The Rivermead Post-Concussion Questionnaire
as a Risk Indicator for
Prolonged Recovery from Concussion

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Declaration of Originality

This is to certify that, to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any other degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

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ABSTRACT

Background

Brain injury is a major health issue with an estimated 36,000 New Zealanders and an estimated 54 to 60 million people sustaining a brain injury worldwide each year. Approximately five percent of brain injuries sustained are deemed to be moderate or severe, with the remaining 95 percent classified as mild TBI, also known as concussion (Feigin et al., 2013). While many quickly return to pre-injury functioning, up to one third of people with a concussion will have symptoms which persist for more than three months and some develop Post-Concussion Syndrome (PCS). This has been the subject of much research, however there is still no conclusive way to identify those who are at risk of slower recovery (Bunnage, 2013). This research aims to determine if the Rivermead Post-Concussion Questionnaire (RPQ) can be useful in identifying people who may be at risk of a slower recovery.

Aim of Research

Are any of the symptoms, or clusters of symptoms (physical, psychological or cognitive), assessed using the RPQ, associated with a slowed recovery from concussion? Are there any demographic factors associated with a slower recovery time?

Method

A retrospective, medical record review was undertaken to gather data from clients discharged from Concussion Service over a six-month period in 2014. The final study sample was comprised of 107 people – 53 were female and 54 were male. All participants were aged between 16 and 65 years of age, had completed an RPQ during the triage assessment and had been diagnosed with a concussion or post-concussion syndrome by a medical doctor.

Data extracted from files included RPQ scores at initial assessment, client demographics, injury details including severity, duration of services, status at discharge and other services required. Duration of services provided was calculated from the date of triage until the date of discharge - when clients were free of symptoms, or able to self-manage these and return to their pre-injury level of functioning and lifestyle.

Statistical analysis was then performed on the data collected. Descriptive statistics were used to describe the sample population. Differences between means were ascertained using one-way ANOVA while differences in proportions were assessed using z-tests (Bonferroni corrected). Associations between the variables and the duration of time in the concussion service were
explored using a General Linear Mixed-effects Model (GLMM); Pearson’s correlations; and forward and stepwise linear regressions.

**Findings**

There were no statistical differences related to gender, ethnicity or accident type and duration of services. Headache was the most frequently reported symptom, reported by 94.4% of clients. The proportion this symptom contributed to the overall RPQ score was negatively correlated with service duration. Fatigue, forgetfulness/poor memory, taking longer to think and poor concentration were the next highest reported symptoms on RPQ.

A significant association was found between the symptoms of sensitivity to noise, feeling depressed and feeling frustrated, along with the psychological cluster and a longer duration of services. As the proportion each of these symptoms, or psychological symptom cluster, contributed to the overall RPQ score increased, so too did service duration.

In addition, when correlated with duration of services the total RPQ score shows a moderate correlation (R=0.425, P<0.001) as did 13 of the 16 individual RPQ symptom scores. This suggests that the total RPQ score is a useful indicator in determining risk of a slower recovery.

**Conclusion**

The findings of this study indicate that certain individual symptom scores, and notably the scores associated with the individual variables of sensitivity to noise, feeling depressed or tearful and feeling frustrated or impatient, as well as the psychological cluster score and the total summed score on the RPQ, are all correlated with length of stay in the service. This indicated that the RPQ is an effective tool to assist in identifying increased risk of a slower recovery.
CHAPTER 1  INTRODUCTION ........................................................................................................... 1
  1.1  Background ........................................................................................................................... 1
  1.2  The Research Context ........................................................................................................... 5
  1.3  Research aims and objectives ............................................................................................... 5
  1.4  Research questions ................................................................................................................ 5
CHAPTER 2  LITERATURE REVIEW ............................................................................................. 6
  2.1  Incidence of TBI in New Zealand .......................................................................................... 6
  2.2  Concussion Recovery Timeframes ....................................................................................... 7
  2.3  Incidence of Post-Concussion Syndrome ............................................................................. 8
  2.4  Common Symptoms after a Concussion .............................................................................. 9
  2.5  Factors associated with slower recovery ............................................................................ 13
  2.6  Symptom Clusters ............................................................................................................... 16
  2.7  The Rivermead Post-Concussion Questionnaire ................................................................. 17
CHAPTER 3  METHODOLOGY ....................................................................................................... 18
  3.1  Research Context ................................................................................................................ 18
  3.2  Hypothesis .......................................................................................................................... 18
  3.3  Methods ................................................................................................................................ 19
  3.4  Analysis ................................................................................................................................ 21
  3.5  Ethics Approval ................................................................................................................... 22
CHAPTER 4  FINDINGS .................................................................................................................. 23
  4.1  Demographics ...................................................................................................................... 23
  4.2  Inputs Received ...................................................................................................................... 24
  4.3  Duration of Services (Assessment to Discharge) Associations ............................................. 25
  4.4  Rivermead Post-Concussion Questionnaire Associations ................................................... 25
CHAPTER 5  DISCUSSION ................................................................................................................ 28
  5.1  Demographics ...................................................................................................................... 28
  5.2  Total RPQ score ................................................................................................................... 29
  5.3  Significant RPQ Variables .................................................................................................... 29
  5.4  Headache ............................................................................................................................. 30
  5.5  Sensitivity to noise ............................................................................................................... 30
  5.6  Feeling frustrated or impatient ............................................................................................ 31
  5.7  Feeling depressed or tearful .................................................................................................. 32
  5.8  Symptom Clusters ................................................................................................................. 33
  5.9  Clients who ‘Did Not Achieve’ outcomes at Discharge ......................................................... 33
INDEX OF TABLES

Table 1: Classification of traumatic brain injuries (TBI) \(^{1,2}\) ........................................................................................................ 4
Table 2: Demographic profile of the sample split by gender (n=107) ......................................................................................... 23
Table 3: Descriptive statistics for the sample population; including mean age when injured, and number of days from assessment to discharge ........................................................................................................... 24
Table 4: Pearson correlations indicating associations, or lack of, with the number of days from triage assessment to discharge and the Rivermead Post-Concussion Symptom Questionnaire (RPQ) scores and the proportion these scores contribute to the overall RPQ score ......................................................................................................................... 26
CHAPTER 1 INTRODUCTION

1.1 Background

Brain injury is a significant health issue that affects a large number of people both locally and globally. In New Zealand, over 36,000 new traumatic brain injuries (TBI) are sustained each year and it is estimated that between 54 and 60 million people worldwide sustain a brain injury annually (Feigin et al., 2013). Evidence indicates that

TBI will become the third largest cause of global disease burden by 2020 (Edge, 2010).

Approximately five percent of these injuries are deemed to be moderate or severe, highlighting the magnitude of brain injury as a growing global health issue. The remaining 95 percent are mild TBI (mTBI) also known as concussion (Feigin et al., 2013). The majority of people who sustain a concussion fully recover within three months (Sharp & Jenkins, 2015). However, up to one third of people with a concussion report symptoms lasting more than six months, which can impact on their ability to carry out their activities of daily living and participate fully in their life roles (Hou et al., 2012).

Despite the high incidence, it has been difficult to identify a consistent definition for concussion. This is further complicated by the fact that the terms ‘concussion’ and ‘mTBI’ can be used interchangeably (Iverson 2005), but for the purposes of this study the term mTBI will be used.

In an attempt to improve consistency in diagnosis and management, a consensus was recently reached by the American Medical Society for Sports Medicine, the American Academy of Neurology and the Consensus Statement on Concussion in Sport: The 4th International Conference on Concussion in Sport in Zurich, 2012 (McCrory et al., 2013). This agreed definition is summarised by West and Marion (2013, p166),

Concussion is a traumatically, or biochemically, induced alteration in brain function. Emphasis is placed on pathophysiological process, or functional disruption, as opposed to anatomic, structural or tissue injury.

A growing body of research indicates that the physiological changes that occur in concussion arise from neuro-pathologic changes rather than from psychological origins related to the trauma (Iverson, 2005; Ruff, 2005). Concussion injuries are usually caused by blunt trauma, or linear or rotational acceleration and deceleration forces on the brain (Meaney et al., 1995). According to McKee & Daneshvar (2015, p. 50) these impacts will:
cause the brain to elongate and deform, stretching individual neurons, glial cells, and blood vessels and altering membrane permeability.

This, in turn, can affect how neurons process and transmit information between cells and, while affected cells usually recover, some may degenerate and die (Iverson, 2005). The neurological changes can be identified acutely in the first week post-injury, and later for some clients with persistent post-concussion syndromes, on photon emission computerised tomography (PET), single photon emission computerised tomography (SPECT) and functional magnetic resonance imaging (fMRI) (Iverson, 2005). Other useful technologies for detecting structural changes after a brain injury are diffusion tensor imaging (DTI) and susceptibility-weighted imaging (SWI) (Daneshvar et al., 2011). Using these advances in technology, researchers have found that concussion can produce changes in different parts of the brain influencing the severity of symptoms reported after concussion (McKee & Daneshvar, 2015). Elevated levels of biomarkers, such as S100B, a useful neurobiochemical marker of brain damage, can also be found after concussion and are associated with unfavourable outcomes (Bitonte, 2014; Yardan, Erenler, Baydin, Aydin, & Cokluk, 2011).

In New Zealand, the current diagnostic techniques available for general medical usage are magnetic resonance imaging (MRI) and computerised tomography (CT), neither of which are helpful in confirming the presence or absence of concussion (Sharp & Jenkins, 2015). While PET and fMRI technology is available for research purposes, these are not yet generally available in New Zealand for diagnosis of concussion. It is generally accepted that technology only provides a part of the diagnostic picture, and with or without these technologies, clinical diagnosis should be carried out by a healthcare provider experienced in concussion diagnosis and management. The diagnosis must consider “clinical symptoms, physical signs, cognitive impairment, neuro-behavioural features and sleep disturbance” (West & Marion, 2014).

In assessing and treating concussion sequelae it is important to not only consider the biological changes, but also the psychosocial and psychological factors, premorbid and co-morbid physical and mental health factors and other stressors which may contribute to an individual’s experience of, and recovery from, brain injury (Bunnage, 2013). The tools most commonly used in New Zealand to assess the severity of TBI are: The Rivermead Post-Concussion Questionnaire (RPQ); The Glasgow Coma Scale (GCS); the Westmead Post-Traumatic Amnesia (PTA) Scale; and the Sport Concussion Assessment Tool, version 3 (SCAT3).
The GCS, developed by Teasdale and Jennett in 1974, provides a practical, simple-to-administer method for assessment of impairment of consciousness level in response to defined stimuli (Teasdale & Jennett, 1974). Mainly used in hospitals, the GCS identifies fifteen levels of consciousness from deeply comatose and unresponsive to any stimuli, which would be rated between one and three; to fully alert, conscious and orientated at a score of fifteen. Eighty to ninety percent of people with a concussion do not lose consciousness (Accident Compensation Corporation, 2015). However, scores between nine and thirteen indicate a moderate injury and scores of thirteen to fifteen are associated with mild brain injury.

The Westmead PTA Scale, used to assess orientation and memory, can also be used in conjunction with the GCS (Ponsford et al., 2004; Shores, Marosszeky, Sandanam, & Batchelor, 1986). Used primarily in hospital or residential care, the PTA scale assesses the duration of and emergence from PTA to assist with the classification of severity of the brain injury. With this tool, a concussion is diagnosed if the PTA lasts less than 24 hours and there are no complicating factors such as changes on a CT or MRI scan (Ponsford et al., 2004).

While both the GCS and PTA scales are primarily used in medical settings, the SCAT3 is frequently used as a side-line evaluation of concussion on the sports field (McCrory et al., 2013). The SCAT3 is a multimodal, standardised tool to assess athletes for concussion (Davies, 2014). It is appropriate for athletes thirteen years and over, while the Child-SCAT should be used for athletes of five to twelve years of age. The SCAT3 incorporates the GCS, a brief assessment of orientation, screening for clinical symptoms, a neck examination, and tests of balance and coordination (Davies, 2014).

