contexts, and clinician training, that influence a patient's recovery that are not process variables. This is consistent with the current literature, which suggests that process variables are different from the structural factors of a health care system, such as physical facilities and organisational management systems (Jesus & Hoenig, 2015). The participants agreed that process variables are also distinct from quality indicators that are used measure health care processes, organisational structures, and outcome measures (Sand-Svartrud et al., 2022; Westby et al., 2016). The group was unanimous that process variables can influence patient outcomes regardless of where the patient is in

the care pathway. This finding supports previous research in which others have stated that process variables can influence patient outcomes whether or not they precede or follow treatment input (Baron & Kenny, 1986; Morse et al., 1994).

An area of robust discussion focused on the question of whether process variables are patient centric. Group opinion was divided in this regard, with some participants suggesting that process variables are always patient-centric, as they will continuously drive the care for a patient, be it positive or negative. The participants with this opinion considered that the effect of process variables on individual patient choice and preference needs to be considered, as this forms the basis for patient-centered care within MSK care pathways (Jesus & Hoenig, 2015; Lin et al., 2020). Conversely, other participants stated that process variables are not patient-centric and that sometimes process variables are driven by the insurer or business model of the MSK care pathway that the patient is in. This supports the ideas of Donabedian, who believes that within health care systems, structure (including funding models) influences process, which in turn influences outcome (Donabedian, 1988, 2005).

There was general agreement between the participants that a process variable is a single modifiable factor within a care pathway, and it is not the collective processes of care of a given care pathway. This is compatible with the ideas of Lleras, who suggest that each process variable regulates the path of care toward one's recovery (Lleras, 2005) and that paths are not linear (Munévar, 2021). There was a clear view among the non-clinical participants that individual process variables could improve healthcare delivery, leading to efficiencies in health systems and enhancing a patient's recovery. The use of business or industrial processes to improve the quality and delivery of patient healthcare has received interest from researchers (Boak et al., 2017; James & Savitz, 2011; Sand-Svartrud et al., 2022; Wyles et al., 2021; Young et al., 2004). Healthcare organisations often use a 'whole system' quality improvement (QI) approach to improve the processes of care, streamline flow and improve costs (Boak et al., 2017; Westby et al., 2016). Although a QI process can bring about opportunities for systemwide efficiency and productivity, it can be a labour intensive, time consuming and costly process for healthcare organisations (Young et al., 2004). The confidence that participants in the current study have in the importance of individual process variables on patient outcomes provides support for health researchers and clinicians to examine the effect of single modifiable factors on health outcomes, most likely a less daunting task than having to consider the 'whole system'. The consensus-based definition of a process variable determined by this study will provide a better 'start-point' for such research.

Despite the diverse backgrounds of the study participants, there was a synergistic and collaborative approach to addressing the research question during the vNGT. The work completed by participants prior to the vNGT helped give the participants context and to 'sensitise' them to the need for a definition (Cook et al., 2023; Khurshid et al., 2023). It also helped to prepare them to generate a range of ideas and to facilitate the sharing of those ideas in the group discussion stages of the v-NGT (Potter et al., 2004). The participant's feedback at the conclusion of the vNGT session highlighted that they had an overwhelming positive experience. The features of the Microsoft Teams platform, such as screen sharing and chat functions, were appreciated by the participants, as was the use of the Qualtrics voting system. The moderator adopted a structured vNGT approach and facilitated an environment that promoted equal participation and open communication, so all participants had their voices heard and their perspectives valued (Khurshid et al., 2023). The participant's quality of their NGT experiences and the knowledge they impart is considered more important than quantity when ensuring data validity in an NGT (Humphrey-Murto et al., 2023; Potter et al., 2003, 2004).

The growing burden of MSK conditions and disorders worldwide continues unabated and change needs to occur (Blyth et al., 2019; Briggs et al., 2018; James et al., 2018). To the best of our knowledge, the current study is the first attempt to define an expert, consensus-based definition of a process variable within an MSK care pathway or indeed a health care system. The NGT participants unanimously agreed upon the definition of a health process variable that recognises that it must be modifiable, quantifiable and be able to influence a patient's outcome. This is a robust consensus agreement, and the authors believe that if future researchers or health system designers adopt this contemporary definition, it will help standardize the way in which process variables are identified and examined.

Future research should focus on gaining a better understanding of the association between process variables and their influence on patient and operational outcomes of MSK care pathways. Specifically, researchers should examine whether a single process variable or any specific combination of process variables in an MSK care pathway or other healthcare system can influence outcomes (Brennan et al., 2015). Understanding patient experiences and determining what process variables matter to patients in their musculoskeletal rehabilitation journey will provide valuable insights into the barriers and facilitators to a patient's recovery (O'Keeffe et al., 2016; Reid et al., 2021).

Increasing our comprehension of process variables may also inform future decisions about the design and implementation of health care pathways for patients with MSK

conditions, including the integration of artificial intelligence and digital technology (Alsobhi et al., 2022; Davenport & Kalakota, 2019).

Having a definition of a process variable may also allow researchers to develop a conceptual framework for examining process variables, and this may assist in the global effort to reduce the burden of disability and cost currently associated with MSK conditions (Briggs et al., 2021; Briggs et al., 2018; Traeger et al., 2019; World Health Organisation, 2022).

## Limitations

Although this study has provided a consensus-based definition of a process variable, there are some limitations of the study. Although the recommended number of NGT participants was satisfied and there was a good balance of males to females and between clinician and non-clinicians, the participants with clinical backgrounds were solely MSK physiotherapists. Additionally, most participants only had experience in the New Zealand health system, perhaps limiting the generalisability of our definition of a process variable to other jurisdictions.

The use of the virtual platform instead of a traditional face-to-face NGT may have influenced the interaction between participants in the group discussion phase given that non-face-to-face communication such as body language could not be readily observed and that some participants may have felt less confident in speaking in this environment. We attempted to mitigate this by effective moderation to facilitate equal opportunity to participate and contribute. We could have used another method, such as Delphi, but we feel the vNGT was an effective method to deliberate and reach a timely consensus on a unique aspect of health care that had limited time or cost constraints on both the participants and the researchers. The vNGT adheres to the foundational principles established for consensus methods, including structured interaction, iteration, controlled feedback, and anonymous voting (Humphrey-Murto et al., 2023; Jones & Hunter, 1995; Potter et al., 2004).

## Conclusion

Our study of experts has formed a consensus-based agreement for a definition of a process variable in a MSK care pathway within the New Zealand setting. This is an important first step in developing our understanding of process variables, and further research is needed to establish the link between process variables and their influence on the outcomes of patients with MSK conditions.

## Abbreviations

*MSK*: Musculoskeletal

*YLD:* Years lived with disability

*TKA:* Total knee arthroplasty

*ACC*: Accident Compensation Corporation

*ECP:* Escalated Care Pathway

*AUTEC*: Auckland University of Technology Ethics Committee

*vNGT*: Virtual nominal group technique

## Acknowledgements

The authors wish to acknowledge the participants involved in the nominal group technique.

## Informed consent statement

All participants in the vNGT study gave signed informed consent to participate.

## Acknowledgements

The authors wish to acknowledge the participants involved in the nominal group technique. Informed consent statement

## Availability of data and materials

We don’t have any research data outside the submitted manuscript file.

## Authors’ contributions

DH, SW, DR and CC contributed to the conception and design of the study. DH carried out the nominal group technique. DH drafted the manuscript and SW revised it. DH, SW, DR and CC read and approved the final manuscript.

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at AUT University, investigating the effects of process variables on musculoskeletal patient outcomes.

## Funding

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## Data availability

No datasets were generated or analysed during the current study.

## Ethics approval and consent to participate

The Auckland University of Technology Ethics Committee (AUTEC) approved this study (AUTEC 23/94) and in accordance with the Declaration of Helsinki.

## Consent for publication

Written informed consent for publication was obtained from all participants.
Availability of data and materials.

## Competing interests

The authors declare no competing interests.

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## Novel contributions of Chapter 3

This chapter is the first to define a contemporary process variable within a healthcare system or MSK care pathway. It enhances our understanding of process variables and their role in healthcare. This definition underpins the subsequent two chapters, which explore patient perspectives of process variables and their impact on patient outcomes in MSK care pathways.

# Chapter 4: Patient perspectives of process variables in musculoskeletal care pathways

## Reference

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## Preface

The previous chapter highlighted the lack of a contemporary description of a process variable. Expert consensus was used to define a process variable within an MSK care pathway in the New Zealand context. This definition guided the second study by anchoring our understanding of patients' perspectives of what processes within their MSK journey seemed important to them. The definition from Chapter 3 enabled us to identify factors and themes that patients raised, which align with our definition; hence, these variables can be identified and discussed. This represents an essential first step towards understanding process variables, but further research is needed to examine the relationship between process variables and their impact on patient outcomes in MSK conditions.

The review in Chapter 2 identified that organisational aspects of care within MSK health systems may influence the therapist-patient interaction and patient satisfaction with physiotherapy treatment. What remains unclear is the patient's perspective on process variables in MSK healthcare pathways and their impact on outcomes. This chapter explored patient perspectives on process variables in MSK care pathways in New Zealand. It addressed RQ2: What process variables do patients consider 'matter' or 'are important' in their MSK rehabilitation journey?

The knowledge gained from this study is crucial because patient perspectives on process variables will improve understanding of how processes affect outcomes in their MSK rehabilitation journey. The key processes and themes identified by patients will help guide the selection of specific process variables to examine in Chapter 5 during the quantitative analysis of their impact on patient outcomes.

## Abstract

### Background

The prevalence of disability caused by musculoskeletal conditions continues to increase. Little research has considered the effect of process variables of a musculoskeletal care pathway on patient outcomes. A process variable is as any modifiable factor in a pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome. The perspective of patients on what process variables are important in musculoskeletal care pathways remains unknown.

### Objective

The aim of this study was to investigate which process variables are important to patients and what their experiences of these processes were during the rehabilitation of their musculoskeletal conditions.

### Method

A qualitative study using a reflexive thematic analytical approach was undertaken. Four focus groups with 12 participants were conducted. Thematic analysis was utilized on the focus group data.

### Results

Four key themes were generated: 1) Process matters; (2) Quantifying progress facilitated patient engagement; (3) Benefits of equitable access of care; and (4) Recovery made easier with navigation.

### Conclusion

Patients with musculoskeletal conditions recognise the importance of process variables, especially timeliness, order of care, coordination of care delivery, quantifying progress, equity of access and navigation. These findings offer insights to care pathway designers as well as future research opportunities examining the effects of process variables on the outcomes of patients with musculoskeletal conditions.



### Keywords

Physiotherapy; Process variables; Patient perspectives; Musculoskeletal; Care pathways

## Highlights

- Rehabilitation experiences were influenced by process variables within the musculoskeletal care pathways.
- Regular physical impairment testing and outcome measurements facilitated patient engagement.
- The removal of gym and physiotherapy financial costs enhanced rehabilitation access.
- Patients saw value in physiotherapists as musculoskeletal care pathway navigators.

## Introduction

The prevalence of disability caused by musculoskeletal (MSK) conditions continues to increase, presenting a mounting burden on healthcare systems around the world (Briggs et al., 2018; Vos et al., 2020). In New Zealand, 25% of adults are affected by a MSK disorder and over 15% of all New Zealanders visit their General Practitioners (GP) each year with MSK conditions (Bossley & Miles, 2009). The New Zealand health system expenditure due to MSK diseases is sizeable, contributing 16% of the total expenditure for non-communicable disease and nearly 10% of the total health expenditure spend (Blakely et al., 2019).

In response to this growing problem, researchers have shifted their focus to high value care for MSK conditions (Lentz et al., 2020; Traeger et al., 2019). This value-based approach includes care that is patient-centered, guideline concordant, measures patient outcomes and is cost effective (Cook et al., 2021). Value-based MSK care also considers process variables of a health system, for example the amount and timing of treatment, order and co-ordination of care, as well as ensuring unnecessary treatment provision doesn't occur (Jesus & Hoenig, 2015; Lentz et al., 2020). A process variable has been defined as any modifiable factor in a pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome (Harvey et al., 2024).

In New Zealand, the Accident Compensation Corporation (ACC) insurance scheme funds most accident-related MSK conditions and recently it commissioned pilot rehabilitation programmes called Escalated Care Pathways (ECP). Under the ECP, treatment suppliers (such as Careway) were asked to design and implement innovative high value care pathways to manage specific MSK conditions including the knee, shoulder and low back(Accident Compensation Corporation, 2022g; Reid et al., 2021). A feature of these pathways is that validated outcome measures are taken at specific time points and there is a defined exit criterion. Hence, these ECP provide an opportunity to consider and examine how processes variables influence patient outcomes.

There has been little research into patient perspectives regarding process variables in MSK care pathways. Hills & Kitchen (2007) employed focus groups to explore satisfaction with outpatient physiotherapy treatment in patients with acute and chronic MSK conditions. The authors identified four themes, one of which was ‘treatment process’. Specifically, patients expressed that ease of accessibility and not having long waiting lists for care enhanced their treatment satisfaction (Hills & Kitchen, 2007). A qualitative systematic review and meta-analysis of research that

had investigated factors that influence patient-therapist interactions in MSK physiotherapy was performed by O'Keeffe et al., in 2016. They reported that organisational and environmental aspects of physical therapy were key themes, with patients being generally dissatisfied about a lack of organization regarding timing of appointments, delays in gaining appointments and lack of appropriate resources and facilities (O'Keeffe et al., 2016).

The existing evidence indicates that the organisational aspects of care within MSK health systems may contribute to the therapist-patient interaction and patient satisfaction with physiotherapy treatment. What is not known is the patient's perspective on processes variables in MSK health care pathways and how they affect outcomes. The aim of this study was to investigate which process variables are important to patients and what their experiences of these processes were during the rehabilitation of their MSK conditions within the Careway ECP.

## Methods

### Design

A qualitative research design using reflexive thematic analysis was used (Terry & Hayfield, 2021). The consolidated criteria for reporting qualitative research (COREQ) guidelines was used to guide reporting of the research (Tong et al., 2007). Ethical approval (number 23/229) was obtained for this study by the Auckland University of Technology Ethics Committee.

### Participants

Participants were former patients (from the greater Auckland region, New Zealand) with MSK injuries covered by ACC and included in the Careway ECP rehabilitation programme. Participants needed to have completed or been discharged from treatment within the six months prior to inclusion in the study. The sampling strategy was to purposively sample the participants so that they were representative of different genders, ethnicities, ages and musculoskeletal conditions, to ensure diversity. Potential participants were recruited independently of the research team by a Careway database administrator. Included in this initial email was a consent form, a study information sheet and an invitation to contact the primary researcher to participate. Participants contacted the primary researcher to discuss any questions they had about the study and to confirm they satisfied the inclusion criteria. Participants were then invited to one of four focus groups held at the Auckland University of Technology northern campus in late 2023. Participants

were not known to the primary researcher or research team prior to the focus groups. Fifteen participants contacted the primary researcher, and all met the inclusion criteria. All 15 completed a consent form but only 12 participants attended the focus groups (see Table 3). Three participants were unable to attend the focus groups due to clashes with their work or study schedule. Females (50%) and Māori (17%) were represented in the sample, and most participants had completed either a knee or shoulder (83%) rehabilitation pathway. The age range of the participants was 19–77 years, and the median age was 50 years old.

*Table 3*

*Participant demographic information*

| Participant reference | Focus group | Ethnicity | Gender | Age | Injury pathway |
|---|---|---|---|---|---|
| P1 | 1 | NZ European | Male | 70 | Shoulder (Post-operative) |
| P2 | 1 | NZ European | Female | 43 | Knee (Post-operative) |
| P3 | 1 | NZ European | Female | 38 | Ankle (Non-operative) |
| P4 | 1 | NZ European | Female | 60 | Shoulder (Post-operative) |
| P5 | 2 | NZ European | Male | 51 | Knee (Non-operative) |
| P6 | 2 | Sth American | Female | 30 | Knee (Post-operative) |
| P7 | 3 | Māori | Male | 50 | Shoulder (Post-operative) |
| P8 | 3 | Asian/Māori | Female | 42 | Ankle (Non-operative) |
| P9 | 4 | NZ European | Male | 77 | Shoulder (Post-operative) |
| P10 | 4 | NZ European | Male | 55 | Shoulder (Post-operative) |
| P11 | 4 | NZ European | Female | 19 | Shoulder (Post-operative) |
| P12 | 4 | NZ European | Male | 55 | Knee (Post-operative) |

## Data collection

Four face-to-face focus groups took place. The focus groups were recorded using Otter audio recording technology (Otter.AI, Mountain View, CA, USA) on an iPhone. The primary researcher conducted all the focus groups and took field notes. The focus groups with two participants took 45–60 min each and the focus groups with four participants took 75–90 min each. Prior to the focus group the participants received a detailed information sheet about the study's aim and with an explanation and example of a process variable within a care pathway. Open

questions were piloted in a practice focus group and following feedback from those participants and the research team, a list of guiding questions was used in the focus groups. During the focus groups the open questions were reframed to clarify which processes went well or not.

- Tell us about your rehabilitation experiences during Careway?
- What processes worked well?
- Did you reach you goals?
- What did not go so well?
- Can you expand on why things did not go so well?
- What things were barriers to a good outcome and what things facilitated a good outcome?

Repeated reflection of answers to the participants was used by the primary researcher during the focus groups as a method of informal participant checking. The focus group session ended once all the questions had been discussed thoroughly. Participants were asked if they wanted to review transcripts, but none indicated that they wished to do this. The research team did not need to return to participants for clarification of the transcribed focus group interviews.

## Data Analysis

Analysis using Braun and Clarke's six-phase approach was used to construct meaning-based patterns and themes (Braun & Clarke, 2006, 2013; Terry & Hayfield, 2021). The primary researcher's engagement with the data was guided by an interpretive and post-positivist lens with a realist ontological approach. This allowed the primary researcher to be reflexive to the reality of patients and the processes that matter to them in the management of MSK conditions.

Data analysis was supported by NVivo software (V.12.1.0; NVivo 12, QSR international Pty, Australia). Focus group recordings were transcribed verbatim by Otter audio recording technology, before being de-identified and checked for accuracy by the primary researcher. Familiarization of data occurred immediately through listening to the audio recordings, and re-reading transcripts and field notes. Familiarization notes were made for each focus group. Coding was completed by the primary researcher who employed an inductive approach utilising mainly semantic (explicit meaning) as well as latent (implicit deeper meaning) coding.

Informed by the research question, the primary researcher created a code book with 40 codes from the focus groups. The codes were examined by the research team for similar ideas and meanings and clustered together to generate four prototype themes. The primary researcher tested these initial themes using a thematic table to visualise the codes that built each theme and how the themes related to each other (Appendix 9).

The next phase was the development and refinement of the themes which was an iterative process for the research team. There were many revisions and refinements with the themes being tested against the coded data to ensure the story being told was a fair reflective interpretation (Terry & Hayfield, 2021). The next step was the theme definition and naming phase. In this stage the primary researcher wrote theme definitions to bring together each theme's central organising concepts and to confirm the theme and subthemes had the necessary theoretical and explanatory richness to begin writing. The research team discussed and met again at this stage to agree on the theme definitions and to decide the final names of the four themes.

## Results

Four themes were generated: (1) Process matters; (2) Quantifying progress facilitated patient engagement; (3) Benefits of equitable access of care; and (4) Recovery made easier with navigation.

## Process matters

Participants described how their rehabilitation experiences were influenced by the process variables and the interaction between different health professionals within the care pathway. Participants strongly acknowledged the timeliness of the care they received once in the care pathway, however, there were some delays with initial entry into the care pathway. The theme encompasses the participant's belief that access to physiotherapy, and the wider rehabilitation team took place in an efficient and well-organised manner. Participants appreciated seeing the correct health professional in the care pathway at the right stage of their recovery journey and valued the collaboration between members of the interdisciplinary team and the interprofessional communication. However, several participants stated that having to have the surgeon approve when physiotherapy or certain activities could start after surgery was not ideal. The participants thought the care received was individualized and of high quality. Table 4 provides examples of statements that represent the various subthemes that contributed to this theme.

*Table 4*

*Examples of statements that represent the various subthemes that contributed to the process matters theme*

| Subthemes | Participant quotes |
|---|---|
| Timeliness | *Actually, really quick! Yeah. I think being on Careway helps" (P8) "Physio started straight away; there wasn't any delays" (P1) "I was delayed with getting put into the Careway programme" (P2)* |
| Co-ordination of care | *"Because you're not having to chase after people and run around. And because it's sort of basically done for you really, the surgeon contacted me and said you had this referral. Can you please call for an appointment? Okay. It was all done sort of in the background, really. And I found that great, helpful"* (P4)<br>*"I wasn't allowed to work. It was the surgeon. I wasn't allowed to drive for six weeks he said"* (P2)<br>*"No don't move for six weeks the surgeon said. And then the physio told me she wouldn't see me for another six weeks"* (P4) |
| Right clinician, right time | *"The physio explained it to me that the next step would be the occupational therapist because of the job that I do"* (P4)<br>*"I got to the right people at the right time*" (P12) |
| Collaboration and interprofessional communication | *"It was more collaborative"* (P3)<br>*"You are in physio hands the whole lot. And it just progressed to the surgeon, and everybody was involved, and it just went on from there and they just took care of it for me. But I did get it all explained to me right from the start and the physio, the physio, she did tell me the whole system and how it worked and what it was about"* (P4) |
| Individualisation and high-quality care | *So, we would meet initially once a week, and then every fortnight and she (physiotherapist) would show me the exercises herself, which was great. And she would see me watch me do it. And correct me or say, you're doing okay, so that was great*" (P6)<br>*"It's a good principle rather than the minimal threshold you are aiming for an optimal threshold or an optimal recovery it's nice, it makes it more pleasant you know"* (P12) |

## Quantifying progress facilitated patient engagement

Participants appreciated the regular outcome and physical impairment measurements that were performed throughout their rehabilitation. Most participants reported that these measures enabled them to see progress, which both encouraged them and kept them accountable. Quantifying progress helped participants with frustrations and improved commitment towards rehabilitation. Some participants commented how the questionnaires weren't helpful to them. Table 5 provides examples of statements that reflect the various subthemes that contributed to this theme.

