Treatments for Mild Traumatic Brain Injury: Fish Oil Supplementation and Information Provision in New Zealand Health Care Services

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Abstract

Mild Traumatic Brain Injury (mTBI) has the highest incidence of all brain injuries and can lead to symptoms in the physical, cognitive and mood domains. Most symptoms abate within weeks to months, however some individuals experience ongoing symptoms leading to longer-term disruption of social and occupational functioning. Current mTBI management recommendations include providing early injury related education, and addressing symptoms in a multidisciplinary fashion as they arise. As with any injury, it is important to ensure treatments are effective in order to reduce the costs to both the health system and the individual. The studies presented in this thesis aimed to assess the effectiveness of fish oil – a novel treatment for mTBI symptoms, and the current practice for providing information to mTBI patients. Study One was a randomised placebo controlled trial of fish oil as an adjunct treatment for mTBI symptoms. This study was cancelled due to recruitment difficulties, nevertheless the literature review delineates the pre-clinical evidence of its potential to treat both cognitive and mood symptoms via various pathways. In addition, the outlined procedures and the researcher's reflections highlight the unforeseen difficulties that will need to be addressed should a similar trial be conducted in future. Study Two surveyed New Zealand health practitioners on their current practice of information provision for mTBI patients. It aimed to assess whether practices have changed in the 16 years since similar research was published, and since the introduction of information sheets by the Accident Compensation Corporation (ACC). It also assessed the quality and accessibility of the information provided. The frequency of information provision after mTBI has improved since 2004, though the issues with variability and formatting of presented information remain similar. The majority of respondents provided information verbally and in writing, and had information available only in English and standard print formats, potentially disadvantaging those with visual impairment or whose first language is not English. Time constraints, patient concentration and distress, and a lack of appropriate resources were cited as barriers to providing information.

Acknowledgements

Conducting clinical research cannot be done singlehandedly. It requires the input and support of many people, perhaps even more so when things do not go according to plan. First, I would like to acknowledge the people suffering mTBI who participated in Study One. They kindly gave their time and energy during a time of illness and uncertainty when these personal resources were already scarce, and I am incredibly grateful for this. I hope that they obtained some benefit from their participation, and made timely and complete recoveries from their injuries.

Thank you also to the numerous psychologists, occupational therapists, and physiotherapists who undertook recruitment for Study One. They accommodated me in team meetings to discuss the project, stored materials and took responsibility for majority of the recruitment work. These professionals did their best to recruit participants in often trying conditions, and their enthusiasm for the research provided a much needed boost when our collective efforts struggled to bear fruit. Many of these individuals mourned the termination of Study One alongside me, and provided encouragement for Study Two as well as future fish oil research. For all of this and more, I am very grateful.

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Overview

Mild Traumatic Brain Injury (mTBI) represents 70-90 percent of all TBI and a significant public health problem. Typical symptoms in the acute phase of mTBI include headache; dizziness; nausea; confusion; focal neurological signs such as tinnitus; and cognitive symptoms such as memory, attention, and executive function difficulties. These symptoms usually abate within days or weeks post-injury, however 20-30% of sufferers develop ongoing symptoms that can persist for many months, or even years (Barker-Collo et al., 2015; Heitger et al., 2009). Ongoing symptoms can delay an individual's return to work, school, or other premorbid activities, and are associated with increased rates of anxiety and depression (Macleod, 2010; McCauley et al., 2008; Mickeviciene et al., 2002; Styrke, Sojka, Björnstig, Bylund, & Stålnacke, 2013).

Post-concussion syndrome (PCS) is the common term for the experience of ongoing symptoms after mTBI, but is a contentious issue. Debate exists about both the classification and causation of post-concussion symptoms. Rates of diagnosis may differ greatly depending on the criteria used, and some studies have found persisting cognitive deficits in individuals who do not meet diagnostic criteria for any specific disorder (Barker-Collo et al., 2015; Oldenburg, Lundin, Edman, Nygren-De Boussard, & Bartfai, 2016). Regardless of diagnosis, symptoms may persist and cause distress for some individuals.

Standard practice for treating mTBI in New Zealand involves taking a symptom-based approach within a bio-psycho-social framework, including offering reassurance and information regarding symptoms and their management (The New Zealand Guidelines Group, 2006). For those ongoing, more severe or complex post-concussion symptoms, treatment such as occupational therapy or cognitive-behavioural therapy may be offered alongside medical intervention, through a concussion service (Accident Compensation Corporation [ACC], 2019). For the majority of individuals who suffer injury, returning to work and normal function as

soon as possible is desirable, and having a safe, non-invasive and readily available treatment option would be welcomed.

Omega 3 polyunsaturated fatty acids (*n*-3 PUFA) have been found to have many health benefits and may have a role to play in the recovery of cognitive function following brain injury. Studies using rodent models of mTBI have demonstrated multiple possible pathways of injury attenuation. These include lowered neuroinflammation, axonal and neuronal damage, and apoptosis after injury (Barrett, McBurney, & Ciappio, 2014); lowered levels of beta amyloid precursor protein (APP; Trojian & Jackson, 2011); lowered expression of pro-inflammatory cytokines, and prevention of microglial activation to their pro-apoptotic form, significantly lessening both neuroinflammation and the associated behavioural deficits (Zendedel et al., 2015).

The few studies that have included *n*-3 PUFA as a treatment for TBI sequelae have utilised multiple supplements and medications thus precluding a causal inference of *n*-3 PUFA's role in participant improvement. As *n*-3 PUFAs have shown experimental efficacy in treating mTBI symptoms, they may have an additive effect in treating these symptoms within the current standard practice. Due to the dearth of research with human mTBI participants, high quality human trials are necessary to determine whether *n*-3 PUFA supplementation could be an effective treatment.

The opportunity to conduct the present research arose as I entered the Doctor of Clinical Psychology Programme. A PhD student under the same lead supervisor had a significant quantity of a high-quality fish oil supplement, and placebo, left over from a randomised control trial (RCT) with a different population, and after reading the research cited above, sufferers of mTBI were seen as a population who may benefit from further RCT research.

Despite the significant efforts of all involved, Study One did not attract enough participants to be a feasible trial. Due to this and the impending expiry date of the

supplements the timeframe could not be extended, and so the trial was ceased. Factors contributing to lower than expected participation are discussed in Chapter Four. Throughout the recruitment period and during practical placements, I noted that many mTBI sufferers expressed confusion and concern regarding their symptoms and recovery, and often did not possess written materials to refer to. These individuals were distressed by their uncertainty, which was concerning given the potential for such distress to maintain mTBI symptoms and for quality information to lower distress. It was clear that the provision of information to mTBI patients warranted investigation. As Study One drew to a close, information provision became the focus of a subsequent study, which replicated and extend previous survey research conducted by the lead supervisor and a former master's student approximately sixteen years prior.

Moore and Leathem (2004) found that only 45.9% of the New Zealand Emergency Departments and General Practitioners that responded to their postal survey provided written information to patients who had a confirmed or suspected mTBI. These ranged from one to ten pages in length, and just over half met the criteria for being able to be read by 70% of the population. Since this study took place, at least two mTBI-specific patient leaflets have been produced by the ACC. It is not known however, whether these are routinely provided to patients by their healthcare practitioners, how accessible they are, or which leaflets are most used.

International studies have shown substantial variability in the written information provided to patients after mTBI (Baker, Unsworth, & Lannin, 2015; Kempe, Sullivan, & Edmed, 2014; Macdonald, McMillan, & Kerr, 2010; Peachey, Hawley, Cooke, Mason, & Morris, 2011). Patients should be provided with written discharge information that advises about what to expect and what to do in the first few days post-injury, a description of which symptoms signal a medical emergency or require a reassessment, and a description of the symptoms that may be experienced in the post-acute period and how to manage these (Kempe et al., 2014;

Peachey et al., 2011). Given the New Zealand Guidelines Group's (2006) recommendations for information and reassurance as a first-line treatment for mTBI, the lack of recent New Zealand research into mTBI information provision and the frequent uncertainty noted from mTBI sufferers, a replication of Moore and Leathem's 2004 work was warranted. In addition, this would provide an indication of if and how practice has changed since 2004.

Chapter One provides a background for the two studies by presenting the definitions, diagnostic criteria, and epidemiology of both mTBI and PCS. It also includes a discussion of the contention surrounding PCS as a diagnostic entity. Evidence for biological and psychological aetiologies of post-concussion symptoms is presented, as are the current treatment guidelines for New Zealand.

As background to Study One, Chapter Two presents a history of dietary *n*-3 PUFA consumption and evidence of its benefits, before discussing several randomised controlled trials of *n*-3 PUFA supplementation in human populations with various cognitive difficulties. As there are currently no published trials of the specific effect on human mTBI, a discussion of rodent models of *n*-3 PUFA supplementation following mTBI is also presented, along with an outline of the possible mechanisms of effect.

Chapter Three draws together the evidence of *n*-3 PUFAs potential for effect on post-concussion symptoms and presents justification for Study One as well as specific aims, hypotheses, and methodology. Chapter Four describes alterations made to Study One's methodology in response to operational challenges, and its ultimate cessation. It also outlines the key limitations and recommendations for future research.

Chapter Five reviews literature relating to the importance of providing information to those who have suffered mTBI. The measures for assessing the quality of information are presented and common issues with post-mTBI information provision are discussed. Chapter Six contains the hypotheses and methodology for Study Two. Chapter Seven presents the results

from the Study Two survey, and Chapter Eight discusses these results in relation to prior research and future recommendations.

Finally, Chapter Nine provides a discussion of the research as a whole and sets out limitations and recommendations for further research in the area of treatment following mTBI. The thesis concludes with researcher reflections on the process, difficulties, and highlights of conducting these studies, from both professional and personal perspectives.

Chapter One: Mild Traumatic Brain Injury and Post-Concussion Syndrome

This chapter reviews the current literature on mild traumatic brain injury (mTBI) and post-concussion syndrome (PCS). It includes an examination of the differing terminology within this field of research before presenting incidence rates and diagnostic criteria for both mTBI and PCS. The review then proceeds from a more integrated standpoint, considering the symptoms experienced after suffering mTBI rather than specific diagnoses. Research relating to the acute and chronic symptoms suffered after mTBI is presented, as is the aetiology of symptoms, and their assessment and treatment in current practice. The purpose of this review is to provide a background for both Study One and Study Two. For Study One it will address the rationale for the recruitment criteria adopted, and the possible mechanisms of effect of a fish oil supplement on mTBI related symptoms. For Study Two, it will provide an overview of symptoms and their potential duration, which comprises part of the information patients may benefit from receiving.

Terminology

Many different terms have been used to describe mTBI and the symptoms experienced afterwards. Some alternative terms include mild head injury, minor head injury, concussion, and post-concussion disorder. New terms are also being suggested, such as post-inflammatory brain syndrome (Rathbone, Tharmaradinam, Jiang, Rathbone, & Kumbhare, 2015), as evidence for similar symptoms across differing trauma aetiologies is discovered. The New Zealand Guidelines Group (2006) used 'head trauma' or 'head injury' to describe the initial injury to the head, rather than the brain, because head injuries do not always cause brain injuries and individuals who have had an injury to the head may not always consider 'brain injury' information applicable to them. This group also noted that while classification of the initial severity of the injury can be useful for predicting some short- and long-term outcomes, some terms (e.g., mild) may not be acceptable to the injured individual, as the impact on their functioning may be far from mild.

The term concussion is common in research as well as everyday language, however most recent research instead uses the term mild traumatic brain injury or mTBI. Concussion and mTBI are considered synonymous, though as outlined in the next section, mTBI is sometimes considered more severe than concussion. The term concussion is frequently used in the context of sport related head injury, and is often considered to be at the milder end of the mTBI spectrum as while the acute symptoms are the same as any other injury mechanism, recovery reportedly occurs within a shorter timeframe (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004; Karr, Grindstaff, & Alexander, 2012; Reuben, Sampson, Harris, Williams, & Yates, 2014). In line with previous research, the present study will use the terms concussion and mTBI synonymously.

The differing diagnostic criteria used to categorise PCS have led to some confusion within the literature. The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition – Text Revised (DSM-IV-TR; American Psychiatric Association [APA], 2000) stipulates that symptoms must have been present for a minimum of three months after sustaining mTBI, while other classification systems do not clearly state a required timeframe. In line with this, many studies use the term post-concussion syndrome to describe any symptoms occurring after mTBI, without considering a specific timeframe, thus there may be overlap between mTBI and PCS. Definitions and classifications of both mTBI and PCS are explained in more detail in the following two sections.

Mild Traumatic Brain Injury

Diagnosis. Traumatic brain injury (TBI) is sustained when a direct external mechanical force, or acceleration and deceleration forces, are applied to the head and result in a disruption of brain function. There are countless scenarios in which such injuries can occur, though some of the most common are motor vehicle accidents, falls, and assaults (Feigin et al., 2013). The severity of TBI is usually classified using the Glasgow Coma Scale (GCS) score from the initial emergency room presentation, the duration of loss of consciousness (LoC), and/or

the duration of post-traumatic amnesia (PTA), and may be considered mild, moderate, or severe. Seventy to 90 percent of TBI fall into the 'mild' category (Cassidy et al., 2004); this end of the spectrum is the focus of the present studies.

The World Health Organisation (WHO) Collaborating Centre for Neurotrauma Task Force on Mild Traumatic Brain Injury recommend the following criteria as an operational definition of mTBI, based on the American Congress of Rehabilitation Medicine (ACRM) and their own literature review:

> MTBI is an acute brain injury resulting from mechanical energy to the head from external physical forces. Operational criteria for clinical identification include: (i) 1 or more of the following: confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and/or other transient neurological abnormalities such as focal signs, seizure, and intracranial lesion not requiring surgery; (ii) Glasgow Coma Scale score of 13–15 after 30 minutes post-injury or later upon presentation for healthcare. These manifestations of MTBI must not be due to drugs, alcohol, medications, caused by other injuries or treatment for other injuries (e.g., systemic injuries, facial injuries or intubation), caused by other problems (e.g., psychological trauma, language barrier or coexisting medical conditions) or caused by penetrating craniocerebral injury. (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004, p. 115).

Variations of these criteria, including one or more of the listed signs and symptoms but excluding others, can be found throughout the literature. It is because of such discrepancy in the previous research that the above-listed criteria were published, however as Levin and Diaz-Arrastia (2015) note, neither WHO nor ACRM specified any minimum duration for LoC or PTA, nor did they specify how practitioners should differentiate between extreme stress caused by a traumatic event, and confusion caused by trauma to the head. The possibility of misclassification remains.

Incidence. Cassidy and colleagues (2004) reviewed 121 studies from around the world and found that the annual incidence of mTBI was approximately 100-300 cases per 100,000 population. These researchers acknowledge that while most research comes from hospital settings, many cases of mTBI are not treated in hospitals, thus the true incidence is likely closer to 600 per 100,000 population. In a population based study in the Waikato region of New Zealand Feigin et al. (2013) reported 790 traumatic brain injuries per 100,000 person years. Of these 790 injuries, 749 - almost 95% - were considered mild, classified by a GCS score of 13 – 15 or a period PTA less than 24 hours in duration. This incidence rate is likely more accurate than the vast majority reported in the literature, owing to sampling techniques that involved review of hospital and general practitioner records, contact with sports clubs and schools, and offered individuals the chance to self-refer through responding to advertisements.

Cost. Traumatic Brain Injury (TBI) is a major public health concern both abroad and in New Zealand. The Accident Compensation Corporation[1] (ACC; 2016) recorded 13,519 new claims for head injuries/concussion in the year leading up to June 2015, and the 17,416 active claims during this time cost a total of $75,616,367. These costs represent rehabilitation, compensation for being incapacitated for work, and ancillary services such as transport to treatment. Although these cost statistics do not account for severity, with 95% of TBI in New Zealand being mild it is likely that a large proportion of the total cost represents recovery from mTBI. Indeed in a study of the cost of TBI in New Zealand from a societal perspective, Te Ao and colleagues (2014) estimated the one year cost of mTBI in 2010 to be US $3395 (NZ $4719) per case, and the lifetime cost per case as US $4636 (NZ $6444). While the per case cost for mild injury was considerably lower than the cost per moderate/severe case, the substantially higher incidence of mild cases meant that the total cost of mTBI was approximately three times higher than moderate and severe TBI.

[1] ACC is a state-sector organisation providing no-fault accident insurance and injury prevention initiatives. It is funded by levies on income tax, business, fuel, vehicle licencing, and government funding, and is available to every person who suffers an injury caused by an accident in New Zealand.

Post-Concussion Syndrome

Diagnostic criteria. The two most widely used classification systems in the field of psychology are the DSM and the International Classification of Diseases (ICD). Both of these systems provide diagnostic labels for ongoing symptoms after mTBI and the different iterations of each system list different criteria. The DSM-5 (American Psychiatric Association [APA], 2013) label for such ongoing symptoms is 'mild neurocognitive disorder due to traumatic brain injury' and criteria include:

- Evidence of modest cognitive decline compared to premorbid function in one or more cognitive domains. This may be based on the concern of the injured individual, the clinician, or a knowledgeable third party. The impairment must be documented by an appropriate quantified clinical assessment.
- Cognitive deficits do not prevent the individual from completing instrumental activities of daily living, though compensatory strategies or extra effort may be necessary.
- The symptoms do not occur solely during an episode of delirium and are not better attributed to another mental disorder.
- There must be evidence of TBI such as loss of consciousness, post-traumatic amnesia, disorientation and confusion, or neurological signs.
- The problems present immediately after injury, or upon regaining consciousness, and "persists past the acute post-injury period" (APA, 2013, p. 624).

While criteria for the duration of LoC and PTA, as well as a GCS score of 13-15 are outlined as necessary for evidencing a mTBI, the DSM-5 does not provide guidelines for the duration of the acute post-injury period, other than a rather vague statement that mTBI usually resolves within a few weeks to months (APA, 2013).

The DSM-5 criteria represent a change from the DSM-IV-TR research criteria for postconcussional disorder. The DSM-IV-TR criteria focused on assessment of attention and memory rather than other cognitive domains, and required the individual to be experiencing

three or more symptoms such as: becoming fatigued easily; disordered sleep; headache; vertigo or dizziness; irritability or aggression on little or no provocation; anxiety, depression, or affective lability; apathy or lack of spontaneity; and other changes in personality. These symptoms must have developed following a head trauma of sufficient severity to cause significant concussion, be present for more than three months, and if pre-existing symptoms were present, they must have been significantly worsened by the trauma. Contrary to the DMS-5's neurocognitive disorder, the symptoms of postconcussional disorder must lead to a significant impairment in social or occupational functioning (APA, 2000).

In line with changes to the DSM, the ICD criteria evolved from a 'postconcussional syndrome' to a 'mild neurocognitive disorder' when moving to the latest version. The ICD 10 postconcussional syndrome simply required the presence of three or more symptoms similar to those from the DSM-IV-TR postconcussional disorder criteria, and stated that depression or anxiety may be present, attributing this to loss of self-esteem and fear of permanent brain injury (World Health Organisation [WHO], 2004) thereby highlighting the psycho-social aspects of PCS while to some extent discounting the possible neuro-chemical causes of mood dysfunction. Like the DSM-5, neither the ICD-10 or -11 provides guidance for the timeframe of symptoms or recovery. Mild neurocognitive disorder in the ICD-11, as with the DSM-5 disorder of the same name, requires a subjective decline from the previous level of functioning and objective evidence of such a decline in one or more cognitive domains that does not significantly interfere with activities of daily living. While this can be specified as due to concussion, no limits are placed on the severity of the initial injury (WHO, 2019).

The lack of consensus in the diagnostic criteria both reflects and perpetuates disparities in the PCS literature. High quality research is required to inform diagnostic criteria, and standardised criteria are necessary for comparing conclusions between studies and collecting valid epidemiological data. It is not yet clear when the acute phase of mTBI ends and

PCS begins, nor what degree of dysfunction the sufferer must experience in order to qualify for diagnosis.

Prevalence and cost. Diagnostic criteria chosen may have serious repercussions on prevalence rates, cost to the health system, and compensation claims. In a study comparing the ICD-10 and DSM-IV-TR criteria for postconcussional syndrome (PCS) and postconcussional disorder (PCD) at 6 months post-injury, it was found that 14.4% of the participants met PCD criteria, and 44.6% met criteria for PCS (McCauley et al., 2008). Additionally, higher proportions of participants who had the potential to access compensation for their injury through workplace compensation schemes or litigation met criteria for each disorder. Of those who had the potential to access compensation, 28.3% met criteria for PCD and 60.9 % met criteria for PCS, compared with 7.8% and 37.8% respectively for those who did not have the potential for compensation. While the effect sizes of these findings were considered small, the costs to healthcare systems could potentially be large.