The RPQ, unlike the GCS, PTA and SCAT3, is not a diagnostic tool for the presence or absence of concussion. Instead, it is a subjective, self-reporting tool for the assessment of the severity of symptoms after a concussion (Potter, Leigh, Wade, & Fleminger, 2006). The injured person rates the severity of sixteen symptoms on a zero to four scale - zero indicating they have not experienced this problem, four indicating they are experiencing the symptom as severe, and mild and moderate in between (see Appendix 1). The use of the RPQ assists the health professional to identify persisting symptoms and the level of perceived disability.

Prolonged persistence of symptoms after a concussion is, according to Hou et al. (2012), associated with ongoing disability and distress.

Commonly reported symptoms fall into three distinct groupings: **physical symptoms** which include headache, fatigue, dizziness, sleep disturbance, sensitivity to noise and light; **cognitive symptoms** including poor memory, attention and concentration difficulties; and **affective**
symptoms including alterations in mood, increased irritability and lability, anxiety and depression (Ontario Neurotrauma Foundation, 2013). Of these, the most frequently reported initial symptom is headache (Ganti et al., 2014), however, at three and six months fatigue is the most frequently reported symptom (Hou et al., 2012). According to the Diagnostic and Statistical Manual IV (American Psychiatric Association, 2000), Post-Concussion Syndrome (PCS) may be present if symptoms have not resolved by three months and they meet a particular criteria (see section 2.3).

The severity of the TBI is classified according to the criteria in (Accident Compensation Corporation, 2006) below:

**Table 1: Classification of traumatic brain injuries (TBI)**

<table>
<thead>
<tr>
<th>SEVERITY OF TBI</th>
<th>GLASGOW COMA SCORE</th>
<th>DURATION OF POST-TRAUMATIC AMNESIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MILD</td>
<td>13 – 15</td>
<td>&lt; 24 hours</td>
</tr>
<tr>
<td>MODERATE</td>
<td>9 – 12</td>
<td>1 – 6 days</td>
</tr>
<tr>
<td>SEVERE</td>
<td>3 – 8</td>
<td>7 days or more</td>
</tr>
</tbody>
</table>

1Sourced from Accident Compensation Corporation, 2006

If there is a discrepancy between the level of Glasgow coma score and post traumatic amnesia it is appropriate to use the more severe category.

It is important to note that in the New Zealand study by Feigin et al. (2013) 36 percent of study participants who sustained a mild brain injury did not present to a hospital at the time of the injury, but were identified later through accident and medical clinics and other sources when they presented with persisting symptoms. This suggests that many people are not screened at the time of the injury to accurately determine the severity, or the presence or absence of a concussion so the actual diagnosis is often reliant on a clinical examination by a medical doctor, supported by the client history and self-reported symptoms, conducted sometime after injury.

Worldwide, health and funding systems differ which impacts on the services provided for people with a concussion. New Zealand is in a unique position as concussion services are funded by the Accident Compensation Corporation (ACC). This is a Crown entity and is responsible for administering the country's no-fault accidental injury scheme for injuries that occur as a result of an accident and meet specific criteria. It must arise from a personal injury as defined by the Accident Compensation Act 2001, and the injury must be caused by the accident (New Zealand Parliamentary Counsel Office, 2016).

Most injury-related medical and rehabilitation services are subsidised or free, minimising the cost barrier to those seeking treatment (ACC, 2006).
1.2 The Research Context

This research was conducted in a Concussion Clinic which provides assessment and rehabilitation in the community for clients who have sustained a concussion or moderate TBI. Clients are usually referred for services by ACC Case Managers. The service consists of a community-based interdisciplinary team of health professionals including neurologists, neuropsychologists, registered nurses, physiotherapists, occupational therapists, speech and language therapists, and clinical psychologists. Each year approximately 1000 clients who have persistent symptoms after a concussion are referred for assessment and intervention.

Once referred, clients are provided with education about their TBI and undergo a comprehensive assessment, which includes the RPQ, to determine their needs. Following this, clients can access a continuum of services, if required, to assist them to return to independence in their work, study and usual life roles. It is not an acute service so people are not referred until days or weeks after the injury when their symptoms persist longer than expected and assistance is required to address these.

As a Registered Nurse working in a concussion service this researcher has a particular interest in promoting recovery from concussion.

1.3 Research aims and objectives

The aim of this study was to identify whether any symptom, or cluster of symptoms (physical, psychological or cognitive) rated on the RPQ at initial assessment, was associated with a prolonged recovery. This would facilitate the provision of early, appropriate therapeutic input in an effort to reduce recovery times and avoid the development of PCS.

1.4 Research questions

Are any of the symptoms, or clusters of symptoms (physical, psychological or cognitive) assessed using the RPQ, associated with a slowed recovery from concussion? Are there any demographic factors associated with a slower recovery time?
CHAPTER 2 LITERATURE REVIEW

This research explored whether individual symptoms and/or symptom cluster scores on the RPQ, recorded at the initial triage assessment, were associated with clients’ recovery timeframes. There is a growing body of research about concussion, however, very little has focussed on the utility of RPQ as a predictor of outcomes or timeframes for recovery. To provide context for the thesis, this review will examine the literature in order to ascertain the incidence of concussion, identify the usual symptom development and recovery pathway after a concussion, and identify what factors are already known to contribute to recovery duration. The use of the RPQ will also be reviewed, as it formed the basis of this study.

An extensive search of databases was conducted to identify any previous research looking at the incidence of concussion and mTBI, recovery pathways and timeframes, clusters of symptoms and the RPQ, with an emphasis on predicting outcomes and identifying specific symptom clusters that may be relevant. The search included PubMed, Google Scholar and Ebscohost with all databases selected, including SPORTDiscus; CINAHL; Australia/New Zealand Reference Centre. A number of search queries were entered, including concussion symptom scores, concussion outcomes, early predictors of PCS, PCS prognostic indicators and Rivermead Post-Concussion Symptoms which generated several thousand articles. This was further refined to show only peer reviewed articles which were scanned to find the most relevant, and additional articles were sourced from references in these articles, resulting in 80 studies which had most relevance to this research.

Few relevant New Zealand studies were identified except for studies by Snell and Surgenor (2006) and Rifshana (2009). Snell et al. (2006) reviewed characteristics of referrals to a concussion service as well as outcome at discharge. Rifshana (2009) compared levels of post-concussion symptoms between and intervention group and a control group at admission to a concussion clinic as well as at discharge, as well as exploring non-attendance at clinic and participants’ perception of recovery.

2.1 Incidence of TBI in New Zealand

The extent to which brain injury is a significant health issue in New Zealand is well documented in the population-based Brain Injury Incidence and Outcomes in the New Zealand Community (BIONIC) study conducted by Feigin and colleagues (Feigin et al., 2013). This study captured all cases of TBI registered over a year in an urban (Hamilton) and rural (Waikato District) population. The total incidence of TBI was 790 cases per 100,000 person-years of which 749 were concussion and 41 were moderate to severe TBI. This translated to over 36,000 new TBIs each year in New
Zealand and was significantly higher than other high-income countries such as Europe (47–453 cases per 100,000 person-years) or North America (51–618 cases per 100,000 person-years) (Feigin et al., 2013). Globally, an estimated 54–60 million people sustain a TBI each year (Feigin et al., 2013). A World Health Organisation (WHO) systematic review of the incidence of mild TBI (concussion) found an annual incidence of between 100–300 cases per 100,000 population, based on hospital presentations, but it was estimated that the true incidence was likely to be over 600 cases per 100 000 people, per year (Cassidy et al., 2004).

The BIONIC study (Feigin et al., 2013) showed that in New Zealand, 95 percent of all TBI are mild and most people will recover completely within three to twelve months. However, approximately 10 percent experienced long lasting effects which impacted on their ability to carry out their activities of daily living and participate fully in their life roles. Accident Compensation Corporation figures show that, over the last five years, on average only 13,500 people lodged a claim for a concussion or brain injury each year, with approximately 11,700 deemed to be mild and moderate injuries. Of these, only approximately 4500 people are referred to a concussion service for assistance (Accident Compensation Corporation, 2016). Thus, only 37.5 percent of people who sustain a TBI report to a doctor or hospital to register a claim (Accident Compensation Corporation, 2016) and only 14 percent of people who sustain a concussion seek assistance for persisting problems, which supports Iverson’s statement that we should expect good recovery for most people after a concussion (Iverson, 2005).

The BIONIC study also found that, in line with international statistics, brain injury in New Zealand was more common in males than in females (Relative risk 1·77, 95% CI 1·58–1·97) (Feigin et al., 2013). The main cause of brain injuries was due to falls (38%), followed by mechanical forces (21%), transport accidents (20%), and assaults (17%). From an ethnic perspective, this study found Māori people to be more at risk of concussion (Relative risk 1·23, 95% CI 1·08–1·39) when compared with Europeans (Feigin et al., 2013). Looking at differences by age group, statistics from ACC show the highest rate of concussion and TBI occurred in those aged 15 to 19 years of age (Accident Compensation Corporation, 2006).

2.2 Concussion Recovery Timeframes

It is widely reported that most people who sustain a concussion recover within the first three months (Hou et al., 2012; King, 2014; Ruff, 2005; Schretlen & Shapiro, 2003; Sharp et al. 2015) and that 90 percent of athletes are symptom free within two weeks of the injury (Iverson, 2005; McCrory et al., 2013) or by one month post-injury (Meehan 3rd, Mannix, Monuteaux, Stein, & Bachur, 2014). Symptoms persist beyond three months in 15 – 34 percent of concussion cases.
Lannsjö (2012) found that of the 34 percent who reported persistent symptoms, 24 percent reported three or more symptoms and 10 percent reported experiencing seven or more symptoms at three months. In a systematic review, Carroll et al. (2004) found that in adults, cognitive deficits and post-concussion symptoms (with headache being the most frequently reported) were common in the acute stage after a concussion, but the majority were fully recovered between three and 12 months post-injury, although some will experience longer-lasting effects from the injury.

In New Zealand, the figures are difficult to establish as, according to ACC statistics, 76 percent do not even present for treatment, possibly because their symptoms have resolved, or are not sufficiently problematic or persistent to need medical attention. Only 4500, or 37.5 percent of the 34 percent (who see a doctor and are diagnosed with concussion) are referred on for specialised concussion services (ACC, 2016). This is only 13% of those who sustain a mild brain injury each year. Those who are referred are usually the people who report more troubling or persisting symptoms. According to unpublished statistics collected by the Concussion Service they are usually assessed at the concussion service, on average, within 56 days of injury.

### 2.3 Incidence of Post-Concussion Syndrome

Post-concussion Syndrome (PCS) may be diagnosed if concussion symptoms have not resolved by three months and they meet particular criteria (Appendix 2). Post-Concussion Syndrome is generally described as a syndrome that involves headache, dizziness, fatigue, sensitivity to light or sound, sleep disturbance, and concentration difficulties, however, the definitions (and therefore the diagnosis) of PCS vary (Bryant, 2011). Either the International Classification of Diseases (ICD-10) or the Diagnostic and Statistical Manual of Mental Disorders (DSM-1V) are used to diagnose PCS (Appendix 2).

It is widely accepted that up to one third of people who suffer a concussion will not be fully recovered at three months post injury, and some studies estimate this to be much higher (Bazaraian et al. 1999). A study by Bazarian et al. (1999) documented an incidence of 43 percent reporting PCS at three months. This was very similar to the findings of Roe et al. (Roe, Sveen, Alvsaker, & Bautz-Holter, 2009) that 56 percent met the criteria for PCS at three months. These researchers found higher rates for cognitive rather than physical or behavioural symptoms.

Iverson (2005) reported that in a study in Lithuania, which followed up on 200 people who were admitted to the emergency room with concussion, 78 percent reported the presence of three or
more symptoms (DSMIV criteria) at three months. When the threshold was raised to six symptoms this dropped to only two percent (Iverson, 2005).

A study by Eyres et al. (2005), which reviewed reliability and construct validity of the RPQ, found that 83 percent of clients still reported post-concussion symptoms at three months - higher than many other studies.

Of note, the incidence of PCS from sports concussion is reported to be much lower than the incidence arising after trauma such as motor vehicle accidents, falls and assaults (McCrory et al., 2013). Bazarian et al., (1999, p 179) found that patients sustaining a concussion from a sports injury were significantly less likely to have post-concussion symptoms at one month compared to concussions incurred from other mechanisms of injury (33% vs 64.7%, p = 0.33). A reason for the faster recovery times after a sports concussion is thought to be due to the fact that they occur in a unique group of individuals who tend to be younger, healthier and highly motivated, and are often anticipating the blow or impact (Ontario Neurotrauma Foundation, 2013).