*Table 5*

*Examples of statements that represent the various subthemes that contributed to the quantifying progress facilitated patient engagement theme*

| Subtheme | Participant quote |
|---|---|
| Motivating and engaging | *"But the Careway (pathway), it was more. I could see the progress. So, I'm going to keep going until I'm fixed. And the level of fix at the end was a much higher-level fix"* (P10)<br>*"The questionnaire wasn't helpful to me. I didn't mind doing because I knew the physiotherapist needed those results"* (P6) |
| Accountability and progress towards goals | *"Well, what ended up happening is my physio would show me the results of the physical test part of it, and that was a motivator. It was good to see the whole progression"* (P11)<br>*"So, it was cutting-edge rehab that I received, it was optimal, measured. And you know when I was slipping off or I wasn't doing well"* (P12)<br>*"The quality-of-life survey each month is fine but very generic. And it didn't really have any insight into whether things were getting much better or much worse because you're ending up with roughly the same score each month"* (P5) |
| Reduced frustrations | *"And I was getting frustrated because I felt like I wasn't making any progress. But I realized that it is a slow, slow progress for the recovery. And I think seeing my physio and he's like, Yep, you're doing good and on track"* (P2) |

## Benefits of equitable access of care

Participants reflected on the accessibility to physiotherapy rehabilitation and how this influenced their recovery. They unanimously agreed that the removal of financial costs to having physiotherapy allowed them to attend and receive the necessary care required for their rehabilitation. There were frustrations from participants with accessing insurer funded taxi transportation. Participants acknowledged that physiotherapists were able to deliver an appropriate amount of treatment based on the participant's individual needs and were not constrained by a pre-set approved number of treatments. In contrast participants reported how physiotherapy sometimes continued when they thought it was no longer required. Participants also reported that no-cost access to gym facilities for their rehabilitation was valuable and enabled them to commit to the prescribed exercise program. Equally, free access to equipment to use at home to complete daily rehabilitation was appreciated. Table 6 provides examples of statements that represent the various subthemes that contributed to this theme.

*Table 6*

*Examples of statements that represent the various subthemes that contributed to the benefits of equitable access of care theme*

| Subthemes | Participant quotes |
|---|---|
| Access to physiotherapy | *"Removing that barrier allowed me to have all the treatment I needed and if I didn't it would have taken longer to recover" (P3)*<br>*"It was important that it was close. They were there within walking distance" (P10)*<br>*"And I think I tried a couple of times to arrange a taxi but just, it just didn't work. And it just was too hard. Yeah, too hard basket" (P2)* |
| Removal of financial barriers | *"Absolutely the costs. Otherwise, I would not have gone and see my physio weekly, I'm not sure about the specialist appointment, I would have. I don't even know how that would have worked in terms of funding how much I might have had to pay. But I certainly would have been a little more reluctant to pursue physio that diligently. And that quickly, hugely aided my recovery" (P3)*<br>*"Because it was for free. I saw my physio weekly. Otherwise, I don't think I would have if I'd had to pay for it or at least pay part of it. Yeah, I don't think I would have gone as often" (P1)* |
| Correct amount of treatment | *"So that they (physiotherapist) can give you the treatment that they think you need. Careway makes it easier for them to do that. Because they're not fighting with ACC, to get the treatment, they're saying we're going to be able to get you better. And we're not going to be mucking around about trying to do it within 12 visits or in 24 visits. It's a case of we're here to help you get better. And you'll be getting what you need to get better" (P5)*<br>*"The goal was to stop physio as soon as possible. I didn't want to go if I didn't need to. It was physio fatigue, physio overload" (P10)* |
| Gym facilities and equipment was valuable | *"I think the cost to but in parallel with that the opportunity or the ability to use the facilities like the gym, with no access to a gym, my rehab would have been way slower" (P2)*<br>*"Rehab resistance bands, gym membership, and swimming pool access, which was really good for pain relief and movement" (P5).*<br>*"I got a bike for my rehab which was good" (P11)* |

## Recovery made easier with navigation

Participants reflected on the value of having the treating physiotherapist as their main guide and source of information for their rehabilitation pathway and recovery care plan. They appreciated the availability of the physiotherapist to answer specific questions about their recovery and advice to negotiate barriers to their rehabilitation. Some participants reported some frustration with the return to sport testing. Participants valued the physiotherapists provision of support and advocacy for their physical and mental needs as well as information about additional entitlements and logistical support. Not all physiotherapists had the required information regarding participant entitlements. Reinforcing theme two, participants

valued the physiotherapist's role in reassessing, reevaluating and changing rehabilitation goals as required. Table 7 provides examples of statements that reflect the various subthemes that contributed to this theme.

*Table 7*

*Examples of statements that represent the various subthemes that contributed to the recovery made easier with navigation theme*

| **Subthemes** | **Participant quotes** |
|---|---|
| Physiotherapist the main guide | *"You can see how to navigate the pathway because having the physio recommend somebody or the next step and telling me this is what's going to happen" (P4)*<br>*"It was explained as the goal to get to. I mean, it was pretty much explained to me to be able to pass was to limit the risk of reinjury to not only the leg that operated on, but also to help in the way that I wouldn't injure the non-operated leg. They took the time to explain" (P2)*<br>*"I had kind of been prepared from my specialist who said, no one ever passes at first. And I'm like, why? What's the point of the physio putting someone up to a test if no one ever passes it the first time?" (P6)* |
| Navigating barriers | *"He was a senior physio for the organization. And he obviously had a record of how things were tracking. So, his (physiotherapist) comments suggested that there would be a steady range of improvements as we went long. But occasionally, I used to run into pain barriers, and he said don't go there. Leave the exercises for a fortnight. Those exercises which caused the pain. He helped me understand" (P9)* |
| Support and advocacy | *"Like that would be my word for it, is thorough, which just meant like mental health wise confidence that you can get back to it wiser, like, just makes the whole thing, the whole recovery process easy. But it's a traumatic process, you know, surgery and however it affects you to not be able to play sport, not be able to work like so it's really nice to know that you have something that's going to get you back into life" (P11)* |
| Goals changed | *"Along the way, I found out that I wasn't going to (fully recover), it doesn't feel the same, it's not going to be the same. So, I gave up on my (return to sport) goals. And ultimately, I had reached a point where me and the physiotherapist agree that that's the maximum" (P6)* |
| Entitlements | *"It was great, the physio gave me the info. After surgery. I needed a taxi to and from appointments. I got someone to come in to clean my house somehow. Yeah, that was great" (P6)*<br>*"The physio didn't know so I looked it up. Used Google to find out the sort of the process and then rang ACC and you had to do it this way" (P2)* |

## Discussion

The theme, '*process matters'* to participants and their recovery, was the dominant finding from this study. A range of process variables were identified by the participants as being important and significant to their outcomes and overall recovery. Our findings support that of previous qualitative research that has investigated both patient and therapist perspectives on factors that influence patient-therapist interactions in MSK physiotherapy (O'Keeffe et al., 2016). O'Keefe and co-authors reported that physiotherapist interpersonal and practical skills, individualized patient-centered care and organizational factors, such as the length of time of appointments and the flexibility to change appointments easily, were important. Patients and therapists both identified these processes variables as important for patient-therapist interactions in MSK physiotherapy.

In contrast, in a recent review of MSK patients and their perceptions of their experiences of health services, none of the themes identified were related to process variables (Chi-Lun-Chiao et al., 2020). Themes related to the functional and relational aspects of patient's care highlighted the significance of the physical and environmental needs, trusted clinician expertise, information needs and understanding patient expectations (Chi-Lun-Chiao et al., 2020). Our study adds new understanding to these previous studies by solely exploring patient perspectives of which process variables matter to them in MSK care pathways and how this influences their rehabilitation experiences and outcomes.

Timeliness of care appears to be an important process variable identified by the participants. Our findings support those of previous qualitative research in this field that has reported that short waiting times and access to prompt orthopaedic and physiotherapy care is important to MSK patients and is linked to patient satisfaction (Potter et al., 2003). Timeliness has been investigated in MSK care pathways by Brennan et al. (2015) who performed a retrospective analysis of electronic health data to evaluate the timing of outpatient care following total knee arthroplasty. These authors reported that fewer days between discharge as an inpatient to the initiation of outpatient clinic based physiotherapy, was associated with lower pain and higher functional levels at the completion of the outpatient rehabilitation (Brennan et al., 2015).

As well as not having any unnecessary delay to their assessment and treatment, our participants recognised that coordinated care allowed them to see the right clinician at the right time and to flow smoothly through the pathway. In healthcare, the term flow represents the journey of patients between clinicians, departments,

and organisations along a pathway of care (Health Foundation, 2013; Showell et al., 2012). A seamless journey through a MSK care pathway requires a defined patient population to be matched with an appropriate clinical expert in a synchronized and efficient manner (James & Savitz, 2011; Jesus & Hoenig, 2015). Our findings demonstrate that the Careway participants recognised and valued its streamlined processes that facilitated communication between the different health professionals (via a digital patient management system) and the delivery of collaborative and coordinated care. These processes enabled the interdisciplinary teams to facilitate patients in an end-to-end care pathway from entry, through to orthopaedic, physiotherapy and vocational rehabilitation.

In this research, participants were unanimous in their belief that their access to care was enhanced by the removal of financial and logistical barriers to treatment and that this was beneficial to the outcome of their treatment. Our participants were clear that having access to conveniently located physiotherapy care and rehabilitation facilities without paying a co-payment charge or gym fees allowed them to engage with the rehabilitation program and to attain their goals. This supports the findings of previous research which has demonstrated that cost is a barrier to access primary health care treatment in New Zealand (Jatrana & Crampton, 2021; Perry et al., 2015). In the study by Perry and colleagues, participants who were receiving outpatient physiotherapy (without a co-payment) in a socioeconomically deprived area of New Zealand were interviewed and reported the convenience of a nearby location influenced their attendance (Perry et al., 2015). Although our cohort of participants did not come from a socioeconomically deprived area, they did have their physiotherapy co-payment removed and also reported that accessing a physiotherapist local to them was important. In a recent review of factors affecting patient engagement in exercise rehabilitation, variables such as having easily accessible and no cost rehabilitation and resources were essential to rehabilitation patients (Teo et al., 2022).

There has been a focus recently towards the use of high value care for MSK patients (Cook et al., 2021). High value care is defined as care that delivers the most value for the patient, and the clinical benefits outweigh the costs to the individual or system providing the care (Gleadhill et al., 2023). Under the Careway programme the patient had no financial burden, and they received treatment sessions based on clinical need and their progress towards their goals. Interestingly, in a recent one year follow up study it was found that neither the number of visits or the financial cost of nonsurgical shoulder related care was associated with patient improvements or outcomes (Clewley et al., 2020).

Removing financial barriers and costs for patients was seen as beneficial in our study, and health system designers should consider having processes in place to ensure the cost of treatments funded within a MSK care pathway is of high value.

Participants in this study reported that regular use of patient reported outcome measures (PROMs), and physical measurements of their strength, helped motivate them to engage in their rehabilitation plan and assisted their recovery. Previous research has highlighted this relationship between process and outcomes, labelled as the process-outcomes interface (Jesus & Hoenig, 2015). As patients receive treatment and clinicians quantify and measure their progress towards their functional goals, both patients and clinicians receive valuable information. Physiotherapists taking regular muscle strength measurements and reviewing PROMs receive up to date information on the patient's clinical progress. Based on this monitoring process variable, clinicians can adjust their interpersonal communication and treatment to meet the patient needs, leading to a more rapid improvement in patient functional outcomes (Jesus & Hoenig, 2015; Lin et al., 2020; O'Keeffe et al., 2016).

From a patient's perspective, seeing real-time updates on their functional progress can facilitate behavioural and psychosocial outcomes such as engagement and motivation (Cook et al., 2021; Jesus & Hoenig, 2015). It was found in a recent review of patient engagement to rehabilitation that increasing self-efficacy, improving perceived capability to exercise, using goal setting and enhancing the perceived benefits of the exercise, all improved patient adherence (Teo et al., 2022). Our results showed that giving patients visibility over their PROMs and strength measures and having the physiotherapist explain the test results, increased the patient's confidence, motivation and engagement. In a prospective observational cohort study, the associations between physiotherapy treatment processes for musculoskeletal conditions and outcome measures were investigated (Deutscher et al., 2009). These authors found that compliance with the rehabilitation exercise programme was one of the strongest predictors overall for patient outcomes and the strongest predictor among process variables (Deutscher et al., 2009) . These results are comparable with the patients view from our study, that better outcomes were achieved when the patients were more engaged and dedicated with their exercise programme.

Our participants valued the role of the physiotherapist as the main source of support, information and navigation during their rehabilitation and recovery. They described that their recovery was made easier with physiotherapists being readily

available to answer questions on their recovery, rehabilitation goals, as well as provide clinical support, advocacy and advice on entitlements and resources. The benefits of health care navigators was first reported in the field of oncology where navigators were introduced to improved access to timely screening and better coordination of cancer care delivery (Freeman, 2006; Paskett et al., 2011). Research in socioeconomically deprived areas of the USA has demonstrated that patient navigation is an effective intervention in promoting screening, timely diagnosis and treatment of different cancers (Freeman, 2006; Paskett et al., 2011). A recent review examined the effectiveness of system navigation programmes linking primary care with community-based health and social services to improve patient, caregiver, and health system outcomes (Teggart et al., 2023). These authors concluded that both lay person-led or health professional-led system navigation models seem to improve patient experiences with quality of care compared to usual care (Teggart et al., 2023). Our findings demonstrate that that a dedicated navigator is considered important to patients with a MSK injury, supporting these previous research findings.

Whilst navigation seems important to MSK patients, what is unclear is its cost-effectiveness or if it improves patient-related outcomes (Teggart et al., 2023). This has been explored in a recent study where the effects of the use of a non-clinical lay navigator on the cost and resource use of older adults with cancer was investigated (Rocque et al., 2017). Rocque and colleagues reported significant reductions in hospital patient costs, emergency department visits, hospitalizations, and intensive care. The clinical advantages and cost benefit of a layperson acting as a navigator in a MSK care pathway versus a physiotherapist fulfilling the navigator role in addition to their normal clinical duties should be examined.

The findings from our study extends our understanding of the theoretical frameworks of process variables within care pathways. Donabedian states that within health care systems and care pathways an inter-dependent relationship between structure, process, and outcomes exists (Donabedian, 1988). A process variable has been recently defined as any modifiable factor in a care pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome (Harvey et al., 2024). In our qualitative study we looked to explore what process variables in MSK care pathways are important for recovery. Participants in our focus groups identified the process variables of timeliness, co-ordination of care, collaboration, individualisation of treatment, equity of access, quantifying progress, as well as navigation of the pathway are important for their recovery from their MSK condition. They also identified frustrations with the

failure of some of the process variables. Our results are in line with a theoretically proposed and unvalidated quality framework for post-acute (PAC) rehabilitation (Jesus & Hoenig, 2015). The authors theorised several process variables in their framework considered important for post-acute rehabilitation patient outcomes: individualisation, amount and timing of treatment, and coordination of care. The authors also identified the need for the care framework to have structure including personnel, facilities and equipment and organisation management (Jesus & Hoenig, 2015). Our study highlights the importance of MSK care pathways to provide the structure that enable effective process variables to facilitate and moderate patient outcomes (Batalden & Davidoff, 2007; Gartner et al., 2022; Hancock & Kent, 2022).

## Implications

This study is the first to investigate which process-related variables are considered important for patients enrolled in a MSK care pathway. Our findings clearly demonstrate that there are a variety of process variables that matter to MSK patients. Timeliness, order of care, processes that facilitate interdisciplinary collaboration, and the collection of outcome measures should be considered and prioritised. Additionally, patients value high quality physiotherapy treatment, the removal of financial barriers and visibility on their progress towards their functional goals. Clinicians should consider how regular measurement of patient progress and navigational support through the MSK care pathway influences patient engagement. These findings should help inform the design of future care pathways and highlights the importance of process variables on patient experiences and outcomes.

## Limitations

There were several limitations from our study that must be considered. Firstly, the participants may have given responses that they thought the primary researcher wanted to hear and the findings may not reflect the experiences of all patients enrolled in the Careway ECP programme. We don't know if our participants were just a select group with positive experiences of the Careway programme or if it was a group that had problems with the programme and wanted this opportunity to express their opinions. We tried to mitigate this risk of selection bias by having a balance of open-ended questions focussing on process variables that both did and did not go well for the patients. Members of the research team were familiar with the Careway ECP programme and played a role in the development of the process of the care pathways which may have affected data analysis through observer bias.

This was mitigated by the primary research maintaining reflexivity through an interpretive and post-positivist lens with a realist ontological approach and by critical reflection by the researcher team. A final possible limitation is that this study only explored the perspectives of patients in New Zealand, and most patients had either knee or shoulder conditions, which may limit the generalizability of the results to other settings.

## Conclusion

Patients with MSK conditions recognise the importance of process variables, especially timeliness, order of care, coordination of care delivery, quantifying progress, equity of access and navigation. Patients also identified that process plays a significant role in how they flow through a MSK care pathway. These findings offer insights to care pathway designers as well as future research opportunities examining the effects of process variables on the outcomes of patients with MSK conditions. Additionally, the cost effectiveness of patient navigators within care pathways should be explored.

## CRediT authorship contribution statement

**Daniel Harvey:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Steve White:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Duncan Reid:** Writing – review & editing, Validation, Methodology, Conceptualization. **Chad Cook:** Writing – review & editing.

## Disclosure of interest

Daniel Harvey and Duncan Reid are clinical advisors for Careway. Daniel Harvey is a treatment provider for Careway. Steve White and Chad Cook have no disclosures.

## Acknowledgements

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**Appendix 9.** Thematic table from Chapter Four to show the codes that were clustered to develop the four prototype themes

## Novel contributions of Chapter 4

The findings from this qualitative study provide a deeper understanding of the process variables within MSK care pathways. Patients identified a variety of process variables they believed were crucial to achieving good outcomes in MSK care pathways. The themes of process matters; quantifying progress facilitated patient engagement; benefits of equitable access of care; and recovery made easier with navigation, were identified. These findings highlight the importance of process variables on patient experiences and should be considered by others involved in designing future healthcare pathways. The conclusions influenced the design of the subsequent research study (see Chapter 5).

# Chapter 5: Associations between process variables and patient outcomes. A retrospective regression analysis of New Zealand musculoskeletal care pathways

## Reference

The article produced in this chapter is under review in *Musculoskeletal Science and Practice.*

## Preface

This chapter focuses on the final study in this body of research. This study examined the quantitative effects of process variables by investigating their associations with patient outcomes in New Zealand MSK care pathways. It answers RQ3: Do process variables influence patient outcomes in MSK care pathways?

The study was guided by the findings from the narrative review in Chapter 2 and the earlier research studies in Chapters 3 and 4, which defined what a process variable is and examined patient perspectives on process variables in MSK care pathways in New Zealand. The literature review presented in Chapter 2 identified that several process variables within MSK healthcare systems may contribute to outcomes. However, it remains unclear what the direct impact of these process variables is on patient outcomes. It is also uncertain whether any other process variables within MSK care pathways can influence patient outcomes.

Chapter 3 is the first to define a contemporary process variable within a healthcare system or MSK care pathway. It enhances the current understanding of process variables and their function in healthcare. The previous study in Chapter 4 examined the patient perspectives on process variables in MSK care pathways in New Zealand. Several themes and subthemes emerged from the qualitative research, indicating that various process variables and factors during the rehabilitation journey are considered significant by MSK patients and may influence their outcomes. These findings highlight the significance of process variables on patient experiences, which informed the current research study and guided the selection of process variables to be investigated and analysed.

## Abstract

### Background

The prevalence of disability caused by musculoskeletal (MSK) conditions and the associated healthcare costs continue to increase. There is a paucity of research that has considered the effect of process variables within MSK care pathways on patient outcomes. A process variable is as any modifiable factor in a pathway that can be quantified and measured and that if varied may achieve a different operational or patient outcome. The quantifiable associations between process variables and patient outcomes in MSK care pathways remain unknown.

### Objective

The aim of this study is to examine the associations between process variables and patient outcomes in MSK care pathways. It was hypothesised that significant associations with strong standardized coefficients would be found between process variables and patient outcomes.

### Method

An observational cohort study retrospectively reviewed the database of patients with MSK injuries included in the Careway Escalated Care Pathway (ECP) rehabilitation programme. Descriptive analyses and quantile linear regressions were utilised to analyse the associations between predictors, confounders and the different quantiles of the dependent variables.