In the 2015 calendar year, ACC received 1168 claims for PCS, which included diagnoses termed 'postconcussional syndrome' and 'post-traumatic brain syndrome' (ACC, 2016). The 1927 active (requiring some form of payment from ACC) claims for these diagnoses during 2015 cost $31,159,993 (ACC, 2016). Individuals initially covered for TBI may have their diagnosis changed (or added to) and therefore their injury costs initially attributed to TBI then later covered under PCS, thus the PCS cost differs from the TBI costs discussed previously. It may be that if PCD criteria were required for cover, the above figure would be considerably lower.

Post concussion syndrome as a diagnostic entity. Post-concussion syndrome is a contentious issue. According to several studies (e.g., Heitger et al., 2009; Barker-Collo, et al., 2015) the symptoms of mTBI usually abate within days or weeks post-injury, however 20-30% of sufferers develop ongoing symptoms that can persist for many months, or even years. Several researchers (e.g., Levin & Diaz-Arrastia, 2015; Meares et al., 2011; Mounce et al., 2012;

Rathbone et al., 2015) argue that residual symptoms such as fatigue and headaches are non-specific, occur frequently in the general population, and may be misattributed to mTBI. Levin and Diaz-Arrastia (2015) state that the evidence for persisting cognitive deficits is weak, as there are few prospective longitudinal studies longer than six months. Many authors however, seem to consider chronic symptoms to be those that persist for longer than one to three months (Carroll et al., 2014). This is sometimes stated explicitly, but is more often implicit in the assertion that symptoms usually remit within this time for the majority of individuals.

In a three month prospective study of 62 adults with mTBI and 58 non-brain trauma controls, Meares et al. (2011) found that mTBI did not predict PCS using the ICD-10 criteria; PCS rates and symptoms did not differ between groups. Pain however, was associated with PCS and the authors posited this may be due to the increased attention given to physical sensations when people experience chronic pain, leading to greater endorsement of PCS like symtoms. In contrast, Webb and colleagues' (2015) study of US airmen with mTBI compared to those with other injuries, reported hazard ratios for cognitive disorder NOS (not otherwise specified) and memory loss at 180 days or longer since injury as 10.75 and 4 respectively. This study excluded individuals who had suffered mTBI in the two years prior to the study entry, or mTBI during the study period, indicating that a single mTBI event can have ongoing effects.

Oldenburg, Lundin, Edman, Nygren-De Boussard, and Bartfai (2016) compared a PCS group, recovered mTBI group and a community control group on measures of post-concussion symptoms and various cognitive domains. The PCS group was defined as those who endorsed three or more symptoms of the Rivermead Postconcussion Symptoms Questionnaire (RPQ) at three months post-injury, thus meeting the ICD-10 criteria for PCS, while the recovered mTBI group had fewer or no symptoms three months post injury. There was limited evidence of the PCS group performing lower on cognitive measures than the recovered group, and the authors attributed the slight variation to the pre-morbid characteristics of the PCS group as they were found to have a lower 'cognitive reserve' based on IQ, education and occupation information.

There was however, a small but significant difference between the combined PCS and recovered group when compared with the community control group on the total recall, consistent long-term recall, and cued recall trials of the Selective Reminding Test (SRT). This led the authors to conclude that PCS sufferers are not a subgroup of individuals who have suffered mTBI, but that mTBI is associated with ongoing subtle executive memory deficits. In this study 23.5% of the recovered group (15.6% of the total sample) were experiencing one or two ongoing symptoms from the RPQ. Had the DSM-5 criteria requiring only evidence of modest cognitive decline in one domain been employed, the PCS group may have been substantially larger and between group results may have differed. This study highlights not only the problems of inconsistent diagnostic criteria, but also a common question within mTBI research: Should PCS be a diagnostic entity?

Most researchers agree that a small percentage of individuals do suffer ongoing symptoms after mTBI, however some such as Oldenburg and colleagues (2016) believe that many of those suffering mTBI experience ongoing but very subtle effects rather than a clinical syndrome or disorder. Similarly, in a 12 month prospective cohort study of adult mTBI sufferers, Booker, Sinha, Choudhari, Dawson, and Singh (2019) considered 'persistent post-concussion symptoms' (PPCS) rather than a specific diagnosis due to the lack of consensus on PCS as a diagnosis.

Because participants in Study One may have been given various diagnoses for similar symptoms, and such different labels may lead to confusion within both academic and patient literature, the review will consider the experience of symptoms after mTBI rather than specific diagnoses from this point forward.

Injury Processes

Initial Injury. As the mechanisms of injury that lead to mTBI are varied, different areas of the brain may be affected depending on the site of the force to the head. Frontal and temporal areas are most frequently injured (Broshek, De Marco, & Freeman, 2015; Mathias,

Beall, & Bigler, 2004). These injuries are usually diffuse, though focal symptoms and space occupying lesions may occur in a minority of cases (Borgaro, Prigatano, Kwasnica, & Rexer, 2003).

Secondary neuronal injury. Secondary to the initial mechanical trauma, a complex cascade of reactions occurs in the damaged area of the brain. Membrane disruption and stretching leads to a loss of $Na^+/K^+/Ca^{2+}$ flux, neural membrane depolarisation, and indiscriminate release of excitatory neurotransmitters (MacFarlane & Glenn, 2015). These neurotransmitters bind to N-methyl-D-aspartate (NMDA) receptors, leading to further neuronal depolarisation and contributing to the excitotoxicity (Giza & Hovda, 2001). In an effort to restore chemical balance to the damaged area of the brain, sodium/potassium pumps work excessively, a process which requires a large amount of energy, or adenosine triphosphate (ATP); this hyper-metabolic state occurs during a time of reduced cerebral blood flow, resulting in a disparity between energy supply and demand, and thus leads to energy crisis (Barkhoudarian, Hovda, & Giza, 2011). The influx of calcium during the excitotoxicity phase can further damage axonal structures and exacerbate the energy crisis (Barret, McBurney & Ciappo, 2014); as the brain attempts to provide more ATP during a time of decreased oxidative metabolism, it increases rates of glycolysis, leading to the production of lactate, which due to the decreased rate of oxidative metabolism cannot be metabolised effectively. Lactate accumulation may lead to neuron dysfunction by way of acidosis, membrane damage, altered blood brain barrier permeability, and oedema (Giza & Hovda, 2001). ATP stores become diminished after the period of hyper-metabolism, leading to a hypo-metabolic state where insufficient supplies of energy are available; this may last days to weeks (MacFarlane & Glenn, 2015).

Secondary glial involvement. Damaged neural cells signal the activation of microglia. This is initially a protective factor but may become a positive feedback loop where an overactive inflammatory response can damage neuron cell membranes further (Barret et al.,

2014). Inflammation and other brain injury phenomena are frequently studied in animals, to allow for controlled injury and treatment conditions as well as close study of the brain post-mortem. A study of diffuse mTBI in pigs observed neuroinflammation 6 hours post injury (Lafrenaye, Todani, Walker, & Povlishock, 2015). It found pervasive microglial activation in thalamic areas of injured pigs, the degree of which was correlated with the amount of observed diffuse axonal injury (DAI). Activated microglial processes exhibited increased contact with neurons positive for amyloid precursor protein (APP) – a marker of the axon damage that occurs due to the initial injury, exacerbated by the resultant excitotoxicity and oxidative stress (Barrett et al., 2014) – when compared with microglial process contact with myelinated axons in sham injured animals. The majority of contacts in injured animals were bulbous end processes, rather than the passing by/crossing over of microglial processes and axons in sham pigs, who were operated on but not injured. The authors speculate that the influx of calcium that occurs in neural injury may alter the extracellular calcium concentration, signalling the observed convergence of microglial processes. Activated microglia perform a number of functions that may be helpful or harmful in the injured brain, such as phagocytosis, cytokine secretion and/or neutrophil secretion, thus this study was among the first to show the relationship between DAI and acute neuroinflammation (Lafrenaye et al., 2015).

In a rat study using closed head injury as an mTBI model, Singh, Trivedi, Devi, Tripathi, and Khushu (2016) discovered evidence of an inflammatory cascade. This began with increases in the pro-inflammatory cytokine TNF-α four hours post-injury, proceeding to increases in the anti-inflammatory cytokine IL-10 one day post-injury, and at three- and five-days post-injury increased amounts of hypertrophied astrocytes and glial fibrillary acidic proteins (GFAP) were found. GFAP is a brain specific protein expressed predominantly by astroglia and has been found to differentiate mTBI sufferers from others (Singh et al., 2016).

Injury cascades occur in both neurons and glia after the initial mechanical insult to the brain. These processes lead to energy crisis, inflammation, and impaired neurotransmission,

which in turn lead to the experience of symptoms such as fatigue, headache, and cognitive difficulties that characterise mTBI (MacFarlane & Glenn, 2015); acute and ongoing symptoms are discussed further in the following sections. See Figure 1.1 below for a pictographic representation of the neurochemical processes that occur after mTBI. This provides a background for the possible points of intervention by *n*-3 PUFA, which will be discussed in depth in the following chapter.

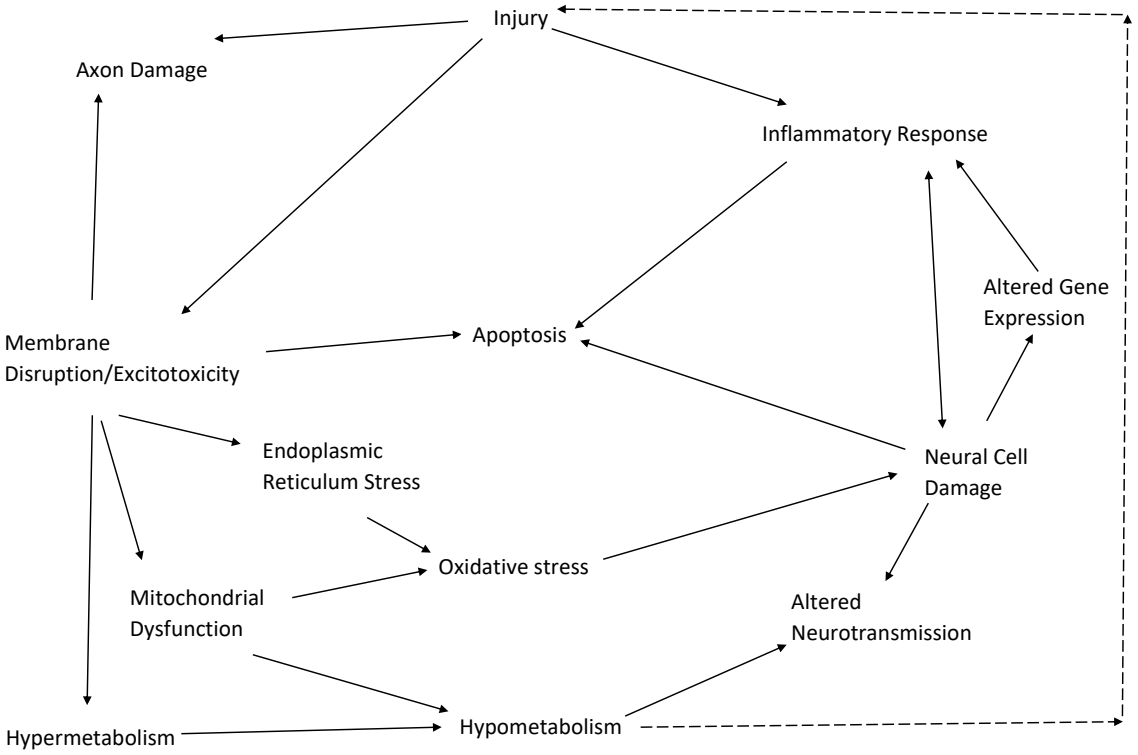

Figure 1.1. The neurochemical cascade of concussion. Adapted from 'ω-3 fatty acid supplementation as a potential therapeutic aid for the recovery from mild traumatic brain injury/concussion' by E. Barret, M. McBurney and E. Ciappio, 2014, *Advances in Nutrition: An International Review Journal, 5,* p. 269.

Symptoms

Acute symptoms. Upon regaining consciousness or recovering from post-traumatic amnesia, most individuals who have sustained mTBI experience symptoms, though the duration of the symptoms varies widely (Karr, Areshenkoff, & Garcia-Barrera, 2014). Nausea, tinnitus, difficulty concentrating, and memory loss are common symptoms that Macleod

(2010) states wear off within days to weeks, as the cellular physiology heals. However, according to Donovan, Cancelliere, & Cassidy (2014), self-reported symptoms of fatigue, dizziness, and headache are the most common reasons for seeking treatment after mTBI.

With regard to cognitive symptoms, Kay, Newman, Cavallo, Ezrachi and Resnick (1992) found that speed and ease of processing were the primary cognitive deficits after mTBI. Using the Rey Auditory Verbal Learning Test (RAVLT), they found that what appeared to be difficulty with memory related more to the encoding and registration of new information, rather than a deficit in retrieval. Similarly, Shanmukhi and Panigrahi (2003) found significant differences in learning and remembering a non-verbal pattern when comparing 40 sufferers of mTBI approximately two weeks post-injury with 40 uninjured controls. This was considered a deficit in procedural learning.

A common criticism of research into the symptoms of mTBI is the comparison to uninjured control groups, as the pain of the injury and shock of the injury event may confound findings. To combat this, Landre, Poppe, Davis, Schmaus, and Hobbs (2006) administered the adult vigilance and distractibility subtests of the Gordon Diagnostic System, the Wechsler Memory Scales logical memory 1 and 2 subtests, the Trail Making Test A and B, as well as measures of body pain, mental health, and post-concussive symptoms to 37 hospitalised patients with mTBI and 39 patients hospitalised for other traumas, approximately 5 days after injury. The mTBI patients scored significantly lower on all the cognitive measures with moderate to large effect sizes, and scores on these measures were not related to pain or stress. Interestingly, no differences were found in self-reported post-concussive symptoms, as measured by a modified version of the Postconcussive Symptom Checklist, between groups. It may be that such checklists measure symptoms common to multiple traumas, while the cognitive tests are more specific to mTBI.

In a retrospective cohort study using electronic data for active duty US Air Force airmen, Webb and colleagues compared mTBI, other injured, and non-injured groups at less

than 30, 31-179, and 180 days or longer post-injury. In accordance with Landre and colleagues (2006), many cognitive symptoms were more prevalent in the mTBI group. In the 'acute period' (<30 days post-injury) hazard ratios for the mTBI group compared to the other-injured group were 55.88 for memory loss/amnesia and 85.17 for 'cognitive disorder NOS'. However, the risk of seizures, headaches, migraines, pain, dizziness, and sleep disorders were also significantly higher in the mTBI group, compared with both the other-injured group and the full cohort for the acute injury period. Results were adjusted for post-traumatic stress disorder (PTSD) and depression, thus the symptoms reported are likely to be accounted for by the brain injury.

The research presented above provides evidence of both cognitive and physical symptoms occurring within the first week to first month of injury. Donovan and colleagues (2014) formed the International Collaboration on mTBI prognosis (ICoMP) to update the WHO task-force meta analytic results from 2004 and stated that substantial evidence exists for the presence of cognitive deficits in the first two weeks after injury. However, according to both the ICoMP authors and Karr et al. (2014) the cognitive deficits reported are very heterogeneous, and effect sizes range greatly between studies. Less evidence exists for ongoing cognitive difficulties following mTBI.

Ongoing Symptoms. As Carroll and colleagues (2014) and Levin and Diaz-Arrastia (2015) point out, longitudinal studies of cognitive deficits following mTBI with a follow up period greater than six months are lacking. The few that have been published yield varied results and contain methodological biases that make generalisation questionable.

In a prospective cohort study, Røe, Sveen, Alvsåker, and Bautz-Holter (2009) followed up with 52 adult mTBI sufferers at 3, 6, and 12 months post-injury. More than half (55.8%) of the sample met the ICD-10 criteria for PCS at 3 months post injury, and 42.3% met criteria at 6- and 12-months post-injury. Cognitive symptoms were more prominent at each time point than physical or behavioural symptoms. Two participants who met criteria at 6 months no longer

met criteria at 12 months; interestingly, two participants developed PCS between the 6 and 12 month follow up. The authors did not theorise the reasoning for this, however they did highlight the high degree of between participant variability in the progression of symptoms. The authors analysed results for differences between males and females in the development of PCS; no sex differences were found. However, this study included a range of ICD-10 diagnostic codes covering diagnoses including coma; haemorrhage; focal, diffuse, and unspecified injury. While participants were required to have a GCS of 13-15, they were recruited after being admitted to hospital care up to 48 hours post-injury, so at least some of the injuries suffered may have been on the moderate to severe end of the TBI scale. In addition, individuals who dropped out of the study tended to report fewer symptoms than those who completed all follow ups, and the sample size of 52 participants completing all follow ups was small.

In a Swedish population based three year follow up study, it was found that 50% of females and 30% of males who had presented to an emergency department after mTBI met the ICD-10 criteria for PCS according to their RPQ scores (Styrke et al., 2013). In contrast to Røe et al. (2009), these results represented a significant difference between sexes. In this study almost all RPQ symptoms, with the exception of double vision in females, were significantly higher in the mTBI population than the control group of blood donors. The Rivermead Head Injury Follow Up Questionnaire (RHFUQ) assessed disability, finding 52% of females and 37% of males experienced some level of disability after mTBI. The most frequently endorsed items were tiredness at work, difficulty sustaining previous workload, and difficulty in ability to enjoy previous leisure activities. Unsurprisingly, endorsement of a high frequency of symptoms on the RPQ predicted disability in both sexes (Styrke et al., 2013). This study may represent a higher injury severity than other research on mTBI, as although each individual in the mTBI group had a GCS of 13-15 upon presentation to the ED, it included any degree of LOC or disorientation, PTA, nausea, vomiting, severe headache, & neurological deficit. It may also

have been subject to non-response bias; while alcohol intoxication at the time of the injury – which has the potential to lower GCS scores – was more common among individuals who declined to participate in the study, loss of consciousness was more prevalent among respondents. This may indicate that those who responded to the postal survey were more severely injured.

In a six month prospective cohort study Roy et al. (2019) found that injury severity factors predicted PCS at both one and six months post-injury. A combination of loss of consciousness and altered mental state (feeling dazed, confused, or disoriented) within 24 hours of mTBI predicted both depression and PCS symptoms, as per the RPQ, one and six months later. Similarly, a six month Dutch cohort study found a higher injury severity scores on the Injury Severity Scale (ISS) and Abbreviated Injury Scale – Head (AISH) were associated with PCS six months post mTBI (Voormolen et al., 2019). Additionally, Voormolen and colleagues found that female sex, lower education, assault as the injury mechanism, hospitalisation and a higher RPQ score predicted lower health-related quality of life on the SF-36 health survey. The participants meeting PCS criteria had on average a 20% lower health-related quality of life compared with mTBI sufferers who were not experiencing three or more PCS symptoms, and had lower scores on all SF-36 domains (physical functioning, bodily pain, role limitations due to physical health problems, role limitations due to personal or emotional problems, emotional well-being, social functioning, energy/fatigue, and general health perceptions) than the Dutch population norm. In line with Voormolen and colleagues, a 12 month English adult mTBI cohort study found female sex, assault as the injury mechanism, and injury severity factors (GCS of less than 15) as well as psychiatric illness history and alcohol intoxication at the time of injury was associated with poorer outcomes on the RPQ and RHFUQ (Booker et al., 2019). While these studies found similar causes of poor outcomes including injury severity, they all represent samples collected from hospital emergency departments and thus likely more 'severe' mTBI.

In contrast to the previously discussed studies, Barker-Collo and colleagues (2015) recruited participants from numerous settings including self-referrals (participants responded to advertisements), and utilised cognitive testing rather than solely self-report measures for a 12 month follow up study. They found that symptoms endorsed on the RPQ declined steadily over the 12 months. At baseline, the majority of participants performed within the average ranges of the CNS Vital Signs neurocognitive assessment, but a substantial proportion of individuals performed in the very low range for executive ability (21.5%), complex attention (26.0%) and cognitive flexibility (27.4%). In addition, over 20% of the sample produced below average scores across indices of processing speed, executive ability, psychomotor speed, reaction time and cognitive flexibility. The mean performance on all cognitive domains except for memory improved from baseline to 12 months, with the majority of this improvement from baseline to six months; improvements from six to 12 months were non-significant for all domains except for processing speed – one of the most common deficits following mTBI (Barker-Collo et al., 2015; Borgaro et al., 2003; Diwakar et al., 2015; Killgore et al., 2016). At 12 months follow up 16.3% of participants remained in the very low range on the test of complex attention, where only 0.13% of the general population would be expected to score (Barker-Collo et al., 2015). Additionally, over 20% of participants continued to have some level of difficulty with complex attention and memory at the 12 month follow up period.