In addition, sport injuries are often assessed on the side-line, immediately after the injury, so earlier intervention could also be a factor in their faster recovery timeframe. An alternative theory is that PCS is related to more traumatic injuries such as motor vehicle accidents or assaults (McCauley, Boake, Levin, Contant, & Song, 2001). McCauley et al. (2001) also found that the likelihood of having PCS three months post-injury is 3.1 times higher if there is a concurrent diagnosis of post-traumatic stress disorder (PTSD).

### 2.4 Common Symptoms after a Concussion

While a range of symptoms are associated with concussion (Appendix 3), there is some debate around their origin and therefore how they should be clustered. In 1995, Cicerone et al.(1995) identified the presence of four clusters of symptoms - affective, cognitive, somatic and sensory - but did not attribute headaches or sleep disturbance to a particular cluster. Several subsequent studies have used three clusters: physical symptoms which include headache, fatigue, dizziness, sleep disturbance, sensitivity to noise and light; cognitive symptoms including poor memory, attention and concentration difficulties; and affective or psychological symptoms including alterations in mood, increased irritability and lability, anxiety and depression (Potter, 2005; Smith-Seemiller et al., 2003; Roe et al., 2009). Eyres et al. (2005) found that good test retest reliability was achieved by dividing RPQ symptoms into two groups, one comprised of the first three symptoms: headache, dizziness, and nausea and the second with the remaining 13 symptoms.
A study by Ganti (2004) found that the most commonly reported concussion symptoms at one week were headache (27%), trouble falling asleep (18%), fatigue (17%), difficulty remembering (16%), and dizziness (16%) demonstrating a focus on physical symptoms in the early recovery phase. At three months the commonly reported symptoms tend to be headache, fatigue, sleep difficulties, dizziness, poor concentration, poor memory, slowed processing, and mood changes (including increased irritability, anger and frustration, anxiety, depression), and sensitivity to noise and light, and blurred vision (Ontario Neurotrauma Foundation, 2013). These symptoms can be quite disabling and can impact on the person’s ability to function in their normal roles.

Headaches are a common symptom after a concussion. Post-traumatic headache (PTH) is recognised by the ICD-10 version 2010 and sits within section IV, diseases of the nervous system. It is differentiated from other common types of headache including migraine, tension headaches and cluster headaches (American Psychiatric Association, 2000).

Post-traumatic headaches are thought to arise after a concussion when the damaged neurons release excitatory neurotransmitters, including acetylcholine, glutamate, and aspartate which are thought be a neuro-chemical substrate for mild head injury. Impairment in cerebral vascular autoregulation can occur (Evans, 2004). PTH can occur without there being any abnormality on neurological examination, neuro-imaging studies (CT, MRI), neuropsychological testing, electroencephalogram (EEG), or vestibular function testing (Ontario Neurotrauma Foundation, 2013) although some structural and functional deficits can be demonstrated at times. No link has been demonstrated between severity or mechanism of injury and the development of PTH, however, research does indicate that having a history of headaches, migraine, neck or neck injury, or chronic pain prior to a concussion is a risk factor for developing PTH, as is being female (Hoffman et al, 2011).

In three studies at one week and three months, headache and fatigue were consistently rated as the top two symptoms reported, while sleep disturbance, memory problems/forgetfulness, and dizziness consistently featured in the top five (Eyres, Carey, Gilworth, Neumann, & Tennant, 2005; Hou et al., 2012). At 18 months and three years post-injury, fatigue was the main problem. The other most troubling symptoms consistently reported were sleep disturbance, headache, memory problems/forgetfulness, poor concentration, slowed processing, irritability, frustration and depression.

Although PTH is the most frequently reported symptom experienced after a concussion, its actual incidence is hard to ascertain. Hoffman et al. (2011) reported that retrospective studies to date identify the prevalence of PTH as between 30 and 90 percent and estimates that one third of
these will develop a chronic PTH. Keidel et al. (1997) reported that 20 percent of patients were still reporting PTH at six months and Lew et al. (2006) found that 18 to 33 percent of people had persistent PTHs for more than one year after head trauma (Lew et al., 2006). Edna (1987) found that 24 percent of people still had persisting headaches at four years, indicating that it is a significant problem for a considerable number of people (Edna, 1987).

Along with PTH, fatigue is one of the most frequent and disabling symptoms after a concussion. People report that they are slower to complete tasks after a concussion and that their physical and cognitive stamina is reduced - so most things they do are draining, they tire much faster than they did pre-injury and any mental exertion has a significant impact (Tombaugh, 1999a). Even seemingly simple tasks such as having a conversation, socialising, reading, studying, working, driving or watching television can drain energy and leave the injured person feeling exhausted and needing to sleep, however people report that sleep is often unrefreshing and they wake still feeling tired (Tombaugh, 1999a). According to Belmont et al. (2006) fatigue is present in 43–73 percent of all concussion patients.

The mechanisms of fatigue are complex and multi-factorial and the precise reason why fatigue is such a problem is largely unknown. It is believed that fatigue can be related to the cognitive effort required to counter difficulties with attention deficit and slowed processing after a concussion injury, and that disrupted sleep may also be a factor (Belmont, Agar, Hugeron, Gallais, & Azouvi, 2006). Following a concussion, brain function is altered due to neuronal damaged causing inefficiencies and disruptions to the flow of information through the brain, resulting in the brain using more energy than previously, causing increased cognitive fatigue (Belmont et al., 2006). Scans taken by fMRI after brain injury when patients are completing a cognitive task demonstrated increased neuronal activity compared to controls. This is thought to indicate increased cerebral effort after brain injury which can manifest as increased cognitive fatigue (Kohl, Wylie, Genova, Hillary, & Deluca, 2009). Subjective assessment of fatigue has shown correlation with information processing and complex selective attention (Ziino & Ponsford, 2005) and information processing speed (Johansson, Berglund, & Rönnbäck, 2009).

After a mild brain injury, 30 to 70 percent of individuals have also reported suffering sleep disturbance, which exacerbated their feelings of increased fatigue (Viola-Saltzman & Watson, 2012). The most common sleep-related problems reported are delayed onset of sleep, sleeping lightly and waking repeatedly through the night and then having difficulty getting back to sleep, and feeling unrefreshed upon waking (Ziino & Ponsford, 2005). Some people also report excessive daytime sleepiness and they need to nap frequently during the day (Parcell, Ponsford,
Rajaratnam, & Redman, 2006). The latter is consistent with some patients who have reported circadian rhythm sleep disorders and delayed circadian timing (Ayalon, Borodkin, Dishon, Kanety, & Dagan, 2007). Some studies have also shown increased stage four sleep and decreased rapid-eye movement (REM) sleep (Parcell, Ponsford, Redman, & Rajaratnam, 2008). It is believed that these alterations in sleep patterns may arise from damage to the sleep-wake regulating centres (Parcell et al., 2008). Chaudari and Khan (2004) found that sleep change in brain injury was caused by injury to the ascending reticular activating system, limbic (emotional) system, and the basal ganglia, affecting the striatal-thalamic-frontal cortical system. Sleep difficulties can also arise from anxiety and depression (Ouellet & Morin, 2006). It is important to identify the origin of the sleep problem in order to treat it appropriately.

In addition to headaches, fatigue and sleep disorders, people with concussion often report that they are forgetful, lose things and cannot remember names and what they have been told or read (Tombaugh, 1999b). In the early phase after a concussion, people have reported deficits in recall, speed of information processing and attention, although most recovered within three to twelve months. Some reported persisting difficulties and show cognitive dysfunction consistent with brain injury on neuropsychological testing (Carroll et al., 2004). Newcombe et al. (2013) also found that more than 15 percent of people have a measurable cognitive deficit at one year post-injury. The cognitive issues identified include attention deficits which impact on concentration, multitasking, learning and recall (McCre, 2008). According to King and Kirwilliam (2013) this is often attributed to being cognitive–affective in origin and it was thought this could be a result of predominantly limbic dysfunction.

Hypersensitivity to sounds (hyperacusis) and tinnitus are symptoms that persist for approximately 10 percent of people with PCS (Hall, Hall, & Chapman, 2005). These can present as acute or later onset symptoms which reduce the injured person’s tolerance of ambient sounds such as the television, music or radio, children playing, machinery working, or people talking (Landon, Shepherd, Stuart, Theadom, & Freundlich, 2012). This makes these individuals more prone to noise induced annoyance (Miedema & Vos, 1999). The emotional disturbances observed after concussion may arise as an indirect psychological response to the injury or from damage to the limbic system (Draper & Ponsford, 2009). Hallberg et al. (2005) suggested that concussion related noise sensitivity was a consequence of an extra-cochlear phenomenon caused by central efferent auditory dysfunction.

Hyperacusis can have a negative impact on an individual’s quality of life as they can find it very difficult to endure ambient noise. This can lead to social isolation and depression and affect their
work and social life, reducing their quality of life (American Academy of Otolaryngology, 2016). Despite being a major issue for some people, the impact of hyperacusis is not yet well documented in health research.

Disturbances of mood and emotions including increased irritability and frustration, anxiety and depression are frequently reported after a concussion, but these symptoms tend to be reported later than the initial physical symptoms (Ashman et al., 2004).

Measures of emotional factors, when taken early, have been found to be strong predictors of PCS three months after head injury according to King et al. (1995). Although the causes of emotional disturbances are still not fully understood it is thought that, after concussion, this may arise as an indirect psychological response to the injury, or from damage to the limbic system (Draper & Ponsford, 2009). There is a disruption of neuronal connections from the shearing and stretching forces of the accident (Graham, McIntosh, Maxwell, & Nicoll, 2000) which could disrupt the neuro-functional circuits, decreasing cerebral processing speed and interacting with cerebral functions. Whatever the cause, psychological disturbances can have a significant effect on quality of life and impact on social, family and professional lives (Konrad et al., 2011).

2.5 Factors associated with slower recovery

The identification of factors that may predispose people to PCS has been the focus of much research, with the intention of being able to intervene and prevent or reduce the unacceptable incidence of poor outcomes. These factors have proven difficult to identify conclusively and there are several varying opinions regarding this, including whether PCS is related to brain damage or arising from psychological or psychiatric factors, or a combination of these (Bunnage, 2013). Regardless of the actual cause, it is agreed that PCS has a substantial negative impact on some individuals and can cause significant psychosocial problems, including difficulties returning to work, stress on relationships and an inability to pursue or enjoy leisure activities (King, Crawford, Wenden, Caldwell, & Wade, 1999).

King et al. (1996) reported that a combination of measures (emotional, organic and neuropsychological) can assist early on after the injury in predicting those who are most likely to develop PCS. This study used the total RPQ score with all 16 symptoms but no predictive qualities were identified. However, other measures including the Hospital Anxiety and Depression Scale (HADS), Impact of Injury Scale (IES) and duration of PTA were confirmed as useful combined predictors – although they are not all routinely used during initial screening of concussion clients.
Furthermore, it was found that the predictive ability of these measures diminished as time post-injury increased. Likewise, Hou et al. (2012) found that while physical symptoms (headache, fatigue, sleep disturbance) were the most prevalent symptoms reported initially, a patient’s early belief about their concussion was a significant independent predictor at six months. Hou et al. (2012) also found that the presence of “all-or-nothing coping behaviour shortly after a concussion was the most important predictor of PCS at three months” (Hou et al., 2012). Similar to these findings Åhman et al. (2013) identified that both physical and psychological symptoms (fatigue, headache, poor memory, depression and sleep disturbance) persisted together in 50 percent of study participants at three years post-injury.

In New Zealand, a study by Snell et al. (2013) showed that participants with stronger injury identity beliefs, expectations of lasting severe consequences, and distress at initial assessment, had greater odds of a poor outcome at six months. Similar to this study, Dischinger et al. also found that 42 percent of participants admitted to a level one trauma centre after a concussion demonstrated PCS at three months and that the presence of anxiety, noise sensitivity, and difficulty thinking were the strongest individual symptom predictors of this (Dischinger, Ryb, Kufera, & Auman, 2009); with anxiety reported by 49 percent, noise sensitivity by 27 percent, and trouble thinking by 31 percent of these participants within the first ten days. Similarly, McCauley et al., (2013) flagged poor social support and elevated reporting of depressive symptoms at one month as predictors of PCS.