### Results

Significant associations with strong standardized coefficients between predictor process variables, confounders and patient outcomes were found in some of the ECP surgical and non-surgical pathways.

### Conclusion

Process variables are associated with patients achieving outcomes for knee, shoulder and lumbar surgical and non-surgical MSK conditions. Future research should investigate a wider range of process variables using a prospective design and in other

jurisdictions outside of the New Zealand ACC setting to determine the generalisability of these findings.


## Keywords

Physiotherapy; Process variables; Patient outcomes; Musculoskeletal care pathways


## Highlights

- Associations exist between process variables and patient outcomes in musculoskeletal care pathways.
- Timeliness to physiotherapy and vocational rehabilitation significantly influenced patient outcomes.
- The process variable of collecting and analysing PROM data was a strong process variable following surgery.
- Regular measurements of strength was a significant process variable in knee and shoulder pathways.

## Introduction

Musculoskeletal (MSK) conditions, including soft tissue injuries and persistent pain disorders, contribute the largest share of disability worldwide and the greatest requirement of rehabilitation over the lifespan (Blyth et al., 2019; Briggs et al., 2021; Cieza et al., 2021). In New Zealand, the Accident Compensation Corporation (ACC) insurance scheme funds workers' compensation and treatment costs for most accident-related MSK conditions. Analysed ACC claim data of tendon and ligament injuries between 2010 and 2016 identified that knee and shoulder-related tendon and ligament injury claims were the most common and costly sites of injury (Clark et al., 2020). There were over 281,000 knee and 371,000 shoulder injury claims in a country with less than 5 million people, costing $423 million and $569 million respectively. Clark et al. reported that treatment costs increased by 28% for knee and by 36% for shoulder conditions over this six-year period.

The growing burden of disability from MSK conditions and the significant healthcare costs has led to calls to strengthen MSK health care systems (Briggs et al., 2021; Traeger et al., 2019). Researchers and funders have recently moved toward value-based care for the management of MSK conditions focusing on patients' experiences during care and avoiding low-value treatment (Gleadhill et al., 2023; Lentz et al., 2020; Rundell et al., 2015; Teisberg et al., 2020). Value based care aims to ensure efficient healthcare spending while achieving effective and measurable patient outcomes. It could be argued that the shift toward value-based care is an attempt to improve the process variables of MSK care pathways so that patients are seen by appropriate health professionals in a timely manner using guideline orientated integrated care (Cook et al., 2021; Institute of Medicine Roundtable on Value Science-Driven Health Care, 2010; Kreindler, 2017; Porter, 2010). A recent study involving New Zealand-based experts defined MSK process variables as "any modifiable factor in a health process or pathway that can be quantified and measured and that if varied may result in a different operational or patient outcome" (Harvey et al., 2024, p. 5).

In 2019, ACC commissioned a pilot rehabilitation programme, called Escalated Care Pathways (ECP), in which treatment suppliers were asked to implement high value care pathways to manage specific knee, shoulder and lumbar spine injuries that required surgical and non-surgical care (Accident Compensation Corporation, 2022g; Reid et al., 2021). The ECPs were designed with no financial costs to patients, strict diagnostic entry and exit criteria, and required the incorporation of strength measures and validated electronic patient reported outcome measures taken at regular time points. One ECP supplier was Careway, a large multidisciplinary consortium of

community-based providers in Auckland, New Zealand. The Careway patient database provided the opportunity to evaluate and quantify how process variables within an ECP might influence patient outcomes. Hence, this study aimed to review the clinical care patients received and look for associations between process variables and outcomes for patients included in the Careway ECP. It was hypothesised that significant associations with strong standardized coefficients would be found between process variables and patient outcomes, particularly those process variables mandated in the ECP.

## Methods

### Design

An observational cohort study retrospectively reviewed data from patients with MSK injuries covered by ACC and included in the Careway ECP rehabilitation programme. All patients who had completed rehabilitation and were discharged from the Careway ECP programme between 1st January 2021 and 31st December 2023 were included. The standalone database of the Careway ECP contained the demographic, treatment and outcome information of patients in the programme. Ethical approval (number 23/329) was obtained from Auckland University of Technology Ethics Committee.

### Participants

To be eligible for the ECP an individual must have had a complex MSK injury that would require surgery or medical specialist oversight and confirmation by diagnostic imaging. Patients were assigned to either a surgical or non-surgical rehabilitation pathway based on the multidisciplinary team's assessment recommendation and patient preference. Anonymised patient data from the individual knee, shoulder and lumbar spine surgical and non-surgical care pathways (n=2292) were extracted from the Careway database and imported into Excel (Microsoft Office 2021, version 16).

### Variables

Data was examined to determine if there was any association between patient outcome measures at discharge (dependent variables), individual process variables (predictors) and confounders within the respective ECP care pathways (Table 8). Process variables selected were those mandated in the ECP, along with potential predictors linked to

previous ACC patient outcomes that could be captured retrospectively from the Careway database (Fausett et al., 2019; Harvey et al., 2024, 2025).

## Bias

The Careway ECP programme had strict entry criteria allowing homogeneity of the participants' specific MSK condition within the respective care pathway. Information bias was minimised by clinicians using standardised measurement procedures and automatically sent electronic PROMs. Confounding bias was controlled by including confounders in the multivariable regression analysis.

## Sample size estimation

The sample size estimation was conducted based on the guideline of requiring 20 subjects per independent variable with the expectation of incorporating significant predictors into a multivariable regression analysis. Given the assumption that 50% of the sample would meet the criteria for a poor outcome and considering a maximum of four process predictor variables for our seven cohorts of body part regions, a suitable sample size of 160 per pathway was determined to mitigate the risk of overfitting the model while ensuring sufficient statistical power.

## Statistical methods

Baseline descriptive characteristics of the participants and their physiotherapy usage for each of the surgical and non-surgical pathways were calculated using IBM SPSS Statistics for Windows version 30.0 (Armonk, NY: IBM Corp). The Mann-Whitney and Fisher's exact tests were used to compare for differences of the continuous and categorical baseline measures between each respective surgical and non-surgical pathway. Exploratory data analysis was used to check for normal distribution, detect data errors, examine records and perform any data editing. Little's MCAR test was used to check the missing data was missing completely at random. The PROMs data at discharge (dependent variable) was skewed as the outcome measures were understandably high for the patients to achieve the exit criterion from the care pathways. The relationship between the coexisting predictors and confounders at the median and upper quartile ($75^{th}$ percentile) distribution of the respective dependent variable was modelled using multivariable quantile linear regression (see Supplementary file Appendix 10). Significance level was set at $p<0.05$.

*Table 8*

*Predictors, confounders and dependent variables*

| **Process Variables (Predictors)** |
|---|
| *Number of patient reported outcome measures (PROMs)*- The total number of electronic PROMs taken for each of the patients during their rehabilitation from entry to exit from the care pathway. |
| *Number of strength measures*- The total number of manual strength assessment measures taken for the patient and their respective injured body site to determine limb symmetry index (LSI) during their rehabilitation, from entry to exit from the care pathway. |
| *Physiotherapy timeliness* - First physiotherapy session, measured in days from entry into the pathway to first physiotherapy session. |
| *Vocational rehabilitation timeliness*- First vocational rehabilitation session, measured in days from entry into the pathway to first vocational rehabilitation (by an occupational therapist or occupational health physiotherapist). |
| **Confounders** |
| *Age*- Age of the patient at entry into the care pathway categorised for the regression analysis as either <39 years; 40-59 years or 60+ years. |
| *Ethnicity*- Ethnicity of the patient categorised as either Māori/Pasifika or not Māori/Pasifika. |
| *Gender*- Gender of the patient categorised as either male or female. |
| **Outcome measures (Dependent variables)** |
| *Patient reported outcome measures at discharge for each patient*- The Oswestry Disability Index (ODI) was used for lumbar radiculopathy patients, the Knee Injury and Osteoarthritis Outcome Score (KOOS) was used for knee anterior cruciate (ACL) patients, the Shoulder Pain and Disability Index (SPADI) was used for shoulder instability patients, and the Short Version of the Western Ontario Rotator Cuff Index (WORC) was used for shoulder rotator cuff patients. |

## Results

## Descriptive analyses

The following tables provide detail of the descriptive analyses of patients and their physiotherapy treatment usage for each care pathway. Most patients in the care pathways were younger, male, and were not of Māori/Pasifika ethnicity. There were significant differences between the surgical and non-surgical knee, shoulder and lumbar pathways for the number of physiotherapy treatment sessions and the total duration of the physiotherapy treatments. Timeliness of the first physiotherapy session ranged from 13 - 50 days across all pathways (see Supplementary file Appendix 10).

*Table 9*

*Descriptive data of surgical and non-surgical knee anterior cruciate ligament care pathways*

| **Variable** *Data presented is mean, SD and 95% CI* | **Surgical ACL** (n=332) | **Non-surgical ACL** (n=418) | **Significance** **indicates significant P<0.05* |
|---|---|---|---|
| **Age** | 33.18 (13.1) (95% CI = 31.76 – 34.60) | 35.81 (15.05) (95% CI = 33.83 – 37.79) | 0.18 |
| **Gender (Male)** | 195/332 = 58.7% | 241/418 = 57.7% | 0.59 |
| **Ethnicity (Māori and/or Pasifika)** | 88/332 = 26.5% | 90/418 = 21.5% | <0.001* |
| **Number of physiotherapy sessions** | 25.36 (19.6) (95% CI = 23.24 – 27.48) | 13.11 (14.12) (95% CI = 11.71 – 17.20) | <0.001* |
| **Treatment duration in days** | 317.24 (141.5) (95% CI= 301.95 – 332.52) | 280.20 (158.18) (95% CI = 260.00 – 291. 60) | <0.001* |

*Table 10*

*Descriptive data of surgical and non-surgical shoulder dislocation care pathways*

| **Variable** *Data presented is mean, SD and 95% CI* | **Surgical shoulder instability** (n=180) | **Non-surgical shoulder combined** (n=426) | **Significance** **indicates significant P<0.05* |
|---|---|---|---|
| **Age** | 30.09 (8.8) (95% CI = 28.15 – 32.04) | 45.36 (16.4) (95% CI = 43.12 – 47.60) | <0.001* |
| **Gender (Male)** | 150/180 = 83.3% | 278/476 = 58.4% | <0.001* |
| **Ethnicity (Māori and/or Pasifika)** | 50/180 = 27.8% | 73/426 = 17.1% | 0.007* |
| **Number of physiotherapy sessions** | 26.76 (20.5) (95% CI = 22.26 – 31.27) | 18.47 (12.7) (95% CI = 16.7 – 20.20) | 0.005* |
| **Treatment duration in days** | 381.06 (165.4) (95% CI = 344.70 – 417.41) | 230.80 (152.8) (95% CI = 210.00 – 251. 60) | <0.001* |

*Table 11*

*Descriptive data of surgical and non-surgical shoulder rotator cuff care pathways*

| **Variable** *Data presented is mean, SD and 95% CI* | **Surgical rotator cuff** (n=233) | **Non-surgical shoulder combined** (n=426) | **Significance** **indicates significant P<0.05* |
|---|---|---|---|
| **Age** | 57.03 (11.9) (95% CI = 54.80 – 59.26) | 45.36 (16.4) (95% CI = 43.12 – 47.60) | <0.001* |
| **Gender** | 186/233 = 79.8% | 278/476 = 58.4% | <0.001* |
| **Ethnicity (Māori and/or Pasifika)** | 28/233 = 12% | 73/426 = 17.1% | 0.187 |
| **Number of physiotherapy sessions** | 27.5 (16.8) (95% CI = 24.38 – 30.65) | 18.47 (12.7) (95% CI = 16.7 – 20.20) | <0.001* |
| **Treatment duration in days** | 380.42 (165.0) (95% CI = 349.66 – 411.18) | 230.80 (152.8) (95% CI = 210.00 – 251. 60) | <0.001* |

*Table 12*

*Descriptive data of surgical and non-surgical lumbar care pathways*

| **Variable** *Data presented is mean, SD and 95% CI* | **Surgical lumbar** (n=223) | **Non-surgical lumbar** (n=480) | **Significance** **indicates significant P<0.05* |
|---|---|---|---|
| **Age** | 44.99 (13.6) (95% CI= 43.19 – 46.79) | 42.97 (14.4) (95% CI= 41.68 – 44.27) | 0.077 |
| **Gender (Male)** | 130/223 = 58.3% | 260/480 Male = 54.2% | 0.545 |
| **Ethnicity (Māori and/or Pasifika)** | 39/223 = 17.5% | 93/480 = 19.4% | 0.17 |
| **Number of physiotherapy sessions** | 10.91 (15.9) (95% CI= 8.80 – 13.02) | 14.79 (13.7) (95% CI= 13.56 – 16.02) | <0.001* |
| **Treatment duration in days** | 296.59 (186.5) (95% CI= 271.92 – 321.27) | 237.23 (178.0) (95% CI = 221.25 – 253.21) | <0.001* |

## Multivariable regression

Multivariable quantile regressions for each care pathway demonstrated significant associations between several predictor process variables and confounders across the

median and 75th quantiles of the dependent variables. However, pseudo-R-squared measures were low (less than 0.18) for all predictors (see Supplementary files Appendix 10).

The standardised coefficients of the predictors that demonstrated this relationship for each care pathway have been presented below, along with the estimated clinical effect of the predictor relative to a minimal clinically important difference (MCID) change in the PROM score at discharge.

### Knee surgical pathway

In this pathway, three predictor variables demonstrated significant associations with the dependent variable: the number of times that the patient completed a PROM, the number of times strength measures were taken, and the age of the participant.

Within Careway, PROMs were required to be collected every six weeks. The coefficient of 1.74 (95% CI= 0.69 – 2.80) for PROMS indicates that for every five times the PROM was completed, there was an estimated effect of a 9-point MCID increase in the median level KOOS outcome. This association was also seen when the 75th quantile was examined where the collection of eight PROMS (coefficient of 1.19; 95% CI= 0.27 – 2.12), had an estimated effect of a 9-point MCID increase.

Strength measures were taken every six weeks and for every seven strength measures taken (coefficient of 1.27; 95% CI= 0.29 – 2.24) there was a significant estimated effect of a 9-point MCID increase in the median level KOOS outcome score. Whilst not a process variable, age was significantly associated with outcomes. Patients under the age of 39 years had an estimated effect of a 16.95 (95% CI= 3.33 – 30.58) increase in the median level KOOS outcome score.

### Lumbar surgical pathway

In this pathway two process variables demonstrated significant associations with the dependent variable: the number of times patients completed a PROMs and physiotherapy timeliness.

The coefficient of -2.62 (95% CI= -1.45 – -3.79) for PROMs indicates for every four PROMS collected, there was an estimated effect of a 10-point MCID decrease in the 75th level ODI disability outcome score. The coefficient of -0.09 (95% CI= -0.03 – -0.15) for timeliness of physiotherapy indicates that if there is a 111-day delay in starting physiotherapy treatment, there would be an estimated effect of a 10-point MCID decrease in the 75th level ODI outcome score.

The confounder of being under 39 years of age was significantly associated with the dependent variable. There was an estimated effect of a 13.3 decrease (95% CI= -3.41– -23.17) in the 75th quantile ODI outcome score and an estimated effect of a 12.2 decrease (95% CI= -0.48 – 23.91) in the median level ODI outcome score.

The confounder of being male had a significant association with an estimated effect of a 9.7 (95% CI= 2.87– -16.46) decrease in the 75th quantile ODI outcome score and an estimated effect of an 8.1 (95% CI= -0.05 – -16.18) decrease in the median level ODI outcome.

### Lumbar non-surgical pathway

In this pathway the process variable of the timeliness of vocational rehabilitation was a significant factor associated with not achieving outcomes in the median quantile. The coefficient of 0.05 (95% CI= 0.004 – 0.098) indicates if there is a 200-day delay to commencing vocational rehabilitation there would be an estimated effect of a 10-point MCID increase in the median level of the ODI disability outcome score.

The confounder of being of Māori or Pasifika ethnicity had a significant association with an estimated effect of an 11 point (95% CI= 6.13 – 15.83) increase in disability in the median level ODI outcome score. Being of Māori or Pasifika ethnicity had a significant association with an estimated effect of an increase in disability with a 10-point (95% CI= 1.96 –18.05) increase in the 75th quantile ODI outcome score.

### Surgical rotator cuff pathway

In this pathway the process variable of timeliness of physiotherapy was a significant factor associated with decreasing outcomes in the median quantile. The coefficient of 0.059 (95% CI= 0.003 – 0.11) indicates if there is a 338-day delay to commencing physiotherapy there would an estimated effect of an MCID 20-point increase in the median WORC outcome score.

The process variable of PROMs taken was a significant factor associated with achieving a good outcome in the 75th quantile. The coefficient of -2.25 (95% CI= -0.89 – -3.61) indicated that for every nine PROMS taken there was an estimated effect of an MCID 20-point decrease in the WORC outcome score.

The confounder of male gender had a significant association with an estimated effect of a 12.7 (95% CI= 4.1 – 21.3) decrease in the 75th quantile WORC outcome score.

### Surgical shoulder dislocation pathway

In this pathway the confounder of being of younger age (<39 years) had a significant association with an estimated effect 41.28 (95% CI= 10.9 – 71.6) decrease in the median quantile SPADI outcome score. Being aged 40-59 also had a significant association with an estimated effect of a 35.4 (95% CI= 4.1 – 66.8) decrease in the median quantile SPADI outcome score.

### Non-surgical shoulder pathway

In this pathway three predictor variables demonstrated significant associations with the dependent variable at the median quantile: the number of times that the patient completed PROMs, the number of times strength measures were taken, and the age of the participant.

The coefficient of -1.03 (95% CI= -0.44 – -1.63) for PROMS collected indicates that for every 10 PROMs taken there was an estimated effect of a 10-point decrease in the median level outcome score (WORC or SPADI).

Similar findings were found for strength measures taken, with a coefficient of -0.69 (95% CI= -0.07 – -1.31) indicating for every 14 strength measures assessed there was an estimated effect of a 10-point decrease in the median level outcome score (WORC or SPADI).

The confounder of being aged under 39 years had a significant association with an estimated effect of a 5.4 (95% CI= 1.8 – 9.1) decrease in the median level outcome score (WORC or SPADI).

Comparable results were found in the 75$^{th}$ quantile with PROMs taken, strength measures collected and age all significantly associated with good outcomes.

The coefficient of -1.51 (95% CI= -0.42 – -2.60) for PROMS taken indicates that for every seven PROMS there was an estimated effect of a 10-point decrease in the 75$^{th}$ quantile outcome score (WORC or SPADI).

Similarly, the coefficient of-1.39 (95% CI= -0.25- – 2.53) indicates that for every seven strength measures collected there was an estimated effect of a 10-point decrease in the 75$^{th}$ quantile outcome score (WORC or SPADI).

For non-surgical shoulder pathways, the confounder of being younger in age (<39 years) had a significant association with an estimated effect of a 10.87 (95% CI= 4.3 – 17.5) decrease in the 75$^{th}$ quantile outcome score (WORC or SPADI).

The confounder of being male had a significant association with an estimated effect of a 6.3 (95% CI= 1.1 – 11.6) decrease in the 75$^{th}$ quantile outcome score (WORC or SPADI).

## Discussion

To the best of our knowledge this is the first study to directly investigate the effects of process variables within MSK surgical and non-surgical care pathways. As hypothesised, the regression analysis identified significant associations with strong standardized coefficients between predictor process variables and patient outcomes in some pathways. However, these results should be interpreted with caution as the explanatory power of the regression modelling for the studied predictors was low.

Our regression analysis demonstrated that the number of times PROMs were collected during rehabilitation was significantly associated with a better outcome for patients in the surgical knee, lumbar and shoulder rotator cuff groups. This positive association supports the findings of Deutscher et al., 2009 who reported that patients who completed three (including one at baseline and one at discharge) or more PROMs had significantly better outcomes than those who completed two or less. That study cohort had relatively straightforward MSK conditions which differs to these ECP patients who required surgical intervention and post-surgical rehabilitation. The greater the complexity of a patient's condition, the more frequent PROM utilisation during rehabilitation may be required (Fennelly et al., 2018; Meerhoff et al., 2021).

The evidence from our study supports previous research indicating that collecting and analysing electronic PROMs during patient MSK rehabilitation is associated with good patient experiences and outcomes (Deutscher et al., 2009; Garcia et al., 2025; Harvey et al., 2025; Meirte et al., 2020). Whilst these findings suggest that clinicians should utilise PROMs during a patient's rehabilitation journey, it should be noted the ACC ECP operation guidelines only required treatment suppliers to collect an entry and exit PROM. Careway management implemented six-weekly clinician PROM reassessments which was over and above ACC's minimum measurement requirements for the ECP pilot and in line with best practice (Cook et al., 2021; Lin et al., 2020).

Some may argue that that collection of PROMs at regular intervals during rehabilitation is simply a placeholder for a patient who needs time to receive necessary treatment following surgery. The experiences of patients during the ECP pilot and their perspectives of process variables have been recently explored in a qualitative study. Patients stated that regular PROM reassessments helped them track their recovery, stay motivated, and reduced frustrations - even through phases with slow progress

(Harvey et al., 2025). Routinely collecting PROMS provides a chance for clinicians to engage in collaborative patient-centred communication and a personalised partnership over the course of their rehabilitation (Cook et al., 2021; Lin et al., 2020). Additionally, the collection of PROMs during complex rehabilitation affords clinicians with valuable quantifiable feedback at the process-outcome interface, to review recovery trajectories and guide future treatment decisions towards patient goals (Harvey et al., 2025; Jesus & Hoenig, 2015; Meerhoff et al., 2021). Clearly, collecting PROMs from a patient who does not engage in rehabilitation would not likely result in a good patient outcome. Therefore, the process variable of collecting and analysing PROM data is likely to be a proxy for patient-therapist rehabilitation engagement.