While a substantial subset of Barker-Collo and colleagues' participants experienced ongoing symptoms, the authors noted that a high proportion of participants scored in the above average ranges on tests of visual memory and executive ability from one-month follow-up onwards, and on cognitive flexibility and complex attention at six- and 12-months follow up. Much like Oldenburg and colleagues (2016) these authors theorise that this may be due to the relatively high education level of their sample, as those with higher education tend to have a larger cognitive reserve and may be less prone to difficulties after mild brain injury (Satz et al., 1993; Stern, 2002).

It seems that regardless of whether or not PCS is diagnosed, a proportion of individuals who have suffered a mTBI may benefit from treatment of cognitive symptoms, and the assessment of some factors, such as cognitive reserve and injury severity features, may help to prospectively identify who will fall into this group.

Aetiology of ongoing symptoms. As mentioned earlier**,** post-concussion symptoms are a complex problem of unclear aetiology. The differing classification systems used to diagnose PCS and PCD allude to divergence in the literature regarding the cause of ongoing symptoms. The ICD-10 (WHO, 2004) states that PCS aetiology is unclear and includes both neurological and psychological factors, but seems to consider the ongoing symptoms from a psychosocial standpoint with its assertion that the depression and anxiety commonly found in PCS sufferers is due to fear of permanent disability and an injury to self-esteem, rather than the physical injury (McCauley et al., 2008). Some sufferers may become hypochondriacal, search for diagnosis and cure, and adopt a permanent sick role (WHO, 2004). The DSM-5 (APA, 2013) acknowledges both psychological and biological factors. Traditionally, initial symptoms such as headache and dizziness have been attributed to biological processes, while ongoing symptoms have been attributed to psychosocial problems. Psychosocial issues typically include anxiety and depression that develop following injury, as well as pre-injury morbidity and personality styles. There is however, a growing body of evidence highlighting potential physiological causes of persisting symptoms after mTBI.

Psychogenic symptoms. Acute symptoms usually remit within days or weeks, however for some individuals psychological symptoms evolve during this time and complicate the clinical picture. According to Kay et al. (1992) persisting cognitive symptoms may alter an individual's sense of self, leading to anxiety and low mood which exacerbate cognitive symptoms, causing further frustration and distress, maintaining the disorder. In this positive feedback loop psychological sequelae may become more disabling than the initial injury. There are many factors that may contribute to emotional upset following mTBI, for example, a

distressing injury event such as an assault, or cognitive difficulties preventing normal functioning.

Mickeviciene et al. (2002) found few differences between mTBI sufferers and age and sex matched controls in their postal survey 22-35 months post-injury. The only significant differences between groups were sensitivity to alcohol, worry about brain injury, and feelings of depression which were higher in the mTBI group. Symptoms may have remitted by the time of follow up. McCauley et al (2008) found an increased incidence of major depressive episodes and post-traumatic stress disorder six months post-injury.

Rather than post-injury psychological symptoms, Meares' and colleagues' (2011) found that pre-injury psychological symptoms predicted PCS. Their study of acute PCS symptoms in mTBI and other trauma patients found that pre-injury depression or anxiety and pre-injury post-traumatic stress disorder increased the odds of developing PCS after both brain and non-brain injury (OR for depression or anxiety: 2.99, OR for PTSD: 1.05).

Pre-injury psychological difficulties and personality traits may also affect the duration of symptoms. Hou et al. (2012) conducted a prospective cohort study with 107 adult mTBI sufferers recruited from a hospital. After phone-based follow ups three and six months post injury, they discovered that 22% of participants met the ICD-10 criteria for PCS at three months, and 21% met this criteria at 6 months. Regression analyses showed that all-or-nothing behaviour, as measured by the Behavioural Response to Illness Questionnaire (BRIQ), was the only significant predictor of PCS at three months post-injury, and head injury perceptions as measured by the Brief Illness Perception Questionnaire (BIPQ) were the only significant predictor of PCS six months post-injury, with all-or-nothing behaviour trending towards significance (Hou et al., 2012). Maladaptive cognitive responses to injury were present early in the recovery process and may have been reinforced over time, as individuals attempted too much and experienced cognitive and physical failures. The authors suggest early mTBI

intervention targeting coping processes as a way to prevent the development or lessen the severity of PCS.

Like Mickeviciene et al. (2002), Styrke and colleagues (2013) discovered a higher rate of depression three years post-injury. However, Barker-Collo and colleagues (2015) found that the incidence of depression declined over their 12-month study period, while anxiety increased until 6 months post-injury, then declined until the 12-month end point.

Similar to Hou et al. (2012) Snell, Hay-Smith, Surgenor & Siegert (2013) interviewed 147 mTBI sufferers within 3 months of their injuries, then again 6 months later, and found that participants with stronger injury identity beliefs, expectations of lasting severe consequences, and distress at the initial meeting had higher odds of poor outcomes at the second meeting. The authors applied Leventhal's Common Sense Model, whereby individuals construct their own representations of a health condition to help make sense of the symptoms experienced and provide a basis for coping. In a 2015 cluster analysis study Snell and colleagues found that participants could be grouped into high, medium, and low adaptation clusters based on injury beliefs. This presents a possibility for identifying individuals who may be at risk of developing PCS, and thus may benefit from higher intensity intervention to prevent the development or shorten the course of the syndrome.

In a study of 171 individuals with TBI of all severities, Lee, Jayasinghe, Swenson, and Dams-O'Connor (2019) found that the personality trait of dispositional optimism was positively correlated with cognitive function at least one year post-injury. This association was significant after controlling for age, race, positive and negative affect, health status, and injury severity. The authors state that optimism is a teachable skill and recommend further research into its utility as a TBI symptom reduction tool.

Considering the above studies, it seems that psychological symptoms may be both a risk factor for, as well as an outcome of, mTBI. Pre-existing psychological difficulties and maladaptive injury related beliefs may affect the development and duration of other mTBI

symptoms, and psychological symptoms may develop after mTBI complicating recovery from cognitive symptoms.

Neurogenic symptoms. Broshek and colleagues (2015) suggest that emotional difficulties experienced after mTBI may be due to the initial structural and secondary metabolic injury, noting that injury often involves frontal-temporal damage or diffuse axonal injury (DAI) to cortical areas connecting to the limbic system. Indeed in a neuroimaging study of 56 young male athletes, Chen, Johnston, Petrides, and Ptito (2008) found that athletes suffering both PCS and depressive symptoms exhibited altered neural responses during a working memory task. There were no significant differences in performance on the task between the four groups which consisted of: three groups of concussed athletes with PCS symptoms five to seven months post-injury – without depression, with mild depression, or with moderate depression as measured by the BDI-II; and a healthy control group. The PCS with depression groups showed reduced activation in the prefrontal cortex and striatum, less task related reduction in activity in several other brain regions, and reduced grey matter volume in the medial frontal and temporal cortical regions when compared to healthy controls and concussed athletes without depressive symptoms. As these athletes were young and had no history of mood disorders, the authors reason that it is unlikely that the lower grey matter volumes were premorbid and acted as a diathesis for the development of depression, but were probably due to injury processes.

Heitger and colleagues (2009) compared 36 PCS sufferers to matched controls who had recovered well after mTBI, on measures of eye movements and cognition. Eye movement control relates closely to the functional integrity of the brain, as it requires the coordination of neural circuitry in both cortical and subcortical structures, as well as the cerebellum; several parameters of eye movements are beyond cognitive control (Cifu et al., 2015; Heitger et al., 2009). The PCS group in the Heitger et al. (2009) study performed lower than controls on anti and self-paced saccades, memory guided sequences, and smooth pursuit eye movements,

suggesting problems in response inhibition, short-term spatial memory, motor-sequence programming, visuospatial processing, and visual attention. The PCS group also performed lower on neuropsychological measures of memory, complex attention, and executive function, however the oculomotor measures were more strongly related to symptom load as measured by the RPQ. The control group in this study were found to have a higher predicted IQ determined by the Wechsler Test of Adult Reading (WTAR), which affected some of the neuropsychological measures; the oculomotor deficits however, were unrelated to depression, intellectual functioning, or malingering, indicating ongoing cerebral impairment in the PCS group.

Su et al. (2014) examined the C-reactive protein (CRP) levels of 213 patients with mTBI in a three month follow up study. CRP is a biomarker of systemic inflammation that is sensitive, but not specific, to trauma. Thus, participants who had suffered other injuries, recent infection, previous head trauma, were cognitively impaired or had psychiatric diagnoses were excluded from the study. Su and colleagues (2014) found that higher CRP levels at baseline were associated with persistent post-concussion symptoms, psychological problems (anxiety and depression), and cognitive impairment, with odds ratios of 2.72, 1.54, and 1.69 respectively. This indicates that systemic inflammation, as well as neuro inflammation, may play a role in post concussive symptoms.

A small Diffusion Tensor Imaging (DTI) study of 15 mild to moderate TBI sufferers and 15 matched controls found that alterations in the microstructural integrity of white matter was associated with poor balance and cognitive symptoms after injury (Kim et al., 2019). This suggests glial involvement in ongoing symptoms as well as the systemic, neural, and psychological involvement found in other studies.

There is consistent evidence of acute cognitive symptoms such as memory, attention, and processing speed deficits, after mTBI. There also exists some evidence for ongoing symptoms, however methodological issues as well as the heterogeneity of both symptoms

experienced as well as their progression, prevent a consensus being reached regarding the typical course of symptoms and the utility of diagnosis. Both psychological and physiological processes underlie symptoms, though more research is needed to delineate their respective contributions and interactions. Understanding the mechanisms behind post-mTBI symptoms helps to inform intervention. As will be discussed in later chapters, *n*-3 PUFA may exert effects on symptoms via physiological pathways, while information provision affects psychological processes.

Assessment of Post-Concussion Symptoms

The assessment of PCS depends on the diagnostic criteria used. The vast majority of studies employ the ICD-10 criteria and rely on self-report symptom measures such as the RPQ , and the Post-Concussion Symptom Checklist. As with all self-report measures this introduces the possibility of several biases. One bias particularly common with post-concussion symptom reporting is the 'good old days' bias. After suffering mTBI many individuals under-report premorbid symptoms, misperceiving their premorbid functioning to be better than the average person (Iverson, Lange, Brooks, & Ashton Rennison, 2010; Lange, Iverson, & Rose, 2010; Yang et al., 2014). Unsurprisingly, Iverson and colleagues (2010) found that this effect was more pronounced in participants who failed an effort test. Those who failed the Test of Memory Malingering (TOMM) under reported premorbid symptoms, and reported more current symptoms, than both mTBI participants who passed the TOMM, and healthy controls (Iverson et al, 2010).

As outlined in above sections, various neuropsychological tests are used to evaluate cognitive symptoms following mTBI. Tests of memory, attention, processing speed and executive function are common. According to Heitger and colleagues' (2009) study however, oculomotor testing had a stronger correlation than the neuropsychological measures with post-concussion symptom load and problems with activities of daily living. Both Heitger et al. (2009) and Cifu et al. (2015) propose eye movement tracking as an effective measure to

distinguish PCS sufferers from healthy or recovered controls, however the required equipment is not yet commonly possessed by concussion clinics and more research may be necessary before this method can be considered for standard practice.

Treatment of Post-Concussion Symptoms

Current treatment for symptoms after mTBI includes rest and information regarding the course of injury, with more specialist treatment such as occupational therapy or psychological therapy offered for individuals who are identified by the concussion service as requiring further input (The New Zealand Guidelines group, 2006; ACC, 2019). For treatment of ongoing symptoms after mTBI, the New Zealand Guidelines Group (2006) recommend symptom-based approach to minor problems, and offering the injured individual reassurance and information regarding symptom management and strategies. For clinically significant TBI, which may encompass PCS, the New Zealand Guidelines Group (2006) posit that rehabilitation should be functionally oriented, provide information and support to family/whānau/carers of the injured individual, and provide access to psychological assessment and intervention when required.

A Canadian paper by Marshall and colleagues (2015) recommended a similar symptom-based approach. Their paper updating clinical practice guidelines for the treatment of persisting symptoms following mTBI recommended: initiating rehabilitation of any cognitive impairments found during formal cognitive assessment, or if learning compensatory strategies would facilitate the individual returning to work or other functional activity; including both compensatory and remediation approaches to cognitive rehabilitation; and where possible, informing employers or teachers of potential temporary alternative duties or working hours in order to avoid anxiety related to cognitive difficulties and experiencing repeated errors or setbacks in work or school. They also recommended Cognitive Behavioural Therapy (CBT) for ongoing mood, anxiety and/or sleep difficulties, gradual return to sport/exercise and leisure

activity as symptoms allow, physiotherapy and/or neurology for peripheral and vestibular problems, and pharmacotherapy for headache.

MTBI and PCS are heterogeneous conditions; every case involves a unique combination of forces acting on an individual's unique anatomy (Taber & Hurley, 2013) and is likely moderated by his or her unique personality, beliefs, and coping styles. Thus, there is no 'one size fits all' solution to intervention and as the New Zealand Guidelines Group (2006) recommend, a multi-disciplinary approach is favourable.

ACC manage the rehabilitation of head injuries caused by accidents in New Zealand, and employ a 'concussion service' for claimants who have suffered mild or moderate TBI. These concussion services are non-governmental organisations (NGOs) that apply to ACC to provide services for a contracted price. The concussion service is offered from a biopsychosocial perspective, and each service provider must include a minimum of a medical specialist with qualification in neurology, or internal medicine with a focus on brain injury; a clinical neuropsychologist; and an occupational therapist (ACC, 2019). Each service provider must also have access to other professionals such as optometrists, various types of counsellors, cultural advisors, and advocacy services. Individuals are referred to the concussion service via primary health care professionals (e.g., a general practitioner [GP], or a medical or allied health professional from a district health board [DHB] if the individual presented to a hospital) or by an ACC case manager. ACC (2019) stress the individual nature of injury, and as such each individual's pathway through the service is dependent on recommendations made after a comprehensive assessment. The organisation also places emphasis on educating clients about mTBI in order to prevent PCS, though explicitly states within the services operational guidelines that clients should not be provided such education if the diagnosis has not yet been confirmed. If treatment within the service is indicated, this may include medical consultation, psychological counselling, and/or allied health and vocational services specific to the individual's goals and circumstances (ACC, 2019).

Summary

Mild traumatic brain injury (mTBI) is caused by mechanical forces to the head which disrupt normal brain function. Traditionally mTBI has been referred to as concussion, a term that continues to be used in some services and by some researchers though is frequently considered to be at the 'milder' end of the mTBI spectrum and heal within weeks. Regardless of terminology, the injury involves primary and secondary components, as complex injury cascades begin in the acute period and continue into the post-acute period. Many individuals suffer from physical, cognitive, and affective symptoms in the acute period, but recovery is usually rapid, occurring within days or weeks for most individuals. A small percentage of mTBI sufferers however, experience symptoms that persist beyond this time. Chronic symptoms tend to include fatigue, headache, and difficulties with memory and attention.

There is debate around the classification and cause of ongoing symptoms. While chronic symptoms have traditionally been attributed to psychological causes, recent research has outlined physiological deficits and processes that contribute to symptoms and suggest ongoing cerebral impairment. A biopsychosocial approach to treatment is usually taken, and in New Zealand multidisciplinary teams are engaged to provide intervention. Interventions include education, reassurance, and psychotherapy when necessary, as well as allied health input depending on the individual's circumstances. This approach adheres to guidelines for individualised treatment, however given the significant minority who suffer ongoing symptoms and an increasing understanding of the mechanisms and aetiology of symptoms, there is scope for adjunct intervention. One possible adjunct intervention is omega-3 polyunsaturated fatty acid supplementation, discussed in the next chapter.

Chapter Two: Omega-3 Polyunsaturated Fatty Acids

Omega-3 polyunsaturated fatty acids (*n*-3 PUFAs) are a class of nutrients essential to the human body. Fats perform many functions in the body: they provide the most energy per gram (37kJ/g) of all the macronutrients; provide a means of storing energy; insulate the body and its organs; form part of cell membranes, hormones, and other chemical messengers; and aid the absorption of fat soluble vitamins (Whitney, Rolfes, Crowe, Cameron-Smith, & Walsh, 2011). Fatty acids consist of a hydrocarbon chain with a carboxyl group at one end (named the alpha end) and a methyl group at the other (named the omega end); different types of fats have different saturation levels – the saturated fats contain the maximum number of hydrogen atoms as can be attached to the carbon chain (the carbon chain is 'saturated' with hydrogen atoms), the unsaturated fats contain at least one carbon that is not saturated with hydrogen, and at this point a double bond exists with the next carbon in the chain (Whitney et al., 2011).

The present research focuses on the long chain *n*-3 PUFAs (LC *n*-3 PUFAs) eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) as these have shown promise in various arenas of health research, including cognitive health. These fatty acids consist of hydrocarbon chains 20 (EPA) and 22 (DHA) carbon atoms in length. Each has a carbon to carbon double bond three carbons from the omega end of the chain, hence the term 'omega-3' and contains further double bonds – or points of unsaturation – hence the term polyunsaturated (Lunn & Theobald, 2006). See Figure 2.1 for a depiction of these molecules.

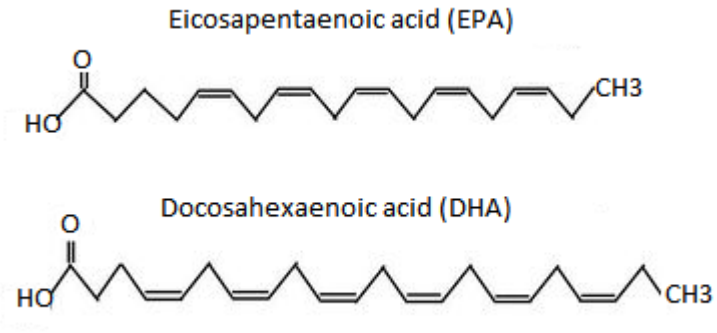

Figure 2.1. The chemical structure of EPA and DHA. Each line represents the bond between carbon atoms; double lines represent double bonds. This illustrates the polyunsaturated nature of these fatty acids. Adapted from Whitney et al., (2011).

While most fats can be synthesised in the human body, alpha linolenic acid (ALA) – the precursor to both EPA and DHA – and linoleic acid (LA) cannot; these are termed essential fatty acids as they must be obtained from the diet (Whitney et al., 2011). Although EPA and DHA can be synthesised from ALA, the rate of synthesis is very low and may not meet an individual's requirements, making them 'conditionally essential' nutrients – it is essential to obtain them from the diet when synthesis is inadequate (Whitney et al., 2011). Estimates of the amount of ALA converted to DHA in the body range from less than one percent, to up to nine percent (Arterburn, Hall, & Oken, 2006). A limiting factor in the conversion of the *n*-3 PUFAs is competition for the enzymes necessary for this process.

The omega-6 (*n*-6) fatty acids, present in many foods such as nuts, grains, and vegetable oils, use the same enzymes for similar conversion processes, thus the presence of these fats can impede EPA and DHA synthesis, particularly when the ratio of *n*-6 to *n*-3 is high (Whitney et al., 2011). The optimal ratio of *n*-6 to *n*-3 fats is approximately 1-2:1, however the typical 'western diet' has a widely varied but largely out of proportion ratio of 10-25:1 (Lewis, 2016). In addition, males convert less ALA to EPA and DHA than females (Arterburn et al., 2006), and individual differences in stress hormones, genes, vitamin and mineral deficiency,

and alcohol consumption can also limit the synthesis of EPA and DHA in the body (Uauy & Valenzuela, 2000). Due to these limitations, dietary sources of EPA and DHA are recommended (Lunn & Theobald, 2006). The richest sources of these fatty acids are oily fish such as salmon, tuna, and mackerel (Whitney et al., 2011), as well as algae sources (Lunn & Theobald, 2006; Weiser, Butt, & Mohajeri, 2016).

The remainder of this chapter will focus on the role of the LC *n*-3 PUFAs in the body – particularly the brain. Information regarding the relationship between a high LC *n*-3 PUFA diet and mortality and morbidity, *n*-3 PUFA consumption in New Zealand and abroad, and studies using EPA and DHA supplements in human populations will be reviewed. The chapter concludes with a specific focus on EPA and DHA supplements for mTBI.