In 2013, Bunnage undertook a selective review of the literature to identify factors that give rise to ongoing disability after concussion. His findings were that this was likely to arise from a combination of factors including “subtle organ damage, psychological factors and situational/motivational factors” (Bunnage, 2013). Past research also identifies the impact of previous psychological issues as a factor that increases the likelihood of PCS developing after a concussion (Bunnage, 2013). This is also the case with psychological distress arising at the time of the trauma (King et al., 1995). McCauley et al. (2013) found that the likelihood of having PCS at three months post-concussion was three times more likely if there was a concurrent post-traumatic stress diagnosis; with those who sustained a more traumatic injury such as from a motor vehicle accident or an assault having a greater likelihood of PCS. This is consistent with a previous study by Iverson (2005) who also found that trauma patients take longer to recover from concussion. Likewise McCauley et al. (2005) found poor social support, psychosocial adversity, post-injury mood, pre-injury affective or anxiety disorders, personality factors and degree of emotional distress following the injury as predictors of developing persistent PCS.
In line with this, Iverson (2005) suggested that permanent problems due to the biological effects of concussion are rare, and that when recovery is incomplete this can be attributed to complications such as “pre-existing psychiatric or substance abuse problems, poor general health, concurrent orthopaedic injuries or co-morbid problems (e.g. chronic pain, depression, substance abuse, life stress, unemployment and protracted litigation)” (Iverson, 2005; Lange et al., 2013) also identified the presence of traumatic stress and depression as one of the main factors in the development of PCS and went so far as to state that PCS “rarely occurred in the absence of depression, traumatic stress, symptom exaggeration, or poor effort” (Lange et al., 2013, p. 224). Conversely, McCauley et al. (2013) found that “euthymic mood and high resilience are potentially protective against anxiety and post-concussion symptoms” (McCauley et al., 2013).

Above-average intelligence, older age and female gender have also been identified as vulnerability factors in the development of prolonged PCS (Dick, 2009; Dischinger et al., 2009; King, 2014; Lannsjö, 2012; McCauley et al., 2013). Dick (2009), however, queried whether the gender differences identified were actual, or if it was the result of more honest reporting by females. Interestingly, a study by Ganti (2014) found no difference in PCS incidence between male and females. Like other studies, Ganti et al., (2014) also identified the presence of a headache post-injury as the most robust predictor of persisting symptoms, but in addition that an alteration in consciousness after the TBI and alcohol consumption prior were significant predictors of persisting symptoms. However, these conclusions were based on data collected at one month post-injury, and not three months, so whether or not these factors predict PCS could not be ascertained. Interestingly, the finding regarding the alteration in consciousness was different to that of Cicerone and Kalmar (1995) who found an inverse relationship between loss of consciousness and symptom severity.

From the research to-date it is apparent that the development of PCS is multifactorial, and frequently includes physical, cognitive, psychological and psychosocial aspects. As seen above, some recent research is beginning to focus on the factors that make some individuals more or less resilient, with some screening for risk factors from a bio-psychosocial framework, to assist in developing a model of prediction than will eventually assist with prevention. What is missing from most of the studies reviewed above is whether there was any education or intervention provided at the time of presentation, or subsequently, in relation to the concussion. In New Zealand, the ACC has found that “there is some evidence that early, relevant information about common symptoms of mild TBI, emphasising high rates of recovery, can influence the rate of later persistent symptoms” (Accident Compensation Corporation, 2006, p. 127).
2.6 Symptom Clusters

Anecdotal evidence from health professionals working within the Concussion Service suggests that clients often appear to present with certain groupings of symptoms. Some report a physical predominance of symptoms with headaches, dizziness, fatigue, noise and light sensitivity and fatigue. Others struggle more with memory, concentration, slowed processing and cognitive fatigue and a third group appear to be more emotionally labile, anxious, irritable and more frustrated. There is a fourth group who ‘tick every box’ and rank high scores across all symptoms. This clustering of symptoms has been investigated previously, but there appears little consistency on the way researchers have grouped the symptoms or in the findings.

In 1995 a study of 50 patients, by Cicerone et al. in the United States of America identified the presence of four clusters of symptoms which were affective, cognitive, somatic and sensory, while studies by Roe, Potter and Smith-Seemiller focused on 3 clusters - cognitive, physical/somatic and emotional/behavioural groupings of symptoms (Roe et al., 2009; Potter et al., 2006; Smith-Seemiller, Fow, Kant, & Franzen, 2003). While Cicerone’s study identified the four separate groupings he did not include headaches and sleep disturbance within the clusters (Cicerone & Kalmar, 1995), which are two of the most commonly reported symptoms now (Hou et al., 2012). King et al. conducted a study in the United Kingdom in 1999 and found that a combination of measures – emotional, organic and neuropsychological – can predict early post-injury those who are most likely to suffer persisting PCS (King, Wenden, Caldwell, & Wade, 1999). Unfortunately this study only used a summed score of the whole RPQ and no predictive qualities were identified from that.

In 2005 Potter used the data collected in a study in the United Kingdom, the Oxford Head Injury Service (OXHIS) between 1993 and 1996, to examine the three-factor structure proposed by Smith-Seemiller et al. (2003), which identified distinct groupings for cognitive, somatic and emotional symptoms (Potter et al., 2006). Their results did not find evidence for the one factor model, however they did find support for the existence of the three separate symptoms groupings but there was also a high degree of covariation between the three factors (Potter et al., 2006).

Reviewing this research has shown that the majority of studies identify a range of persisting post-concussion symptoms and a high rate of persistence of these symptoms. Several of these studies have attempted to group the symptoms reported but there is no consistency among the groupings – Eyres divides the RPQ into 2 groups, and some studies summed the total score (Eyres et al., 2005). Cicerone et al. identified the presence of four clusters of symptoms (Cicerone & Kalmar, 1995), while Roe et al., Potter et al. and Smith-Seemiller et al. focused on a three factor
grouping - cognitive, physical/somatic and emotional/behavioural - of symptoms (Potter et al., 2006; Roe et al., 2009; Smith-Seeomiller et al., 2003). No studies were located that examined the predictive qualities of the different clusters of symptoms which is the focus of this study. This study utilises the three factor cluster used by Smith-Seeomiller et al. (2003) and Potter et al. (2006).

2.7 The Rivermead Post-Concussion Questionnaire

In 1995, King et al. concluded that conventional measures using PTA severity were of limited value in predicting psychosocial outcomes for mild to moderate injuries. To fill this gap, King et al. (1995) developed the Rivermead Post-Concussion Questionnaire (RPQ) at the Oxford Head Injury Service, Rivermead Centre to assess the severity of PCS. This questionnaire asks the patient to rate 16 commonly reported concussion-related symptoms on five-point scale ranging from zero to four, identifying to what degree these symptoms are more of a problem compared to pre-injury. A score of zero indicates that the client has no problem with the specific symptoms, a ‘1’ denotes that it was a problem but is not anymore and 2, 3 and 4 indicate a mild moderate or severe problem respectively, thus the overall RPQ score can range from zero to 64. The RPQ was found to have high reliability both when administered by a clinician and when self-administered (King et al., 1995). The RPQ tool is now widely used to assess post-concussion symptoms as it is both reliable and easy to administer.

The construct validity and reliability of the RPQ was also examined by Eyres et al. (2005). It was found that, if divided into two separate components (the ‘RPQ3’ consisting of headaches, dizziness and nausea and the ‘RPQ13’ covering the remaining items) it showed good test retest reliability - but this was not the case if the RPQ scores were summed together.

Potter et al. performed confirmatory factor analyses on data from the RPQ scores of individuals around six months after a predominantly mild TBI. Although there was poor evidence of a single factor solution there was good support for the cognitive, emotional and somatic factors proposed by Smith-Seeomiller et al. (2003). These findings supported the theory of “a collection of associated but at least partially separable cognitive, somatic and emotional symptoms associated with PCS” (Potter et al., 2006, p. 1610). A high degree of co-variation was found between the symptom groupings, particularly between the emotional and somatic symptom groupings (Potter et al., 2006).
CHAPTER 3  METHODOLOGY

This a retrospective, descriptive, quantitative study and more specifically a retrospective chart review also known as a medical record review (Matt & Matthew, 2013). This is a widely applied methodology in healthcare disciplines which uses pre-recorded, patient-centred information to determine the associations between variables using statistical analyses in order to answer one or more research question (Matt & Matthew, 2013).

3.1  Research Context

This study utilised retrospective information gathered from clients at their initial triage assessment who were referred to a Concussion Service for rehabilitation after sustaining a concussion. The triage assessments were completed by an experienced health professional (registered nurse, occupational therapist or neuro-physiotherapist) in order to assess the injury and to identify the intervention required.

Services that were provided to clients included neurological assessment, neuropsychological screening assessment, allied health assessment (usually neuro-physiotherapist or speech language therapist) along with interventions from allied health professionals and clinical psychologists as required. As part of the service, education was provided to assist clients to understand their injury and recovery pathway, along with strategies to facilitate this. If clients were still symptomatic at the end of the approved package of intervention from the Concussion Service they were transitioned to other parts of the service to complete their recovery. Full discharge from the service related to symptom resolution and completion of all interventions.

The aims of this study were to determine whether there were any associations between demographic and triage assessment data with the length of duration in the service data and to assess whether the associations identified, if any, might act as predictors of delayed recovery in order to provide early, appropriate therapeutic input to prevent the high incidence of delayed recovery frequently reported in the literature.

3.2  Hypothesis

That certain symptoms, or clusters of symptoms, reported on the RPQ at the initial triage assessment may act as predictors of delayed recovery from concussion-related symptoms.
3.3 Methods

**Data collection**

Data were extracted manually from information stored on the clients’ electronic file (composed of information from several sources listed below) to capture the client demographics, injury details including severity, RPQ scores at initial assessment and duration in the concussion services.

Sources of information included:

- The referral and accompanying medical notes if any were provided
- The Initial Interview form
- The completed RPQ
- The completed ACC884: Concussion Service - client summary; concussion service discharge reports;
- Vocational service discharge reports
- Billing information.

The data collected were as follows:

Demographics: age, gender, ethnicity

Health information: previous mental health diagnosis, history of drug and alcohol abuse

Injury information: mechanism of injury, date of injury, severity of injury,

Triage information: date of referral, date of triage assessment, RPQ scores by each variable and total score. This is a 16 item checklist.

Discharge status: date of discharge, outcomes at discharge, if required referral to other services (Neuropsychology, Training for Independence)

Demographics such as age, ethnicity, gender, and mechanism of injury were collected in this study and analysed to ensure they were not confounding and that any effects identified were from the RPQ variables, not from the demographic variables.

The information gathered was reliant on clients’ self-report of symptoms and their disclosure of any relevant history including pre-existing health conditions so is predominantly subjective and may not always be accurate, as some clients may not always disclose a psychiatric or addiction history.
Inclusion and exclusion factors

Those eligible for inclusion were discharged between 1st January and the 30th June 2014; aged between 16 and 65 years of age; had completed a RPQ during the triage assessment; and had been diagnosed with a concussion or post-concussion syndrome by a medical doctor.

Those who reported a moderate TBI, a previously diagnosed mental illness or history of drug and alcohol abuse were excluded from this study. The latter factors are known to complicate recovery from concussion (Corrigan, 1995).

Clients were discharged under several circumstances - when they no longer required, or would benefit from further input; when they were lost to follow-up (moved away or did not attend appointments so essentially self-discharged); or when the funder did not approve further input which led to discharge before this was clinically indicated.

There were 255 discharges completed over that period, however, the final sample comprised of 107 clients with concussion after the following were excluded:

- 28 who were over 65
- 25 who were under 16
- 33 who had a pre-existing diagnosed mental health condition
- 5 who had insufficient information on file
- 29 who did have not completed RPQs on file
- 2 who did not meet the concussion service criteria for admission
- 18 who had sustained a moderate injury
- 6 who were lost to follow up
- 2 clients who were not recovered by discharge were removed, as this was too small a sample size for statistical comparisons with the ‘achieved’ group.