Regular measurements of strength were associated with significant improvements in patient outcomes in the surgical knee and the non-surgical shoulder pathways. In regard to knee quadriceps strength, it is known that achieving a limb symmetry index (LSI) of 90% or greater is associated with favourable functional outcomes following knee ACL surgery (Arhos et al., 2022; Drigny et al., 2022). Regular strength measures are a further opportunity for clinicians to encourage patient accountability and action towards their functional goals. Having visibility over the real time measures of their LSI may increase patient compliance with their home strengthening programme and this could explain how regular strength measures are associated with better outcomes (Collado-Mateo et al., 2021; Deutscher et al., 2009; Harvey et al., 2025).

Another process variable that previous research has reported to be significantly associated with better patient outcomes is timeliness in respect to any delay between injury and the start of physiotherapy treatment (Brennan et al., 2015; Deutscher et al., 2009; Mekonnen et al., 2025). In the current study, delays to the initiation of physiotherapy had significant associations with reduced patient outcomes in the lumbar surgical and shoulder rotator cuff surgical pathways but had no significant associations with any of the non-surgical pathways. This was anticipated as the ECP was designed to ensure that for less complex conditions, physiotherapy treatment started immediately to minimise the effect that a prolonged delay would have on recovery (Accident Compensation Corporation, 2022g). On average, patients in the non-surgical pathways had their first physiotherapy session within 13 to 20 days of entry into the ECP, which compared favourably to the conventional 30-day post injury treatment benchmark (Ehrmann-Feldman et al., 1996; McDevitt et al., 2023; Mekonnen et al., 2025).

Furthermore, a delay in the commencement of vocational rehabilitation was significantly associated with not achieving good outcomes in the non-surgical lumbar spine pathway. For lumbar pain patients, an early return to work with alternate or

modified duties may help overcome biopsychosocial barriers, but this often requires expert vocational support (Accident Compensation Corporation, 2004b; Christopherson et al., 2022; Harvey et al., 2023; Shaw et al., 2018). This finding supports those of Harvey and colleagues which found that co-ordination of care and "*seeing the right clinician at the right time"* was considered important by patients in achieving good outcomes (Harvey et al., 2025, p. 3). Returning injured MSK patients back to work in a timely manner should be a priority as this reduces downstream workers' compensation costs for insurers (Accident Compensation Corporation, 2022f, 2023; Mekonnen et al., 2025; Waddell et al., 2008).

The ACC reviewed the ECP pilot and found this value-based approach demonstrated a positive patient experience for 95% of patients and 88% of patients had significantly improved health outcomes (Accident Compensation Corporation, 2023). Additionally, over the first two years of the ECP trial, ACC saved over $12 million alone in the surgical pathways from reduced weekly workers' compensation costs, surgery and reinjury savings and decreased long term dependency liability. Results also demonstrated a considerable reduced need for future surgery and a downward trend of reinjury (Accident Compensation Corporation, 2023). The ECP pilot was deemed a success by ACC and the structure and process variables of the ECP have been replicated and incorporated into the new ACC Integrated Care Pathways (ICP-MSK) (Accident Compensation Corporation, 2024).

Lastly, the volume and duration of physiotherapy treatment sessions required to meet the ECP outcome exit criterion exceeded the previous ACC funding limit of 16 physiotherapy sessions for non-ECP providers (Accident Compensation Corporation, 2025a). All care pathways aside from those for lumbar injuries, required on average greater than 16 physiotherapy treatment to achieve good outcomes. In a retrospective review of ACC data by Fausett et al., there was on average 12 physiotherapy treatment sessions undertaken over 161 days following knee ACL surgery. This differs substantially from the current study in which an average of 25 treatment sessions over 317 days were needed for the patient to meet the exit criteria (Fausett et al., 2019). There were also significant differences for physiotherapy treatment numbers and the duration of sessions between the respective surgical and non-surgical knee, shoulder and lumbar care pathways. It is likely the removal of ACC treatment limits and financial costs for ECP patients allowed clinicians to deliver the necessary evidence based rehabilitation to achieve the outcomes required for patient discharge (Fausett et al., 2019; Grevnerts et al., 2022; Harvey et al., 2025).

Overall, this study provides funders with evidence that there are associations between process variables and patient outcomes in MSK care pathways. Process variables such as timeliness to initial commencement of physiotherapy and vocational rehabilitation, and regular measurement of progress through PROMs and measures of strength, play an important role in determining the outcome of rehabilitation of patients with for complex knee, shoulder and lumbar conditions. Additionally, this research has provided clarity about the dosage and duration of physiotherapy treatment required to achieve an optimal level of functional recovery.

## Limitations

This study's design was retrospective and had missing data, putting it at risk of information bias. Little's MCAR test demonstrated the missing data was likely missing completely at random. Due to the missing data being between 10 and 20%, imputation was not included in the current study and the analyses were based on completed data only (Enders, 2010; Fein et al., 2021; Little, 1988). The shoulder non-surgical group had their data combined, which would have likely caused heterogeneity in the results compared to the respective rotator cuff and shoulder instability surgery groups. The number of predictor process variables that could be collected and analysed was limited by the study design and the database. There were significant confounders (age, ethnicity and gender) associated with patient outcomes in some care pathways, consistent with previous research (Deutscher et al., 2009; Mekonnen et al., 2025; Pryymachenko et al., 2023; Song et al., 2013). The non-collection of smoking or socioeconomic status data did not allow for the measurement of those confounders.

## Interpretation

The result of this research provides evidence of associations between process variables in MSK surgical and non-surgical care pathways and outcome measures at discharge. The process variables of collecting PROMs and patient strength measures, and the timeliness of physiotherapy and vocational rehabilitation can influence patient outcomes. The findings identify that process variables are measurable and potentially can be varied to achieve a different operational or patient outcome within a MSK care pathway.

## Funding

No funding was received for this research.

## Conclusion

Process variables are associated with patients achieving outcomes for knee, shoulder and lumbar surgical and non-surgical MSK conditions. These findings offer awareness to funders and MSK care pathway designers of the importance of process variables in contributing towards patient outcomes and improving healthcare cost effectiveness and efficiency. Future research could investigate the ACC ICP-MSK and a wider range of process variables using a prospective design, as well as settings outside of New Zealand to determine the generalisability of these findings.

## CRediT authorship contribution statement

**Daniel Harvey:** Writing – original draft, Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization. **Steve White:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Duncan Reid:** Writing – review & editing, Validation, Methodology, Conceptualization. **Chad Cook:** Writing – review & editing, Validation, Methodology Conceptualisation.

## Disclosure of interest

Daniel Harvey and Duncan Reid are clinical advisors for Careway. Daniel Harvey is a treatment provider for Careway. Steve White and Chad Cook have no disclosures.

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## Novel contribution of Chapter 5

This is the first study in the literature to directly investigate how process variables influence outcomes across a broad range of patients with MSK and orthopaedic conditions. The current study investigated patients in both surgical and non-surgical care pathways. The current research found significant relationships, with strong standardised coefficients, between predictor process variables and patient outcomes across several pathways. These research findings are important because they provide evidence that process variables are connected to patient outcomes for knee, shoulder, and lumbar MSK conditions, whether treated surgically or with non-operative rehabilitation. The findings also support those from the previous research study (reported in Chapter 4) on patient perspectives regarding process variables, laying a foundation for future research into how process affects patient outcomes.

Additionally, the current study provides an analysis of the dosage and duration of physiotherapy treatment needed for patients with complex MSK conditions to achieve optimal functional recovery in the New Zealand ACC primary healthcare setting.

# Chapter 6: Discussion, implications & conclusion

This thesis examined the effects of process variables on patient outcomes in MSK care pathways. This chapter provides an overview and discussion of the main findings of the research. The implications of the research are outlined, including its strengths and limitations, as well as future research directions related to this work. The chapter starts by summarising the main findings and then proceeds to the discussion.

## 6.1 Main Findings

### Research question one: What is the operational definition of a process variable within a healthcare system or musculoskeletal care pathway?

This research has established an expert, consensus-based, operational definition of a process variable within a healthcare system or MSK care pathway: *a health process variable is any modifiable factor in a health process or pathway that can be quantified and measured and that, if varied, may achieve a different operational or patient outcome.*

### Research question two: What process variables do patients consider 'matter' or 'are important' in their musculoskeletal rehabilitation journey?

Four key themes that represent the things that patients considered essential during their MSK rehabilitation were: 1) process matters; 2) quantifying progress facilitated patient engagement; 3) benefits of equitable access of care; and 4) recovery made easier with navigation. Patients with MSK conditions recognise the importance of process variables in achieving their outcomes, especially the timeliness of treatment, the order of care, the coordination of care delivery, quantifying progress, equity of access and patient navigation.

### Research question three: Do process variables influence patient outcomes in musculoskeletal care pathways?

Several process variables are significantly associated with patient outcomes in the MSK care pathways. Regular measurement of progress through PROMs and strength measures, and timeliness of the initial commencement of physiotherapy and vocational

rehabilitation, are linked to positive outcomes for complex knee, shoulder, and lumbar conditions.

## 6.2 Discussion

The burden of MSK pain and disability continues to increase in New Zealand and globally, despite efforts from researchers, funders, and clinicians. The present research enhances understanding of process variables within healthcare systems, especially within MSK care pathways. The consensus-based agreement on a definition of a process variable provides a contemporary understanding of a process variable, developed through collaboration among industry experts. It builds on earlier concepts of process and provides a foundation for further research by researchers, funders, and clinicians. The unified definition of a process variable established in this study allows other researchers to examine process variables from this perspective, facilitating comparisons of future research findings with these original results and opening opportunities for studies in non-MSK fields.

The qualitative study of patient perspectives on process variables demonstrated that patients clearly understand the importance of process in achieving good functional outcomes within MSK care pathways. Patients recognise how the process (good or bad) can significantly affect their rehabilitation journey and recovery from MSK injuries. A factor considered particularly important by all participants was timeliness. The delay between recognising the patient's need for care and the actual initiation of that treatment was crucial to patients. Previous research has reported that timeliness is significantly associated with better patient outcomes if there is no excessive delay between injury and the start of physiotherapy treatment for MSK conditions (Deslauriers et al., 2021; Deutscher et al., 2009; Mekonnen et al., 2025; Ojha et al., 2016).

However, only one study has investigated the effect of timeliness on outcomes following orthopaedic surgery (Brennan et al., 2015). That study examined the delays from inpatient discharge following total knee arthroplasty to the initiation of outpatient physiotherapy and found that each day less between discharge and the start of outpatient physiotherapy was linked to reduced pain intensity and knee disability. The findings from the quantitative research in Chapter 5 build upon the 2015 paper by Brennan and colleagues, and contribute to the literature by emphasising the importance of timeliness in physiotherapy and vocational rehabilitation following lumbar and shoulder rotator cuff orthopaedic surgeries, as well as its association with

favourable patient outcomes (Brennan et al., 2015; Valenzuela-Moss et al., 2023). The quantitative analysis in Chapter 5 also demonstrated that, on average, patients in the non-surgical pathways had their first physiotherapy treatment session within 13 to 20 days of entry into the ECP, which compares favourably to the conventional 30-day post-injury treatment timeliness benchmark (Ehrmann-Feldman et al., 1996; McDevitt et al., 2023; Mekonnen et al., 2025). The non-surgical pathways showed no significant associations with delays in receiving treatment and patient outcomes. This finding was anticipated, as the ECP was designed to ensure that, for less complex conditions, physiotherapy treatment commenced immediately to minimise the effects of a prolonged delay on recovery (Accident Compensation Corporation, 2022g).

The patients' views on key processes in care pathways align with the quantitative analysis of process variables, which clearly show that these variables influence patient outcomes in MSK care pathways. Before this research, the significance of processes supporting patient outcomes in healthcare systems or care pathways was recognised but not directly studied. For patients with MSK conditions, there was limited research or evidence establishing a direct link between process variables and patient outcomes. The present study has demonstrated that individual process variables within MSK care pathways directly affect patient outcomes, both positively and negatively. These findings support research from other fields indicating that methods for improving processes and outcomes used in industrial manufacturing are also relevant to healthcare. Specifically, the process variables of timeliness and the regular measurement and analysis of patient outcomes can address delays, reduce errors, better meet patient needs, minimise waste, and enhance patient flow within the MSK healthcare sector.

The research in Chapters 4 and 5 showed that collecting electronic PROMs and strength measurements from patients every six weeks was beneficial. The current findings support the broader literature demonstrating the advantages of using electronic PROMS and of collecting and analysing LSI data. Previous studies indicate that gathering and analysing electronic PROMs, along with physical strength measures, during patient MSK rehabilitation are associated with positive patient experiences and outcomes (Deutscher et al., 2009; Drigny et al., 2022; Harvey et al., 2025; Meerhoff et al., 2021; Meirte et al., 2020).

A systematic review examined the benefits, barriers, and disadvantages of digital collection of qualitative electronic patient-reported outcome measures (Meirte et al., 2020). Reported benefits of electronic PROMs included greater patient preference and acceptability, lower costs, similar or faster completion times, higher data quality and

response rates, and improved symptom management and patient-clinician communication. Potential disadvantages of electronic PROMs included concerns about privacy protection, a significant initial financial investment, and the exclusion of specific populations or a barrier posed by the ‘digital divide’ (Meirte et al., 2020). Conversely, a recent database analysis of nearly 90,000 patients with MSK disorders found that using paper forms to capture PROMs was linked to a less favourable patient experience (Garcia et al., 2025).

This current research has demonstrated that regular strength measurements are associated with significant improvements in patient outcomes in both the surgical knee (ACL) and non-surgical shoulder pathways. After an ACL injury and subsequent surgery, recovery can take many months and will require extensive physiotherapy rehabilitation to regain functional strength (Grevnerts et al., 2022; Piussi et al., 2023). Achieving an LSI of 90% or greater in the knee extensor muscle is associated with better functional outcomes following knee ACL surgery (Arhos et al., 2022; Drigny et al., 2022). Regular strength measures offer an additional opportunity for clinicians to motivate patients to take accountability and action towards their functional goals. Having visibility over the real-time measures of their LSI may boost patient compliance with their home strengthening programme, and this finding could explain how regular strength measures are associated with better outcomes (Collado-Mateo et al., 2021; Deutscher et al., 2009; Harvey et al., 2025).

The key clinical insight from this research is that regularly measuring patient progress and outcomes using PROMs following orthopaedic surgery helps promote patient-therapist engagement, encourages rehabilitation compliance, improves patient monitoring, and ultimately leads to better recovery. The findings support those of previous quantitative research in the public outpatient setting (Deutscher et al., 2009). Those authors found that patients who completed three or more PROMs (including one at baseline and one at discharge) had significantly better outcomes. In contrast, the present study cohort had higher clinical complexity, including post-surgical patients who required a more extended recovery period and, therefore, likely necessitated more frequent PROM collection and monitoring. The more measures recorded, the better the patient outcomes. The present research found that patients valued these regular objective measures highly (Harvey et al., 2025). However, it is unlikely that the number of measures alone is the sole factor in producing better outcomes; instead, the implementation of more measures was associated with a longer rehabilitation period and was likely linked to a goal-focused pathway, strong patient compliance, and the development of rapport between the patient and clinician.

Having active process variables to continuously capture and analyse regular functional milestones throughout an extensive recovery reduces patient drift and improves patient outcomes. As the patient approaches the set care pathway exit criteria, a continuous feedback loop is established, in which the physiotherapist consistently assesses and demonstrates the patient's progress toward their functional goals. The process of collecting and analysing PROM data and limb symmetry index (LSI) strength measures likely acts as a proxy for patient-therapist engagement, adherence, and monitoring. The present research findings help in understanding how these process variables influence patient-therapist engagement, adherence, monitoring, and outcomes in MSK care pathways, ultimately supporting patient-centred care (Lin et al., 2020).

A recent prospective cohort study aimed to compare expected and actual post-operative barriers after lumbar decompression surgery (Wilson et al., 2025). The authors also sought to assess the relationship between encountering barriers and achieving meaningful improvement (MCID) in Oswestry Disability Index (ODI) scores, and to explore the link between socioeconomic status and barriers using the Social Vulnerability Index (SVI). The findings indicated that exercise adherence, financial stress, and understanding of care were common concerns. Five post-operative barriers reduced the likelihood of achieving MCID: difficulty meeting exercise goals (OR = 0.43, P = 0.00036), difficulty obtaining medications (OR = 0.32, P = 0.030), transportation issues (OR = 0.42, P = 0.036), communication problems with the care team (OR = 0.52, P = 0.015), and limited understanding of the care plan (OR = 0.58, P = 0.044). Higher SVI scores were associated with difficulty obtaining medications (P = 0.035) and increased financial stress (P = 0.033). The findings of the present research highlight an opportunity to use process variables following lumbar decompression surgery, such as regular PROM and strength assessments, to address the barriers identified in the Wilson et al. study.

Clinicians working in New Zealand under the ACC Physiotherapy Services contract (Accident Compensation Corporation, 2009) have previously only been required to use two measures of patient outcomes – the Patient Specific Functional Scale (PSFS) outcome measure (Stratford et al., 1995), and the Numeric Pain Rating Scale (NPRS) (Breivik et al., 2000). ACC recommended these as the two primary tools for all MSK conditions, as both are quick and easy to administer (Accident Compensation Corporation, 2009). The use of these outcome measures has continued in New Zealand physiotherapy private practices and outpatient settings since 2009 without any analysis of patient outcome data by ACC (Collett et al., 2025). This has resulted in limited PROM use among New Zealand physiotherapists, with the main reason for PROM utilisation being for ACC contractual purposes rather than for regularly

measuring and monitoring patient progress after surgery. A recommendation from the present research is that physiotherapists working with complex MSK conditions should more regularly collect a range of valid and reliable PROMs and LSI strength measures to monitor and improve patient outcomes.

The research from Chapter 5 has clarified the appropriate dosage and duration of physiotherapy needed to achieve optimal functional recovery after complex MSK injuries. Post-surgery, the treatment period required for patients to meet the Careway exit criteria (≥90% LSI) and to reach their functional goals ranged from 9 to 12 months across all surgical pathways. It was shown that the volume and duration of physiotherapy sessions needed to meet the ECP outcome exit criterion exceeded the previous ACC funding cap of 16 physiotherapy sessions for non-ECP providers for an ACL-injured knee (Accident Compensation Corporation, 2009, 2025a) .

All surgical and non-surgical care pathways, except those for lumbar injuries, required more than 16 physiotherapy treatment sessions to achieve good outcomes. In a retrospective review of ACC treatment injury data by Fausett et al. (2019), the average number of physiotherapy sessions over 161 days following knee ACL surgery was 12. This figure differs significantly from the current study, where an average of 25 sessions over 317 days was needed for patients to meet the exit criteria of achieving a knee extensor muscle LSI of ≥90%, returning to work, and reaching functional independence (Collett et al., 2025; Fausett et al., 2019). This also indicates that, under the previous standard ACC system, there was limited visibility into why and when patients left the system or achieved a meaningful exit goal.

The data in the present study, from Chapter 5, demonstrated a statistically significant difference between the surgical and non-surgical lumbar, knee and shoulder rehabilitation care pathways in terms of volume and duration, aligning with previous literature (Arhos et al., 2022; Collett et al., 2025; Handoll et al., 2004; Rhon & Tucker, 2022; Surakanti et al., 2023). Rehabilitation following invasive orthopaedic surgery for complex knee and shoulder MSK conditions requires a higher number of physiotherapy sessions over a longer period. This data from Chapter 5 should better inform ACC, clinicians and patients by providing an up-to-date description of the volume and duration of physiotherapy needed to attain optimal patient outcomes in the New Zealand ACC setting following surgery for complex MSK conditions.

## 6.2 Implications and future directions

This thesis presents significant findings that enhance the understanding of process variables within healthcare systems and MSK care pathways. Process variables can be viewed as an additional element in Donabedian's traditional healthcare framework of structure, process, and outcomes and may represent interconnected variables that assist complex health systems to function (Donabedian, 1988; Geary, 2024). Recognising these process variables and their specific impact on patient outcomes should motivate further research in quality improvement and potentially allow for their inclusion in existing frameworks that assess and improve MSK models of care (Briggs et al., 2017; Briggs et al., 2016). Moreover, there is potential to incorporate process variables into current MSK care pathways or models of care in measurable ways, such as tracking the time from injury to initial consultation with a healthcare provider, or the interval between referral and the completion of advanced imaging. The findings from this research will enable managers, clinicians, and funders to monitor and adjust process variables to promote quality improvements and to influence operational and patient outcomes within MSK care pathways.