A Brief History of Dietary Omega-3. Diet plays an essential role in health and development through the lifespan and may have played a central role in human evolution. A high quality diet was both necessary for, and a consequence of the evolution of the large human brain (Kyriacou, Parkington, Marais, & Braun, 2014). A key dietary factor for the development of the large brain in the human species was fish and/or shellfish due to their concentration of iodine, iron, and DHA (Cunnane, 2005; Cunnane, Plourde, Stewart, & Crawford, 2007). Indeed, excavation of stone age sites have unearthed evidence of abundant and intentional fish and shellfish intake by both humans and Neanderthals (Cunnane et al., 2007; Kyriacou et al., 2014; Stringer et al., 2008). Given that the nutrients present in these foods, particularly DHA, are essential for the development of brain structure and function, the exploitation of such marine resources may have played an essential role in making humans what we are today.

Omega-3 Fatty Acids and Brain Structure and Function. The brain is a fat-rich organ; DHA represents over 90% of its *n*-3 PUFA, and 10-20% of its total lipids (Weiser et al., 2016). While EPA exerts acute actions in the brain and is absorbed in approximately equal proportions to DHA, very little EPA exists in brain tissue as it is rapidly oxidised and removed,

or converted into other fatty acids (Weiser et al., 2016). Therefore, *n*-3 PUFAs' effects on brain structure and function are considered to be significantly dependent on DHA.

DHA begins to accumulate in neural tissues at a high rate from the third trimester of gestation, continuing at this rate to the end of the second year of life (Lauritzen et al., 2016; McCann & Ames, 2005). High levels are then maintained throughout the lifespan. Individual differences exist in DHA accretion, with an important factor being dietary consumption. For infants, this includes consumption via maternal DHA stores, which are transferred through the placenta and breast milk (Innis, 2007). Later in life, DHA must be consumed in its complete form, or synthesised following the consumption of other *n*-3 PUFAs, though as outlined previously the synthesis process is inefficient. Brain DHA has an estimated half-life of 2.5 years, as it is metabolised at a rate of approximately 4mg per day (Barceló-Coblijn & Murphy, 2009; Weiser et al., 2016). As DHA is mainly synthesised in the liver and the rate of synthesis in the brain is very low, brain DHA levels are maintained through delivery via the circulating blood (Chen et al., 2015).

DHA is concentrated in the cerebral grey matter, and stored primarily in membrane phospholipids (Brenna & Diau, 2007). It cycles in and out of the membrane from phospholipids to the intracellular free fatty acid pool, providing a mechanism to help meet the energy demands of rapid growth and other cellular challenges (Chen, Green, Orr, & Bazinet, 2008; Weiser et al., 2016). DHA can influence membrane fluidity, lipid raft function, neurotransmitter release, transmembrane receptor function, gene expression, signal transduction, myelination, neuroinflammation, and neuronal growth and differentiation (Innis, 2007). Thus it plays several important roles in the structure and function of the brain throughout the lifespan. DHA deficiency has been associated with alterations in normal neurodevelopment, neural inflammation, and increased mortality and morbidity (Muldoon et al., 2010).

Dietary Omega-3 Fatty Acids and Mortality and Morbidity

The Mediterranean Diet. Dietary patterns high in LC *n*-3 PUFA have shown an association with health and longevity. Possibly the most well known and most widely researched of these is the Mediterranean diet. This dietary pattern includes large amounts of fruit, vegetables and wholegrains; moderate consumption of nuts, seeds, legumes, olives/olive oil, alcohol (mainly red wine with meals) and fish/shellfish; and limited meat, dairy and sweets (Serra-Majem & Medina, 2015). Such a diet provides substantial micronutrients, adequate macronutrients and dietary fibre, and a favourable profile of lipids, including DHA (Buckland & Agudo, 2014).

Numerous prospective cohort studies have found an inverse association between the Mediterranean diet and all-cause mortality. In a study of middle aged Spanish university alumni, the highest level of adherence to a Mediterranean diet, which was characterised by high vegetable, fish and seafood, fruit, and virgin olive oil intake, was associated with a 47% decreased risk of mortality from all causes when compared with the lowest level of adherence (Martínez-González et al., 2015). Similarly, a 38% reduction in all-cause mortality was noted with high adherence to the Mediterranean diet pattern in a 20 year cohort study of 40-74 year old Italians (Prinelli et al., 2015). This reduced to a 21% lower risk for those who had a medium level of adherence to the Mediterranean diet. In a United States cohort, a 20% and 21% reduction in all-cause mortality was found for women and men adhering to the Mediterranean diet respectively (Mitrou et al., 2007). Danish and Swedish cohorts also showed a reduction in mortality with higher adherence to a Mediterranean dietary pattern, however these were more modest results, with a reduction of 7% in both studies (Tognon, Lissner, Saebye, Walker, & Heitmann, 2013; Tognon et al., 2011). Taken together, this shows a pattern of decreased all-cause mortality in several cultures. Some studies suggest a dose-response relationship, with a 4%-5% (Prinelli et al., 2015; Vormund et al., 2015) decrease in all-cause mortality with every point on a scale of adherence to the diet, and a meta-analysis (Sofi, Macchi, Abbate, Gensini, &

Casini, 2013) found an 8% decrease in all-cause mortality, 10% decrease in cardiovascular mortality, and 4% decrease in cancer mortality for each 2 points on an adherence scale.

The Mediterranean diet has consistently been associated with a lower risk of cardiovascular disease and stroke (Estruch et al., 2013; Reedy et al., 2014; Sofi et al., 2013) however its association with cognitive function is still under frequent investigation. In a systematic review of the Mediterranean diet's association with cognitive function and dementia, Lourida et al. (2013) found a consistent inverse association between adherence to the diet, cognitive decline, and risk of dementia. However, the relationships for Mild Cognitive Impairment (MCI) – a possible dementia prodrome – were inconsistent. Using the Mini Mental Status Exam (MMSE), Trichopoulou et al. (2015) found an inverse relationship between Mediterranean diet adherence and cognitive decline in a 7 year follow up study with a Greek cohort.

Which aspect of the diet accounts for the reduction in the risk of cognitive decline is not clear. In Trichopulou and colleagues' (2015) study, only vegetable intake had a significant relationship with cognitive performance. Galbete et al. (2015) however, observed a significant relationship only with the monounsaturated to saturated fatty acid ratio in their study of a Spanish cohort. In this study, those with low or moderate adherence to the Mediterranean diet at baseline exhibited higher levels of cognitive decline when followed up with the Telephone Interview of Cognitive Status – Modified, 6-8 years later. The authors noted that the differences between adherence groups were small in magnitude, however it appears that fatty acids played an important part in explaining the relationship seen.

While no statistically significant relationship between fish consumption and mortality was found in single dietary component analyses from the aforementioned studies, Féart et al. (2011) found that adherence to the Mediterranean diet was positively correlated with plasma DHA, the EPA+DHA index, and total *n*-3 PUFA. This indicates that the diet provides the necessary elements for maintaining DHA levels in the blood, and consequently the brain.

Fish Consumption. In a 1999 study of fish consumption and mortality data from 36 countries, Zhang, Sasaki, Amano, and Kesteloot found significant inverse correlations between fish consumption, all-cause mortality, and mortality from ischaemic heart disease and stroke. Wang et al. (2011) also found that fish consumption was inversely related to all-cause mortality as well as ischaemic heart disease, stroke, and cancer mortality in a Chinese case-control study, though suggest further longitudinal study be conducted to support the relationship seen. Villegas, Takata, Murff, and Blot (2015) found differences in cooking methods altered relationships between fish and all-cause mortality, and this also varied between ethnicities. Total fish consumption, fried fish, and baked/grilled fish were associated with decreased all-cause mortality over the total sample, though only baked/grilled fish and total fish was associated with mortality in black participants. These results suggests that fish consumption may be associated with decreased mortality and morbidity, but preparation methods could be a mediating factor for some populations, thus should be taken into account when analysing data and setting recommendations.

Studies of fish consumption and cognitive performance have yielded mixed results. A French study discovered a positive relationship between fish consumption and cognitive performance in older adults (Kesse-Guyot et al., 2011), though after adjusting for psychological health and education the observed relationships only just reached statistical significance. A large study of Swedish adolescents Kim et al. (2010) found a dose-response relationship between fish consumption and academic performance, which remained after adjustment for parental education. At the other end of the age span Del Brutto, Mera, Gillman, Zambrano, and Ha, (2016) found a positive dose-response relationship between oily fish consumption and cognitive performance as assessed by the Montreal Cognitive Assessment (MoCA) in community dwelling older adults in rural Ecuador. In contrast, Danthiir et al. (2014) found that higher levels of current and childhood fish consumption both predicted lower performance on measures of cognitive speed and reaction time.

The differences in results between studies may stem from the differences in the measures used, populations studied, type of fish consumed, and its typical method of preparation. This highlights the difficulty of comparing populations, and recommending a whole food group for health benefits without considering the local food supply and customs.

Omega-3 intake in New Zealand

Dietary recommendations. An adequate Intake (AI) of *n*-3 PUFA for New Zealand and Australian adults has been set as 160mg/d for males, and 90mg/d for females (National Health and Medical Research Council [NHMRC], 2006). These values are based on observed median intakes for groups of apparently healthy Australian adults, and are assumed to be adequate for both Australian and New Zealand populations (NHMRC, 2006), but may not represent optimal intake. The AI relates to *n*-3 PUFA in the form of ALA only; no separate value for DHA or EPA has been set. The NHMRC (2006) also propose a combined suggested dietary target (SDT) for DHA, EPA, and DPA (another LC *n*-3 PUFA) of 610 mg/d for males and 430 mg/d for females; this value is suggested for lowering risk of chronic disease. The NHMRC have also set an upper level (UL) reference value for the LC *n*-3 PUFAs (DHA, EPA, and DPA) of 3000mg per day, which is based on the United States' Food and Drug Administration's recommendations for levels generally considered safe for US adults.

New Zealand population intake. Findings from the 2008/09 New Zealand Adult Nutrition Survey showed that on average adult New Zealand males consume 13.5g/d all PUFAs and females 10g/d, with 5.2% of this coming from fish and other seafood sources (Ministry of Health [MOH], 2011). No data is available for the *n*-3 PUFAs or the type of fish/seafood consumed, thus it is unclear whether New Zealanders are meeting the dietary targets for more specific types of fat. This lack of information, as well as the individual differences in the conversion of other PUFAs to DHA, mean it is difficult to infer whether the NZ population are meeting the *n*-3 PUFA or DHA dietary requirements. One study, however, has labelled NZ LC *n*-3 PUFA status 'marginal' (Stonehouse et al., 2011).

Supplemental intake. Recent years have seen a worldwide increase in supplement use for a wide variety of ailments (Millen, Dodd, & Subar, 2004; Ritchie, 2007). The 2008/09 New Zealand Adult Nutrition Survey found that oil supplements – which included both *n*-3 and *n*-6 PUFAs – were the most commonly used (MOH, 2011). There were differences in use by ethnicity, with 4.6% males and 4.5% females of Pacific Island descent using oil supplements, 7.7% males and 8% females of Māori descent using such supplements, and 14.7% males and 20.8% females of New Zealand European/other descent using oil supplements. There also appeared to be a social gradient to supplementation, with 19.4% of male and 24.6% of female oil supplement users living in the least deprived areas, while only 10.6% of male and 9.6% of female oil supplement users lived in the most deprived areas according to the NZDep2006 index of deprivation quintiles (MOH, 2011; Salmond, Crampton, & Atkinson, 2007). This may be indicative of a cost barrier to obtaining supplements.

A more recent cross-sectional study of fish oil supplement use in New Zealand found that 21.9% of the 334 respondents were regular fish oil consumers (Mengelberg, Leathem, & Podd, 2018). These self-identified consumers were more likely to also be regular consumers of oily fish, thus less likely to be deficient in *n*-3 PUFA intake. This sample of survey respondents were mainly female, under 40 years of age, and highly educated, therefore not representative of the wider New Zealand population, nor a population particularly susceptible to mTBI. In addition, the fish oil users were more likely to earn over $150,000 per annum, adding further support to the notion of a cost barrier for the general population obtaining such supplements. Interestingly, just 26% of this consumer group were taking a dose that would meet the daily recommendations of DHA+EPA.

Due to the lack of information regarding New Zealander's intake of *n*-3 PUFAs from both food and supplementary sources, it cannot be determined whether the NZ population is consuming this important nutrient in adequate amounts. However like most Western countries, it is likely that they are not (Hibbeln, Blasbalg, & Riggs, 2006). It appears that those

of lower socioeconomic status may be less likely to consume adequate DHA and EPA, possibly due to the high cost of both supplements and LC *n*-3 PUFA rich seafood. It is also possible that deficiency is more common in non-coastal areas, where fishing and gathering shellfish is not an option. This is a line of inquiry that needs further investigation.

Supplemental Omega-3 PUFA Intervention Studies in Human populations

Several randomised controlled trials have been conducted to assess both cognitive function and mood after LC *n*-3 PUFA supplementation. Results have been mixed, and do not always support observational evidence. Please see Table 2.1 for a summary of these studies.

Table 2.1

Randomised Placebo Controlled Trials of the Cognitive and Mood Effects of LC n-3 PUFA Supplementation

Title	Authors	Year	Population	Duration	Treatment and dose	Placebo	*n*-3 PUFA status	Mood outcomes	Cognitive outcomes
Randomised double-blind placebo-controlled trial of fish oil in the treatment of depression	Silvers et al.	2004	59 18-65 y/o being treated for mild to severe depression	12 weeks	8g/day tuna oil – 2.4g DHA + 0.6g EPA	Olive oil	Circulating RBC levels of DHA and EPA more than doubled from baseline to completion in the treatment group.	No effects with treatment, assessed using BDI-II and HDRS-SF.	N/A
Dietary supplementation of arachidonic and docosahexaenoic acids improves cognitive dysfunction	Kotani et al.	2006	39 amnestic adults from Japan, aged 45+ - 21 with MCI, 10 with organic brain injury, and 8 with early stage Alzheimer's	90 days	240mg arachidonic acid (ARA) + 240mg DHA/day	Olive oil	N/A	N/A	Immediate memory improved in MCI and organic injury groups, delayed memory improved in the organic injury group, and attention improved in the MCI group. All domains measured using a Japanese version of the RBANS.
Effect of 2-y n-3 long-chain polyunsaturated fatty acid supplementation on cognitive function in older people: a randomized, double-blind, controlled trial	Dangour et al.	2010	748 70-79 y/o healthy adults	2 years	500mg DHA + 200mg EPA/day	Olive oil	Serum EPA and DHA significantly higher in treatment group at completion	N/A	No difference with treatment

Docosahexaenoic acid-concentrated fish oil supplementation in subjects with mild cognitive impairment (MCI): A 12 month randomized double-blind placebo-controlled trial	Lee et al.	2012	36 60+y/o Malaysian adults suffering MCI	1 year	1.3g DHA + 45mg EPA/day	Corn oil	Serum EPA and DHA significantly increased after 12 months for the treatment group	N/A	Treatment group showed improved short term memory, working memory, immediate verbal memory, and delayed recall as measured by Visual Reproduction I from WMS-R, Digit Span backwards, and the RAVLT.
Effects of *n*-3 fatty acids, EPA v. DHA, on depressive symptoms, quality of life, memory and executive function in older adults with mild cognitive impairment: A 6-month randomised controlled trial	Sinn et al.	2012	40 adults aged 65+, with MCI	6 months	1.67g EPA + .16g DHA/day, or 1.55g DHA + .4g EPA/day	Safflower oil	Mean baseline RBC EPA and DHA ranged from .95 to 4.75% total fatty acids. This increased significantly after 6 months in both treatment groups.	Scores on the GDS improved significantly in both treatment groups compared with the control group. Within-group changes on GDS scores only significant for the DHA-rich group. Increased DHA was associated with improved self-reported physical function.	Verbal fluency, measured by a letter fluency test, improved in the DHA-rich treatment group.
No effect of 12 weeks' supplementation with 1g DHA-rich or EPA-rich fish oil on	Jackson et al.	2012	140 healthy 18-35 y/o university students or graduates	12 weeks	450mg DHA + 90 mg EPA/day, or 300mg EPA +	Olive oil	Serum concentrations of DHA significantly increased in both treatment groups	No differences between groups, as measured by visual analogue scales the DASS.	DHA rich group faster on Stroop test; both treatment groups matched fewer

cognitive function or mood in healthy young adults aged 18-35 years					200mg DHA/day		compared to placebo.		names and faces in a recall test. EPA rich group reported significantly lower mental fatigue on a visual analogue scale after completing a cognitive demand battery. The study concluded no differences with treatment.
DHA supplementation improved both memory and reaction time in healthy young adults: a randomized controlled trial	Stonehouse et al.	2013	176 healthy 18-45 y/o adults	6 months	1.16g DHA + .17g EPA/day	High oleic acid sunflower oil	Both groups had habitually low DHA intake (<200mg/week), RBC DHA increased significantly in the treatment group from baseline to completion.	N/A	Treatment improved reaction time of episodic memory in both sexes, reaction time of working memory in males, and episodic memory in females.
Supplementation with DHA and the psychological functioning of young adults	Benton et al.	2013	285 healthy female university students, mean age 21.8 y/o	50 days	400mg DHA/day	Soya oil	N/A	No change in visual analogue scales relating to the last week.	Treatment participants forgot more than control on a word list recall task.
The effects of long-chain omega-3 fish oils and multivitamins on cognitive and	Pase et al.	2015	160 healthy 50-70 y/o	16 weeks	480mg DHA + 480 mg EPA + multi-vitamin/day, or 240mg	High oleic sunflower oil	Baseline RBC *n*-3 PUFA lower than reference values obtained from	N/A	No effects on cognitive performance by treatment; increases in the

cardiovascular function: A randomized, controlled clinical trial					DHA + 240mg EPA + multi-vitamin/day or 480mg DHA + 480 mg EPA/day no multivitamin.		the general population.		omega 3:6 ratio resulted in faster spatial working memory response times.
DHA supplements alone or in combination with other nutrients does not modulate cerebral hemodynamics or cognitive function in healthy older adults	Jackson et al.	2016	86 healthy 50-70 y/o with subjective memory deficits	6 months	896mg DHA + 128mg EPA/day, or 946mg DHA + 160mg EPA + multi-nutrient formula	High oleic acid sunflower oil + 120mg fish oil (32mg DHA + EPA)	Mean baseline EPA and DHA ranged from .93-2.85% total fatty acids. Percentage of whole-blood DHA and EPA approximately doubled from baseline to completion for both treatment groups.	N/A	No effect on cerebral hemodynamics, performance on the Cognitive Demand Battery, or mental fatigue reported on a visual analogue scale.
The *n*-3 polyunsaturated fatty acids supplementation improved the cognitive function in the Chinese elderly with mild cognitive impairment: A double blind randomized controlled trial	Bo et al.	2017	86 Chinese adults with MCI, mean age 71 y/o	6 months	480mg DHA + 720 mg EPA/day	Olive oil	DHA and EPA concentrations were significantly higher in treatment group after 6 months. Mean baseline EPA and DHA ranged from .8-1.62% total fatty acids.	N/A	Total Basic Cognitive Aptitude Test, perceptual speed, and space imagery efficiency scores improved with treatment in both sexes, working memory scores improved in males only.

Effect of long term omega-3 polyunsaturated fatty acid supplementation with or without multimodal intervention on cognitive function in elderly adults with memory complaints (MAPT): A randomised placebo controlled trial	Andrieu et al.	2017	1680 adults 70+ y/o in France and Monaco	3 years	800 mg DHA + 225 mg EPA/day	Flavoured paraffin oil	Used to test adherence. RBC DHA+EPA significantly higher in active supplement treatment groups than placebo groups.	No between group differences on GDS	Composite Z score of 10x MMSE orientation items, SRT, Digit Symbol Substitution Test and Category Naming Test. Also Trail Making Test A&B, COWAT. Lower rate of decline on MMSE items in combined intervention group v placebo. No other between group differences.

Notes. RBC, red blood cell; MCI, mild cognitive impairment; BDI-II, Beck Depression Inventory II; HDRS-SF, Hamilton Depression Rating Scale – Short Form; RBANS, Repeatable battery for the Assessment of Neuropsychological Status; WMS-R, Wechsler Memory Scales – Revised; RAVLT, Rey Auditory Verbal Learning Test; GDS, Geriatric Depression Scale; DASS, Depression Anxiety and Stress Scales; SRT, Selective Reminding Test; COWAT, Controlled Oral Word Association Test.