Duration of services provided was calculated from the date of triage until the date of discharge when clients were free of symptoms, or able to self-manage these and return to their pre-injury level of functioning in their usual activities of daily living, including work and school and no longer required input.

Rivermead Post-Concussion Questionnaire Variables

All study participants were asked to complete the RPQ to indicate the level of symptoms they were experiencing at the time of the initial triage assessment. They were asked to rate a standard list of symptoms, and compare what they are feeling now with before the injury. They were asked to circle the appropriate number for each of the variables listed (see Appendix 1).
The rating scale is subjective, and numbers from 0 – 4 with the key as follows:

0  Not experienced at all
1  Was a problem but no more
2  A mild problem
3  A moderate problem
4  A severe problem

The 16 symptoms listed on the RPQ were divided into three clusters according to the Smith-Seemiller model (Smith-Seemiller et al., 2003). The physical cluster included headaches; feelings of dizziness; nausea and/or vomiting; sensitivity to noise; poor sleep; tiring more easily, fatigue; blurred vision; upset by bright light; and double vision. The psychological cluster included being irritable, easily angered; feeling depressed or tearful; and feeling frustrated or impatient. Finally, the cognitive cluster included forgetfulness, poor memory; poor concentration; and taking longer to think.

For each cluster a score was calculated from the individual scores of each item that made up that cluster. A total RPQ score was also calculated. The individual symptoms and clusters scores were also expressed as a proportion of the total score to account for the varying numbers of symptoms in each cluster to ensure correct weighting when assessing the impact of each cluster on service duration. (The physical cluster was comprised of nine symptom variables, the cognitive cluster contained three and the psychological cluster was made up of four variables.)

3.4 Analysis

The dependent variable being investigated is the number of days from assessment to discharge which represented the duration of time that each individual spent in the concussion service. The number of days from assessment to discharge was chosen in preference to number of days from injury to discharge as the RPQ was completed at the assessment.

All of the data extracted from the concussion service files was collated and entered into a spreadsheet from which statistical analyses were conducted using the IBM SPSS Statistics version 22. Descriptive statistic (means, standard error of the mean, and frequencies expressed as percentages) were used to describe the sample population. Differences between means were ascertained using one way ANOVA while differences in proportions were assessed using z-tests (Bonferroni corrected). Associations between the variables and the duration of time in the concussion service were explored using the following:

1. A General Linear Mixed-effects Model (GLMM) that explored the association of the number of days from assessment to discharge with age at injury, gender and ethnicity.
2. Pearson’s correlations to identify any linear correlations, both negative and positive, between individual symptom RPQ scores, symptom cluster scores and the total RPQ score with the duration in the concussion service.

3. Total RPQ was also calculated along with the proportion that each item on the questionnaire contributed to the total score and the proportion that the physical, psychological, and cognitive components contributed to the total score.

4. Forward and stepwise linear regression. Five models were run as follows: all the symptoms (expressed as a proportion of the overall score) included as independent variables; all three clusters scores (expressed as a percentage of the overall score) as independent variables; and three separate models using the symptoms score (expressed as a percentage of the overall score) specific to each cluster.

The average length of service for these clients was also identified and compared to those who do not achieve the intended outcome at discharge.

In all statistical analyses a significance level of $\alpha = 0.05$ was used.

3.5 Ethics Approval

The Eastern Institute of Technology Research Approval process was completed and Ethics approval was gained. Refer to EIT approval letters (Appendix 4).

Permission was also sought and gained from the IPH Concussion Service (Appendix 5).
CHAPTER 4  FINDINGS

This chapter presents the results of this research and statistical analysis of the data collected to assess whether there were associations between certain symptoms, or clusters of symptoms, reported on the RPQ at the initial triage assessment and the duration of services. The demographic variables of gender, ethnicity, and mechanism of injury were also examined to identify if these variables were responsible for any effect detected in the study sample.

4.1 Demographics

Of the 107 people whose data was included in the final study sample, 49.5% were female and 50.5% were male (Table 2). The mean age of the people within the study sample was 35 years.

Europeans comprised 57% of the sample with Asians being the next largest group, making up 20.6%. Māori were 11.2% and Pacific and Other each made up 7.5% of the sample number (Table 2). This is very similar to the composition of Auckland’s population which according to the 2013 Census which showed 53.3% were Europeans, 11.2% identified as Māori, 7.5% as Pacific People, 20.6% as Asian and 7.5% as other (Statistics New Zealand, 2013).

The leading cause of injury in the group was falls which made 27.1% of referrals, with sports injuries leading to 24.3% and road accidents 23.4%. Other injuries, which included injuries such as being hit on the head by an object, struck head on object and hit by falling object, made up 16%. The fourth, and smallest group, at 10.3%, were those who presented as the result of an assault (Table 2). Table 3 shows that there is a significant difference in mode of injury due to age. Those experiencing mTBI from sports injuries were significantly younger (average 27 years old) than those experiencing mTBI from falls (average age of 42 years).

Table 2: Demographic profile of the sample split by gender (n=107).

<table>
<thead>
<tr>
<th>Category</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European</td>
<td>33 (62.3) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>24 (44.4) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>57 (53.3)</td>
</tr>
<tr>
<td>Māori</td>
<td>7 (13.2) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>5 (9.3) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>12 (11.2)</td>
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<tr>
<td>Pacific</td>
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<td>4 (7.4) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>8 (7.5)</td>
</tr>
<tr>
<td>Asian</td>
<td>7 (13.2) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>15 (27.8) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>22 (20.6)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (3.8) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>6 (11.1) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>8 (7.5)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Accident Type</th>
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<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road accident</td>
<td>15 (28.3) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>10 (18.5) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>25 (23.4)</td>
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<td>Fall</td>
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<td>13 (24.1) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>29 (27.1)</td>
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<tr>
<td>Assault</td>
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<td>9 (16.7) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>11 (10.3)</td>
</tr>
<tr>
<td>Sport</td>
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<td>15 (27.8) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>26 (24.3)</td>
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<tr>
<td>Other</td>
<td>9 (17.0) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>7 (13.0) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>16 (15.0)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Table 2: Different superscript letters indicate column proportions for gender are significantly different at the α=0.05 level using a z-test.
There was no detectable gender difference between ethnicities or accident types, with the exception of assault (Table 2, P>0.05). From the data it is clear that falls are more common in older people and sporting injuries are more common in younger people, as expected (Table 3).

**Table 3: Descriptive statistics for the sample population; including mean age when injured, and number of days from assessment to discharge**

<table>
<thead>
<tr>
<th>Category</th>
<th>n</th>
<th>Mean (SE; minimum-maximum)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age when injured (years)</td>
<td>Assessment to discharge (days)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>53</td>
<td>33.1 (1.76; 16-63)</td>
<td>119.7 (12.89; 0-428)</td>
</tr>
<tr>
<td>Male</td>
<td>54</td>
<td>36.1 (1.91; 16-65)</td>
<td>106.8 (13.22; 0-400)</td>
</tr>
<tr>
<td>P value&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td>0.258</td>
<td>0.485</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European</td>
<td>57</td>
<td>35.3 (1.76; 16-63)</td>
<td>122.5 (13.06; 0-400)</td>
</tr>
<tr>
<td>Maori</td>
<td>12</td>
<td>30.6 (4.22; 16-55)</td>
<td>85.8 (16.43; 13-196)</td>
</tr>
<tr>
<td>Pacific</td>
<td>8</td>
<td>29.4 (5.12; 16-57)</td>
<td>98.8 (30.4; 23-274)</td>
</tr>
<tr>
<td>Asian</td>
<td>22</td>
<td>36.1 (2.88; 18-65)</td>
<td>104.6 (24.27; 0-428)</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>37.1 (4.50; 17-53)</td>
<td>125.8 (26.91; 13-209)</td>
</tr>
<tr>
<td>P value&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td>0.568</td>
<td>0.735</td>
</tr>
<tr>
<td>Accident Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td>25</td>
<td>33.0 (2.44; 18-59)</td>
<td>85.6 (15.14; 0-318)</td>
</tr>
<tr>
<td>Fall</td>
<td>29</td>
<td>41.6 (2.55; 16-65)</td>
<td>140.6 (19.61; 0-400)</td>
</tr>
<tr>
<td>Assault</td>
<td>11</td>
<td>34.3 (3.60; 18-57)</td>
<td>86.5 (25.72; 0-274)</td>
</tr>
<tr>
<td>Sport</td>
<td>26</td>
<td>26.7 (1.88; 16-44)</td>
<td>103.7 (14.94; 0-274)</td>
</tr>
<tr>
<td>Other</td>
<td>16</td>
<td>38.0 (3.73; 18-65)</td>
<td>140.5 (31.14; 8-428)</td>
</tr>
<tr>
<td>P value&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td>0.001</td>
<td>0.138</td>
</tr>
<tr>
<td>Total</td>
<td>107</td>
<td>34.6 (1.30; 16-65)</td>
<td>113.2 (9.2; 0-428)</td>
</tr>
</tbody>
</table>

<sup>1</sup> P value derived for an ANOVA to test for differences between the means of the groups within each category within each column. Where p<0.05 significant differences between the means are indicated by different superscripts (Bonferroni adjusted).

### 4.2 Inputs Received

Of the 107 clients in this study, 85 (80%) required only concussion service input and achieved the desired outcomes of return to work and usual activities at the end of this. The remaining 22 clients (20%) required some further input which was provided under other services in the same organisation. Nine clients required some vocational input under a Vocational Rehabilitation contract, six required further rehabilitation accessed under a Training for Independence Programme, and three required psychological therapy to assist them to complete their recovery.

A further four people required a combination of services with one needing a Training for Independence Programme as well as psychology input and three requiring both Vocational Rehabilitation and Psychological therapy to complete their rehabilitation and prepare them for discharge and return to their previous activities. However, following input, all clients were deemed to have achieved their desired outcomes after an average stay of 113.19 days and were discharged.
4.3 Duration of Services (Assessment to Discharge) Associations

The mean number of days from assessment to discharge was 113 with a range from zero days to 428 days, with no significant gender difference between male and female. However, while it was not statistically significant, males were discharged on average 13 days earlier (mean days to discharge = 107) than females (mean days to discharge = 120). No significant differences between the mean number of days from assessment to discharge based on ethnicity groups or mechanism of injury groups were detected. The lack of significant difference in length of stay by ethnicity could be due to insufficient sample size as the means indicate that Maori may have stayed a shorter time in the service. This requires further investigation.

A general linear mixed effects model confirmed that age (P=0.527), gender (P=0.468), ethnicity (P=0.933) and mode of injury (P=0.488) were not main effects on the mean number of days from assessment to discharge.

Additionally, there was no correlation between length of time from injury to assessment and duration of services (Pearson’s correlation: R=0.076, p=0.437); indicating that a longer time between injury date to assessment date was not associated with a longer stay in the service.

4.4 Rivermead Post-Concussion Questionnaire Associations

Headache was the most reported symptom, followed by fatigue, forgetfulness/poor memory, taking longer to think and poor concentration (Table 4). Double vision was the least reported symptom followed by nausea and vomiting, restlessness, upset by bright light and blurred vision (Table 4).

When correlated with duration of services the total RPQ score shows a moderate correlation (Table 4, R=0.425, P<0.001). This confirms that as the scores reported on each of the 16 RPQ symptoms increased, the total RPQ score increased, and so did the duration of services. Thirteen of the sixteen individual RPQ symptom scores also show moderate correlations as shown in Table 4. However, nausea/vomiting, blurred vision and double vision did not show a significant correlation.
Table 4: Pearson correlations indicating associations, or lack of, with the number of days from triage assessment to discharge and the Rivermead Post-Concussion Symptom Questionnaire (RPQ) scores and the proportion these scores contribute to the overall RPQ score.