Additionally, further process variables will need to be evaluated based on the findings of this research; the impact of specific clusters or groupings of process variables should be explored. There will likely be an interaction between various process variables and certain MSK conditions or patient clinical characteristics that may, in combination, predict patient outcomes (Lentz et al., 2020; O'Keeffe et al., 2016). In healthcare, an interaction occurs when the effect of one variable on an outcome depends on the level or value of another variable. Process variables could also be a focus for future investigations in non-MSK care pathways within the broader health system. Our research findings suggest that the greater the complexity of the patient's condition or designated care pathway, the more significant the effect of the process variable on patient outcomes. The rising global epidemic of non-communicable diseases (Biswas & Roy, 2024; Geng et al., 2025; Peng et al., 2024), such as cardiovascular disease and diabetes, arguably provide a greater challenge to health system planners than MSK conditions and could be a promising area of further research (Piovani et al., 2022).

While this research indicates that individual process variables within MSK care pathways can independently improve patient outcomes, Donabedian noted that, when evaluating healthcare systems, structure, process, and outcomes are closely interconnected, with structure shaping process, which then influences outcomes (Donabedian, 1988). Although individual process variables demonstrated significant

links to patient outcomes, the explanatory power of these relationships was limited. The interconnected nature of structure and process likely affected the strength of these links. Structural factors, such as the personnel involved in the patient journey (not just healthcare professionals), organisational management, and facilities, were not specifically ‘controlled’ in the ECP pathways that provided the data for this study. The ACC provided guidance on minimum standards and service specifications for all treatment providers within the ECP, likely facilitating some standardisation of the pathway’s structural components. Future research into process variables within care pathways might focus on further standardising structural elements to minimise the impact of extraneous or confounding factors, while recognising the complex sociotechnical nature of healthcare systems (Donabedian, 2005; Geary, 2024; James & Savitz, 2011; Moore et al., 2015).

The findings from the present research, which investigates process variables, align closely with the principles of value-based care (VBC) (Chapter 1). VBC emphasises the organisation of care around specific patient conditions, while integrating the appropriate healthcare professionals to deliver high-quality care at the right time (Cook et al., 2021). Chapter 4 explored patient perspectives and the importance they attributed to process variables in achieving their outcomes. Process variables enabled patients to receive timely, coordinated care, high-quality treatment, continuous monitoring, and patient-centred support. Process variables appear to allow the addition or subtraction of value from patient trajectories within MSK care pathways or VBC models of care. The findings from the quantitative research (Chapter 5) confirmed that a process variable acts as a moderator and supported the assumptions (Chapter 2) that each process variable moderates the patient’s care journey and progress toward their recovery and outcome (Geary, 2024; Health Foundation, 2013; Lleras, 2005; Munévar, 2021; Rosvall & Bergstrom, 2010; Showell et al., 2012).

For example, the process variable of collecting and assessing patient progress using PROMs after lumbar spine surgery had a strong association and standardised coefficient with a reduction in disability. The more frequently PROMs were measured and analysed, the greater the reduction in disability and improvement in patient outcomes. In contrast, delays in commencing physiotherapy after rotator cuff surgery were associated with poorer clinical and functional outcomes. Process variables should be considered a crucial factor in VBC, as healthcare providers in that setting are funded based on patient outcomes rather than the volume of treatment delivered.

### 6.2.1 Implications for funders and health system planners

This current research demonstrates that process variables offer funders and health system planners the opportunity to modify processes, add value, and enhance patient outcomes in MSK care pathways. As outlined in Chapter 1, the ACC is a distinctive system with low administrative costs, and the process of making an ACC insurance claim and having it approved is straightforward compared to other schemes worldwide (Accident Compensation Corporation, 2022a, 2025b; Bismark & Paterson, 2006). New Zealand, with its government-funded insurance monopoly, provided an ideal setting to measure and analyse the effects of process variables within the ACC ECP pathways.

The ECP was ACC's first value-based proposition to manage MSK conditions in New Zealand. When ACC reviewed the ECP pilot, it found that this value-based approach demonstrated a positive patient experience for 95% of patients, and 88% of patients had significantly improved health outcomes (Accident Compensation Corporation, 2023). Additionally, from an initial financial review of the first two years of the ECP trial, ACC spent $11 million on additional treatment but had saved over $12 million through reduced weekly workers' compensation and costs alone, as well as decreased long-term dependency liability in surgical pathways. Results also demonstrated a considerably reduced need for future surgery and a downward trend of reinjury (Accident Compensation Corporation, 2023). The financial savings from the surgical pathways are not surprising, as the more complex a condition or rehabilitation care pathway, the greater the costs, inefficiencies and constraints to patient flow are likely to be present (Showell et al., 2012; Wyles et al., 2021; Young et al., 2004). Conversely, ACC reported $8.5 million invested in the non-surgical (rehabilitation-only) treatment pathways, but the performance was less dramatic, with only $3.5 million in savings in the first two years of ECP (Accident Compensation Corporation, 2023). This result could be because the volume of patients seen in the non-operative pathways was lower than that managed in the surgical pathways in the early stages of the pilot ECP programme.

Recently, ACC released a detailed summary of the ECP programme's full performance under the New Zealand Official Information Act (OIA reference: GOV-042726) (Accident Compensation Corporation, 2025c). Between 06/12/2019 and 31/03/2025, 9,468 clients were treated under the surgical pathways in ECP, and ACC incurred $24 million in additional treatment costs for this group compared to baseline. Additionally, ACC saved nearly $48 million in various areas, including weekly compensation ($7 million), surgery savings ($13 million), re-injury savings (almost $2 million), and long-term dependency ($18 million) (Accident Compensation Corporation, 2025c). The

performance data for the ECP non-surgical pathways were not as strong as those for the surgical pathways. Between June 12, 2019, and March 31, 2025, there were 10,464 clients in the ECP non-surgical pathways. ACC incurred $31 million in additional treatment costs for this cohort compared with baseline. ACC saved a total of $307,000 across various areas, including weekly compensation (-$4.1 million), surgical prevention ($2.5 million), re-injury savings (nearly -$1.7 million), and long-term dependency ($4 million) (Accident Compensation Corporation, 2025c).

When comparing surgical and non-surgical performance, several conclusions can be drawn to explain the greater savings achieved through surgery. The ECP pilot replaced a disjointed ACC structure, which previously often led to wide variations in patient care and, consequently, outcomes. Patients were frequently frustrated by wait times, the cost of rehabilitation, and the fragmented communication between treatment providers (Accident Compensation Corporation, 2023). The ECP is a more integrated care model that allows orthopaedic surgeons and allied health professionals to work collaboratively. The patients in the surgical ECP pathways had medium to high complexity; however, their recovery trajectory was considered relatively predictable (Accident Compensation Corporation, 2023).

The ECP value proposition involved a higher initial bundle cost, including surgery, physiotherapy, vocational (return-to-work) rehabilitation, gym membership fees, and patient navigation services; offset by savings in weekly compensation payments, potential re-surgery, and a lower risk of future ACC claims on the same injured body part (Accident Compensation Corporation, 2019, 2022g, 2023). On the other hand, a thorough review of the ECP data showed that the non-surgical pathway resulted in $4 million in lost savings due to earnings-related weekly compensation costs and nearly $2 million in missed reinjury savings. Clearly, higher upfront bundle treatment costs did not necessarily translate into better patient outcomes within the ECP for the non-surgical pathways beyond the first two years (Accident Compensation Corporation, 2023). The non-surgical performance, representing a half-million-dollar loss, indicates that the traditional pre-ECP ACC model was comparable to the ECP non-surgical care pathways in the long run.

The ECP structure and processes, which include an interdisciplinary team of physiotherapists, orthopaedic surgeons, and vocational rehabilitation providers, entry criteria, timely physiotherapy and vocational rehabilitation care, regular measured PROMs and strength assessments, and clear exit criteria, represent a significant improvement on the previous ACC patient rehabilitation experience (Accident Compensation Corporation, 2023; Collett et al., 2025; Harvey et al., 2025). As

previously discussed, in the case of rehabilitation following ACL surgery, physiotherapy underservicing was likely occurring under the pre-ECP ACC model (Fausett et al., 2019). Implementing process variables that enable timely care and objectively measure and monitor patient progress from entry to exit within the MSK care pathway exemplifies value within VBC models.

Porter has previously noted that measuring perceived value in a care pathway should encompass all specific services and processes that collectively influence a successful patient outcome (Porter, 2009). The ECP VBC model showed greater savings and a 2:1 return on investment from surgical pathways, compared to a negative return on non-surgical pathways (Accident Compensation Corporation, 2025c). Clearly, the more complex an MSK condition, as observed in surgical pathway patients, the greater the opportunity to improve patient outcomes while reducing costs and inefficiencies through a carefully designed MSK care pathway with modifiable process variables (Geary, 2024; James & Savitz, 2011; Kreindler, 2017; Young et al., 2004). This aligns with the current research studies in this thesis, which indicate that process variables were more strongly associated with outcomes in surgical pathways. The ACC data above demonstrate that VBC can offer funders cost savings and optimal MSK patient outcomes for complex MSK conditions; however, establishing well-designed care pathways with appropriate structure, processes, and process variables initially requires a higher investment and a complex systems design perspective (Accident Compensation Corporation, 2025c; Geary, 2024; Porter, 2010).

Some unique lessons and opportunities have emerged from the ECP trial and subsequent research, as outlined in Chapters 4 and 5. Implementing VBC incurs significant financial costs for ACC. Still, the return on investment and reduction in downstream expenses and liability are substantial (Accident Compensation Corporation, 2022g, 2023, 2025c). The intention of VBC for ACC is to achieve better health outcomes for MSK patients and manage costs for the taxpayer by shifting from paying for the volume of services (fee-for-service) to paying for quality, cost-efficient, and outcome-focused results. This service model represents a stark contrast to the current business-as-usual, fee-for-service, single-siloed service model, which is entrenched in the ACC Act 2001 legislation, now nearly 25 years old (Accident Compensation Act, 2001; Accident Compensation Corporation, 2009, 2022a, 2022c).

This research supports the view that the moderator and facilitator of these patient outcomes and financial efficiencies is likely due, in part, to the ECP's process variables, especially in surgical care pathways. The ECP pilot was deemed a success by ACC, and the ECP's structure and process variables have been replicated and incorporated

into the new ACC Integrated Care Pathways (ICP-MSK) (Accident Compensation Corporation, 2024). The ICP-MSK programme has now become the expected business-as-usual model for the high-cost and complex conditions evaluated by the ECP pilot. ACC should consider implementing additional specific process variables in future ACC VBC programmes targeting a range of moderately complex but common conditions, such as concussion, ankle instability, and Achilles tendon rupture. Other opportunities for ACC include the rollout of an ACC-funded standardised digital platform for all suppliers in New Zealand to electronically deliver, analyse, and monitor patient PROMs and LSI results. Doing this could enable nationwide benchmarking of PROMS and LSI results between ACC suppliers, potentially leading to improved patient outcomes, enhanced ACC system performance, and advancement of clinician professional development (Batalden & Davidoff, 2007; Willmington et al., 2022).

This thesis was undertaken within the New Zealand ECP context, using patient data from an ACC-funded value-based care pilot. The extent to which the findings are generalisable to other settings and jurisdictions is likely to depend on each system's structural and regulatory environment. Firstly, ACC is a single national no-fault insurer for personal injury, with a defined entitlement framework and the ability to specify pathway components through commissioning and contracting (Accident Compensation Corporation, 2019; Bismark & Paterson, 2006). The process variables identified in the ACC/ECP system are likely influenced by patients being fully funded for care and by the generous surgery eligibility and entry criteria that shape early access and adherence to the MSK care pathways. The mandated ACC/ECP pathway architecture directly influenced access, sequencing of care, and patient measurement requirements. Together with ACC's performance and contractual expectations within the ECP MSK pathways, these factors may limit the generalisability of the thesis results to other health systems.

In contrast, within tax-funded universal systems (including parts of the New Zealand public health system), timely access to specialist medical services (secondary care) is commonly mediated by GP (primary care) gatekeeping and further constrained by centrally managed outpatient and elective surgical waiting lists (Ntais et al., 2024). MSK rehabilitation frequently competes with other system demand pressures, and delays in diagnostics, orthopaedic specialist assessment, and community rehabilitation appear to be driven primarily by capacity constraints rather than insurer authorisation (Baxter et al., 2020; Gamble et al., 2026; Health Foundation, 2013; Hill et al., 2023; M. Yang et al., 2021). Conversely, in private or multi-payer systems, access to care and the sequencing of treatment are often strongly influenced by benefit design and provider payment mechanisms (Leao et al., 2023; Simmons et al., 2024). These

systemic variations complicate the generalisability of process variables beyond the ACC/ECP system, as delays may reflect structural capacity issues within the healthcare system rather than insurer authorisation hurdles. Similarly, equitable access to patient care is shaped by several mechanisms, including geographic proximity and financial barriers (Baxter et al., 2019; Harvey et al., 2025; Krumholz, 2013; Perry et al., 2015; Sigawi et al., 2025).

### 6.2.2 Implications for researchers and educators

This thesis provides a clearer insight into the complexity of MSK conditions and the many factors that influence patient outcomes. The effects of process variables on patient outcomes have not previously received detailed attention by researchers. The contemporary definition of a process variable proposed in the vNGT study may serve as a common starting point, facilitating future research on process variables and enabling comparisons of findings. The measuring and investigating of process variables using this new operational definition and their potential to reduce worldwide MSK pain and disability should be a priority for researchers (Briggs et al., 2021; Briggs et al., 2018; Traeger et al., 2019; World Health Organisation, 2022).

Recently, Cook et al. (2023) defined contextual factors as components of a therapeutic encounter that influence the trajectory of a health-related outcome. The authors proposed that a therapeutic encounter encompasses a range of contextual factors, including patient characteristics, practitioner characteristics, treatment characteristics, the dynamic between the patient and practitioner, and characteristics of the setting in which the encounter is delivered (Cook et al., 2023). The present research findings align with Cook and colleagues and highlight that factors external to the MSK condition itself influence patient outcomes (both positively and negatively). A future challenge for researchers should be to examine the explanatory power and causal effect of process variables on MSK patient outcomes, as well as their associated impact on costs and savings.

To strengthen the practical contribution of this thesis, future research should articulate a more rigorous, standardised approach to measuring and quantifying the process variables identified across studies (Jesus & Hoenig, 2015; van Trijffel et al., 2019). A useful next step would be to explicitly map each process variable to a functioning definition and a pragmatic measurement strategy. This could combine validated patient-reported experience measures to capture relational and functional aspects of care, structured process variables derived from clinical documentation (e.g., goal

setting, IDT shared care plans, IDT handover/communication events), and targeted patient satisfaction or perceived-appropriateness instruments to assess perceived adequacy of treatment dose and tailoring (Bonsel et al., 2024; Bowden et al., 2025; Chi-Lun-Chiao et al., 2020; Mainz, 2003; O'Keeffe et al., 2016). Triangulating data sources in this way would improve construct validity and provide a clearer framework for translating process variables into scalable observational research (Braun & Clarke, 2006; Treur et al., 2024).

Once further process variables are operationalised, future studies should carefully plan how to integrate them into practice management systems and into study designs for subsequent analysis. Additional priority research should explore other process variables beyond the four examined in Chapter 5. Expanding the range of process variables will help strengthen the findings in this thesis and enhance our understanding of which process variables influence specific MSK conditions. As previously mentioned, the impact of particular clusters or groupings of process variables warrants investigation. Process variables could also serve as a focus for future research in non-MSK or non-communicable disease care pathways within the broader health system.

Building on the findings from Chapter 4, researchers can explore the perspectives of physiotherapists, clinicians, and funders, focusing on their views on process variables within MSK care pathways. Gathering input from key stakeholders involved in MSK care may provide researchers with important insights into how process variables can be better utilised or integrated into healthcare systems to enhance patient outcomes. Patients with MSK conditions can already see the clinical benefits of these process variables; however, the healthcare system providing treatment and management does not seem as patient- or process-centred as it could be. Future research in this area could inform the design of MSK care pathways, leading to reduced costs, increased patient engagement and satisfaction, and ultimately, improved patient outcomes (Callan et al., 2025). The qualitative research design from Chapter 4 offers a valuable template for conducting such a study and serves as a model for a future focus group approach.

A quantitative prospective cohort study should be prioritised for the New Zealand ACC ICP-MSK pathways with strict controls to minimise the risk of information bias. If feasible, the research should involve additional treatment providers beyond Careway. Considering the significant burden of ACC earnings-related compensation on the New Zealand levy and taxpayers, and understanding how process variables influence return-to-work outcomes should be a primary focus for future ACC research. Lastly, research into process variables outside the New Zealand ACC healthcare system is

essential to verify the broader applicability and generalisability of the findings from this thesis.

Alongside traditional basic and clinical sciences, systems sciences have become a standard part of health and medical professional training (Lucey, 2013). Educators now have the opportunity to teach health professional students about the processes within MSK care pathways and the variables that clinicians can influence in their clinical settings (Cook et al., 2021; Lentz et al., 2020). There has been a focus by educators and researchers for several decades on addressing MSK pain and disability using the biopsychosocial model of healthcare. However, this model has been criticised for lacking substantial technical content and being misused as a scientific framework without sufficient explanation (Card, 2023; Engel, 1981; Lin et al., 2020; Roberts, 2023; Waddell, 1987). Additionally, it faces criticism for not clearly outlining how to improve patient health outcomes and, from a procedural perspective, for lacking an established implementation process (Card, 2023; Roberts, 2023). MSK patient outcomes may be improved by focusing on process variables rather than relying on healthcare frameworks, such as the biopsychosocial model, which has yet to be proven effective for MSK conditions (Booth et al., 2017; Smart, 2023).

In New Zealand, emerging models of care within the MSK sector are rapidly developing across both the ACC and public health systems, challenging local educators to prepare health professional graduates for modern system sciences (Accident Compensation Corporation, 2023; Keef et al., 2025; Naik et al., 2023). Given the health inequities affecting the indigenous Māori population, funders and regulators emphasise the delivery of culturally safe and competent care (Accident Compensation Corporation, 2025d; Physiotherapy Board of New Zealand, 2025; Tipene-Leach et al., 2024). Alongside the interconnected three-pillar framework of basic, clinical and systems sciences, educators have the opportunity to build a foundation for a culturally safe and capable workforce through cultural education frameworks (Tipene-Leach et al., 2024). An example is Te Whare Tapa Whā, a Māori health model based on the interlinked concepts of whānau (family), tinana (physical health), hinengaro (mental health), and wairua (spiritual health) (Ministry of Health, 2023). Developing students and future health professionals to become culturally safe and competent will help them find meaning and relevance in their education through authentic, value-driven, and patient-centred roles as healthcare navigators within the system, thus contributing to better patient outcomes (Gonzalo et al., 2017; Tipene-Leach et al., 2024).

## 6.3 Reflection on the study design

The choice of research paradigm and methodology in this thesis influenced the research question and methods used in the present research studies (Grant & Giddings, 2002). Within a positivist paradigm, knowledge is considered to be discovered, enabling researchers to explain, predict or control events. In the interpretive paradigm, the researcher relates to and interacts with participants in an effort to understand their experiences (Grant & Giddings, 2002). The present research employed both an interpretive and a post-positivist paradigm to facilitate the integration and synthesis of qualitative and quantitative data collection and analysis within a programme of inquiry (Creswell, 2003; Grant & Giddings, 2002).

A mixed-methods approach was utilised, employing an exploratory and explanatory design in a series of planned studies. The exploratory design was a two-phase design where qualitative research helped define and build an understanding of process variables before the quantitative explanatory research took place (Creswell, 2003). A virtual nominal group technique (vNGT) was employed to achieve consensus among key healthcare providers and experts on the operational definition of a process variable. The vNGT method was chosen over other methods, such as Delphi, because it was not time-consuming. The vNGT enabled expert participants with diverse opinions on process variables to come together virtually to discuss differing viewpoints before exploring mutual solutions in real time (Harvey & Holmes, 2012; Humphrey-Murto et al., 2023; Potter et al., 2004). The vNGT method facilitated an exploratory inquiry into this previously undefined area of healthcare, leading to a clear consensus definition of process variables to be used in the next phase of exploratory research (Van de Ven & Delbecq, 1972).

Focus groups were used to investigate in detail which process variables are essential to patients and to understand their experiences of these processes during the rehabilitation of their MSK conditions. Reflexive thematic analysis, employing Braun and Clarke's six-phase approach, was utilised to construct meaning-based patterns and themes (Braun & Clarke, 2006, 2013; Terry & Hayfield, 2021). This qualitative method was chosen for its theoretically flexible, interpretive approach, which recognises the researcher’s subjectivity as a central component of knowledge production, leading to deeper and richer insights. (Terry & Hayfield, 2021). An interpretive and post-positivist lens with a realist ontological approach guided the primary researcher's engagement with the data. This allowed the primary researcher to be reflexive about the reality of patients and the processes that matter to them in the management of MSK conditions. Rigour was established through systematic

engagement with the six phases of Braun and Clarke's method, and by continuous critical reflection by the research team (Braun & Clarke, 2006). The findings from this qualitative research helped to explore and identify essential patient insights into process variables, which informed and were used in the subsequent quantitative analysis.

Finally, the explanatory phase took place, involving a retrospective quantitative analysis of data collected from the ECP. This analysis employed both descriptive statistics and quantile regression to examine and demonstrate the effects of process variables (including some identified by patients in Chapter 4) and their associations with patient outcomes (Cook & Manning, 2013; Rice et al., 2024). The combination of the interpretive and post-positivist paradigms, along with the mixed-methods approach, enabled the primary researcher to integrate, synthesise and analyse the qualitative and quantitative data, effectively answering the research questions.