Omega-3 PUFAs and cognitive function. The observational evidence showing positive associations between LC *n*-3 PUFAs and cognitive function is not always supported by experimental evidence, which reports a mix of positive, negative, and no associations, as outlined in Table 3.1 above. Two trials in healthy young university students and graduates reported increased rates of forgetting after DHA supplementation (Benton, Donohoe, Clayton, & Long, 2013; Jackson, Deary, Reay, Scholey, & Kennedy, 2012). Jackson and colleagues (2012) also reported that their DHA rich supplement group were faster on the Stroop test than the EPA rich and placebo groups, indicating increases in attention and/or response inhibition. However, due to the small number of statistically significant results compared with large number of tests conducted, and the bidirectional nature of the results, the authors concluded that there were no cognitive effects with supplementation. In contrast, Stonehouse and colleagues' (2013) six-month trial in healthy 18-45 year olds found that DHA supplementation improved the reaction time of episodic memory in both sexes, improved episodic memory in females, and improved the reaction time of working memory in males. Participants in this study habitually consumed diets low in DHA, and were provided with a higher dose of DHA for a longer duration than the negative trials.

Several supplement trials have been conducted with older adult populations, with mixed results. A Japanese study (Kotani et al., 2006) was conducted with 39 amnestic participants – 21 with MCI which was split into treatment and control groups, ten with organic brain injuries such as haemorrhage or TBI occurring a minimum of five years before the trial, and eight in the early stages of Alzheimer's disease. The treatment groups received equal amounts of arachidonic acid (a *n*-6 fatty acid) and DHA for 90 days. The Alzheimer's group showed no improvements after supplementation, but the organic injury and MCI treatment groups improved in delayed memory and attention respectively, and both showed improvements in immediate memory.

Similarly, a trial in a Malaysian MCI population from low socioeconomic backgrounds showed improved short-term and working memory after 12 months of DHA supplementation (Lee, Shahar, Chin, & Yusoff, 2012). A 6 month randomised controlled trial of two doses of LC *n*-3 PUFA supplements in older adults with mild cognitive impairment (MCI) found that those receiving the supplement with higher DHA levels showed improvement in verbal fluency and self-reported physical functioning, though did not exhibit any memory improvements (Sinn et al., 2012).

A recent trial in an elderly Chinese population with MCI also showed improvements after supplementation. Perceptual speed and space imagery efficiency improved for both sexes, and working memory for males (Bo et al., 2017). However, a trial in older adults with subjective memory complaints but not diagnosed with MCI yielded no significant results (Jackson et al., 2016) and two further trials in healthy older adult populations have reported no effects of treatment on cognitive performance (Dangour et al., 2010; Pase et al., 2015). An interesting finding from Pase and colleagues' study was that although there were no significant effects from any level of treatment, an increase in the ratio of *n*-3 to *n*-6 was associated with faster spatial working memory response times.

A large three year multicentre randomised placebo controlled trial aimed at preventing Alzheimer's also found no effect with supplemental intervention (Andrieu et al., 2017). Community dwelling individuals over 70 years (n=1680) who either reported a subjective memory complaint, a limitation in one or more instrumental activities of daily living, or had a slow gait speed were assigned to one of four groups. The *n*-3 PUFA supplement consisted of 800mg DHA and 225mg EPA per day, one group took this alone while another combined this with the multimodal intervention, which included 43 group sessions relating to cognitive training, physical activity and nutritional advice as well as three preventive health consultations with a physician. The remaining two groups included the multidimensional intervention in conjunction with placebo, and placebo alone. Outcome measures included the

Selective Reminding Test, Mini Mental State Examination, Digit Symbol Substitution Test, Trail Making Test, Controlled Oral Word Association Test, and the Category Naming Test for cognitive performance, as well as a physical performance battery, activities of daily living prevention instrument, clinical dementia rating, Fried's frailty criteria, and the GDS. While no between group differences were found at the conclusion of the study, the authors conducted further analyses using a 'modified intention to treat' protocol that included participants with some protocol violations (e.g., not attending the end-point session but having some follow-up data available) and found that those in the combined intervention group showed less decline on the MMSE orientation items than the placebo only group.

The lack of significant results in the healthy groups indicate that supplementation may only be useful for individuals with certain impairments, or perhaps a certain level of impairment. However, Pase and colleagues' finding of improvement with higher *n*-3 to *n*-6 ratios as well as Stonehouse and colleagues' results with healthy younger adults, suggest that LC *n*-3 PUFA supplementation does have the potential to benefit healthy individuals. Positive results may be more likely after higher levels of supplementation for longer durations, or perhaps the relationship between supplements and cognitive effects in non-impaired or non-deficient populations is not as straightforward as simply increasing intakes of certain nutrients.

Omega-3 PUFAs and mood. Omega 3 fatty acids are also related to anxiety and depression. Cross sectional studies have found that DHA levels in adipose tissue are significantly inversely related to depression (Sarri, Linardakis, Tzanakis, & Kafatos, 2008), dietary DHA intake is inversely related to anxiety (Jacka et al., 2013) and depression (Meyer et al, 2013), and serum DHA levels are inversely associated with anxiety in early pregnancy (Verly-Miguel et al., 2015). A 2009 meta-analysis of randomised controlled trials by Martin speculated that EPA rather than DHA was responsible for the efficacy of LC *n*-3 PUFAs in the treatment of depression. This study did however also report a significant inverse association between reported efficacy and methodological quality. Both the high DHA and high EPA groups of Sinn

and colleagues (2012) six month trial had improved scores on the Geriatric Depression Scale from pre- to post- intervention. The authors propose that DHA may be equally if not more effective than EPA at improving mood, however, improvements may relate to other factors such as lessened physical pain and improved cognitive performance.

A trial of two different doses of DHA + EPA versus a placebo found no mood differences measured by the Depression Anxiety and Stress Scales (DASS) after supplementing healthy 18-30 year olds for 12 weeks (Jackson et al., 2012). Similarly, Benton and colleagues' (2012) 50 day trial of daily DHA supplements with young female university students found no alterations in mood assessed using visual analogue scales. It is possible that the studies finding no effects were too short in duration to produce an effect, or perhaps the doses were insufficient. However, the populations studied were young and in good health, so as per Sinn and colleagues (2012) suggestion, the lack of mood effects may be due to a lack of alleviation of physical pain or discomfort. Or, perhaps as in the case of DHA supplements and cognition, effects are only present or measurable when some form of disorder exists. The effects of LC *n*-3 PUFA supplementation on mood remain in need of investigation.

Omega-3 PUFAs after brain injury. As the above review shows, several studies have found improvements in various forms of memory (Kotani et al., 2006; Lee et al., 2012; Stonehouse et al., 2013; Pase et al., 2015; Bo et al., 2017) attention (Kotani et al., 2006), perceptual speed and spatial ability (Bo et al., 2017), and executive functions (Jackson et al., 2012; Sinn et al., 2012), after *n*-3 PUFA supplementation. These cognitive domains are frequently impaired after mTBI, thus it holds that *n*-3 PUFA supplements may aid recovery from mTBI symptoms.

Few studies have been conducted with LC *n*-3 PUFA in people who have suffered brain injury and at present no published data exists comparing brain injury outcomes in populations with high versus low LC *n*-3 PUFA diets. Amen, Wu, Taylor, and Willeumier (2011) treated 30 brain damaged and cognitively impaired retired NFL football players with fish oil, weight loss, a

multi-vitamin, and a 'brain enhancement' supplement including acetylcholine, antioxidants, and blood flow enhancers. Participants showed improvements in attention, memory, reasoning, and information processing. Increased perfusion in the prefrontal cortex, parietal lobes, anterior cingulate gyrus, and cerebellum was also noted. However, due to the poly-supplement approach and lack of a control group it is not possible to attribute these effects to fish oil.

Sears, Bailes, and Asselin (2013) presented two case histories of high dose LC *n*-3 PUFA supplementation in severely brain injured individuals. A man with carbon monoxide poisoning beginning *n*-3 therapy 8 days post-injury and a child with anoxic brain injury beginning *n*-3 therapy 82 days post-injury both showed substantial improvements in global functioning following treatment. Sears and colleagues attribute this to the ability of LC *n*-3 PUFA to cross the blood brain barrier and exert anti-inflammatory effects.

In summary, the studies in Table 2.1 above show that the outcomes of research into *n*-3 PUFA interventions with human populations are varied, with very little of this research related directly to TBI. Due to the lack of epidemiological and experimental TBI and *n*-3 PUFA research in human populations, it is important to consider animal research. The following section discusses *n*-3 PUFA supplementation in animal models of brain injury and the insight this provides into *n*-3 PUFA's potential to aid human brain injury recovery.

Supplemental Omega-3 PUFA Studies in Animal Models of mTBI

Several studies have examined the effect of LC *n*-3 PUFA or DHA supplementation on injury outcomes in rat and mouse models of brain injury, and found that LC *n*-3 PUFA appear to exert a neuroprotective effect on the inflammatory aspects of mTBI. The inflammatory response following brain injury is caused by several different processes and appears to be both detrimental and beneficial. Inflammation contributes to secondary injury, but also enables neural repair (Woodcock & Morganti-Kossmann, 2013). Microglia are responsible for much post-injury inflammation and are necessary for the removal of the debris left by other neurochemical processes, for controlling the inflammatory response, and for cell survival and cell death after injury (Harvey et al., 2015). Microglia are known for their plasticity – being able to assume different phenotypes in response to local environmental signals and polarise towards specific functions (Harvey et al., 2015) such as surveillance, phagocytosis, and both pro- and anti- inflammatory extracellular signalling (von Bernhardi, Heredia, Salgado, & Munoz, 2016). These cells have been the focus of several experimental studies.

Trépanier, Hopperton, Orr, and Bazinet (2015) reviewed LC *n*-3 PUFA's effects on animal models of brain inflammation and found consistent anti-neuroinflammatory outcomes for stroke, cognitive impairment, Parkinson's disease, depression, aging, and irradiation. In a similar review Barrett et al. (2014) found that both prophylactic and therapeutic supplementation with LC *n*-3 PUFA reduced the degree of axonal and neuronal damage, inflammation, and apoptosis in animal models of mTBI. Zendedel and colleagues (2015) furthered this by conducting in vitro analyses as part of a study on LC *n*-3 PUFA and neuroinflammation in a rodent model of stroke, finding that the attenuation of neuroinflammation was due to LC *n*-3 PUFA dampening the expression of pro-inflammatory cytokines, and preventing the activation of local microglia from the resting to the pro-apoptotic form. In this study LC *n*-3 PUFA exerted effects directly on astrocytes, microglia, and neurons to significantly lessen both neuroinflammation and behavioural deficits. Similar results

were reported by Harvey and colleagues (2015), who found that DHA administration after TBI moderately decreased proinflammatory markers in the brain, and attenuated the conversion of microglia to the destructive proinflammatory phenotype while increasing the number of microglia taking on a reparative morphology.

Trojian and Jackson (2011) reviewed two studies using axons positive for beta amyloid precursor protein (APP) as a measure of injury severity. APP is a marker of the axon damage that occurs due to the initial injury, and is exacerbated by the resultant excitotoxicity and oxidative stress (Barrett et al., 2014). One study supplemented with pure DHA for 30 days while the other used fish oil (DHA and EPA) supplementation for 30 days, in brain injured rats. In both studies, supplemented rats showed significantly lower levels of this neural membrane protein compared with injured but un-supplemented rats. APP levels in the supplemented animals were near those of the sham injured animals at the end of the 30 day trials. As APP is up-regulated following neural injury (Begum et al., 2014), these findings indicate that the administration of LC *n*-3 PUFA attenuated the injury. Similarly, Begum et al. (2014) found that administration of DHA following brain injury reduced the expression of APP, as well as other proteins which mark stress of the endoplasmic reticulum – a mechanism of chronic neuronal damage after TBI (Harvey et al., 2015). In addition, the rats treated with DHA in Begum and colleagues' study showed earlier recovery of sensorimotor function compared to control rats. Harvey and colleagues (2015) also reported that DHA administration post-TBI reduced neuronal endoplasmic reticulum stress, which prevents injured neurons from committing to apoptotic pathways, thereby reducing the associated subsequent activation of local microglia.

In addition to attenuating inflammation, DHA supplementation after TBI may reduce oxidative stress and preserve neural membrane fluidity and synaptic plasticity by normalising levels of Brain Derived Neurotropic Factor (BNDF) and related proteins (Wu, Ying, & Gomez-Pinilla, 2011). BDNF, its related proteins, and their effects on neural cells have been implicated in both learning and memory, and as such reductions in BDNF seen following brain injury may

account for the commonly experienced cognitive symptoms; rats in Wu and colleagues' (2011) study displayed learning deficits after injury, however this was counteracted by supplementing them with a DHA rich diet.

Together, these studies suggest that DHA may modulate the conversion of microglia from a resting to an activated phenotype, thereby attenuating the inflammatory response without eliminating their neuroprotective effects. In addition, it may help to maintain the structural integrity of cells and plasticity of synapses by normalising protein levels. Based on the studies summarised above, Figure 2.2 shows the potential areas of intervention on the neurometabolic cascade of concussion.

In those studies that have measured behavioural or cognitive outcomes after injury, the effects of DHA in the brain appear to have translated to fewer negative outcomes compared with control animals. It is not yet clear how this will translate to human mTBI, however the results show promise for the attenuation of symptoms. Giza and Hovda's (2014) explanation of the clinical correlates of the physiological perturbations after mTBI suggests that attenuating the axonal injury and other cell damage could also reduce cognitive deficits such as slowed processing speed and reaction times, and potentially prevent these impairments from persisting.

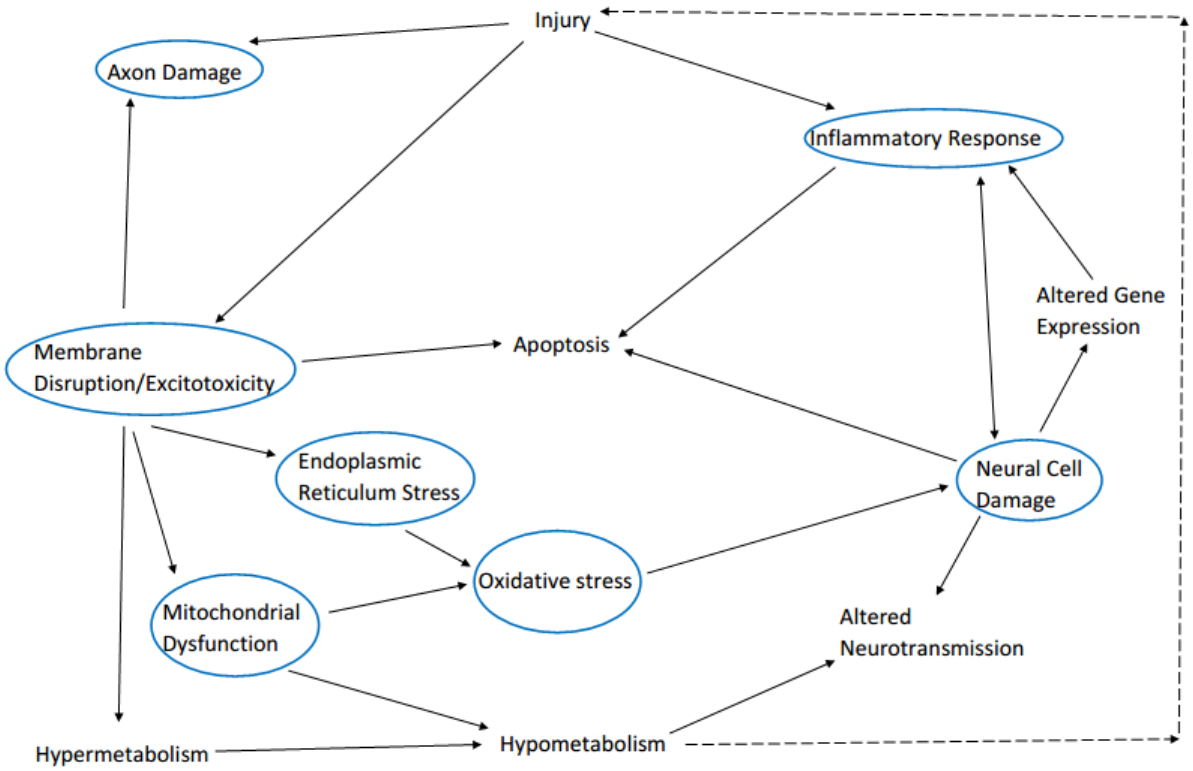

Figure 2.2. Potential points of DHA intervention on the concussion cascade. Intervening at the points circled in blue may lead to lower rates of apoptosis and injury symptoms. Adapted from 'ω-3 fatty acid supplementation as a potential therapeutic aid for the recovery from mild traumatic brain injury/concussion' by E. Barret, M. McBurney and E. Ciappio, 2014, *Advances in Nutrition: An International Review Journal, 5,* p. 269.

Summary

The research reviewed above has shown that the LC *n*-3 PUFA are important for healthy brain development and function, and that while adequate amounts can be obtained from the diet, this is frequently not the case. Overall levels of both dietary and supplemental intake in New Zealand are unclear and while one study suggested approximately one fifth of the population used supplements, this was not a representative sample. In line with other Western nations, New Zealand's overall LC *n*-3 PUFA consumption is likely to be low. Observational research has outlined positive relationships between LC *n*-3 PUFA and health

and longevity, including cognitive and psychological health. Supplementation with high levels of LC *n*-3 PUFA over a minimum of 90 days has shown benefit in some populations, mainly those with amnestic conditions and those with habitually low intakes of *n*-3 PUFA. Groups who have responded well to supplementation have shown improvements in processing speed and working memory – both of which are commonly impaired after mTBI. Animal studies have shown that LC *n*-3 PUFA supplementation may assist recovery from brain injury by reducing inflammation and several forms of cell damage, which prevents or mitigates cognitive and behavioural symptoms. Little research has been conducted into LC *n*-3 PUFA supplementation in human brain injury, however the aforementioned studies provide compelling pre-clinical evidence of LC *n*-3 PUFA's potential to reduce mTBI symptoms in humans, and rationale for conducting a randomised controlled trial with New Zealand adults who have suffered mTBI.

Chapter Three: Study One Methodology

This chapter provides a description of the design for Study One, followed by discussion of the justification of the research, detail regarding participants, materials, procedures, and planning around analyses and dissemination of results.

The main objective of this study was to investigate the effects of dietary supplementation with fish oil on cognitive function after mTBI. Further aims included; investigating the effects of fish oil supplementation on mood after mTBI and whether there were any interactions between mood and cognitive effects, examining whether injury beliefs were associated with cognitive or mood outcomes, and whether supplementation affected post-injury disability ratings. A key consideration and point of difference from other cognitive research was the decision to conduct the majority of the study – all aspects involving participants, aside from recruitment – via telephone. The rationale for conducting the research via telephone related to both cost and time for the researcher and participants, and is discussed in more detail in the design, measures and procedures sections below.

Hypotheses

It was hypothesised that *n*-3 PUFA supplementation post-mTBI would exert a main effect of decreasing the duration and severity of cognitive symptoms compared to a placebo control group. In addition, supplementation would decrease the duration and severity of mood symptoms. An interaction effect was hypothesised between supplementation, mood, and cognitive outcomes. It was also hypothesised that post-injury disability ratings would be lower after supplementation, and participants with negative injury beliefs would experience poorer cognitive and mood outcomes.

Design

The study was a two-arm randomised, double-blind, placebo-controlled, superiority trial. The efficacy of a fish oil supplement as an adjunct to treatment as usual was to be

analysed for superiority over standard treatment within the New Zealand Concussion Services. The active treatment was a high DHA fish oil supplement, while the placebo was a supplement containing sunflower oil.

Due to the emphasis on effectiveness, this study best fits within the phase two category of standard clinical trial phasing models. As fish oil is widely available over-the-counter and considered safe under a level of 3000mg/day (NHMRC, 2006) a phase one trial was not deemed necessary. A phase three trial, which assesses efficacy against other treatments or non-treatment with a large sample, was outside the scope of the researcher's qualification timeframe. However, in order to help control for the effects of time on mTBI recovery it was necessary to include the placebo control within the phase two study design.