<table>
<thead>
<tr>
<th></th>
<th>No. of clients reporting this symptom</th>
<th>Symptom scores (P value)</th>
<th>Proportion of RPQ (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Cluster</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Headaches</td>
<td>101</td>
<td><strong>0.382 (&lt;0.001)</strong></td>
<td><strong>-0.165 (0.089)</strong></td>
</tr>
<tr>
<td>2. Dizziness</td>
<td>91</td>
<td><strong>0.313 (0.002)</strong></td>
<td>0.072 (0.822)</td>
</tr>
<tr>
<td>3. Nausea/vomiting</td>
<td>67</td>
<td>0.177 (0.069)</td>
<td>0.051 (0.600)</td>
</tr>
<tr>
<td>4. Sensitivity to noise</td>
<td>74</td>
<td><strong>0.303 (0.001)</strong></td>
<td><strong>0.222 (0.021)</strong></td>
</tr>
<tr>
<td>5. Poor Sleep</td>
<td>87</td>
<td><strong>0.347 (&lt;0.001)</strong></td>
<td>0.093 (0.342)</td>
</tr>
<tr>
<td>6. Fatigue</td>
<td>98</td>
<td><strong>0.380 (&lt;0.001)</strong></td>
<td>0.007 (0.947)</td>
</tr>
<tr>
<td>13. Blurred Vision</td>
<td>71</td>
<td>0.144 (0.139)</td>
<td>-0.030 (0.760)</td>
</tr>
<tr>
<td>14. Upset by bright light</td>
<td>68</td>
<td><strong>0.263 (&lt;0.001)</strong></td>
<td>0.156 (0.109)</td>
</tr>
<tr>
<td>15. Double vision</td>
<td>40</td>
<td>0.161 (0.099)</td>
<td>-0.012 (0.902)</td>
</tr>
<tr>
<td><strong>Psychological Cluster</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Being irritable, easily angered</td>
<td>82</td>
<td><strong>0.306 (0.001)</strong></td>
<td>0.167 (0.080)</td>
</tr>
<tr>
<td>8. Feeling depressed or tearful</td>
<td>74</td>
<td><strong>0.338 (&lt;0.001)</strong></td>
<td><strong>0.249 (0.010)</strong></td>
</tr>
<tr>
<td>9. Feeling frustrated or impatient</td>
<td>86</td>
<td><strong>0.373 (&lt;0.001)</strong></td>
<td>0.257 (0.008)</td>
</tr>
<tr>
<td>16. Restlessness</td>
<td>68</td>
<td><strong>0.264 (0.006)</strong></td>
<td>0.080 (0.414)</td>
</tr>
<tr>
<td><strong>Cognitive Cluster</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Forgetfulness, poor memory</td>
<td>96</td>
<td><strong>0.395 (&lt;0.001)</strong></td>
<td>-0.073 (0.452)</td>
</tr>
<tr>
<td>11. Poor concentration</td>
<td>93</td>
<td><strong>0.363 (&lt;0.001)</strong></td>
<td>0.069 (0.483)</td>
</tr>
<tr>
<td>12. Taking longer to think</td>
<td>95</td>
<td><strong>0.271 (0.005)</strong></td>
<td>-0.064 (0.515)</td>
</tr>
<tr>
<td><strong>RPQ Total</strong></td>
<td></td>
<td><strong>0.425 (&lt;0.001)</strong></td>
<td>-</td>
</tr>
</tbody>
</table>

1 Total sample n=107
2 Significant correlations are bolded.

When the proportion that each symptom, or symptom cluster, contributed to the overall score was correlated with the duration of services, there was a significant association between a longer duration and the symptoms of sensitivity to noise, feeling depressed and feeling frustrated, along with the psychological cluster (Table 4).

Both headache and sensitivity to noise are symptoms in the physical cluster. Headache was the most reported symptom, reported by 94.4% of clients, and the proportion this symptom contributed to the overall RPQ score was negatively correlated with days to discharge (Table 4) indicating that as the proportion that headache contributed to the total RPQ score increased, duration of services decreased. Headache explained 5.6% of the variation observed in the duration of services.

Conversely, the proportion sensitivity to noise contributed to the overall RPQ score was positively correlated with duration of services (Table 4) and contributed 4.9% to the variance observed. Given these correlations are in opposite directions it is not surprising that no association was detected for the physical cluster (Table 4).
Feeling depressed or tearful and feeling frustrated or impatient are psychological symptoms and the proportion that these symptoms contributed to the overall score were both positively associated with an increase in the duration of services (Table 4) - with the former explaining 6.2% of the variation and the latter explaining 6.6% of the variation observed. Furthermore, the symptom of being irritable or easily angered tended (P<0.001) to be associated with an increase in the duration of services (Table 4). Given that these three psychological symptom correlations are all positive, it is not surprising that the psychological cluster was also associated with an increased duration of services (Table 4), explaining 8.4% of the variation. No associations were detected for the proportion the cognitive symptoms or cluster contributed to the overall RPQ score or their implications on the duration of services (Table 4).

Forward and backward stepwise linear regressions were used to explore the associations between symptoms (expressed as a proportion of the overall score) and symptom clusters (also expressed as a proportion for the overall score) with days to discharge. When the three clusters were entered into the model, only the proportion psychological was retained (R=0.289, P=0.003). When all of the sixteen symptoms were included in the model as proportions of the overall score, only feeling frustrated or impatient (R=0.257, P=0.008) was retained indicating it was an independent effect. For each of the clusters, a model was run with just the symptoms (expressed as a proportion of the overall score) corresponding to that cluster. Headache (R=-0.237, P=0.014) was retained in the model for the physical cluster; feelings of frustration or impatience (R=0.257, P=0.008) for the psychological cluster; and nothing was retained for the cognitive cluster. Regression analysis was used to identify which individual correlations combined to have the greater effect and feeling frustrated or impatient (variable 9) was found to have an independent effect.
CHAPTER 5 DISCUSSION

This objective of this study was to identify any symptoms or clusters of symptoms that were correlated with a delayed recovery after a concussion. Gender, ethnicity, age and mode of injury were also investigated to exclude any bias these may exert.

The clients’ RPQ scores, collected at triage, have been explored in this study to ascertain whether any individual symptom scores or clusters of scores might be an indicator of a risk of a slower recovery so more intense intervention could be provided to avoid the development of PCS.

The findings of this study indicate that certain individual symptom scores, and notably the scores associated with the variables of sensitivity to noise (variable 4), feeling depressed or tearful (variable 8) and feeling frustrated or impatient (variable 9) as well as the total summed score on the RPQ are correlated with length of stay in the service. In addition, the symptom of headaches was negatively correlated with days to discharge.

5.1 Demographics

This study did not find any difference in outcomes based on gender, in line with the findings of Ganti et al. (2014). King (2014) found that female gender and older age were vulnerability factors in the development of prolonged PCS (King 2014) as did Dick (2009), Lannsjo (2012), McCauley et al., (2013) Dischinger et al., (2009) and Bazarian et al., (1999).

Although there was no significant difference in outcomes based on gender, it is of note that women stay on average 13 days longer in the service. The cause for this is unclear and may be a topic for further investigation. In the study by Dick (2009) gender differences were noted, but it was postulated that this related to more honest reporting by females as scores were similar on four out of five neuropsychological domains tested. Dick proposed a cultural explanation that society is more protective of female athletes, but encourage males to play despite injuries, and to avoid reporting injuries (Dick, 2009). He suggested that female athletes may be more concerned about their health and report more honestly.

While Dick’s study was based on athletes and this study relates to a normal population there may well be some parallels.

The stereotypical New Zealand male is viewed as stoic and tough which, based on anecdotal reports from clinicians in the field, frequently appears to be accompanied by minimisation of persisting difficulties, which may lead to earlier discharge. By contrast, females may wait until they believe their symptoms have resolved before agreeing to be discharged.
There was also no significant difference in duration of services by ethnicity, however the mean time in service was shorter for Māori, but this lacked statistical significance due to insufficient sample size. It has long been recognised that disparities in access to healthcare services exist between Māori and non-Māori in New Zealand (Ellison-Loschmann & Pearce, 2006). Ellison-Loschmann points to socio-economic and lifestyle factors as contributors to this, as well as the availability of healthcare, and discrimination (Ellison-Loschmann & Pearce, 2006).

ACC has attempted to decrease barriers to access by fully funding services and providing universal cover for people who meet the criteria of the Accident Compensation Act 2001, which may explain the lack of major discrepancies across ethnic boundaries, however further investigation needs to be conducted to determine why Māori exit the service one month earlier on average than other ethnicities.

It is also of interest that Pacific people were under-represented in the referral statistics, as only eight percent of the study sample were of Pacific origin, while they make up 14.6 percent of the Auckland population (Auckland Council, 2014; Statistics New Zealand, 2013). This is of concern when statistics suggest that Pacific youth are more than twice as likely to be admitted to hospital for injury arising from assault as European youth (Statistics New Zealand, 2010).

5.2 Total RPQ score

The results of this study did find a moderate correlation between the total summed score of the RPQ and duration of services, indicating that as the total score increased so did service duration. This is in line with the findings of King et al. who reported that there was good reliability and validity when they summed all sixteen RPQ scores (excluding scores of 1 which indicated the symptom had been a problem but was not any more. (King, Crawford, et al., 1999).

5.3 Significant RPQ Variables

Three specific variables also show a moderate correlation with duration of services. These are sensitivity to noise, feeling depressed or tearful and feeling frustrated or impatient.

Five other variables also correlated with increased duration of services - forgetfulness/poor memory, fatigue, feeling frustrated or impatient, poor concentration and poor sleep. This is similar to the most frequently reported symptoms at triage in this study with four out of five being the same, with headaches replacing feeling frustrated or impatient. This is consistent with the studies by Roe et al. (2009), Lannjo et al. (2012) and Eyres et al. (2005) who all reported headache, fatigue and poor memory in their top five symptoms. Lannsjo also reported that the most frequently reported symptoms in the Octopus study were fatigue, headaches and dizziness.
(Lannsjö, 2012). In the study by Eyres et al. (2005) poor sleep and feeling depressed or tearful made up the remaining top five symptoms while poor sleep and being irritable, easily angered did so in the findings of Hou et al. (2015). It was taking longer to think and poor concentration that showed in the top five variables in the study by Roe et al. (2009). These variables are addressed in more detail below.

5.4 Headache

The prevalence of headache at triage is interesting given the moderate findings of a negative correlation between headaches and duration of service in this study. This indicates that as the proportion of headaches within the total RPQ score increases the days to discharge decrease. This is likely due to the fact that headaches are relatively easy to diagnose and treat, so this symptom reduced and resolved with treatment at the concussion service so was less of a persisting issue for clients in this study. This suggests that treating headaches effectively early on results in a shortened duration of service for those clients for whom this is one of their more significant symptoms reported at assessment.

In some studies headaches still play a significant part in PCS at 12 months and three years post-injury, (Åhman, Saveman, Styrke, Björnstig, & Stålnacke, 2013). Mittenberg et al. reported that the incidence of headaches was significantly decreased at six months if clients received treatment to assist them to understand and manage their symptoms (Mittenberg & Strauman, 2000). This is similar to the findings by Ponsford et al. (2002) although their study reviewed clients at three months. The provision of education and intervention is a standard part of the Concussion Service model, therefore in line with the findings of Ponsford, it is thought that the education and support provided to clients who reported headaches at triage contributed to a reduction in their symptoms through appropriate management, likely explaining this negative correlation.

5.5 Sensitivity to noise

This study has found that a higher percentage of noise sensitivity in the total RPQ score was associated with increased duration of services, explaining 4.9 percent of the variance. This is in line with the findings of Dischinger et al. (2009) who noted that those whom reported noise sensitivity in the first week post-injury were three times more likely to still have persistent symptoms at three months.

A study by Nolle et al. of thirty-one patients found that auditory brainstem responses were normal for all patients in their study, however 76 percent of participants had a reduced tolerance to, and increased discomfort from, loud noises (Nölle, Todt, Seidl, & Ernst, 2004). This was thought to be
due to auditory dysfunction from head trauma causing diffuse axonal injury of the central auditory pathway (Miedema & Vos, 1999; Nölle et al., 2004). Hallberg et al. also found that some people develop sensitivity to noise after a brain injury, arising from damage to their central auditory processing (Hallberg, Hallberg, Johansson, Jansson, & Wiberg, 2005). Their study found that only 61 percent of participants reported difficulties with noise sensitivity at triage and that there was an increased chance of a slower recovery timeframe for people who did report this as a problem.