## 6.4 Strengths and limitations of the research

This research had several strengths, including the broad range of methodologies and analyses used and their triangulation. Chapters 1 and 2 outlined the growing problem of MSK pain and disability and the current understanding of process variables in the industrial and health sectors. These chapters justified the research and highlighted knowledge gaps that led to the formulation of the questions this series of studies aimed to address. In Chapter 3, a vNGT was used to develop a clear operational definition, which formed the basis for the qualitative, reflexive thematic analysis of patient perspectives on MSK care pathways in Chapter 4. This phase was followed by a detailed descriptive and regression analysis exploring the relationships between process variables and patient outcomes in Chapter 5.

This thesis highlights new insights into process variables in MSK care pathways. The findings show that process variables, such as the timeliness of starting physiotherapy and vocational rehabilitation, as well as consistent progress measurement using PROMs and strength assessments, are crucial in influencing rehabilitation outcomes for patients with complex knee, shoulder, and lumbar conditions. Moreover, this research offers a contemporary view of the optimal dosage and duration of physiotherapy for achieving optimal functional recovery from MSK conditions.

Several limitations to this thesis must be acknowledged. In the qualitative study presented in Chapter 4, three main limitations were identified. Firstly, the focus group's

design called for 15 participants, and despite 15 applicants, only 12 attended the four focus groups. This may have affected the diversity of thought and the range of themes generated by the participants (Terry & Hayfield, 2021). Additionally, the 12 participants were eager, which could introduce bias, as a self-selecting group might not reflect the views of ‘less eager’ patients. Furthermore, the data were collected in group sessions, where participants may have given socially acceptable responses rather than their honest views (Phua et al., 2024). This was mitigated by asking each question multiple times, with different phrasing. The primary researcher and one supervisor were familiar with the Careway ECP programme and played a role in developing the care pathways, which may have influenced data analysis through observer bias. This was mitigated by ensuring the focus group members were not known to the researcher, maintaining reflexivity and by critical reflection by the whole research team.

The study described in Chapter 5 aimed to evaluate the associations between process variables and patient outcomes; however, the PROM data at discharge (dependent variable) were not normally distributed because patients had to meet the criteria determined within the ECP pathways before they could exit the programs. Hence, the final scores across the outcome measures were understandably high. This skewed data meant that our original plan to employ logistic regression (for dichotomous data) and linear regression (for continuous data) needed to be revisited. Traditionally, linear or logistic regression modelling has been used to determine associations between treatment process variables and physiotherapy patient outcomes for MSK conditions (Deutscher et al., 2009; Garcia et al., 2025). However, on advice from the research team's biostatistician, we instead used quantile regression to examine better the associations among predictor process variables at different quantiles of the patient outcome distribution in their MSK care pathways (Aheto, 2020; Oyedapo et al., 2021; Rice et al., 2024; Z. Yang et al., 2021). The three assumptions for quantile regression — linearity, independence of the data, and non-normality of the data — were met. The relationship between the coexisting process variables and confounders was modelled at the median and the 75th percentile of the respective response (PROMs at discharge). Unlike traditional linear regression, which focuses on the mean, quantile regression offers flexibility in identifying different relationships at various parts of the distribution of the dependent variable (Cook & Manning, 2013).

The study design described in Chapter 5 was retrospective, and as is common in such research, there was missing data, which posed a risk of information bias. Little’s test (Fein et al., 2021; Little, 1988) was used to determine if the data were missing completely at random (MCAR) or not, and the p-value from Little's test was not

statistically significant and did not reject the null hypothesis of missing completely at random. The result indicates that the data are likely MCAR, meaning the ‘missingness’ is not systematically related to the observed data. However, because the missing data rate exceeded 10%, imputation was not included in the current study. The quantile regression analyses were based solely on complete data, as recommended in the literature (Enders, 2010; Fein et al., 2021; Little, 1988).

Another limitation of the study presented in Chapter 5 was that the data for the non-surgical shoulder rotator cuff and dislocation/instability groups were combined, because the practice management system could not collect non-operative data for each body region as separate cohorts. This finding likely caused heterogeneity in the results compared to what might have been observed if these groups had been analysed separately. Therefore, the regression analysis was performed using the available combined dataset.

Lastly, only four process variables could be evaluated in the regression analysis because they met our definition of a process variable and were mandated for inclusion in the ECP by ACC (Fausett et al., 2019; Harvey et al., 2024, 2025). Additionally, they were the only ones that could be captured retrospectively by the Careway practice management system. The important process variables of entry criteria, coordination of care, and order of care were identified in the narrative review in Chapter 2 before the commencement of the quantitative study. However, as these were key features embedded into the ECP structure set up by ACC, all patients received these process variables by default in the care pathways and therefore were not additional process variables that could be measured.

## 6.5 Conclusion

The findings of this research will deepen the understanding of process variables and their impact on outcomes for MSK patients. The vNGT study offered an operational definition of a process variable, that is, a modifiable factor in a pathway that can be quantified and measured and that if varied may produce a different operational or patient outcome. It provides researchers, clinicians and funders with a contemporary definition to anchor future research and healthcare sector design, incorporating process variables into MSK care pathways and beyond.

Similarly, the qualitative study explored patient perspectives on process variables in MSK care pathways in New Zealand, focusing on those who had undergone a specific rehabilitation care package aimed at achieving a targeted outcome. The study provided

unique insights into patients' perceptions of the care they received and identified the processes they consider important in their MSK rehabilitation journey. Four themes emerged from the reflexive thematic analysis: process matters; quantifying progress facilitates patient engagement; benefits of equitable access to care; and recovery is made easier with navigation. This study identified several process variables that patients agreed were key to their rehabilitation journey, especially timeliness, the order of care, coordination of care delivery, quantifying progress, equity of access, and navigation. Clinicians have the opportunity to harness this more comprehensive understanding of patients' perspectives on process variables to facilitate patient engagement, exercise rehabilitation compliance, and to remove barriers during their rehabilitation journey.

An observational cohort study retrospectively reviewed ECP patients with MSK injuries who were included in the respective MSK surgical and non-surgical rehabilitation care pathways. Significant associations with varying effects were identified between process variables and patient outcomes in several surgical and non-surgical MSK care pathways. The research found that regularly measuring patient progress using PROMs or strength measures following orthopaedic surgery encouraged patient-therapist engagement, compliance, monitoring, and outcomes. The study demonstrated that the timeliness of care after orthopaedic surgery is a key process variable for achieving patient outcomes. Overall, this research has shown that process variables can impact patient outcomes in MSK care pathways both positively and negatively. Therefore, this thesis urges clinicians, funders, health system planners, educators, and researchers to prioritise the identification, measurement and utilisation of process variables within MSK care pathways to improve patient outcomes. This thesis lays the foundation and creates opportunities for researchers to explore further process variables and their optimal use within healthcare systems and MSK care pathways.

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# Appendices

# Appendix 1: Ethics Approval 1- AUTEC 23/94 For Chapter 3


**Auckland University of Technology Ethics Committee**

**(AUTEC)**

6 June 2023

Steve White
Faculty of Health and Environmental Sciences

Dear Steve

Re Ethics Application: **23/94 A consensus-based agreement of an operational definition of a process variable**

Thank you for your responses to AUTEC's conditions.

Your ethics application has been approved for three years until 1 June 2026.

**Standard Conditions of Approval**

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC.
2. All public facing documents must have the AUTEC approval number and be of a high standard of spelling and grammar. Dates on the Information Sheet(s) and Consent Form(s) must be consistent.
3. Any amendments to the project must be approved by AUTEC prior to being implemented.
4. A progress report is due annually on the anniversary of the approval date.
5. A final report is due at the expiration of the approval period, or, upon completion of project.
6. Any serious or adverse events must be reported to AUTEC, this includes unforeseen issues that might affect continued ethical acceptability of the project.
7. AUTEC grants ethical approval only. You are responsible for obtaining management permission for access from any institution or organisation at which

your research is being conducted, and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

The application number and title need to be referenced on all correspondence related to this project.

All forms are available online http://www.aut.ac.nz/research/researchethics

For any enquiries, please contact ethics@aut.ac.nz
(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
**Auckland University of Technology Ethics Committee**

Cc: daniel@sportsandspinal.co.nz; duncan.reid@aut.ac.nz

# Appendix 2: Participant Information Sheet For Chapter 3


**Participant Information Sheet**

**Date Information Sheet Produced: 27/05/2023**

**Project Title:** A consensus-based agreement on a definition of a process variable

**An Invitation:**

Hello, my name is Daniel Harvey and as part of my PhD I am conducting a study to create an operational definition of what a process variable is within a musculoskeletal care pathway. You have been identified as a potential participant for this study, and I am inviting you to participate.

## What is the purpose of this research?

Pain and disability caused by musculoskeletal (MSK) injuries and disorders continue to be a considerable economic and social burden to health care systems around the world. Significant research efforts have investigated the diagnostic, prognostic, and treatment approaches to these MSK conditions with the aim to improve patient outcomes. Despite attempts to match targeted assessment and treatment approaches to specific MSK conditions, disability levels have failed to improve, and health costs continue to grow. Recently there has been a focus on improving the efficiency of MSK health care systems and delivering high value-based care. Within MSK healthcare systems it appears that processes of care or process variables may influence patient outcomes.

Sparse research has directly investigated if the process variables of a MSK health care system in which a patient is enrolled can influence their trajectory or outcome. In New Zealand, the Accident Compensation Corporation (ACC) insurance scheme funds treatment for most accident related MSK conditions. The ACC Escalated Care Pathways (ECP) are pilot programmes where treatment suppliers design and implement innovative high value healthcare systems and care pathways to manage

specific MSK conditions. The development of the ECP pathways provides an opportunity to consider, examine and quantify how processes variables incorporated in these pilot MSK health care systems affect patient outcomes.

The aim of this proposed research is to explore if process variables influence patient outcomes or can predict patient outcomes in musculoskeletal health care systems. To be able to do this, I need to first define what a process variable is, and this is the purpose of this study. A virtual Nominal Group Technique (120-minute Zoom teleconference) with participants with significant expertise in this area will be undertaken to find a consensus-based agreement on the operational definition of a process variable. Between five to nine participants will be identified as experts in the design and delivery of musculoskeletal healthcare pathways will be purposefully recruited.

The findings of this research will be used for academic publications and presentations, as well as inform other studies in my PhD. Participants will be offered the opportunity to be acknowledged as contributors to the study if they wish.

### How was I identified and why am I being invited to participate in this research?

You would have you been identified as a potential expert in the design, administration, management, and clinical delivery of ACC ECP or ACC related systems/programmes or you have received information about this study from the flyer advertising or online promotion on professional social media about this research.

### How do I agree to participate in this research?

If you agree to participate, you will then be asked questions by the primary researcher about relevant work experience and expertise to see if they meet the study inclusion criteria and to determine the correct mix of experts within the group. If you have any questions about this research, please contact the primary researcher via email or telephone to discuss.

If you meet the inclusion criteria and agree to participate you will be asked to email a signed consent form and return this via email within four weeks of receiving this information sheet. Your participation in this research is voluntary (it is your choice) and whether you choose to participate will neither advantage nor disadvantage you. You can withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging

to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

## What will happen in this research?

Participants and Recruitment:

Once you have consented and been confirmed by the primary research as an expert participant for the study you will be invited via email to attend a two-hour virtual NGT (v-NGT) conducted using Zoom (Microsoft Corp, Redmond, WA). Prior to the v-NGT, participants will be provided with detail that explains the purpose of the study and how the v-NGT will be conducted. Participants will be given 'pre-work' and asked to consider "What is the operational definition of a process variable within a care pathway or health system." This is to allow participants to be prepared to generate a range of ideas that come to mind answering this question and to share their ideas in the group stages of the v-NGT.

Moderator:

The primary researcher (DH) will act as the v-NGT moderator.

Procedure: (Five stages of the NGT):

Introduction and explanation:

You will be welcomed with a karakia and will be encouraged to introduce yourself to the rest of the group (using a pepeha if you so wish).

Silent generation of ideas:

The following question will be introduced to the participants: What is the operational definition of a process variable within a musculoskeletal care pathway or health system? You will be asked to create a list of all ideas that come to mind when considering the question.

Sharing ideas:

Next, chat, speaking and video function are re-enabled, and you will be invited to share your ideas. The moderator will ask each participant to offer one idea in turn while these ideas are recorded in a shared google document. The document will be shared on the screen so participants can see the list being generated in real time. All participants will be given an equal opportunity to participate.

Group discussion:

A group discussion will follow the initial sharing of ideas about the definition of a process variable. In this stage participants will be invited to seek verbal explanation and further details about ideas other participants of the NGT have produced in the sharing ideas stage. During this session, the group may generate and discuss new ideas that emerge and can decide to combine ideas to modify their definition(s). Each participant will 'own' each of their individual generated definition(s). Any edit of definitions will only be made if the 'owner' of that definition agrees with changes suggested during the group discussion (Time allowed: up to 45 minutes)

Voting and ranking:

Once the group discussion has concluded, participants will be asked to individually vote and rank all the definitions from 1 (top choice) to the relevant number for the lowest choice, using an online survey tool.

## What are the discomforts and risks?

It is not anticipated that participants will be exposed to discomfort or risk through their participation in this research.

## What are the benefits?

The benefit from participating in this study is that you will help create a consensus statement/operational definition on what is a process variable within a musculoskeletal health care pathway. This study will act as the foundation for three further studies as part of this PhD and answer the overall question of: Do process variables influence patient outcomes? You will be offered a koha for participating.

## How will my privacy be protected?

Information given in the v-NGT is for the specified research purposes only and participants privacy and confidentiality will be upheld. Confidentiality will be respected by the research team at all times. However, given the size and nature of the pool of potential participants in the study, participants should be aware that only limited confidentiality can be offered and guaranteed to a participant and have the right to withdraw from the study at any time.

## What are the costs of participating in this research?

Approximately 120 minutes of your time.

## What opportunity do I have to consider this invitation?

Yes, you will have four weeks from receiving this information sheet to consider this invitation. Please email the primary researcher if you require additional time.

## Will I receive feedback on the results of this research?

You will receive the results at the end of the NGT study. You will be offered a copy of the journal article once published.

## What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Steve White, steve.white@aut.ac.nz, 09 921 9999 ext. 7073

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, ethics@aut.ac.nz, (+649) 921 9999 ext. 6038.

## Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Daniel Harvey, daniel@sportsandspinal.co.nz, 0274 192 391

Project Supervisor Contact Details:

Dr Steven White; steve.white@aut.ac.nz; phone 09 9219999 ext. 7073.

Approved by the Auckland University of Technology Ethics Committee on 05/05/2023.

AUTEC Reference number 23/94.

# Appendix 3: Participant Consent Form For Chapter 3


**Consent Form**

***Project title:*** **A consensus-based agreement on a definition of a process variable**

***Project Supervisor: Dr Steve White***

***Researcher: Daniel Harvey (PhD candidate)***

- ○ I have read and understood the information provided about this research project in the Participant Information Sheet dated 27/05/2023.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that identity of my fellow participants and our discussions in the group is confidential to the group, and I agree to keep this information confidential.
- ○ However, given the size and nature of the pool of potential participants in the study, I understand that only limited confidentiality can be offered and guaranteed to me as a participant.
- ○ I understand that notes will be taken during the group and that it will not be audio-taped or recorded.
- ○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- ○ I understand that if I withdraw from the study then, while it may not be possible to destroy all records of the group discussion of which I was part, I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- ○ I agree to take part in this research.

○ I understand the primary researcher will use an inclusion criterion to determine the final selection of expert participants for the group.

○ I wish to receive a summary of the research findings (please tick one):

Yes○ No ○

○ I wish to be acknowledged for my participation in the study and in any dissemination or publications of the research findings (please tick one):

Yes○ No ○

Participants signature :

Participants name :

Date :

**Approved by the Auckland University of Technology Ethics Committee on *05/05/2023*.**

**AUTEC Reference number 23/94**

*Note: The Participant should retain a copy of this for*

# Appendix 4: Ethics Approval 2- AUTEC Approval 23/229 For Chapter 4

**Auckland University of Technology Ethics Committee (AUTEC)**

10 October 2023

Steve White

Faculty of Health and Environmental Sciences

Dear Steve

Re Ethics Application: **23/229 Patient perspectives of which processes matter in the management of musculoskeletal conditions: A Focus Group Study.**

Thank you for your responses to AUTEC's conditions.

Your ethics application has been approved for three years until 10 October 2026.

**Standard Conditions of Approval**

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC.
2. All public facing documents must have the AUTEC approval number and be of a high standard of spelling and grammar. Dates on the Information Sheet(s) and Consent Form(s) must be consistent.
3. Any amendments to the project must be approved by AUTEC prior to being implemented.
4. A progress report is due annually on the anniversary of the approval date.
5. A final report is due at the expiration of the approval period, or, upon completion of project.
6. Any serious or adverse events must be reported to AUTEC, this includes unforeseen issues that might affect continued ethical acceptability of the project.
7. AUTEC grants ethical approval only. You are responsible for obtaining management permission for access from any institution or organisation at which your research is being conducted, and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

The application number and title need to be referenced on all correspondence related to this project.

All forms are available online http://www.aut.ac.nz/research/researchethics

For any enquiries, please contact ethics@aut.ac.nz
(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat

**Auckland University of Technology Ethics Committee**

Cc: daniel@sportsandspinal.co.nz; duncan.reid@aut.ac.nz

# Appendix 5: Participant Information Sheet For Chapter 4


**Participant Information Sheet**

**Date Information Sheet Produced:** 21/07/2023

**Project Title:** Patient perspectives of which processes matter in the management of musculoskeletal conditions: A Focus Group Study

**An Invitation**

Hello and kia ora, my name is Daniel Harvey and as part of my PhD I am conducting a study to find out which processes of care or variables are important to patients in the rehabilitation of musculoskeletal conditions. You have been identified as a potential participant for this study, and I am inviting you to participate.

**What is the purpose of this research?**

Pain and disability caused by musculoskeletal (MSK) injuries and disorders continue to be a considerable economic and social burden to health care systems around the world. Significant research efforts have investigated the diagnostic, prognostic, and treatment approaches to these MSK conditions with the aim to improve patient outcomes. Despite attempts to match targeted assessment and treatment approaches to specific MSK conditions, disability levels have failed to improve, and health costs continue to grow. Recently there has been a focus on improving the efficiency of MSK health care systems and delivering high value-based care. Within MSK healthcare systems it appears that processes of care or process variables may influence patient outcomes.

The existing evidence indicates that processes of care contribute to the patient experience and their satisfaction with treatment; however, to date, it appears that no studies have directly investigated what process variables are important to patients in achieving their goals and functional outcomes. In New Zealand, the Accident Compensation Corporation (ACC) insurance scheme funds treatment for most accident-related MSK conditions. The ACC Escalated Care Pathways (ECP) are pilot

programmes where treatment suppliers design and implement innovative high value healthcare systems and care pathways to manage specific MSK conditions. The development of the ECP pathways provides an opportunity to consider, examine and quantify how processes variables incorporated in these pilot MSK health care systems affect patient outcomes.

The aim of this proposed research is to explore if process variables influence patient outcomes or can predict patient outcomes. A focus group-design will be used to investigate which process variables matter to patients and what were their experiences of these processes during their rehabilitation. Prospective participants have been purposively sampled from the database of clients that have completed their ECP/Careway rehabilitation from the greater Auckland region. If you agree to participate, you will be included in one of three focus groups of five participants in the Auckland region.

The findings of this research will be used for academic publications and presentations, as well as to inform other studies in my PhD.

**How was I identified and why am I being invited to participate in this research?**

You have been identified as a potential participant from the database of clients that have completed or been discharged from their ECP/Careway rehabilitation from the greater Auckland region. Your views on your experiences of the care your received is important and you are being invited to take place in one of the focus groups (one Māori only focus group). Potential participants will represent different gender, ethnicities and cultures will be included to facilitate diversity of opinion.

**How do I agree to participate in this research?**

If you agree to participate, please email a signed consent form to daniel@sportsandspinal.co.nz within four weeks of receiving this email. If you have questions about this research, please contact the primary research via email or telephone to discuss.

Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you. You are able to withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

**What will happen in this research?**

Participants and Recruitment:

You have been identified as a potential participant from the database of clients that have completed or been discharged from their ECP/Careway rehabilitation from the greater Auckland region. Your views on your experiences of the care your received is important and you are being invited to take place in one of the focus groups (one Māori only focus group). Potential participants will represent different gender, ethnicities and cultures will be included to facilitate diversity of opinion. Three face-to-face focus groups with five participants in each will take place.

Procedure:

*Introduction and explanation:*

You will be welcomed with a karakia, and personal introductions of all focus group members will take place. Participants will be allowed the time to introduce themselves using a pepeha if they are comfortable. Next, and the purpose and procedure of the focus group will be explained, and participants will be reassurance there is no ‘right’ or ‘wrong’ answer. Participants will be encouraged to talk to one another in the group rather than to the moderator. The moderator will make it clear they are there to direct the meeting and to learn from the participant. Before starting the session, the participants will be reminded of the purpose of the focus group, which is to elicit their views of what processes of care matter in their musculoskeletal rehabilitation journey.

*Focus group discussion and data collection:*

All parts of the focus group will audio recorded for later transcription and analysis. All Participants will be asked open questions and encouraged to collaborate and contribute to answering the research questions. You will be asked to ‘‘think back’’ and recall your experiences during your recovery.