Participants were recruited from four Concussion Services in different regions of New Zealand, with the assistance of the Services' clinicians. As outlined in Chapter One, the Concussion Services are NGOs holding contracts with ACC to deliver their services for a set price. Due to the multi-centre nature of the trial and the placement and classroom requirements of the researcher's programme of study, all testing and contact after recruitment was conducted over the telephone, by the lead researcher. This allowed the study to be conducted from any location. Baseline measures were obtained pre-treatment (baseline), and outcome measures were to be collected three months after beginning treatment, and six months after beginning treatment (conclusion).

Participants

Power analysis. A power analysis was conducted using G*Power 3.1.9.2 (Faul, Erdfelder, Lang, & Buchner, 2007) to calculate the minimum sample size needed. To detect an effect size of partial η^2=.02 and provide a statistical power equal to 0.8 at an α level of .05, a minimum sample size of 82 participants was required. This would detect a 'small' (Cohen, 1988) effect of *n*-3 PUFA supplementation on the duration and severity of post-mTBI cognitive

symptoms using a two way mixed ANOVA. In order to utilise the full amount of available supplement and provide a buffer in case of attrition, the study aimed to recruit 96 participants.

Eligibility criteria. Individuals aged 16 years and older who had suffered mTBI and were experiencing one or more cognitive symptoms were eligible to participate in the study. Participants needed to be engaged with a Concussion Service and have a claim with ACC, which meant they were less than 12 months post-injury and symptomatic at the time of recruitment.

While technically considered a food under section two of the Food Act (1981), the fish oil supplement was to be trialled for therapeutic purposes in the context of health care provision. As such, it was treated as a medicine for the purposes of informed consent. Under section 36 the Care of Children Act (2004) individuals of or over 16 years of age may consent to medical treatment. In addition, adolescents represent an at-risk population, thus could potentially benefit from the trial; in acknowledgement of this vulnerability, parental consent was also to be sought for adolescents under 18 years of age.

Additional requirements included fluency in English, access to a telephone, and a distraction-free environment for the testing sessions.

Exclusion criteria. Individuals were excluded from the trial if they were already taking a fish oil supplement, had taken such a supplement on a regular basis within the previous six months, or consumed more than three servings of oily fish per week. The rationale for this was that the human brain retains DHA well, and those who consume adequate amounts on a regular basis may not benefit from further supplementation (Stonehouse, 2014).

Individuals who were taking any medications known to affect cognitive function (e.g., nootropics, antipsychotics), or had any mental or neurological disorders that significantly affect cognition (e.g., ADHD) were excluded from the trial due to the potential for confounded results.

Additional exclusion criteria included any allergy or opposition to seafood or beef gelatine, difficulty swallowing capsules, pregnancy, lactation, or non-fluency in the English language.

Measures

When selecting measures for the study several considerations were necessary. As the research was conducted via telephone, measures had to be presented verbally in a clear fashion. Measures designed for verbal presentation, and those that could be explained and administered verbally with minimal confusion or repetitiveness, were considered for inclusion.

As the participants would have various difficulties with concentration, motivation, and fatigue as well as headaches, it was important to keep the assessment time to a minimum and the instructions clear. Accordingly, time requirements and ease of instruction were taken into account for each measure considered, and the entire assessment package kept to a maximum of one hour – a shorter time than required for Concussion Service neuropsychological testing.

Participants were to be tested three times for the study, and some underwent repeated cognitive testing as part of treatment as usual within the Concussion Services. Concussion Service assessments could not be used for the study because not all Concussion Service clients undertake cognitive testing, and cognitive assessment measures are chosen by the individual clinicians thus varying between services. In order to minimise overlap between settings, measures not used in the Concussion Services, and those with minimal practice effects and/or alternative forms were chosen.

Perhaps most importantly, to maximise the sensitivity of testing it was essential to assess the domains of functioning most commonly impaired after mTBI. Particular attention was given to memory and executive function as studies have found that speed and ease of processing (Kay et al., 1992), learning and remembering (Shanmukhi & Panigrahi, 2003), executive ability, complex attention, cognitive flexibility and memory (Barker-Collo et al., 2015) may be affected in the first 12 months post-injury.

Studies evaluating the validity of telephone-based cognitive measures primarily assess brief screening tools not suitable for detecting the more subtle cognitive deficits important to this study. Such tools do show good reliability and validity however, and the British Psychological Society (2020) state "the validity of telephone-based administration of many auditory measures… appear relatively consistent with face-to-face and video-based administration." So while validity data for the chosen measures does not relate to the same mode of delivery, it is reasonable to expect a similar level of validity to that reported, when administered via telephone.

In addition, depression, anxiety, and stress are frequent mood-related post-injury difficulties (Barker-Collo et al., 2015; Bay, Sikorskii, & Gao, 2009; Chen et al., 2008; Styrke et al., 2013) that may benefit from fish oil supplementation (Jacka et al., 2012; Meyer et al., 2013; Sarri, Linardakis, Tzanakis, & Kafatos, 2008) thus mood measures were included in the test collection.

Questionnaires.

The Depression Anxiety Stress Scale 21 item version (DASS-21). The DASS-21 (Lovibond & Lovibond, 1995) is a 21 item self-report measure of the experience of depression, anxiety, and stress related symptoms. Participants are asked to rate on a scale of zero to ten how much each of 21 statements applied to him/her in the past week. The DASS-21 was chosen for its briefness and inclusion of three mood states common in mTBI. It is a reliable and valid measure for assessing depression, anxiety, and stress (Antony, Bieling, Cox, Enns, & Swinson, 1998), and had a Cronbach's alpha of .95 when assessing anxiety and depression in a sample of brain injured clients (Dahm, Wong, & Ponsford, 2013).

The Brief Injury Perceptions Questionnaire (Brief IPQ). The Brief IPQ is an eight item questionnaire relating to beliefs about various aspects of injury. It asks participants to rate eight statements on a scale of one to ten. This was adapted with permission (E. Broadbent, personal communication, August 16 2016) from the Brief Illness Perceptions Questionnaire

(Broadbent, Petrie, Main, & Weinman, 2006) by changing the word 'illness' to 'injury'. In addition, the free response item requiring participants to rank order the three main causes of illness was removed, as this information is not required. A meta-analysis found that the brief IPQ has good psychometric properties and has been used with numerous populations and disorders (Broadbent et al., 2015).

The Rivermead Post Concussion Symptoms Questionnaire (RPQ). The RPQ (King, Crawford, Wenden, Moss, & Wade, 1995) is a 16 item self-report questionnaire. Participants rate the extent to which they suffer symptoms on a scale of zero to four. The RPQ assesses physical, cognitive, and mood symptoms, and was used to measure change in self-reported symptoms and symptom severity over time. The questionnaire was designed for use in a mild to moderate TBI population. It was found that the first three items of the questionnaire related to a separate construct to the other 13 items, however when scored separately the two scales have good reliability and adequate external construct validity (Eyres, Carey, Gilworth, Neumann, & Tennant, 2005).

The Rivermead Head Injury Follow Up Questionnaire (RHFUQ). The RHFUQ is a 10 item self-report questionnaire relating to changes in everyday activities and relationships from pre- to post-injury, thus 'following up' with patients post injury (Crawford, Wenden, & Wade, 1996). Rather than rating symptoms as per the RPQ, participants rate the change in their abilities and relationships on a scale of zero to four. The measure has adequate reliability and validity, and is a brief, simple measure of disability after mild to moderate head injury (Crawford et al., 1996). The RHFUQ was to be used to measure self-reported outcomes post-intervention.

Cognitive tests. The cognitive domains assessed were those most frequently affected by mTBI; memory (Landre et al., 2006; Macleod 2010; Barker-Collo et al., 2015), attention (Landre et al., 2006; Macleod, 2010), executive function (Barker-Collo et al., 2015) and

processing speed (Kay et al., 1992). See Table 3.1 below for the measures associated with each domain and the order in which the cognitive assessments were administered.

Table 3.1.

Test Selection and Associated Cognitive Domains in Order of Administration

Measure	Cognitive Domain Assessed
Logical Memory 1	Immediate verbal memory
Digit Span forward	Attention
Digit Span backward	Working memory
Verbal Fluency letter condition	Executive function (phonemic fluency)
Verbal Fluency category condition	Executive function (semantic fluency)
Verbal Fluency switch condition	Executive function (cognitive flexibility)
30 Seconds and Counting	Information processing speed
Paced Auditory Serial Addition Test	Information processing speed
Logical Memory 2	Delayed verbal memory

Logical Memory. Logical memory, a subtest from the Wechsler Memory Scales fourth edition (WMS-IV; Wechsler, 2009), requires participants to recall a short story immediately after its verbal presentation by the examiner, and again 20-30 minutes later. Test-retest reliability coefficients are reported as .74 for the immediate condition and .71 for the delayed condition. Logical memory tests have been found to differentiate mTBI sufferers from matched controls (Guilmette & Rasile, 1995) up to two years post-injury (Dikmen, Machamer, Temkin, & McLean, 1990).

Logical Memory was chosen for inclusion as the Concussion Service initially consulted did not use this measure, using the Rey Auditory Verbal Learning Test (RAVLT) instead. There was concern that using similar word list style measures would result in practice or interference effects that may affect assessment for treatment as usual, as well as the study results.

A literature search revealed two alternative forms for the Logical Memory task, both were used, allowing a different set of stories to be used for each testing time, thus eliminating the chance of participants recalling the story from their previous testing. All stories have 25

score-able items. One alternative form was created for New Zealand testees (Schnabel, 2012) thus did not require modification, however the Morris Revision-fourth edition (MR-IV) was created for American testees (Morris et al., 2014) and as such underwent revision to ensure its suitability for the study population. Revisions were designed to fit the New Zealand context while retaining the same number of syllables and similar meaning to the original terms. See Table 3.2 for the revisions made.

Table 3.2

List of Replacement Terms Used in the MR-IV

Original wording	Revision
St Louis	Mt Albert
Quarterback	Number 10
Savannah	Balclutha
Wolves	Stags
Football team	Rugby team

Digit Span Forwards and Backwards. Digit span forwards is a test of attention and immediate verbal recall from the Wechsler Adult Intelligence Scale fourth edition (WAIS-IV; Wechsler, 2008). Participants must recall increasingly long strings of digits after verbal presentation by the examiner. Wechsler (2008) reports a test-retest reliability coefficient of .77 for this subtest.

Digit span backwards is a subtest of the WAIS-IV that measures working memory. After verbal presentation of a string of digits, participants must repeat the digits in reverse order; the digit strings increase in length with each trial until a participant provides an incorrect response. Test-retest reliability has been reported as .71 (Wechsler, 2008).

In a study involving 20 administrations of several memory measures over four to five weeks, digit span forwards showed the least practice effect, while digit span backwards showed minimal practice effects and differentiated brain injured clients from healthy controls (Wilson, Watson, Baddeley, Emslie, & Evans, 2000).

Verbal Fluency. Verbal fluency is a subtest from the Delis Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001). It requires participants to search for and produce words while following certain rules (e.g., not using proper nouns or repeating words). The letter fluency test asks participants to name as many words beginning with a particular letter within 60 seconds, and the category fluency test to name as many items in a particular category (e.g., animals) as possible within 60 seconds. The category switch condition requires participants to name items from two categories for 60 seconds, alternating between the categories. These tests show good test-retest stability at .79 to .8 (Delis et al., 2001).

Similar tests of semantic and phonemic fluency have shown that mTBI sufferers produce fewer words and made more errors than non-injured controls, but utilised similar clustering strategies (Raskin & Rearick, 1996). Verbal fluency tests were not routinely administered by the Concussion Service that was consulted, thus it was deemed an appropriate measure of executive ability for the present study.

The D-KEFS contains two forms of the Verbal Fluency test, but three testing sessions were to be held. Several alternate versions of the phonemic and semantic fluency tasks are available, however their equivalence to other versions has been questioned (Barry, Bates, & Labouvie, 2008). No alternate version of the switching task could be sourced. Due to this, the standard version of the D-KEFS verbal fluency task was to be used for times one and three, and the alternate form for time two. A study of repeated neuropsychological testing at different intervals over one year found that similar fluency tasks were resistant to, or showed minimal, practice effects (Bartels, Wegrzyn, Wiedl, Ackermann, & Ehrenreich, 2010)

Paced Auditory Serial Addition Test (PASAT). The PASAT is a measure of information processing speed and attention that was created for use with TBI patients. Participants are presented with a string of numbers, every number presented at a pre-set interval, and asked to add together the most recent two numbers heard. It has shown utility with sufferers of both acute and chronic mTBI symptoms (Tombaugh, 2006). As it is somewhat aversive (Wills &

Leathem, 2004), only one trial was to be presented and was the second to last test in the assessment. The majority of information processing tests require visual presentation; the PASAT was chosen due to its verbal presentation mode and absence from the Concussion Service's assessment.

Thirty Seconds and Counting. This task was taken from the Brief Test of Adult Cognition by Telephone (BTACT) and measures speed of self-generated processing. Participants are given 30 seconds to count backwards from 100 as fast as possible. Errors are noted, however the primary measure is the speed of backward counting. A pilot study showed good test-retest reliability of r=.87 with a six month testing interval (Tun & Lachman, 2005). This test was included as an adjunct measure of information processing speed that relies little on arithmetic ability.

Scoring. Although all measures were to be analysed separately, it was important to also assess whether the treatment had an effect on overall cognitive function. To do this, a composite score of all of the cognitive measures was created by taking the sum of the z-scores for each individual.

Materials

Both the fish oil and sunflower oil were contained in 15 mm length, oblong shaped soft-gel capsules. Each fish oil capsule contained 497 mg of DHA and 117 mg of EPA and each sunflower oil capsule contained 1000 mg of sunflower oil. The two types of capsules were identical in size, colour and shape. Both capsules contained an orange oil flavouring which helped to mask the taste of the fish oil. The capsules were dispensed in white opaque plastic bottles, each bottle containing 200 capsules. Each bottle was labelled with the participant's code number, the required dose and directions.

Participants took four capsules each day, equating to a dose of 1.99 grams of DHA and .47 grams of EPA per day. Plasma DHA is considered a useful biomarker for brain DHA (Kuratko

& Salem, 2009) and has a dose-dependent relationship with dietary DHA (Arterburn et al., 2006). Dietary DHA supplementation results in a sharp increase of plasma DHA within the first month, and concentrations peak within 180 days (Katan, Deslypere, van Birgelen, Penders, & Zegwaard, 1997). A dose of approximately 2g DHA per day results in an near maximal plasma response (Arterburn et al., 2006), thus in order to achieve the highest concentration of DHA with the fewest capsules, a regime of 4 capsules per day for six months was selected.

Participants were provided with an A5 sized paper diary to record their fish consumption, missed supplement doses, and any other information they deemed relevant, e.g., side effects, changes in eating or exercising habits.

A toll free telephone number was available to allow participants and those considering participation to call the researcher with any queries. This was linked to the researcher's university computer account, so was accessible from any computer, allowing the researcher to accept and conduct calls from any office, and utilise a private space to conduct testing calls.

Localities

The study was conducted with the assistance of four Concussion Services. Locations covered included the greater Waikato, Bay of Plenty, Taranaki and Wellington/Kāpiti regions of New Zealand; (two of these services served the Waikato region).

Procedure

Randomisation. A research assistant used a random number generator (random.org) to assign study numbers to the fish oil and placebo capsules, create four groups of supplements (one group for each participating service) and create a randomised list to determine the order of distribution.

Two columns of random numbers, representing participant code numbers, were generated; one column assigned to the treatment, and the other to placebo. This list was placed in a sealed envelope and stored until the trial's completion. Four bottles of either the

treatment or the placebo were allocated to each number as determined by the randomised list. The assistant then divided the supplements into four groups with equal numbers of each type of capsule, and used the random number generator to randomise the list of numbers in each group. This became the order of distribution for each Concussion Service. The capsules were set aside in a cool, dark space to await transport to each clinic.

Recruitment. Participants were identified by the health professionals within the Concussion Services. They informed clients about the trial, administered an initial questionnaire to determine eligibility, and provided the information and consent forms. Participants returned their signed forms to the service, where they were assigned to the next study number on the service's random list and collected their supplements with instructions for administration and storage, and the weekly diary. Signed consent forms and participant information were scanned and emailed to the researcher in a password protected document. See Figure 3.1 for an outline of the process undertaken by the Concussion Services.

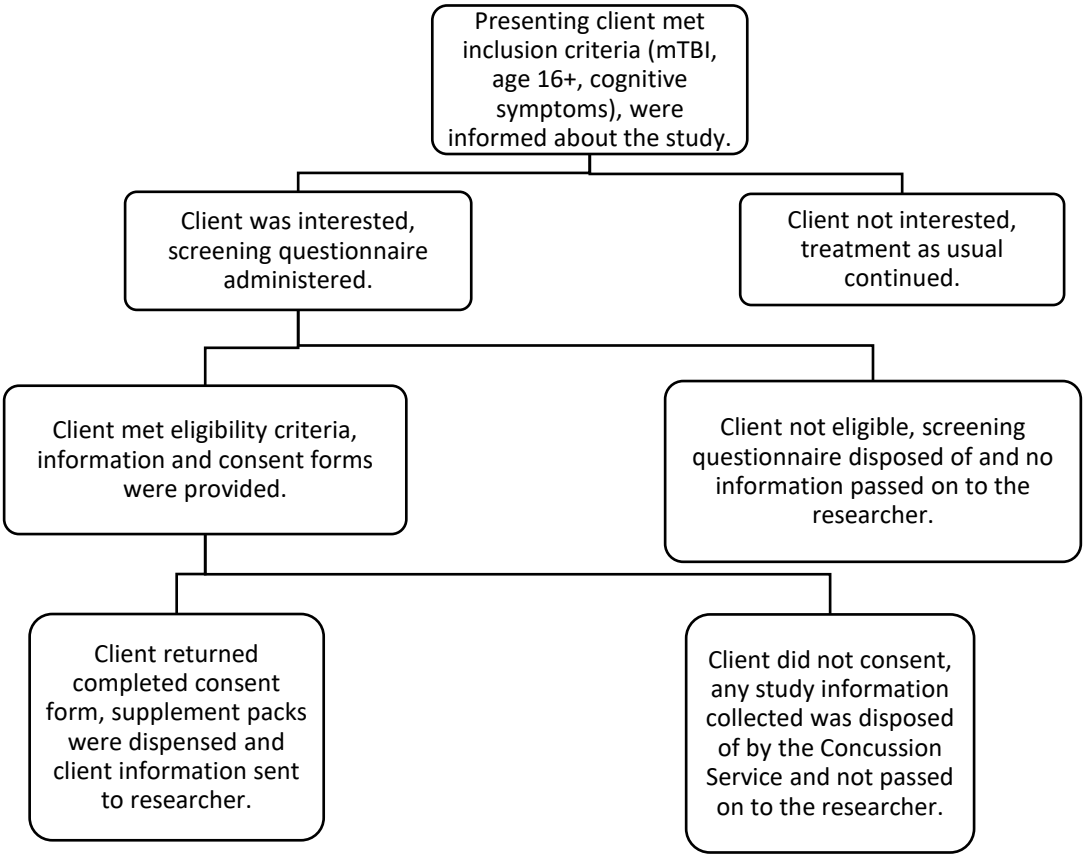

Figure 3.1. Recruitment process undertaken by the Concussion Services.

Testing and Communications. Upon receipt of the signed consent form and contact details, participants were phoned by the lead researcher to discuss the trial, answer any questions, and organise a time for baseline testing. As all testing occurred via telephone, participants were asked to ensure that if using a mobile phone it was fully charged, they had a distraction free environment, and that they were not to use a pen and paper for any part of the tests. For a diagram of participants' intended flow through the study, see Figure 3.2.