People with noise sensitivity have difficulty tolerating normal environmental noise and this can contribute to social isolation and depression after an injury and have a negative impact on an individual’s quality of life (American Academy of Otolaryngology, 2016). Landon et al. (2012) reported that this can be a later onset symptom and makes people more prone to noise induced annoyance (Miedema & Vos, 1999). This annoyance can contribute to the elevated feelings of frustration, impatience, feeling depressed and tearful which are also significant RPQ variables in predicting duration of services.

5.6 Feeling frustrated or impatient

This research has clearly shown that as feelings of frustration or impatience increase, so does the duration of service. After a concussion, people will often initially focus on and report physical symptoms and psychological symptoms are often not reported until later (Yang, Tu, Hua, & Huang, 2007). Feelings of frustration appear to increase when symptoms persist longer than the injured person expects. The study by King et al. showed an increase in the reporting of feelings of frustration and impatience between the initial assessment and follow up assessments completed at 7-10 days post-injury and again at six months post-injury (King et al., 1995). This was mirrored in the findings of Hou et al. who also found an increase in the percentage of people reporting feelings of frustration and impatience from three months to six months (Hou et al., 2012).

In a study by Van de Naalt et al. it was found that irritability was an issue for 35 percent of respondents at one month, but it was ranked eighth behind other cognitive and somatic complaints. At three months this had decreased to 27 percent, still rated behind eight other variables, but at one year post-injury 34 percent reported irritability as a problem and this was the sixth most troublesome complaint, demonstrating that its prevalence tends to increase with time from injury (Van der Naalt, Van Zomeren, Sluiter, & Minderhoud, 1999).

There are two theories relating to the cause of emotional disturbances including increased irritability, frustration and feeling depressed (Ellison-Loschmann & Pearce, 2006). One is that it
is neuro-pathological in origin and is believed to arise from a disruption of neuronal connections from the shearing and stretching forces of the accident disrupting the neural circuits (Graham et al., 2000), or from damage to the emotion regulation system (Draper & Ponsford, 2009; Konrad et al., 2011). The other theory considers whether emotional disturbances occurring after concussion is a psychological response to the injury which can have a significant effect on quality of life and impact on social, family and professional lives (Konrad et al., 2011).

Van Zomeren and van den Burg suggested that post-concussional symptoms result from the constant effort required to cope with persisting information processing deficits. When the reason for these ongoing difficulties is not understood, the individual may develop feelings of frustration and anxiety, which in turn can exacerbate cognitive difficulties (Van Zomeren & Van den Burg, 1985). The development of these difficulties may be offset if appropriate information is provided to explain and manage the symptoms (Ponsford et al., 2002).

5.7 Feeling depressed or tearful

Disturbances of mood and emotions including increased irritability and frustration, anxiety and depression are frequently reported after a mild brain injury (Ashman et al., 2004). These symptoms are often not reported until later (Yang et al., 2007) as initially after a concussion people will focus on their physical symptoms. Although the causes of this are still not fully understood it is thought that the problems arise either as an indirect psychological response to the injury or from damage to the limbic system (Draper & Ponsford, 2009), or from a combination of both. Regardless of the cause it is acknowledged that these symptoms can have a significant effect on people’s quality of life and impact on their social, family and professional lives (Konrad et al., 2011).

The statistical analysis has shown that people who reported feeling depressed or tearful at triage had an increased likelihood of a longer duration of service. This was a moderate correlation, explaining 11.4 percent of the variance. This is similar to the findings of McCauley et al., (2013) who found elevated reporting of depressive symptoms at one month to be one predictor of PCS. Likewise, Snell et al. (2013) reported that those who demonstrated increased distress at initial assessment had greater odds of a poor outcome at six months. This highlights the importance of identifying this risk factor on assessment so that early intervention can be provided to minimise the possibility of a prolonged recovery.
5.8  Symptom Clusters

The presence of symptom clusters has been investigated in previous research, with different studies analysing two, three and four cluster models (Cicerone & Kalmar, 1995; Eyres et al., 2005; Potter et al., 2006; Smith-Seemiller et al., 2003). In this research a three cluster model was used. On analysis, the psychological proportion of the RPQ (irritability, depression, increased frustration and restlessness) did show a moderate correlation with length of time in service ($R = 0.289$, $P = .003$) explaining 8.4 percent of the service duration. As the proportion the psychological cluster contributes to the overall score increases, so does the duration of service, meaning that these scores can be useful in identifying an increased risk for clients who are likely to be slower to recover. However, there was a slight negative correlation for both the physical and cognitive percentage component, showing that as the proportion the clusters of physical and cognitive symptoms contribute increase within the total score, the duration of service decreases.

This negative correlation suggests a physiological contribution to symptoms in the initial post-injury phase (Roe et al., 2009), but these tend to resolve quite quickly and do not often prolong the duration of service.

The variables for the cognitive cluster of symptoms (forgetfulness/poor memory, poor concentration and taking longer to think) are also not correlated with a longer duration of service. The reason for this is unclear as Newcombe et al. found that more than 15 percent of people do have a measurable cognitive deficit at one year post-injury (Newcombe & Menon, 2013). It is possible that these findings are affected by the small size of this study.

5.9  Clients who ‘Did Not Achieve’ outcomes at Discharge

As outlined earlier, the criteria for being deemed to have achieved outcomes at discharge was based on whether the clients were free of symptoms, or able to self-manage their symptoms at discharge and had returned to their pre-injury level of functioning in their usual activities of daily living, including work and school and no longer needed any further input. Of the initial sample of 255 people whose data was reviewed, six were lost to follow-up. Of these, two did not return calls or letters so it is assumed that had recovered, two moved out of Auckland and were lost to follow-up so their outcome is unknown, and two did not get approval from the funder for provision of further services suggested so final outcome is unknown.

In addition to these, there were two clients who did not achieve outcomes and were still symptomatic and had not returned to their usual work or activities at discharge. These two were not included in the data analysis as they provided too small a sample size for statistical
comparisons with the achieved group. On review there are few similarities between these two clients apart from the obvious factor that they are both female. There were also no clear indicators initially to suggest these two would be slow to recover on the RPQ.

The reason that these two clients were discharged without recovery seems to relate to individual factors, pre-existing debilitation from medical complications for one, and unusual personality traits impacting on ability to engage in rehabilitation for the other. This highlights the importance of effective screening and the collection of an in-depth history when planning an appropriate programme.

5.10 Acknowledging the study’s limitations

This study was carried out in one concussion service in a large, predominantly urban area so the results cannot be assumed to be representative of all concussion services operating throughout the country. In addition, this study only included those aged between 16-65 years, so no children or elderly people were included which means that these findings cannot be extrapolated to the general population. Additional exclusions were placed on the study which meant that people with pre-existing conditions (mental health and drug and alcohol) were not included, so these findings are not representative of these populations.

The size of the study (107 participants) was too small to allow meaningful analysis of some of the demographic variables, so replicating this with a larger retrospective or prospective study in the future could be useful to be able to further investigate these aspects.

5.11 Suggestions for further research

As mentioned above, a larger study would allow more in-depth analysis to determine if some results that were trending towards significance in this study may demonstrate a stronger correlation with a larger sample. This would allow further analysis of the impact of ethnicity and gender on length of duration of services. A further study could also explore other variables which are thought to impact on recovery, which were not included in this study such as the presence of alcohol in the system and the number of previous concussions, both of which can be difficult to corroborate, and based on subjective and sometimes faulty recall.

All participants in this study had access to intervention so a study using a control group who did not have intervention could also be beneficial.
People with a history of a diagnosed mental health condition and substance abuse were excluded from this study, however this group could be included in a further study to compare with other participants whether those co-morbidities impacted on recovery timeframes.

It would also be of value to compare and contrast the results from this study, based on one Concussion Service, with those of other Concussion Services around the country. Different operating models would need to be taken into consideration when comparing findings.

Research could be done to identify New Zealand norms for the RPQ to provide context for elevated scores after an mTBI.

Further studies could also explore additional factors that are gaining momentum in the literature such as resilience, pre-existing coping styles, styles of behavior – especially ‘all or nothing’ behaviour; and patient perceptions of the injury (Hou et al., 2012) to see if there are any correlations with recovery timeframes. ‘All or nothing’ thinking is a negative thought process, or cognitive distortion, in which the individual views themselves and their life experiences in black-or-white terms. (Burns, 1980)

5.12 Implications for practice

Several key findings from this research will assist in the screening for risk factors during assessments of clients who are referred to the Concussion Service for assistance after an injury. The statistical analysis has shown the total RPQ symptom score to be a useful measure in identifying those who could be at risk of a prolonged recovery. This is not something that is summed routinely at present but a process will be put in place to facilitate this as it will enhance the overall clinical assessment. This will be further augmented by therapists paying close attention to the variables associated with a longer stay in the service - sensitivity to noise, feeling depressed or tearful and feeling frustrated or impatient. Feeling depressed and tearful and feeling frustrated or impatient are two of the three variables that make up the psychological cluster, which also is an indicator of a potential for a slower recovery, so staff will take note when these symptoms are elevated and be cognisant of the percentage this makes up of the total RPQ score, to evaluate the risk factor.

The importance of the additional variables of forgetfulness/poor memory, fatigue, feeling frustrated or impatient, poor concentration and poor sleep are also correlated with increased days to discharge and should be considered during the assessment. This will enable the team to identify those at risk within the initial assessment and ensure that appropriate therapy is provided to address the specific problems earlier, facilitating a faster recovery and return to work and usual
activities and reducing the incidence of the development of post-concussion syndrome. This would also potentially decrease the average duration of service, reduce costs of therapy and ACC payment of income related earning so would be beneficial for all parties.

For clients who identify headaches as a severe problem on the RPQ, it will be important to continue to assist them to understand and manage their headaches proactively, in conjunction with the service Neurologists, as this does prove to be effective in facilitating a shorter duration of service.

By treating the psychological risk factors identified on the RPQ as proactively as physical symptoms are treated it is hoped that the duration of services for those reporting these symptoms will also reduce.

This research has also confirmed that most other physical symptoms do usually resolve due to natural recovery within the first few weeks after injury so do not need to become a significant focus for intervention.

The exception to this is noise sensitivity as its correlation with a slower recovery has possibly been under-estimated prior to this research. Now the team will be more aware of the importance of thoroughly screening for this, if it is noted to be a problem on the RPQ. This will ensure the issue is fully investigated, any persisting significant problems are noted, and clients will be offered assessment at the hearing and tinnitus clinic or by a neurologist so their problem can be fully assessed and appropriate advice and treatment provided. It may also assist in offsetting the noise-induced annoyance and frustration that has been linked to lowered mood and predisposes people to social isolation (American Academy of Otolaryngology, 2016; Ashman et al., 2004). Treating noise sensitivity more proactively when the problem is identified will hopefully offset the increased risk of a slower recovery and lead to an earlier discharge from the service.
CHAPTER 6  SUMMARY

Over 36,000 New Zealanders and an estimated 54 to 60 million people worldwide sustain a new traumatic brain injury (TBI) each year (Feigin et al., 2013). Predictions that TBI will become the third largest cause of global disease burden by 2020 (Feigin et al., 2013) has led to a growing body of research on this subject in recent years. Approximately five percent of TBIs sustained are deemed to be moderate or severe, with the remaining 95 percent classified as mild TBI, also known as concussion (Feigin et al., 2013). The majority of people who sustain a concussion fully recover within three months (Sharp & Jenkins, 2015). However, up to one third of people with a concussion develop Post-Concussion Syndrome (PCS), characterised by symptoms lasting more than three months, which can impact on their ability to carry out their activities of daily living and participate fully in their life roles (Hou et al., 2012).

There is a large body of research focused on different aspects of concussion - defining concussion and PCS, the incidence of concussion, assessment and diagnosis of concussion and PCS, assessment tools, the nature of concussion, consequence of concussion, predictors for developing PCS, recovery timeframes, theories about the cause and suggestions to improve outcomes. However there is still no conclusive way to identify those who are at risk of slower recovery (Bunnage, 2013). Therefore, this thesis has set out to determine whether there are in fact early indicators, that could be identified early on through the use of the Rivermead Post-Concussion Questionnaire (RPQ), which may predict those patients who are more at risk of a prolonged recovery trajectory.