Types of questions that will be asked include:

What was your experience of your care during your rehabilitation?

Which parts of your care mattered the most during your rehabilitation?

What things mattered to you most in the way your treatment was organised or arranged?

What things do you feel obstructed or contributed to a successful/unsuccessful course of treatment for you?

What things about how the care you received, helped, or hindered you to achieve your goal or recover successfully?

Why were these things important to you?

How do you feel that the organisation or delivery of treatment or rehabilitation could be improved?

*Debriefing and Closing:*

At the end of the focus group session, the moderator will summarise the main issues that had been discussed and will seek verification from the participants by asking ‘‘Is this an accurate account of what has been discussed?’’ Members will be thanked for their contributions, a koha offered and the focus group closed with a karakia and an offer to stay for kai and refreshments.

**What are the discomforts and risks?**

It is not anticipated that participants will be exposed to discomfort or risk through their participation in this research.

**What are the benefits?**

The benefit from participating in this study is that you will help identify define what process variables matter to patients and what barriers or facilitators contribute toward patient outcomes. This study is the second study of my PhD and will help answer my research question:  Do process variables influence patient outcomes?

Additionally, you will be presented with a $50 shopping voucher as a koha for participating.

**How will my privacy be protected?**

Information given in the Focus Group is for the specified research purposes only and your privacy and confidentiality will be upheld. Confidentiality will be respected by the research team. Each participants will be given an identification number/pseudonym so that any information/data used in publication will not identify you. Only Daniel Harvey will be able to access personal data that would allow identification of participants from their identification number/pseudonym. Participants will be reassured again prior to

their Focus Group commencing of their privacy, confidentiality and right to withdraw from the study.

**What are the costs of participating in this research?**

Approximately 60-120 minutes of your time.

**What opportunity do I have to consider this invitation?**

Yes, you will have four weeks to consider this invitation. Please email the primary researcher if you require additional time.

**Will I receive feedback on the results of this research?**

You will receive the results at the end of the Focus Group study. You will be offered a copy of the journal article once published (unless otherwise stated).

**What do I do if I have concerns about this research?**

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, *Dr Steve White,* steve.white@aut.ac.nz, 09 921 9999 ext. 7073

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, *ethics@aut.ac.nz*, (+649) 921 9999 ext. 6038.

**Whom do I contact for further information about this research?**

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

**Researcher Contact Details:**

Daniel Harvey, daniel@sportsandspinal.co.nz; 0274 192 391

**Project Supervisor Contact Details:**

Dr Steven White; steve.white@aut.ac.nz; phone 09 9219999 ext. 7073.

**Approved by the Auckland University of Technology Ethics Committee on 10/10/2023. AUTEC Reference number 23/229.**

# Appendix 6: Participant Consent Form For Chapter 4


**Consent Form**

***Project title:*** **Patient perspectives of which processes matter in the management of musculoskeletal conditions: A Focus Group Study**

***Project Supervisor*: *Dr Steve White***

***Researcher: Daniel Harvey (PhD candidate)***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 21/07/2023.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that identity of my fellow participants and our discussions in the focus group is confidential to the group, and I agree to keep this information confidential.
- ○ I understand that notes will be taken during the focus group and that it will also be audio-taped and transcribed for later analysis.
- ○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- ○ I understand that if I withdraw from the study then, while it may not be possible to destroy all records of the focus group discussion of which I was part, I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- ○ I agree to take part in this research.
- ○ I wish to receive a summary of the research findings (please tick one):

  Yes ○ No ○

Participant’s signature :

Participant’s name :

Participant’s Contact Details (if appropriate) :

Date :

***Approved by the Auckland University of Technology Ethics Committee on 10/10/2023 AUTEC Reference number 23/229***

*Note: The Participant should retain a copy of this form*

# Appendix 7: Ethics Approval 3- AUTEC 23/329 For Chapter 5

**Auckland University of Technology Ethics Committee (AUTEC)**

7 December 2023
Steve White
Faculty of Health and Environmental Sciences

Dear Steve

Re Ethics Application: **23/329 The effect of process variables on patient outcomes: A retrospective analysis of musculoskeletal rehabilitation pathways**

Thank you for your responses to AUTEC's conditions.

Your ethics application has been approved for three years until 7 December 2026.

**Non-Standard Conditions of Approval**

1. The study data is to be stored with the supervisor and not the student. Please see the AUT Data Storage Guidelines for a definition of archive storage https://aut.ac.nz.libguides.com/ld.php?content_id=51223132

Non-standard conditions do not need to be submitted to or reviewed by AUTEC unless requested but must be completed before commencing your study.

**Standard Conditions of Approval**

8. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC.
9. All public facing documents must have the AUTEC approval number and be of a high standard of spelling and grammar. Dates on the Information Sheet(s) and Consent Form(s) must be consistent.
10. Any amendments to the project must be approved by AUTEC prior to being implemented.

11. A progress report is due annually on the anniversary of the approval date.
12. A final report is due at the expiration of the approval period, or, upon completion of project.
13. Any serious or adverse events must be reported to AUTEC, this includes unforeseen issues that might affect continued ethical acceptability of the project.
14. AUTEC grants ethical approval only. You are responsible for obtaining management permission for access from any institution or organisation at which your research is being conducted, and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

The application number and title need to be referenced on all correspondence related to this project.

All forms are available online http://www.aut.ac.nz/research/researchethics

For any enquiries, please contact ethics@aut.ac.nz
(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
**Auckland University of Technology Ethics Committee**

Cc: daniel@sportsandspinal.co.nz; duncan.reid@aut.ac.nz

# Appendix 8: Information Sharing Agreement Form For Chapter 5

**ATA SHARING AGREEMENT**

**This agreement is made between the Discloser and the Recipient (as those parties are identified in Schedule 1). The Discloser[s] and the Recipient[s] may be also referred to as the Parties and singularly as a "Party".**

**Background**

A. The Discloser is the custodian of Data defined below, and the Data includes Personal Information.

B. The Recipient wishes to access and use the Data for the Purpose defined below and acknowledges the importance of safeguarding Personal Information.

C. In consideration of and subject to compliance with the obligations on the part of the Recipient in this agreement, the Discloser is granting the Recipient a right to use and access the Data only for the Purpose.

The Parties agree as follows:

**Definitions**

In this agreement, capitalised terms have the meaning given to them in context and/or as defined below:

**Access Request** means a request by an Individual for access to, or correction of, their personal information in accordance with Privacy Law.

**Additional Security Requirements** means those additional security requirements to prevent unauthorised access or disclosure of the Data required by Discloser set out in Schedule 1 (if any).

**Affected Party** is defined in clause 0.

**Agreement** means this data sharing agreement, including Schedule 1 and Schedule 2 and any schedules that may be added from time to time.

**Authorised Users** means those individuals employed by or working with the Recipient identified Schedule 1, if any, who are authorised to access, use and Process the Data in accordance with the terms of this Agreement.

**Business Day** means any day of the week other than a Saturday, Sunday, public holiday in Auckland, New Zealand, or any day in the period commencing with 25 December in any year and ending with 15 January in the following year.

**Data** means the data shared between the Parties pursuant to this Agreement as described in Schedule 1.

**Data Breach** means:

(a) actual, attempted or suspected unauthorised, unlawful or accidental access to, disclosure or Processing of, loss, destruction, alteration or damage of any Data; or

(b) an action that prevents the Recipient from accessing the Data on either a temporary or permanent basis.

**Delivery Means** means the approved method of delivery of the Data set out in Schedule 1.

**Discloser** means the Party disclosing Data under this Agreement as identified as such in Schedule 1.

**Effective Date** means the date this agreement has been signed by both Parties.

**End Date** means the intended date of expiry of this Agreement noted in Schedule 1.

**Individual** has the meaning given to it under Privacy Law.

**Information Security Program** is defined in clause 4.3.

**Notified Party** is defined in clause 0. 4

**Personal Information** has the meaning given to that term in the New Zealand Privacy Act 2020.

**Privacy Laws** means any applicable statute, regulation, bylaw, rule, order, or subordinate legislation in force from time to time and includes, without limitation, the New Zealand Privacy Act and the Health Information Privacy Code.

**Process** means any operation or sets of operations which is performed on Data or on sets of Data, whether by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction.

**Purpose** means the purpose for which the Recipient may access and use the Data defined in Schedule 1.

**Recipient** means the Party receiving Data under this Agreement and identified as such in Schedule 1.

**Regulator** means any regulator and/or person entitled under Privacy Law to investigate the Processing of Personal Information and includes the New Zealand Privacy Commissioner.

**Special Terms** means any special terms and conditions of this agreement set out in Part B Schedule 1 that either amend or additional to other terms in this agreement.

**Term** is defined in clause 7.1.

1.2 **Interpretation**

In this agreement, except where the context otherwise requires:

(a) words importing the singular number include the plural and vice versa and words importing gender include all genders.

(b) the meaning of general words is not limited by specific examples introduced by ‘including’, ‘for example’ or similar expressions.

(c) another grammatical form of a defined word has a corresponding meaning.

(d) headings are for ease of reference and do not affect interpretation.

(e) references to clauses and other sub clauses are to those parts of this agreement.

(f) a reference to any Law includes regulations made under it and consolidation, amendments, re-enactments or replacement of any of them.

**2. Purpose of Accessing Data**

2.1 The Recipient may only access, use and Process the Data for the Purpose.

2.3 If the Recipient, including any of its Authorised Users, becomes aware of any attempted or actual use of the Data for any other purpose or use, other than the Purpose, the Recipient must immediately notify the Discloser and follow the steps set out in clause 6 Data Breach.

**3. Use of Data and Authorised Users**

3.1 Use and Disclosure

Subject to both Parties having obtained all necessary regulatory and organisational approvals prior, the Discloser shall, using the Delivery Means, deliver the Data on the Effective Date to the Recipient and thereafter the Recipient:

(a) may Process the Data in accordance with this agreement and only as required to fulfil for the Purpose.

(b) will allow Authorised Users only to Process the Data and will procure that each Authorised User (current or future) is made aware of and is bound by the terms of this agreement.

(c) will maintain a record of Authorised Users.

(d) will not without the prior written consent of the Discloser, allow any other person other than an Authorised User to access, use or Process the Data.

3.2 Compliance with Privacy Laws

Each Party shall comply with all applicable Privacy Laws and its respective publicly available privacy policies (as may be amended from time to time) in relation to its access to, possession, use and disclosure of the Data.

3.3 Confidentiality

The Recipient will hold the Data in strict confidence and impose confidentiality obligations on personnel who will be provided access to the Data, including to protect all Data consistent with the requirements of this Agreement and Privacy Law.

3.4 Data Integrity

The Recipient will:

(a) take all reasonably practicable measures to ensure that the Data remains secure, accurate, intact and complete.

(b) ensure that any publication based on the Data Set does not directly or indirectly disclose Personal Information relating to any Study Participant.

(c) not link or combine the Data with any other data or information.

(d) not disclose, share or transfer the Data (or any part of it), or attempt to do so, to any person, including a member of the Discloser's organisation who is not an Authorised User.

(e) may not transfer or save the Data or any part of it to any device, application or storage facility that is not authorised by the Recipient or the Discloser.

(f) promptly comply with all reasonable directions issued by the Discloser in relation to Data.

3.5 Discloser Warranties

The Discloser:

(a) warrants as at the Effective Date and to the best of its knowledge and belief that all necessary consents and approvals have been obtained to enable the Data to be shared and Processed by the Recipient for the Purpose.

(b) provides no other warranties in relation to the Data save as set out in clause 3.5(a) above.

3.6 Publication

Subject to clause 3.4(b), the Recipient will not publish the Data (in whole or part) without the prior written consent of the Discloser.

**4. Security and Confidentiality of Data**

4.1 Standard of Care

Each Party shall exercise at least the same degree of care as it uses with its own data and confidential information, but in no event less than reasonable care, to protect the Data from misuse and unauthorised access or disclosure.

4.2 Safeguards around Data

Each Party must ensure that all Data is protected by such security safeguards as are reasonable in the circumstances to take against loss, unauthorised access, use, modification and disclosure or other misuse, including:

(a) maintaining adequate physical controls and password protections for any server, system or device on which the Data is accessed and/or stored.

(b) ensuring that the Data is not stored on any mobile device (for example, a laptop or smartphone) or transmitted electronically, unless encrypted.

taking any other measures reasonably necessary to prevent any access, use or disclosure of the Data other than as permitted under this Agreement.

4.3 Information Security Safeguards and Additional Security Requirements

The Recipient will meet as a minimum:

(a) the information security safeguards described in Schedule 2; and

(b) such Additional Security Requirements as are listed in Schedule 1,

to protect the Data against Data Breaches and unauthorised Processing. In the event of a conflict between any security provision in this clause, the information security safeguards in Schedule 2 and any Additional Security Requirements in Schedule 1, the latter will prevail.

4.4 Intellectual Property

The Discloser shall retain all intellectual property rights recognised by the laws of New Zealand in relation to Data notwithstanding any rights exercised by the Recipient in relation to the Processing of it.

**5. Subcontractors**

5.1 Subcontractors

The Recipient may not disclose Data to any subcontractors or agents without the Discloser’s prior written consent.

**6. Data Breach**

6.1 Notification of Data Breach

If either Party becomes aware of a Data Breach (the **Affected Party**), that Party shall, without undue delay, notify the other Party of the Data Breach (**Notified Party**), providing sufficient information to enable the Notified Party to meet any obligations to report a Data Breach under Privacy Laws.

6.2 Cooperation

The Affected Party will promptly cooperate with the other Party to take all such reasonable steps as are directed by the Notified Party to assist in the investigation, mitigation and remediation of each Data Breach.

6.3 Public statement

The Parties acknowledge and agree that, in the event of a Data Breach attributable to the Affected Party, the Notified Party may wish to make a public statement in relation to that Data Breach. The Parties will discuss in good faith the contents of any such statement, but the Notified Party may, in its sole discretion, determine the contents of that statement.

6.4 Cooperation and Mitigation

The Parties shall in good faith cooperate with each other in relation to the response to and remediation of any Data Breach, and agree to use reasonable steps to:

(a) address any applicable reporting requirements relating to the Data Breach; and

(b) mitigate any effects of such Data Breach.

**7. Term and Termination**

7.1 Term

This agreement will commence on the Effective Date and continue until the End Date, unless otherwise terminated in accordance with this clause 0 (the **Term**).

7.2 Termination for Convenience 7

Either Party may at any time terminate its status as a Party to this Agreement on not less than two calendar months’ notice served on the other Party.

7.3 Termination Rights

Either Party may terminate this Agreement in the event the other Party:

(a) breaches this Agreement and the breach is not capable of remedy.

(b) breaches this Agreement and does not remedy the breach within fifteen Business (15) days after service of a notice by the non-breaching Party or such other reasonable period as may be specified.

(c) suffers an event of insolvency.

by serving a notice of breach on the breaching Party in accordance with the provisions of clause 8 (Notices).

7.4 Consequences of Termination

(a) Where a Party exercises the right to terminate this Agreement, such termination will not affect the obligations impose on Parties under clauses 2, 0, 0, 0 and 0 of this Agreement with respect to Data disclosed or transferred prior to the termination of this Agreement.

(a) Early termination will be without prejudice to the rights and remedies of either Party in respect of any antecedent breach of this Agreement by the other Party.

(c) Upon any termination, cancellation or expiry of this Agreement:

i. the Recipient shall immediately cease and have no right to use or Process Data or any portion thereof.

ii. the Recipient will delete or destroy, or will procure the deletion or destruction of, the Data (and all copies of it) within 14 days of termination and provide reasonable evidence of the same to the Discloser.

7.4 Ability to Suspend Access

Notwithstanding any other right or action, the Discloser may have under this agreement, the Discloser may suspend access to and Processing of the Data by the Recipient, in the event of a breach of this agreement until the Recipient has corrected the breach to the reasonable satisfaction of the Discloser.

**8. Notices**

8.1 Method of Notice

The Parties shall give all notices and communications between the Parties in writing by personal delivery, prepaid post, or email to the Party's address specified in this agreement, or to the address that a Party has notified to be that Party's address for the purposes of this section.

8.2 Receipt of Notice

A notice given under this agreement will be effective:

(a) if sent by personal or courier delivery, at the time and date that the notice is handed to a representative of the recipient; or

(b) if sent by email, on the day of transmission if received before 5.00pm on a Business Day, and otherwise on the next Business Day, unless a notice of non-delivery is received by the sender.

**9. General Provisions**

9.1 Assignment 8

Neither Party may assign this agreement or any of its rights or obligations under this Agreement.

9.2 Severability

If any part of this Agreement is declared unenforceable or invalid, the remainder will continue to be valid and enforceable.

9.3 Variation

This Agreement may be amended only by an amendment in writing signed by both Parties.

9.4 Waiver

Neither Party's failure or neglect to enforce any of rights under this Agreement will be deemed to be a waiver of that Party's rights. A waiver or extension is only effective if it is in writing and signed by the Party granting it.

9.5 Further actions

Each Party shall take all action and execute all further documents necessary to give full effect to this Agreement.

9.6 Counterparts

This Agreement may be executed in counterparts, each of which is to be deemed an original, but all of which together are to constitute a single agreement.

9.7 Governing Law

This Agreement will be governed by and construed in accordance with the laws in force in New Zealand. The Parties agree to submit to the exclusive jurisdiction of the Courts of New Zealand.

9.8 Several Liability where multiple parties

If either the Discloser or the Recipient are comprised of more than one legal person, then the obligations owed by and liability of those persons is several only, and not joint and several.

9.9 Precedence of Special Terms

If there is any conflict between the Special Terms (if any) and any other term or condition written in this Agreement, the provisions of the Special Terms shall prevail.

**10. Fees**

10.1 Relevance

This clause is only applicable if there are Fees payable under this agreement.

10.2 Fees

(a) In consideration of the ability to use, access and Process the Data during the term of this agreement, the Recipient will pay the Fees to the Discloser, without deduction or set off and exclusive of Goods and Services Tax (GST).

(b) The Discloser shall send a valid, proper GST invoice to the Recipient for the Fees and the Recipient shall settle the invoice in full on the 20th day of the month following issue of the invoice, or other period as the Discloser may specify to the Recipient.

**11. Information Access Requests**

11.1 Each Individual has rights of access and correction

The Recipient agrees that everyone has a right to access, and to seek correction of, their personal information held by the Recipient that is included in the transferred information.

11.2 How to handle a request for access

If an Individual requests access to their transferred information, then subject to clauses 11.4 and 11.5, the Recipient will confirm whether it holds any transferred information about them and, if it does, will provide them with access to the information and advise them that they may request correction of their information.

11.3 How to handle a request for correction

Where an Individual requests correction of their transferred information, the Recipient will take reasonable steps to ensure that the information is accurate considering the Purpose. If the Recipient is not willing to correct the information as requested, the Recipient will take reasonable steps to ensure a statement of the requested correction is attached to the information, to ensure it will always be read with the information. Where the Recipient corrects any transferred information or attaches a statement of correction, the Recipient must take reasonable steps to inform any person to whom the Recipient has disclosed the relevant transferred information.

11.4 Timeframes for responding to requests for access or correction

The Recipient must respond to an Individual’s request for access to or correction of their transferred information as soon as reasonably practicable and no later than 30 days after receiving the request. The Recipient must provide reasonable assistance to the Individual in relation to each request.

11.5 Refusing a request

In relation to any request from an Individual under this clause 11, the Recipient may refuse access, extend the timeframe for complying with the request, and/or charge the Individual for complying with the request, to the extent that this would be permitted if the request was made under the Privacy Act and the Recipient was subject to the Privacy Act.

**12. Legal Compliance**

12.1 The Recipient will comply with its own laws

The Recipient will ensure that its Processing of the Data is consistent with the “Local Data Laws” specified in Schedule 1 and the Governing Law specified in clause 9.7. However, where a requirement of the Local Data Law is less protective than the other requirements of this agreement, to the extent permitted by law the Recipient will

comply with the requirement that is the most protective of the transferred information and the interests of the relevant Individuals.

12.2 The Recipient must notify the Discloser about any use or disclosure compelled by law

If the Recipient is required by a court or government agency under any law to disclose or use the Data or any part of it in a way that would not otherwise be permitted by this agreement, then to the extent law allows the Recipient must notify the Discloser to give it the opportunity to contest that legal requirement (for example, by taking the matter to court).