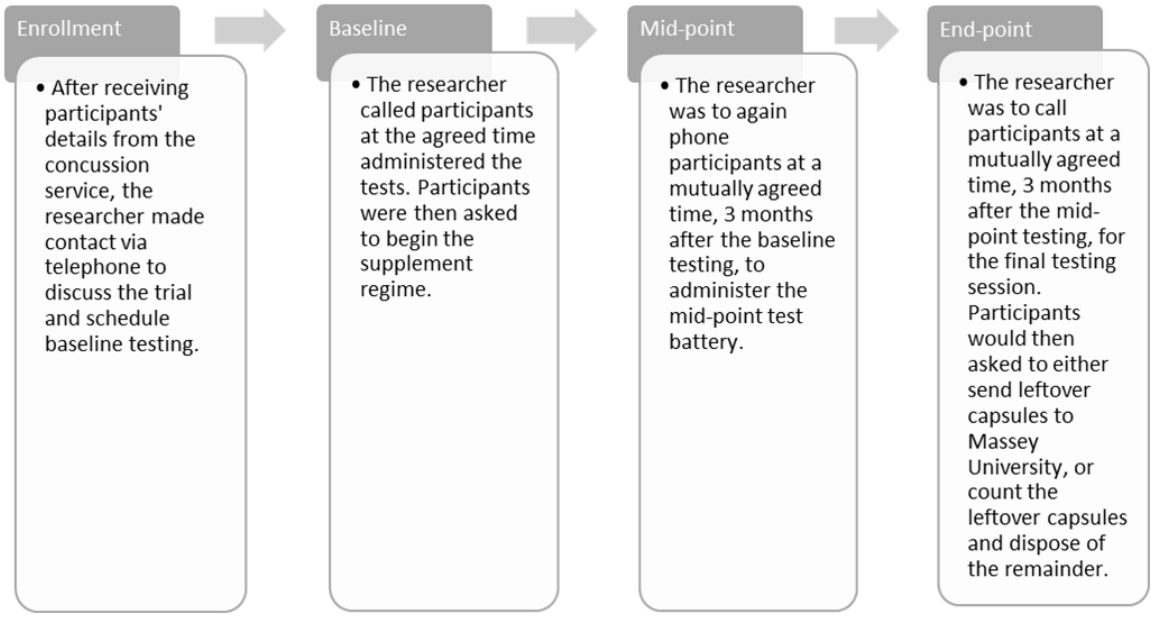

Figure 3.2. Individual Participants' Flow through the Study. In between the three testing sessions, participants were contacted each month to discuss any queries or concerns, and check whether the treatment was being adhered to.

For each testing session the researcher phoned participants from a distraction-free space using a headset to allow for ease of test administration and recording. Testing occurred at a mutually agreed time, and the researcher ensured that this time was still suitable when the phone call was made. Testing was to occur at baseline, three months, and six months after the supplements were begun.

Participants began the supplement regime after baseline testing. All information was provided in written form with the capsules, and reiterated over the phone. Participants were advised to store the capsules in the refrigerator, and take four each morning with breakfast

and water. They were asked to record their fish consumption and any missed doses in the diary.

Participants were contacted via telephone on a monthly basis to discuss their tolerance to the supplements, adherence to the treatment regime, and any questions or concerns they may have had.

At the conclusion of the study participants were asked to return any leftover capsules to the Massey University Psychology Clinic in Wellington, or dispose of them after counting and informing the researcher of the amount left over.

Ethics

The research proposal was approved by the Northern A Health and Disability Ethics Committee (reference: 16/NTA/206) and registered with the Australia New Zealand Clinical Trial Registry under the registration number ACTRN12617000040369.

The study was conducted in accordance with the Declaration of Helsinki (World Medical Association [WMA], 2013). The reporting of the methodology, results, and discussion was guided by the CONSORT statement guidelines for reporting parallel group randomised trials (Schulz, Altman, & Moher, 2011).

Statistical Analyses

Data was to be analysed using the latest available IBM SPSS software. Independent samples T-tests were to test for equivalence between groups on all dependent measures at baseline. Two way mixed between-within analysis of variance (ANOVA) tests were to analyse the outcome variables. The between subjects factor for this model was the group at two levels: treatment and control. The within subjects factor was the outcome measures at baseline, time two, and time three. The primary outcome was the between group comparison of a composite score on the cognitive measures, created by calculating then summing the z scores for each subtest. Secondary outcomes were between group comparisons of mood measures and post-

intervention disability data, and correlation of injury beliefs and cognitive outcomes at completion.

Dissemination of Results to Participants

Participants were offered the opportunity to receive a summary report of the study once it was completed. These were to be disseminated via email and post depending on participants' preferences. Individuals who requested personalised feedback were to receive a brief report outlining their scores on each domain of functioning at each time point.

Chapter Four: Study One Cessation

Due to unforeseen difficulties with recruitment, Study one was deemed unfeasible and terminated prior to the project's planned completion time. This chapter outlines the processes that were followed in attempt to conduct a feasible study, provides explanation for why the trial was cancelled, and discusses both limitations of the approach taken and recommendations for future research.

Study One Processes

Who was involved in recruitment. As the study was to be carried out by an individual researcher rather than a team, it was decided that recruitment would begin slowly, initially involving two services before expanding to others. This aimed to allow time for the researcher to undertake participant screening and testing, service provider liaison, clinical placements and other academic activities required of the Doctor of Clinical Psychology programme. Overall, seven Concussion Services were consulted, four of which agreed to participate and completed the locality approval process with the Health and Disability Ethics Committee (HDEC). As noted in Chapter Three, the four services involved covered the Wellington/Kāpiti, Waikato, Bay of Plenty, and Taranaki regions of New Zealand and included over twenty consulting health professionals. Table 4.1 below provides information about the services consulted and involved in recruitment, as well as their comments regarding the barriers to recruitment. Appendix A contains a detailed log of contact made between the researcher, participating services, and individual participants.

Table 4.1.

Concussion Service Involvement in Trial Recruitment

Service Location	Service Type/ Professionals involved	Date of Initial Consult	Date Locality Approval Completed	Number Recruited	Other Comments
Taranaki	Psychologists to concussion service	7 February 2017	13 February 2017	1	Few potential participants identified Advised neurologist to local concussion service frequently prescribed fish oil supplements
Waikato/ Bay of Plenty	Concussion service occupational and physio- therapists	7 February 2017	8 March 2017	3	Mobile service with no physical office Difficult to fit information into standard session times Many therapists felt clients were too unwell to be given information or make a decision
Waikato	Concussion service psychologists, occupational and physio- therapists	19 June 2017	23 August 2017	2	Several further potential participants identified, who upon discussion with researcher opted to purchase fish oil rather than participate
Wellington/ Kāpiti	Concussion service psychologists, occupational and physio- therapists	3 July 2017	31 October 2017	5	Several further potential participants identified, who upon discussion with researcher opted to purchase fish oil rather than participate Only DHB based service involved
Wellington/ Auckland	Concussion service psychologists	7 February 2017	n/a	n/a	Did not participate due to service's already high research load
Christchurch	Concussion service psychologists	6 March 2017	n/a	n/a	Prepared to participate if required. Not utilised due to difficulty recruiting, geographical distance from researcher, and changes to the study
Taranaki	Concussion service psychologist and occupational therapist	28 August 2017	n/a	n/a	Although initial response was enthusiastic, no further responses to requests for consideration were received

Alterations to Recruitment Processes

Due to the diverse nature of the participating services, some processes were altered in attempts to assist the recruiting clinicians and increase participant numbers. For example, to ensure that client privacy was upheld within each service; the researcher did not receive any client information prior to receiving a signed consent form unless the prospective participant chose to contact the researcher via the designated toll-free phone line. In such cases, the individual's eligibility, symptoms and queries or concerns were discussed but no official health information (e.g., the National Health Index number, clinician recorded LoC or GCS) was collected.

After several clinicians in the Waikato/Bay of Plenty service advised they struggled to make time to discuss the research and administer the eligibility questionnaire during client consults, a self-report eligibility questionnaire was created for participants to complete in their own time and return to their Concussion Service clinician along with their signed consent form at their next consult. This occurred in June 2017 and while clinicians advised they appreciated the change, recruitment continued to prove difficult. See Appendix B for the questionnaire.

The Taranaki based service stated they were better placed than the local Concussion Service physio- and occupational therapists to recruit participants, however they identified few eligible individuals. In order to increase recruitment in this region, in June 2017 a staff member reviewed recent cases and phoned to discuss the trial with those who were potentially eligible. Those interested were posted an information pack, including the self-report eligibility questionnaire and a consent form with a pre-paid envelope to return to the local service. Four information packs were sent, and two received back, however one of these individuals was ineligible due to allergy and the other initially consented but withdrew prior to baseline testing. As this service provided the neuropsychological consults to a local Taranaki concussion service and the Waikato/Bay of Plenty service already engaged with the trial, there was significant overlap in the information received from these teams. As the Waikato/Bay of Plenty

service saw clients prior to neuropsychological consult, the Taranaki team were asked to focus solely on Taranaki when contacting potential participants.

In November 2017 it was clear that it would not be possible to recruit enough participants to conduct the trial as initially planned. As there were several participants actively taking the supplements it was decided that a pilot study of fish oil versus no supplements could be conducted using these participants and any who consented in the coming months. The placebo was to be removed in order to prevent the possibility of a high number of participants taking the placebo compared with the active treatment.

Flow of Participants Through the Study

A total of 12 participants consented to take part in the study, please see Figure 4.1 below for a flow chart of participants' progress through the study. Several more individuals expressed interest to their care providers and/or the researcher, but for various reasons decided not to take part. Frequent reasons for declining were: upon further discussion they were ineligible due to current or recent fish oil supplementation, high fish consumption, vegetarianism, shellfish allergies, or attempting to conceive; the time commitment was too great; the study felt too cumbersome to deal with when feeling unwell; and most frequently the individual decided that she/he wanted to take fish oil and was not willing to risk being part of the placebo group. Those who during conversation with the researcher decided to purchase their own fish oil were advised to look for a supplement containing a high level of DHA and to take enough to reach one to two grams of DHA per day depending on their tolerance of the product. No specific products or brands were recommended.

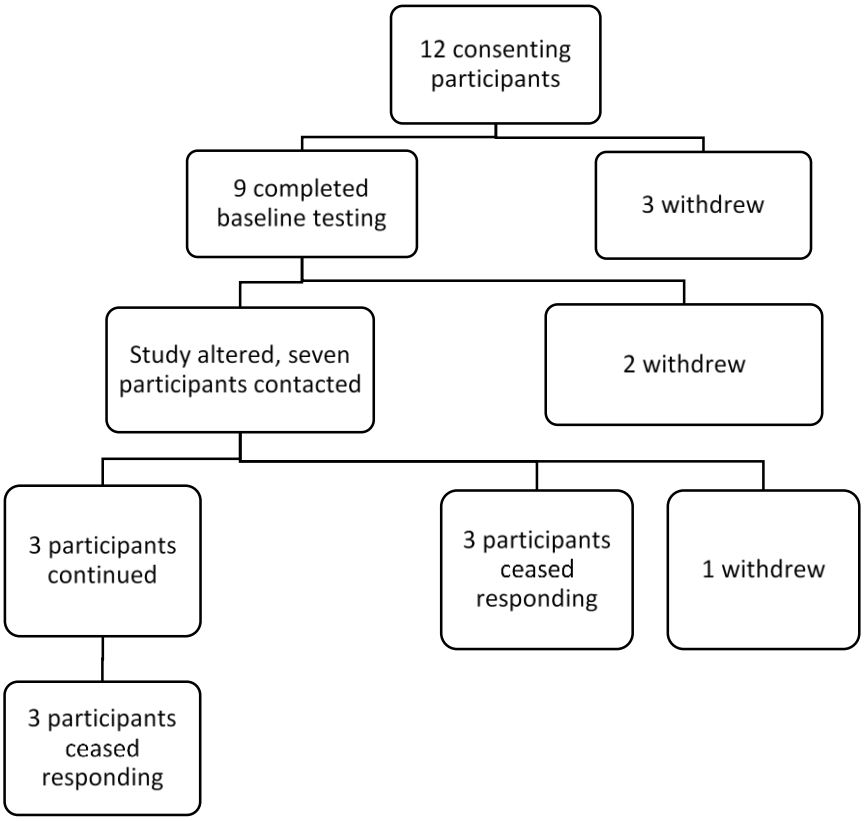

Figure 4.1. Flow of participants through the study.

Of the 12 consenting participants three dropped out prior to baseline testing with one citing stress and communication difficulties as the reasons (this participant did not have mobile reception at home and was struggling with returning to work) and the other two citing a lack of time and feeling much better as their reasons for not continuing. Two participants withdrew after baseline testing and prior to the proposed study changes, one experienced severe gastrointestinal side effects and the other stated she had forgotten to take the supplements "too many times" and could not be contacted to discuss this situation further. After the proposed changes to the study all participants were advised of the planned change and whether they were taking the active treatment or the placebo. They were offered the opportunity to cease the trial and keep or receive the fish oil supplements for their own benefit as a token of gratitude for their time, or if taking the fish oil from the beginning, to continue as per the initial agreement. Those taking the placebo were also offered the

opportunity to cease taking the capsules but remain in the trial as control participants, who at the end of the trial would receive a supermarket voucher as a token of gratitude. Only one participant, who was taking the placebo, decided to drop out of the study, one decided to stop taking the (placebo) supplements and become a control participant, and two elected to receive the fish oil and continue – one of these participants had recently completed the baseline testing and the other had yet to complete the baseline tests. However, several participants could not be reached by phone or by email to conduct this discussion. These participants were then advised of the changes to the study via email and their continued lack of response was deemed withdrawal of consent to participate.

Justification of Cancellation

Because the supplements expired in September 2018 the deadline for recruitment was six months prior to this - early March 2018. By the end of February 2018, no new participants had been recruited and those still active within the study could not be reached via telephone or email despite several attempts at making contact. This meant there were no participants remaining and too little existing data to conduct a feasible study, thus the trial was ceased.

Limitations

As briefly outlined above, the Concussion Service clinicians noted several barriers to successful participation and recruitment. These included being too busy both during consultations and with the resultant paperwork, clients being too unwell to focus on both the standard session content and the study information, having high caseloads so not taking further referrals, and high numbers of clients simply not being eligible. The majority of this feedback came from the Waikato/Bay of Plenty service, which was structured differently to those with a head office and a physical clinic for seeing clients. The other services provided few comments on barriers to effective recruitment when asked.

According to clinicians and several participants and potential participants, taking part in the study required too much effort. Participants were being asked to complete their

standard rehabilitation, continue with everyday life which often involved beginning their return to work while still suffering various effects of mTBI, and liaise with ACC regarding compensation and rehabilitation issues. Several individuals commented that it was difficult to keep track of their appointments, and that they felt very tired by the end of the baseline testing, indicating they were struggling with the very symptoms that the trial was aiming to treat.

Given the added burden during a time of difficulty, it may be that the study lacked adequate reward to justify the extra effort. The uncertainty about whether the supplements were active treatment or placebo, as well as the lack of tangible incentive to complete the trial, may have meant that it became low on individuals' list of priorities leading to eventual attrition.

Conducting the trial by telephone as a separate activity to standard rehabilitation may also have contributed to the high rate of attrition. As well as adding to the individual's mental load, the lack of face to face contact also served to add a sense of distance from the trial making it easier to decline, neglect, or drop out from. Where providers of standard treatment must report to ACC and can remind clients of the consequences of not attending appointments, there was no social or compensatory disadvantage to declining or dropping out from the study.

Recommendations

Given the barriers to participation expressed by both professionals and potential participants, several alterations to the nature and process of any future trial research into *n*-3 PUFA as a treatment for mTBI are suggested.

In order to increase participant eligibility, it is recommended that vegan supplements are manufactured for future trials. Vegan *n*-3 PUFA supplements are sourced from marine algae and use vegetable alternatives to gelatine encapsulating agents. This would prevent participants declining due to dietary choices and fish/shellfish allergies.

To decrease the number of appointments and the amount of testing for participants, future research could be carried out in closer alignment with the concussion services. This may mean employing concussion service psychologists to complete the testing, which would eliminate test crossover between the research and concussion services, eliminate the need for test selection to consider telephone administrability and thus enable more user-friendly tests of processing speed and executive function to be used, and enable the concussion service practitioners to use the data for their own practice with the client. This would likely require liaison with ACC, as concussion service psychologists tend to see clients only once due to ACC's concussion service contract allocating a set number of hours and a set dollar figure for neuropsychological consultation, and could theoretically involve using "their" data. In addition, for a meaningful trial to be conducted with the general population in this manner, sufficient time and funding must be available.

Prior to extending a future trial to the general population, research could be conducted in alliance with high level sports organisations, such as the New Zealand Rugby Union. Improving concussion outcomes, as well as experiencing the other beneficial effects of *n*-3 PUFA, is likely to be beneficial for players and organisations alike, and players with actively managed diets may be more likely to adhere to the treatment and attend testing sessions. Such a population is, however, less likely to be deficient in dietary DHA and more likely to recover from injury in a timely manner. As such, the likelihood of positive results may be lower than the general population who do not have ready access to dietary advice and management, and results may not be generalisable.

Removing the placebo control, as per the proposed changes to the present trial, may increase participation. This would however come at the expense of the scientific "gold standard" and preclude concluding that the *n*-3 PUFA supplements had had an effect over and above that of a placebo.

Conclusion

Numerous difficulties with participant recruitment and retention prevented this study from obtaining a sample large enough to conduct a meaningful trial, or any meaningful data from those who did participate. Due to this, as well as the time constraints associated with both the researcher's qualification framework and the supplements' shelf life, the trial was ceased. Future recommendations include conducting a larger scale trial with greater time and financial resources, in closer alliance with both ACC and the Concussion Service clinicians, as well as using a vegan product to increase client eligibility.

For the researcher, the difficulties encountered during this study provided many valuable lessons. It highlighted the disparity between research goals and researcher ambitions, and the reality of participants' everyday lives. It also underscored the lack of incentive for research participation and how this can affect motivation for both potential participants and those who have agreed to take part. Researcher reflections are discussed in more depth in Chapter Nine.

This concludes the *n*-3 PUFA portion of the present research. The following chapters present Study Two, focusing on healthcare practitioners' provision of information to individuals who have suffered mTBI.

Chapter Five: Information Provision after Mild Traumatic brain Injury

There has been substantial research focused on treating mTBI symptoms after they have arisen, including the consideration of *n*-3 PUFA supplementation as reported earlier. Anecdotal evidence from Study One participants and potential participants suggested that some mTBI patients did not receive adequate or understandable information, and this lack of information was distressing. Indeed, the importance of information to patient wellbeing is supported by literature. Providing patients and the people who support them with appropriate information after mTBI is important for safety, anxiety reduction, and symptom management (Morris, 2001; Ponsford et al., 2002). Several studies have shown that information provision upon discharge from acute settings can reduce an individual's overall health service use, may help to prevent ongoing symptoms, and can be as effective as more intensive treatment for many mTBI sufferers (Borg et al., 2004; Matuseviciene, Borg, Stalnacke, Ulfarsson & de Boussard, 2013; Paniak, Toller-Lobe, Durand, & Nagy, 1998; Paniak, Toller-Lobe, Reynolds, Melnyk & Nagy, 2000; Ponsford et al., 2002). This chapter reviews international and New Zealand based research on the benefits of providing information to mTBI sufferers, guidelines for providing information, and issues regarding the quality of information provided.

Information Provision as Treatment for MTBI

Information provision for adults. Borg and colleagues (2004) from the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury conducted a systematic literature review on non-surgical intervention for mTBI. They found evidence that early educational intervention can reduce long term complaints and that this intervention need not be intensive. The key studies contributing to Borg and colleagues' conclusion are summarised below along with more recent studies of the effectiveness of educational intervention for mTBI.

Paniak and colleagues (1998) compared an education-oriented single session treatment with a more extensive assessment in addition to "treatment-as-needed"

intervention for 111 adults with mTBI . The participants were recruited after admission to a hospital emergency ward and were randomised into the two treatment groups; treatment was begun no later than three weeks post-injury. The single session treatment involved reading a brochure on “Minor Head Injury” and discussing any concerns with the study investigator. The aims of treatment in this group included legitimising participants’ experiences, education about common post-mTBI complaints, advice on dealing with common complaints with a particular focus on rest as needed and gradual reintegration into activities, and reassurance of a positive outcome. Participants in this group were advised no further input would be provided by the study but were encouraged to seek treatment from their GP for any further concerns.

Those in the treatment-as-needed group received the same intervention as the single session group, with the addition of a three to four hour neuropsychological and personality assessment, feedback session, physical therapist consult, and ongoing treatment as needed for any identified mTBI related complaints.

Results on the Problem Checklist (PCL) and Short Form-36 (SF-36) health survey three to four months after injury showed significant improvement with time, but no difference between treatment groups. In addition, vocation related analyses such as occupational status and days before return to full-time pre-injury vocational activity, did not differ between groups. Results on the Community Integration Questionnaire (CIQ) were not significant, indicating no change with time (from pre-injury to follow up), group, or time and group interaction. The groups did not differ on the average number of treatment sessions sought outside of the study protocol, and neither did they differ on their ratings of satisfaction with treatment. Follow up data from 105 of these participants showed that the results did not significantly differ between the groups 12 months post-injury (Paniak et al., 2000). As such, the authors concluded that when applied within three weeks of sustaining a mTBI, a brief educational and reassurance related intervention is as effective as a more intensive assessment and treatment model.