The Rivermead Post-Concussion Questionnaire

The RPQ is a subjective, self-reporting tool for the assessment of the severity of symptoms after a concussion. It is widely used to assess post-concussion symptoms and is both reliable and easy to administer. The injured person is asked to rate the severity of common concussion symptoms on 16 variables on a zero to four scale (none to severe) to identify the level of persisting symptoms they are experiencing.

Commonly reported symptoms fall into three distinct groupings: physical symptoms which include headache, fatigue, dizziness, sleep disturbance, sensitivity to noise and light; cognitive symptoms including poor memory, attention and concentration difficulties; and affective symptoms including alterations in mood, increased irritability and lability, anxiety and depression (Ontario Neurotrauma Foundation, 2013). This thesis has investigated whether any of the symptoms, or clusters of symptoms, assessed using the RPQ are associated with a slowed recovery from concussion.
**Persisting Concussion Symptoms**

From the research conducted to-date, it is apparent that most concussion patients find their symptoms have resolved within three months of the injury. However, for a small percentage of patients, symptoms persist long after this time. The BIONIC study (Feigin et al., 2013) showed that approximately 10 percent of concussion patients continued to experience symptoms after three-months post-injury. ACC statistics are relatively in line with this, showing 14 percent of people who sustain a concussion seek assistance for persisting problems.

The development of PCS is multifactorial, and includes physical, cognitive, psychological and psychosocial aspects (Bunnage, 2013). However, while much of the current research has documented the difficulties people have reported, few identify whether the individuals have been able to access any interventions to aid recovery. Previous research also identifies the impact of previous psychological issues as a factor that increases the likelihood of PCS developing after a concussion (Bunnage, 2013). However, people with a diagnosed psychological condition were not included in this study, so this does not explain why some people reported elevated psychological symptoms following a concussion. The research does however highlight the importance of identifying the risk of any persisting psychological issues as these can impact on recovery from concussion, so effective screening for this is essential.

The current assessment framework is holistic and is based on the bio-psychosocial model, which captures information on physical factors, psychological functioning and the person’s social context and roles. The RPQ is one part of this assessment, and this study has found that risk factors raised by scores on the RPQ should be investigated fully so appropriate intervention can be provided to reduce the risk of developing PCS.

**The study sample**

The final study consisted of the data from 107 people, 53 were female and 54 were male, of various ethnicities (classified as European, Asian, Māori, Pacific or Other) who sustained a concussion from a range of mechanisms of injuries including falls, sports injuries, road accidents, assaults and other injuries (for example: being hit on the head by an object, struck head on object and hit by falling object). The mean age was 35, and the mean number of days from assessment to discharge was 113. Unlike most other studies, no statistical differences were noted between genders, ethnicities or accident type and duration of services.
The RPQ as an indicator of a slowed recovery from concussion

Statistical analysis of the data collected from clients’ RPQs showed that associations could be made between certain individual symptoms, the psychological cluster of symptoms and an extended duration of services.

Headache was the most frequently reported symptom but was negatively correlated with service duration. This is likely due to the early aggressive management of headaches in the service. Fatigue, forgetfulness/poor memory, taking longer to think and poor concentration were the next highest reported symptoms, in-line with the findings of a number of other studies (Eyres et al., 2005; Ganti et al., 2014; Hou et al., 2012; Roe et al., 2009).

When the proportion that each symptom, or symptom cluster, contributed to the overall score was correlated with the duration of services, there was a significant association between a longer duration and the symptoms of sensitivity to noise, feeling depressed and feeling frustrated, along with the psychological cluster. Sensitivity to noise was reported by 74 participants and the proportion sensitivity to noise contributed to the overall RPQ score was positively correlated with duration of services.

In addition, when correlated with duration of services the total RPQ score shows a moderate correlation (Table 4, $R=0.425$, $P<0.001$) as did 13 of the 16 individual RPQ symptom scores. This suggests that the total RPQ score is a useful indicator in determining risk of a slower recovery.

The effectiveness of the RPQ as a predictive indicator of slowed recovery was further corroborated by examination of the data around the psychological cluster and sensitivity to noise. As the proportion each of these symptoms, or symptom cluster, contributed to the overall RPQ score increased, so too did service duration.

The psychological cluster would appear to be the key predictor, given this study’s findings that there was no association between the proportion the cognitive symptoms or cluster contributed to the overall RPQ score and the duration of services. In addition, there was a negative correlation with the physical cluster of symptoms, with regard to service duration, possibly reflecting the fact that the physical symptoms have been found to resolve in the first few weeks post-injury (Iverson, 2005).

Implications for Service Delivery

Key findings from the statistical analysis in this study will influence the way concussion service clinicians utilise RPQ findings to tailor early interventions.
This research has shown that certain individual symptom scores, and notably the scores associated with the variables of sensitivity to noise, feeling depressed or tearful, and feeling frustrated or impatient are moderately correlated with service duration. Once risk is identified, the cause for this can be properly screened and appropriate intervention implemented. Treating psychological risk factors proactively will positively impact on recovery and decrease the length of stay in service.

Previously, elevated scores for noise sensitivity were not regarded as a significant risk indicator. However, this study has shown a moderate correlation between sensitivity to noise and service duration, suggesting that this is a valid indicator of risk of a prolonged recovery and that more attention should be paid to this symptom. Treating noise sensitivity more proactively may offset the increased risk of a slower recovery and lead to an earlier discharge from the service.

**Conclusion**

The reported incidence of PCS varies widely. Iverson (2005) has suggested athletes generally return to pre-injury functioning within 2-14 days of a concussion, while Eyres et al. (2005) found that 83 percent of clients still reported post-concussion symptoms at three months – with many other variables and estimations in between, and beyond. Some reports show post-concussion syndrome persisting for up to 10 years (Åhman et al. 2013) highlighting the on-going disability that can arise after a concussion. This study set out to assess whether the Rivermead Post-Concussion Questionnaire could be used to identify certain symptoms as potential risk indicators for a prolonged recovery to enable clinicians to use this information and provide early targeted intervention to mitigate the risk of developing PCS.

The RPQ has been found to be an effective tool in identifying increased risk of a slower recovery when used to screen clients being triaged at entry to the Concussion Service. Knowledge of the risk posed by elevated scores on some RPQ variables, notably noise sensitivity and the psychological cluster of symptoms, will assist clinicians to make a more informed assessment of risk at the initial assessment. This will then guide effective decision-making and rehabilitation planning to ensure clients receive the input they require to facilitate a faster recovery from concussion.
REFERENCES


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Appendix 1  Rivermead Post-Concussion Symptom Checklist

RIVERMEAD SYMPTOM CHECKLIST

Name: __________________________ Date: ______________________

We would like to know whether, at the present, you suffer from any of the symptoms we list below. Because many of these symptoms occur normally, we would like you to compare yourself as you are now compared with how you were before the accident.

For each, will you please circle the number closest to your answer

KEY
0  Not experienced at all
1  Was a problem but no more
2  A mild problem
3  A moderate problem
4  A severe problem

Compared with before the accident, do you now suffer from (please circle):

- Headaches 0 1 2 3 4
- Feelings of dizziness 0 1 2 3 4
- Nausea and/or vomiting 0 1 2 3 4
- Sensitivity to noise, easily upset by noise 0 1 2 3 4
- Poor sleep 0 1 2 3 4
- Tiring more easily, fatigue 0 1 2 3 4
- Being irritable, easily angered 0 1 2 3 4
- Feeling depressed or tearful 0 1 2 3 4
- Feeling frustrated or impatient 0 1 2 3 4
- Forgetfulness, poor memory 0 1 2 3 4
- Poor concentration 0 1 2 3 4
- Taking longer to think 0 1 2 3 4
- Blurred vision 0 1 2 3 4
- Upset by bright light 0 1 2 3 4
- Double vision 0 1 2 3 4
- Restlessness 0 1 2 3 4

Are you having any other difficulties?

Please describe and rate them as above

1 __________________________ 0 1 2 3 4
2 __________________________ 0 1 2 3 4

Any other comments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Appendix 2  Post-Concussion Syndrome Classification

Excerpt from the Diagnostic and statistical manual-text revision (DSM-IV-TRim, 2000), American Psychiatric Association.

Research criteria for postconcussional disorder

A. A history of head trauma that has caused significant cerebral concussion.

Notes: The manifestations of concussion include loss of consciousness, post-traumatic amnesia, and, less commonly, posttraumatic onset of seizures. The specific method of defining this criterion needs to be established by further research.

B. Evidence from neuropsychological testing or quantified cognitive assessment of difficulty in attention (concentrating, shifting focus of attention, performing simultaneous cognitive tasks) or memory (learning or recalling information).

C. Three (or more) of the following occur shortly after the trauma and last at least 3 months:
   (1) becoming fatigued easily
   (2) disordered sleep
   (3) headache

(continued)

Criteria Sets and Axes Provided for Further Study

Research criteria for postconcussional disorder (continued)

(4) vertigo or dizziness
(5) irritability or aggression on little or no provocation
(6) anxiety, depression, or affective lability
(7) changes in personality (e.g., social or sexual inappropriateness)
(8) apathy or lack of spontaneity

D. The symptoms in Criteria B and C have their onset following head trauma or else represent a substantial worsening of preexisting symptoms.

E. The disturbance causes significant impairment in social or occupational functioning and represents a significant decline from a previous level of functioning. In school-age children, the impairment may be manifested by a significant worsening in school or academic performance dating from the trauma.

F. The symptoms do not meet criteria for Dementia Due to Head Trauma and are not better accounted for by another mental disorder (e.g., Amnestic Disorder Due to Head Trauma, Personality Change Due to Head Trauma).
Appendix 3  
Classification of Concussion

Table B. Diagnostic Criteria for Concussion/Mild Traumatic Brain Injury*

<table>
<thead>
<tr>
<th></th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concussion/mTBI may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an &quot;impulsive&quot; force transmitted to the head.</td>
</tr>
<tr>
<td>2</td>
<td>Concussion/mTBI typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes to hours.</td>
</tr>
<tr>
<td>3</td>
<td>Concussion/mTBI may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.</td>
</tr>
<tr>
<td>4</td>
<td>Concussion/mTBI results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged.</td>
</tr>
</tbody>
</table>

Appendix 4  EIT Letters of Approval

Reference Number 11/15

3 August 2015

Penelope McGarry
M asterate Student
C/- School of Health Science
EIT

Dear Penny

I am pleased to inform you that your research notification "Which variables, or clusters of variables, on the 'Rivermead Post Concussion Symptom Checklist' are associated with a slowed recovery from a concussion? What other individual factors might contribute to that?" was received and endorsed by the Research and Ethics Committee at their meeting held on 31 July 2015.

You are reminded that should the proposal change in any significant way, then you must inform the Committee. Please quote the above reference number on all correspondence to the Committee.

The Committee wishes you well for the project.

Yours sincerely

[Signature]

Jeanette Fifield
Secretary – Research Ethics & Approvals Committee

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www.eit.ac.nz
Reference Number 11/15

28 August 2015

Penelope McGarry
Masterate Student
C/J: School of Health Science
EIT

Dear Penny

Thank you for informing the Committee of the change to your project criteria, which will now align with the same dataset that was approved for your colleague Janis Henry (Ref 11/15), i.e. clients discharged between January and June 2014 between the ages of 16 to 65.

The notification of change was endorsed by the Research and Ethics Committee at their meeting held on 28 August 2015.

You are reminded that should the proposal change in any significant way, then you must inform the Committee. Please quote the above reference number on all correspondence to the Committee.

The Committee wishes you well for the project.

Yours sincerely

[Signature]

Agnete Fifield
Secretary - Research Ethics & Approvals Committee
Appendix 5        IPH Ltd Letter of Approval for Study

10th August 2015

To whom it may concern

This is to confirm that Penny McGarry and Janis Henry have permission, for the purposes of their research for EIT, to utilise the data collected and stored on the IPH Ltd database, and contained in the clients electronic files including the following:

- The referral and accompanying medical notes
- The completed ACS Initial Interview Form and Rivermead Post-concussion Symptom Checklist
- The completed ACC884: Concussion Service Client Summary and discharge reports
- Vocational service discharge reports
- Billing information.

They are aware of their obligations under the Integrated Partners in Health Ltd Privacy and Confidentiality Agreement and the provisions of the Privacy Act 1993 and the Health Information Privacy Code 1994.

Regards

Penny McGarry and Janis Henry

Directors