12.3 The Recipient is not aware of any local laws that would undermine this agreement

The Recipient confirms that at the time of entering into this agreement it has made reasonable efforts to identify whether it is covered by any law that could reasonably be expected to have a substantial adverse effect on the protections intended by this agreement and is not aware of any such law. The Recipient will use reasonable efforts to ensure that, if any such law applies to it in the future, it will promptly notify the Discloser. 10

**Schedule 1– Agreement Definitions & Special Terms**

| **Part A - Agreement Definitions ITEM No** | **DEFINITION USED IN THIS AGREEMENT** | **DESCRIPTION** |
|---|---|---|
| 1 | **Discloser** | Careway Limited |
| 2 | **Recipient** | *Auckland University of Technology.* |
| 3 | **Data** | *Data dictionary is appended.* |
| 4 | **Authorised Users** | *Duncan Arthur Reid and Daniel Harvey* |
| 5 | **Delivery Means** | *By Password-protected Excel file.* |

| | | |
|---|---|---|
| 6 | **End Date** | *This agreement will run from 1st December 2023*<br><br>*Until the 31st of December 2024* |
| 7 | **Purpose** | *The purpose of sharing this data is twofold. Firstly, accessing the data will allow Daniel Harvey to complete a research project to fulfil part of his PhD degree. Secondly, Careway has been part of a unique ACC pilot programme called Escalated Care. Over the last 4 year over 9,000 patients have been through the Careway system and received rehabilitation for significant knee, shoulder, ankle and spinal conditions. In this ACC pilot, Careway providers have had to record patient reported outcomes and functional measures over the course of the rehabilitation pathway. The ability to look at the outcomes and impact of this new approach has not currently been done, and the Careway staff have not had a chance to look at these key variables as they have been busy managing the patients through the system. Interrogating this* |

| | | |
|---|---|---|
| | | *data retrospectively will be of value to, ACC, Careway, the patients and the providers to see what range of success has been achieved with this new pilot programme before it is rolled out as a nationwide initiative by ACC.* |
| 8 | **Additional Security Requirements** | *Describe any additional security requirements, both physical and technological, to protect the Data. If in doubt consult with ICT. Some example considerations below:*<br><br>***Physical requirements:***<br><br>i The Careway administrator will deidentify the data. The anonymised (no names, identifiers etc) data will be transferred from the Careway practice management system into an excel spreadsheet.<br><br>ii Daniel will be situated both at the Careway office (Epsom) and AUT whilst examining the data.<br><br>iii He will have supervision and support from his supervisor Prof Duncan Reid. |

**Schedule 2– Security Standards**

The overview below represents the minimum-security measures that will be taken by Recipient. In the event of a conflict between these standards and the Additional Security Requirements (if any).

**1.1 Information Security Policies and Standards**

The Recipient has and will retain security requirements that are designed to:

(a) Prevent unauthorised persons from gaining access to Data processing systems (physical access control).

(b) Ensure that persons entitled to use a Data processing system gain access only to such Data as they are entitled to access in accordance with their access rights and that, while Processing or use and after storage, Data cannot be read, copied, modified or deleted without authorization (data access control).

(c) Ensure that the Data cannot be read, copied, modified or deleted without authorization during electronic transmission, transport or storage and that the target entities for any transfer of Data by means of data transmission facilities can be established and verified (data transfer control).

(d) Ensure that the Data is protected against accidental destruction or loss (availability control); and

(a) Ensure all Data security incidents are managed in accordance with appropriate incident response procedures.

**1.2 Network Security**

The Recipient maintains network security using commercially available equipment and industry standard techniques, including firewalls, intrusion detection and/or prevention systems, access control lists and routing protocols.

**1.3 Virus and Malware Controls**

The Recipient installs and maintains anti-virus and malware protection software on the system to protect Data from anticipated threats or hazards and protect against unauthorized access to or use of Data.

**Signed by or on behalf of the Parties:**

The Discloser by:

Signature of authorised signatory

Alexis Stewart

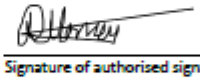
Name of authorised signatory

[AND]

Signature of authorised signatory

Name of authorised signatory

The Recipient by:



Signature of authorised signatory

Daniel Harvey

Name of authorised signatory

[AND]

Signature of authorised signatory

Name of authorised signatory

# Appendix 9: Thematic table From Chapter 4 To Show The Codes That Were Clustered To Develop The Four Prototype Themes

The table below shows the codes that were clustered to develop the four prototype themes in Chapter 4.

| Pathway structure enables process of care | High value care facilitated engagement and motivation | Cost and location were important | Recovery made easier with navigation |
|---|---|---|---|
| *Clear pathway or flow through the programme* | *Access to exercise equipment or gym membership access* | *Cost was a barrier* | *VIP-feeling important by the MDT* |
| *Compare and contrast versus business-as-usual physio care* | *Attendance and engagement enhanced* | *Location close by is important* | *Surgeon laying down law-strict guidelines* |
| *Exit criteria or finishing the pathway not clear* | *Confidence in the physio is important* | *Logistics of accessing the gym was frustrating* | *Patient goals and expectations* |
| *External physio for return to sport (RTS)- validate patient and physio effort* | *Patient reports experience measures (PREMS)- used regularly* | *Physio rehabbing client in the gym* | *Physio was the main contact or navigator for the patient* |
| *ECP allowed physios to deliver good care* | *Goal focussed rehabilitation* | *Ordering a taxi or transport was challenging* | *LSI explained and its importance* |
| *Communication between the health professionals was beneficial and valued* | *Motivating trying to beat the limb symmetry index (LSI) testing* | *No charge-free physio was a facilitator* | *More explanation needed for strength and RTS tests* |
| *Surgeon laying down law-strict guidelines* | *Physio rehabbing client in the gym* | *Quick timely access to specialist under Careway* | *Motivating trying to beat the LSI testing* |
| *Initial delay being entered into Careway* | *Length of time receiving care and treatment* | *Length of time* | *Trust with a physio from previous experience was important* |
| *Specialist writing medical certificates to clear for work gatekeeper* | *Physio fatigue- ongoing sessions when patient was recovered* | *Accessing (General Practitioners) GPs difficult* | *Vocational rehabilitation added to the rehabilitation journey* |
| *Logistics of accessing the gym was frustrating* | *Prehabilitation as recommended by surgeon/physio* | *Access to exercise equipment or gym membership access* | *Seeing physio regularly increased engagement* |
| *Physio and surgeon entered patient* | *Patient report outcome measures* | *Appointment times were important* | *Physio fatigue- ongoing sessions when patient was recovered* |

| Pathway structure enables process of care | High value care facilitated engagement and motivation | Cost and location were important | Recovery made easier with navigation |
|---|---|---|---|
| | *(PROMS)- used regularly* | | |
| *Ordering a taxi or transport was challenging* | *Rehab plan helped achieve the goal and outcomes* | *Compare and contrast versus business-as-usual physio care* | *Ordering a taxi or transport was challenging* |
| *Quick timely access to specialist under Careway* | *Seeing physio regularly increased engagement* | *Physio fatigue- ongoing sessions when patient was recovered* | *Hurt vs harm - setting expectations* |
| *Specialist or Surgeon entering patient* | *Value in physio rehab* | *Structure of the pathway and expected timeframes and stages of rehab was beneficial* | *Difference between patient perceived progress vs physio's perceived progress* |
| *Structure of the pathway and expected timeframes and stages of rehab was beneficial* | *Appointment times were important* | *Vocational rehabilitation added to the rehabilitation journey* | *Communication between the health professionals was beneficial and valued* |

# Appendix 10: Supplementary Information For The Chapter 5 Study

The tables below show the descriptive statistics and the median and 75th quantile regression analyses from Chapter 5.

**Descriptive statistics for timeliness- ACL, lumbar and shoulder surgical pathways**

| **Variable** | **Surgical lumbar** | **Surgical ACL** | **Surgical shoulder instability** | **Surgical rotator cuff** |
|---|---|---|---|---|
| *Data presented is mean, SD and 95% CI* | (n=223) | (n=332) | (n=180) | (n=233) |
| **Timeliness (days) of physiotherapy** | 31.62 (59.42) (95% CI= 23.77 – 39.46) | 21.95 (45.27) (95% CI= 17.07 – 26.84) | 45.67 (67.45) (95% CI = 35.75 – 55.59) | 49.93 (72.52) (95% CI= 40.57 – 59.29) |
| **Timeliness (days) to vocational rehabilitation** | 26.56 (78.39) (95% CI= 16.21- 36.90) | 17.34 (53.76) (95% CI = 11.5 – 23.14) | 25.15 (79.26) (95% CI= 13.49- 36.81) | 47.18 (112.91) (95% CI= 32.61 – 61.76) |

**Descriptive statistics for timeliness-ACL, lumbar and shoulder non-surgical pathways**

| **Variable** | **Non-surgical lumbar** | **Non-surgical ACL** | **Non-surgical shoulder combined** |
|---|---|---|---|
| *Data presented is mean, SD and 95% CI* | (n=480) | (n=418) | (n=426) |
| **Timeliness (days) of physiotherapy** | 17.17 (45.49) (95% CI = 12.60 – 21.73) | 19.89 (34.37) (95% CI = 16.58 – 23.19) | 13.39 (29.49) (95% CI = 10.86 – 15.93) |
| **Timeliness (days) to vocational rehabilitation** | 11.24 (45.49) (95% CI = 7.16 - 15.32) | 7.30 (36.80) (95% CI = 3.77 – 10.84) | 3.73 (29.49) (95% CI = 0.93 – 6.54) |

| *Median quantile multiple regression by pathway: Predictor process variables and confounders* | | | | | | | * p<0.05 |
|---|---|---|---|---|---|---|---|
| **Predictors & confounders** | **Non-surgical ACL knees (N = 418; Pseudo $R^2$ = 0.029, MAE = 12.93)** | **Surgical ACL knees (N = 322; Pseudo $R^2$ = 0.131, MAE = 14.23)** | **Non-surgical lumbar (N= 480; Pseudo $R^2$ = 0.065, MAE = 10.34)** | **Surgical lumbar (N=223; Pseudo $R^2$ = 0.132, MAE = 11.98)** | **All non-surgical shoulders (N= 426; Pseudo $R^2$ = 0.081, MAE = 9.45)** | **Surgical shoulder instability (N= 180; Pseudo $R^2$ = 0.074, MAE = 11.06)** | **Surgical rotator cuff (N= 233; Pseudo $R^2$ = 0.053, MAE = 12.54)** |
| **Number of PROMs** | CoE= -0.06 (0.44) (95% CI= -0.93 – 0.81) P= 0.88 | CoE= 1.74 (0.53) (95% CI= 0.69 – 2.80) P= 0.001* | CoE= -0.76 (0.41) (95% CI= -1.58 – 0.06) P= 0.06 | CoE= -0.99 (0.70) (95% CI= -2.38 – 0.39) P= 0.16 | CoE= -1.03 (0.30) (95% CI= -1.63 – -0.44) P= <0.001* | CoE= -0.33 (0.52) (95% CI= -1.38 – 0.71) P= 0.53 | CoE= -0.86 (0.59) (95% CI= -2.04 – 0.31) P= 0.15 |
| **Number of strength measures** | CoE= 0.09 (0.46) (95% CI= -0.81 – 0.99) P= 0.84 | CoE= 1.27 (0.49) (95% CI= 0.29 – 2.24) P= 0.011* | CoE= -0.10 (0.61) (95% CI= -1.29 – 1.09) P= 0.86 | CoE= 1.78 (2.35) (95% CI= -2.88 – 6.46) P= 0.45 | CoE= -0.69 (0.31) (95% CI= -1.31 – -0.07) P= 0.029* | CoE= -0.47 (0.60) (95% CI= -1.66 – 0.72) P= 0.44 | CoE= -0.34 (0.66) (95% CI= -1.64 – 0.96) P= 0.60 |
| **Physio timeliness** | CoE= 0.02 (0.05) (95% CI= -0.07– 0.11) P= 0.68 | CoE= 0.02 (0.03) (95% CI= 0.04 – 0.08) P= 0.48 | CoE= 0.07 (0.04) (95% CI= -0.01 – 0.16) P= 0.08 | CoE= -0.04 (0.04) (95% CI= -0.11 – 0.03) P= 0.24 | CoE= -0.03 (0.03) (95% CI= -0.08 – -0.03) P= 0.33 | CoE= 0.006 (0.02) (95% CI= -0.04 – 0.05) P= 0.82 | CoE= 0.059 (0.03) (95% CI= 0.003 – 0.11) P= 0.039* |
| **Vocational rehab timeliness** | CoE= -0.04 (0.04) (95% CI= -0.11 – 0.04) P= 0.32 | CoE= 0.04 (0.02) (95% CI= 0.08 – 0.01) P= 0.12 | CoE= 0.05 (0.02) (95% CI= 0.004 – 0.098) P= 0.032* | CoE= 0.01 (0.03) (95% CI= -0.04 – 0.07) P= 0.60 | CoE= 0.02 (0.02) (95% CI= -0.03 – -0.06) P= 0.46 | CoE= 0.03 (0.02) (95% CI= -0.003 – 0.06) P= 0.08 | CoE= 0.00 (0.01) (95% CI= -0.03 – 0.11) P= 0.97 |
| **Ethnicity – Māori/or Pasifika** | CoE= 0.38 (3.23) (95% CI= -5.99 – 6.74) P= 0.91 | CoE= -4.99 (3.15) (95% CI= -11.20 – 1.20) P= 0.11 | CoE= 10.98 (2.46) (95% CI= 6.13 – 15.83) P= <0.001* | CoE= 8.91 (5.28) (95% CI= -1.56 – 19.39) P= 0.09 | CoE= 2.56 (1.84) (95% CI= -1.07 – -6.19) P= 0.16 | CoE= -4.29 (3.33) (95% CI= -10.90 – 2.31) P= 0.20 | CoE= 6.15 (5.06) (95% CI= -3.84 – 16.14) P= 0.22 |
| **Age <39** | CoE= 2.48 (4.44) (95% CI= -6.26 – 11.23) P= 0.02* | CoE= 16.95 (6.92) (95% CI= 3.33 – 30.58) P= 0.015* | CoE= -3.95 (2.55) (95% CI= -8.98 – 1.06) P= 0.12 | CoE= -12.19 (5.91) (95% CI= -23.91 – -0.48) P= 0.04* | CoE= -5.43 (1.84) (95% CI= -9.08 – -1.80) P= 0.004* | CoE= -41.28 (15.34) (95% CI= -71.66 – 10.91) P= 0.008* | CoE= -5.86 (5.86) (95% CI= -17.43 – 5.71) P= 0.32 |
| **Age 40-59** | CoE= -3.94 (4.73) (95% CI= -13.25 – 5.37) P= 0.41 | CoE= 13.44 (7.19) (95% CI= -0.70 – 27.59) P= 0.06 | CoE= -2.55 (2.54) (95% CI= -7.55 – 2.44) P= 0.31 | CoE= -5.28 (5.75) (95% CI= -16.69 – 6.13) P= 0.36 | CoE= -2.93 (1.79) (95% CI= -6.46 – 0.58) P= 0.10 | CoE= 35.40 (15.83) (95% CI= -66.76 – 4.06) P= 0.027* | CoE= -1.30 (3.15) (95% CI= -7.52 – 4.91) P= 0.68 |
| **Gender - Male** | CoE= 0.37 (2.50) (95% CI= -4.57 – 5.30) P= 0.88 | CoE= 1.85 (2.70) (95% CI= -3.48 – 7.17) P= 0.49 | CoE= -2.33 (1.80) (95% CI= -5.88 – 1.21) P= 0.19 | CoE= -8.11 (4.06) (95% CI= -16.18 – -0.05) P= 0.04* | CoE= -1.46 (1.46) (95% CI= -4.35 – 1.42) P= 0.32 | CoE= 0.64 (3.90) (95% CI= -7.08 – 8.37) P= 0.87 | CoE= -4.83 (3.77) (95% CI= -12.28 – 2.62) P= 0.20 |

| *75th quantile multiple regression by pathway: Predictor process variables and confounders* | | | | | | | * p<0.05 |
|---|---|---|---|---|---|---|---|
| **Predictors & confounders** | **Non-surgical ACL knees (N = 418; Pseudo $R^2$ = 0.029, MAE = 15.26)** | **Surgical ACL knees (N = 322; Pseudo $R^2$ = 0.056, MAE = 17.21)** | **Non-surgical lumbar (N= 480; Pseudo $R^2$ = 0.057, MAE = 12.55)** | **Surgical lumbar (N= 223; Pseudo $R^2$ = 0.175, MAE = 15.55)** | **All non-surgical shoulders (N= 426; Pseudo $R^2$ = 0.150, MAE = 12.10)** | **Surgical shoulder instability (N= 180; Pseudo $R^2$ = 0.154, MAE = 14.29)** | **Surgical rotator cuff (N= 233; Pseudo $R^2$ = 0.177, MAE = 16.83)** |
| **No. PROMs** | CoE= 0.22 (0.32) (95% CI= -0.40 – 0.85) P= 0.48 | CoE= 1.19 (0.47) (95% CI= 0.27 – 2.12) P= 0.012* | CoE= -0.64 (0.69) (95% CI= -2.00 – 0.73) P= 0.36 | CoE= -2.62 (0.59) (95% CI = - 3.79 – -1.45) P= <0.001* | CoE= -1.51 (0.55) (95% CI= -2.60 – -0.42) P= 0.007* | CoE= -1.61 (0.89) (95% CI= -3.39 – 0.15) P= 0.74 | CoE= -2.25 (0.68) (95% CI= -3.61 – -0.89) P= 0.001* |
| **Strength m.** | CoE= 0.26 (0.33) (95% CI= -0.39 – 0.91) P= 0.43 | CoE= 0.24 (0.43) (95% CI= 0.61– 1.01) P= 0.570 | CoE= -0.57 (1.00) (95% CI= -2.55 – 1.40) P= 0.56 | CoE= -0.29 (1.98) (95% CI= -4.23 – 3.64) P= 0.88 | CoE= -1.39 (0.58) (95% CI= -2.53 – -0.25) P= 0.017* | CoE= -1.29 (1.02) (95% CI= -3.33 – 0.73) P= 0.21 | CoE= -0.46 (0.76) (95% CI= -1.96 – 1.05) P= 0.55 |
| **Physio time.** | CoE= 0.02 (0.03) (95% CI= -0.05 – 0.08) P= 0.64 | CoE= -0.02 (0.03) (95% CI= -0.07 – 0.04) P= 0.60 | CoE= 0.02 (0.07) (95% CI= -0.11 – 0.16) P= 0.74 | CoE= -0.09 (0.03) (95% CI= -0.03 – -0.15) P= 0.004* | CoE= -0.07 (0.05) (95% CI= -0.17 – 0.03) P= 0.18 | CoE= 0.003 (0.04) (95% CI= -0.08 – -0.08) P= 0.93 | CoE= 0.002 (0.03) (95% CI= -0.06 – 0.07) P= 0.96 |
| **Vocational rehab time** | CoE= -0.04 (0.03) (95% CI= -0.09– 0.01) P= 0.14 | CoE= -0.04 (0.02) (95% CI= -0.08 – 0.01) P= 0.07 | CoE= 0.13 (0.04) (95% CI= -0.64 – 0.09) P= 0.73 | CoE= -0.01 (0.02) (95% CI= -0.56 – 0.03) P= 0.57 | CoE= 0.02 (0.04) (95% CI= -0.06 – 0.10) P= 0.57 | CoE= 0.01 (0.03) (95% CI= -0.08 – 0.08) P= 0.70 | CoE= -0.002 (0.12) (95% CI= -0.03 – 0.03) P= 0.92 |
| **Ethnicity – Māori/ Pasif.** | CoE= -2.18 (2.32) (95% CI= -6.75 – 2.39) P= 0.35 | CoE= -0.39 (2.75) (95% CI= -5.81 – 5.01) P= 0.88 | CoE= 10.00 (4.08) (95% CI= 1.96 – 18.05) P= 0.015 | CoE= 2.54 (4.45) (95% CI= -6.28 – 11.37) P= 0.56 | CoE= 4.67 (3.36) (95% CI= -1.94 – 11.29) P= 0.17 | CoE= -8.59 (5.68) (95% CI= -19.85 – 2.65) P= 0.13 | CoE= 9.59 (5.84) (95% CI= -1.93 – 21.13) P= 0.10 |
| **Age <39** | CoE= 2.02 (3.19) (95% CI= -4.3 – 8.30) P= 0.53 | CoE= 0.88 (6.03) (95% CI= -11.00 – 12.76) P= 0.88 | CoE= -1.84 (4.23) (95% CI= -10.18 – 6.49) P= 0.66 | CoE= -13.29 (4.98) (95% CI= -23.17 – -3.41) P= 0.009* | CoE= -10.87 (3.37) (95% CI= -17.50 – -4.25) P= 0.001* | CoE= -27.60 (26.12) (95% CI= -79.32 – 24.10) P= 0.29 | CoE= -9.06 (6.76) (95% CI= -22.41 – 4.29) P= 0.18 |
| **Age 40-59** | CoE= -2.4 (3.39) (95% CI= -9.08 – 4.27) P= 0.48 | CoE= 0.20 (6.27) (95% CI= -12.14 – 12.53) P= 0.97 | CoE= 1.05 (4.21) (95% CI= -7.24 – 9.35) P= 0.80 | CoE= -6.18 (4.85) (95% CI= -15.79 – 3.44) P= 0.21 | CoE= -5.46 (3.26) (95% CI= -11.88 – 0.96) P= 0.09 | CoE= -14.16 (26.95) (95% CI= -67.52 – 39.21) P= 0.60 | CoE= -0.75 (3.63) (95% CI= -1.93 – 21.13) P= 0.10 |
| **Gender - Male** | CoE= 0.77 (1.80) (95% CI= -2.77 – 4.31) P= 0.67 | CoE= -4.88 (2.36) (95% CI= -5.14 – 4.16) P= 0.84 | CoE= -1.13 (2.99) (95% CI= -7.02 – 4.75) P= 0.70 | CoE= -9.67 (3.43) (95% CI= -16.46 – -2.87) P= 0.006* | CoE= -6.35 (1.46) (95% CI= -4.35 – 1.42) P= 0.018* | CoE= -5.64 (6.64) (95% CI= -18.79 – 7.50) P= 0.39 | CoE= -12.72 (4.35) (95% CI= -21.32 – 4.12) P= 0.004* |

**Thanks for your interest in my work.**