Matuseviciene et al., (2013) like Paniak and colleagues, showed that the provision of information can be just as effective as more intensive treatment, even for those at higher risk of ongoing difficulties. The 80 participants deemed to be at high risk of experiencing enduring symptoms were randomised into an 'early intervention visit' group who were seen by a specialist rehabilitation medicine physician two to three weeks post-injury, and a treatment as usual group who were treated according to local routines and received written information about common mTBI symptoms and outcomes. No between group differences in the rate of overall or specific symptom amelioration were found on the RPQ, and no differences were found on the Hospital Anxiety and Depression Scales (HADS).

Rather than comparing two treatment groups, Ponsford and colleagues (2002) compared an intervention with a non-intervention group. They recruited 202 adult mTBI patients from two hospital emergency departments. The 79 individuals assigned to the intervention group were seen five to seven days post-injury, at which time they completed a detailed history and neuropsychological assessment before receiving an information booklet about mTBI symptoms, their likely time course, and suggested coping strategies. No specific feedback regarding assessment results was provided. The non-intervention group did not participate in assessment until the three month follow up period, nor did they receive the information booklet, however all participants were provided with standard emergency department care including advice to contact their family doctor with any further concerns.

At three months post-injury those in the non-intervention group were more likely to report symptoms on the Post-concussion Syndrome Checklist (PCSL), particularly difficulty sleeping and anxiety, and had higher scores on the Symptom Checklist 90-R global severity index, particularly the paranoia and hostility subscales. The groups performed similarly on the neuropsychological measures. The authors concluded that the provision of an information booklet reduces anxiety and reporting of ongoing symptoms after mTBI, however this does not consider a possible effect of the initial consultation and testing at the baseline assessment

period which may have provided additional reassurance for the intervention group as they had been seen and heard by a professional who was likely obliged to act on any issues had they been identified.

In a New Zealand based qualitative study by Snell, Martin, Surgenor, Siegert, and Hay-Smith, (2016) adult former mTBI patients also identified information as a necessary element of their treatment. Regardless of whether they had fully recovered by the time of their interview for the study, participants identified having a coherent understanding of their injury and recovery as important to their wellbeing. This coherent understanding included social support, validation and reassurance, and credible evidence-based information. They described feeling distressed when they weren't provided with information regarding what to expect with their recovery and what constituted a reasonable recovery timeline, or when the information provided was contradictory. Participants reported varied advice and levels of validation from their treatment providers, which served to either reassure them or magnify their distress and confusion. One participant described a health provider explaining how the experienced symptoms 'lined up' with the injury to a particular part of the head, which facilitated the individual's understanding of the experience. Up until this point, the participant had been "terrified". This study was conducted with various health and recovery professionals and shows that there may be a lack of coherence in the treatment of mTBI, including the information provided to patients by consulting professionals, in New Zealand.

Both quantitative and qualitative research has shown that timely information provision after mTBI is important for adult populations. Relevant information may be as effective as more intensive intervention for preventing the development of ongoing symptoms, as well as alleviating stress and anxiety, thus reducing service use.

Information provision for young persons. The majority of studies on information provision, and indeed treatment, for mTBI have focused on adults; few have considered adolescence as a unique developmental stage requiring different approaches to standard adult

or paediatric practices. Gagnon, Swaine, Champagne, and Lefebvre, (2008) considered adolescent and parent perspectives regarding adolescents' mTBI related service needs in a qualitative study. They interviewed individuals with varied levels of service use in the 12 months since injury and covered the impact of mTBI on different areas of the adolescent's life, their needs following injury, quality of services received, and any services they wish had been available to assist recovery. All adolescents and parents interviewed spoke of the need for information falling into the three broad categories of "what happened?... what to expect… and what can I/my teen do now?" (Gagnon et al., 2008, p. 165) and the expectation that healthcare providers should address the adolescents directly, rather than speaking only to their parents. All parents expressed a need to know about the injury and what to expect, and if these were not answered by the treatment providers they did not hesitate to look elsewhere for information, including to less reputable sources such as the internet or their friends. The adolescents expressed a need for timely service and professionals who are caring and acknowledge their differences from younger children, while many parents and some adolescents spoke about needing better communication between the health and school systems in order to assist the return to academic activity. Those with more severe or multiple injuries, and those experiencing ongoing symptoms, also wanted information regarding the prevention of future injury.

A related study also considered service provider perspectives using an eight person multidisciplinary focus group and validation survey of 33 further professionals (Swaine et al., 2008). Providers agreed that adolescents are a unique group but expressed that they often found them challenging. They spoke of risk taking behaviours such as fighting and taking drugs, as well as the strong desire to perform well in school and sporting endeavours which is often driven by parents, making it difficult to get them to take breaks or pace themselves in times of illness or injury. They agreed that information was the most important element of service provision but expressed wariness of providing too much information out of concern for

encouraging symptom malingering. The authors however, found no evidence of a relationship between the amount of information received and persisting symptoms following mTBI. A study with mTBI sufferers aged six to 15 years provided with an information booklet reported fewer symptoms and less stress three months post-injury than those who did not receive the booklet (Ponsford et al., 2001). This booklet included symptom information and coping strategies, was given to the parents/guardians of the participants, but was written with simple language and cartoon illustrations, and directly addressed the child.

A Chicago based longitudinal cohort study found that adolescents who had suffered mTBI experienced significantly greater levels of aggressive behaviour, delinquency and anxiety and depression symptoms compared with non-mTBI sufferers two to three years after injury, even after controlling for previous psychopathology (Connolly & McCormick, 2019). Together these studies suggest a need for information in the adolescent population, and perhaps a degree of disconnection between patient needs and service provision, potentially owing to value judgements from some practitioners acting as a barrier to providing best-practice care.

Taken together, these studies show that the timely provision of detailed information and reassurance may reduce ongoing symptoms and related service use, as well as patient distress, post-mTBI. Relevant information and reassurance is important and effective for adults, young persons and caregivers. It is also evident that the information routinely provided is not always timely and/or detailed enough to have these effects.

Recommendations for Information Provision

The United Kingdom based National Institute for Health and Care excellence (NICE) and Scottish Intercollegiate Guidelines Network (SIGN) have created guidelines for healthcare professionals providing information to mTBI sufferers and/or their caregivers. Both organisations recommend giving both verbal and printed discharge advice to patients – and their families or carers – with mTBI upon discharge. They both provide examples of

appropriate leaflets, though rather than being specific to mTBI these are for adults who have sustained any degree of 'head injury'.

According to NICE (2014), printed information should be age appropriate and inclusive of both acute care and ongoing recovery related details. For the acute period they recommend including details of the nature and severity of the injury, risk factors signalling a need to return to the emergency department (e.g., lack of full consciousness, prolonged drowsiness during normal wake times, confusion, focal signs, vomiting, seizures, bleeding from the ears, fluid discharge from ears or nose), and a specification that a responsible adult should stay with the patient for the first 24 hours after their injury. Ongoing care information should include: details about the recovery process, including the fact that some patients may appear to make a quick recovery but later experience symptoms; some may experience ongoing symptoms; contact details of community and hospital services in case of delayed or ongoing complications; information about return to everyday activities, including school, work, sports and driving; and details of support organisations. For those who presented with drug or alcohol intoxication, information and advice on alcohol or drug misuse is also recommended.

Some of the advice on the suggested information sheet is ambiguous, for example the advice regarding driving, operating machinery, and returning to work or school states that patients should not return to these activities until they feel that they have "fully recovered". However it may be difficult for an individual suffering cognitive difficulties to know when they are 'fully recovered' or it may not be feasible to completely abstain from such activities for the time required for all symptoms to fully remit. Also, regarding the use of sedatives, tranquilisers or sleeping pills the leaflet states these shouldn't be taken "unless given by a doctor" which some patients may take to mean they can safely continue taking such medications if they were prescribed pre-injury.

While the NICE example discharge advice card provides the details listed above for patients discharged after any degree of head injury, SIGN (2009) provide a similar, though

slightly less detailed, information sheet for patients "allowed home from the ED" indicating it may be targeted toward more mild injuries as they have not required hospital admission. The SIGN example leaflet provides brief information regarding common symptoms and recovery. It advises that people can feel unwell with symptoms such as slight headache, dizziness, memory problems, poor concentration, irritability or being easily annoyed, tiredness, and/or poor sleep, even after discharge. It states that symptoms should clear up without any treatment, but if they persist for two weeks the patient should see their doctor. It also provides some extra advice to aid recovery such as resting and avoiding stressful and noisy situations; abstaining from alcohol, non-prescribed drugs, sleeping pills, sedatives and tranquillisers; and avoiding contact sport for at least three weeks unless cleared by a doctor. Unlike the NICE guidelines, SIGN do not advise on symptoms that warrant a return to the emergency department.

The Centres for Disease Control and Prevention (CDC) produced a 'patient take-home instructions' information sheet for sufferers of 'concussion', based on mTBI policy published by Jagoda et al. (2009). This sheet provides space for personalised instructions from the healthcare provider and tick boxes for whether or not the patient underwent CT scanning and the reassurance of no injury findings if yes, or rationale if no. They provide a list of reasons to return to the emergency department (repeated vomiting, worsening headache, loss of or waning consciousness, confusion or agitation, seizure, difficulty with walking or balance, weakness or numbness, vision problems, and any symptom that concerns the patient or their family or friends) along with the explanation that serious problems sometimes develop after a head injury. This sheet goes on to provide information and advice via a question and answer section, making it stylistically quite different to the NICE and SIGN leaflets. The Q&A section explains what a concussion is and that most people recover quickly and fully, lists common symptoms grouped into four domains (thinking/remembering, physical, emotional/mood, and sleep), and provides advice on rest, alcohol consumption, discussing the injury with work for

compensation purposes if the injury was work related, when to seek a doctor's advice (e.g., before return to driving, sport and recreational activities, or not improving after a week) and avoiding concussion in future.

Like both NICE and SIGN, the New Zealand Guidelines Group (NZGG, 2006) recommendations for post-injury information are often in the context of TBI of any severity rather than specific to mTBI. Unlike the other groups discussed above, the NZGG did not produce a sample information sheet, however they did recommend that all patients with suspected or confirmed TBI receive both verbal and written advice upon discharge. They advise that patient information should cover symptoms and signs which may indicate a need for further investigation, including what action the patient or their caregiver should take if they experience any of these (such as, go to a general practitioner or Emergency Department); reassurance about common symptoms and signs that need not be cause for concern (e.g., headache, nausea, dizziness, blurred vision, confusion, fatigue, poor concentration, memory problems, sleep difficulties, irritability and noise intolerance), including the expected progress and resolution of such after-effects of the injury. The NZGG acknowledge that early, relevant information about common symptoms of mild TBI, emphasising high rates of recovery, can positively influence the rate of later persistent symptoms.

Regarding longer term difficulties or disability, NZGG state that all people with head injury of any severity, and their carers, should be made aware of the possibility of long-term symptoms and disabilities from a TBI, as well as the existence of services that they could contact should they experience long-term problems. Details of support services should be included on written discharge advice and patients should also be advised to contact their doctors about these problems. Advice about safety and self-care, including minimising the risk of re-injury and caution with use of drugs and alcohol, information and advice on alcohol or drug misuse for people who initially presented with drug or alcohol intoxication, and information about community resources should also be provided.

The NZGG also stipulate the manner in which information should be provided. They advise that information about possible long-term effects should be given in a practical and reassuring manner, and efforts should be made to alleviate concerns. They state that this is particularly important for people who appear more anxious and thus may attribute unrelated symptoms to the TBI, after the TBI sequelae have resolved. The details of this written information should be discussed with the patient and their carer and if necessary, other formats (such as other languages, pictures, tapes or videos) should be used to communicate. Written information should be offered proactively rather than upon request and when being given the material, patients and support persons should be given the opportunity to ask questions and express concerns, with the practitioner available to provide reassurance and advice.

All of the above guidelines recommend providing similar information, with variation relating to how detailed discharge forms should be and the timing of further consultation for ongoing issues or returning to activities. The NZGG may recommend the most detailed discharge information, however this advice relates to TBI of any severity and is spread across several chapters of their guideline document. They have not provided a template for patient information sheets; doing so could assist professionals to adhere to the guidelines and ensure patients receive the recommended timely and detailed advice. The NZGG also add valuable advice for practitioners regarding the manner of providing information, as well as formats that should be available.

Issues with Information Provided Following MTBI

International studies have shown substantial variability in the written information provided to patients after a mTBI in terms of both content and accessibility of the information (Baker et al., 2015; Kempe et al., 2014; Macdonald et al., 2010; Peachey et al., 2011). This is perhaps unsurprising given the variation in guidelines and examples provided by prominent groups such as NICE, SIGN, CDC and NZGG.

Macdonald and colleagues (2010) compared 45 head injury related leaflets from the 30 Emergency Departments in Scotland with the SIGN recommendations on early management of head injuries. They scored each leaflet one point for each guideline included, then calculated the total as a percentage of the SIGN guidelines. Twenty-four of the leaflets provided less than half of the information recommended by SIGN, and none provided all of the recommended information. In addition, readability was assessed using the Simplified Measure of Gobbeldygook (SMOG) and the Flesch Reading Ease (FRE) scale, while legibility was assessed against the Royal National Institute for the Blind (RNIB) clear print guidelines. No leaflets met the recommendation for a 5th grade or lower reading level with all written at the 8th grade level or above, the mean FRE score was in the 'fairly difficult' range which is able to be understood by approximately 40% of the population, and mean compliance with RNIB guidelines was 78%, with many leaflets neglecting the font size and text justification criteria thereby making them difficult to read.

A study by Peachy and colleagues (2011) also found issues with the content of written discharge information for mTBI sufferers. The authors created a comprehensive leaflet based on the NICE and SIGN guidelines and used this as a template against which to evaluate leaflets received from the 35 Emergency Departments in the Republic of Ireland. The authors reported that all EDs discharged patients with written information, but there was substantial variability in the amount and quality. Most sheets included information on symptoms that should trigger a return to the ED, though this was varied, particularly the advice regarding vomiting. Many information leaflets lacked important information regarding post-concussion symptoms and how to aid recovery. In addition, only 46% of EDs used separate information sheets for children, with only one providing a specialised sheet for infants and toddlers; 54% provided information for carers, with two EDs not providing information for the patient him/herself. One ED offered their leaflet in large print, and none provided leaflets in braille, audio-format,

or languages other than English, thus the vast majority of information available was accessible only to English speakers with adequate visual ability.

Kempe and colleagues (2014) assessed written information provided to mTBI sufferers by four hospitals in South-East Queensland, Australia, as well as publications available from reputable sources (e.g., government departments) on the internet. These authors also found highly varied information and accessibility, showing that some publications met most of the NICE and SIGN guidelines while others did not. On average, the publications covered approximately two thirds of the recommended content with the most common omissions relating to post-injury symptoms (e.g., what symptoms to expect and how long they may last) and recovery advice. Eighty percent of the assessed publications had an FRE score less than 70, indicating some were considered 'standard' while others were more difficult, and therefore the information was inaccessible to much of the population.

Another Australian study focused on advice regarding fitness to drive after mTBI. Baker and colleagues (2015) surveyed EDs across Australia and found only 36% of responding EDs recommended a period of no driving following mTBI, and the advice regarding when to return to driving was varied. Many clinicians reportedly expressed a need for a review of fitness to drive guidelines. As noted previously the driving advice recommended by NICE is somewhat ambiguous and possibly difficult for a patient to gauge, particularly when not provided with sufficient information regarding ongoing symptoms and how to manage these. The CDC recommend asking a healthcare professional for advice before returning to driving, and when discussing the present study Baker et al. (2015) posit that occupational therapists are well positioned to be those healthcare professionals. It may be unlikely however, that most mTBI sufferers are able to consult an occupational therapist prior to returning to driving.

These international studies show considerable variability in the content of advice provided to mTBI patients and suggest that many did not adhere to published guidelines. In

addition, information tended to be available in limited language and format options, potentially disadvantaging those with disabilities or diverse cultural backgrounds.

Information Provision in the New Zealand Context

A New Zealand study (Moore & Leathem, 2004) found that only 45.9% of the New Zealand Emergency Departments and General Practitioners that responded to their postal survey, provided written information to patients who had a confirmed or suspected mTBI. Considerably more EDs (93.4%) than GPs (42.8%) provided written information. The information sheets ranged from one to ten pages in length thus were varied in content and quality, though all provided information regarding what symptoms to watch for (e.g., vomiting, severe headache, weakness, visual disturbance, and inability to rouse the patient). Approximately half of the sheets included information regarding the return to activities such as driving (61.7%), sport or exercise (58.3%) and school or work (40%), though the quality of this information varied, for example driving advice ranged from many suggesting periods of at least 24 hours before driving and others leaving it to individual judgement. Forty three percent of information sheets identified the likelihood of ongoing symptoms, with only 10% providing advice about what to do about any ongoing concerns. Regarding the accessibility of these information sheets, just over half of the sheets provided by GPs were considered readable by 70% of the population, while over 92% of ED information sheets met this criterion (FRE score over 61). The majority of information sheets adhered to the National Institute for the Blind recommendations to use at least 12 point font, keep the right margin unjustified and to use headings and bullet points to guide the reader. Since this study took place, several patient leaflets have been produced by the ACC and are based on the NZGG recommendations, but it is not known if these are routinely provided to patients by their healthcare providers, or which leaflets are most used. These leaflets are brief advice forms aimed at patients being discharged after ‘head injury’ or ‘concussion’ and/or their caregivers.

Like participants in Snell and colleagues' (2016) Christchurch based study, individuals discussing participation in Study One with the researcher frequently indicated uncertainty about what was happening with their health and recovery. They indicated that they did not have a clear understanding of which symptoms commonly occurred in the weeks and sometimes months after a mTBI and were often surprised to learn that what they were experiencing was not uncommon. This may suggest that the ACC and other leaflets are not in routine use, however this cannot be gauged by the small sample from study one. In several instances, treatment providers had recommended these individuals take dietary supplements (as well as prescribed medications), though the individuals concerned were not certain why, other than being "good for concussion". As outlined in the background for Study One there is some evidence of dietary supplements such as long chain omega-3 fatty acids (e.g., fish oil) having the potential to treat mTBI symptoms, however this does not form part of standard treatment guidelines. Patient information guidelines (e.g., the EQIP by Moult, Franck & Brady, 2004) recommend providing patients with an overview of benefits, risks, and alternatives to any prescribed or recommended treatments. It appears that the information provided to mTBI sufferers in New Zealand remains highly varied and neither restricted to, nor encompassing all of, the guidelines published by reputable organisations such as SIGN, NICE, CDC or the NZGG.

Summary

Taken together the studies reviewed above suggest that the routine provision of more intensive treatment may not be necessary in this patient population, and the timely provision of information relating to injury symptoms, recovery timeframes, advice on returning to premorbid activities, and the expectation of a positive outcome may reduce future morbidity and related service use. Patients have expressed the need for such advice, distress when it is not forthcoming or is contradictory, and the tendency to seek said advice from less than reputable sources when not received by healthcare providers. The guidelines for information provision also recommend that health practitioners provide such advice in a

timely and reassuring manner while remaining available to address follow up questions and concerns. Provision of this information and service to mTBI sufferers however, is inconsistent both internationally and nationally in terms of the content of the information provided, the manner in which it is provided, and how accessible it is to the general population. In addition, previous New Zealand based research on the content and accessibility of patient information is out of date, particularly considering the subsequent publication of the NZGG advice and ACC leaflets, as well as the increasing tendency of individuals to source information from the internet. Study Two aimed to assess the consistency, quality, and accessibility of information provided to mTBI sufferers in New Zealand.

Chapter Six: Study Two Methodology

This chapter provides a description of Study Two's design, including the rationale, participants, procedures, analyses and dissemination of results.

The main objective of this study was to investigate the consistency, quality and accessibility of information provided to patients and/or caregivers after mTBI. Only patient literature, rather than information accessible on the internet, was considered. The study also aimed to determine the frequency with which health practitioners provided information, including the ACC leaflets. A key consideration and point of difference from prior research was the inclusion of allied health professionals and providers working in post-acute settings (e.g., concussion clinics) in addition to medical and administrative staff from emergency departments and general practices, who have been the focus of prior studies.

The survey also sought to replicate and expand on Moore and Leathem's 2004 study to gain an understanding of contemporary practices for providing information to mTBI patients. It assessed provided information using multiple established criteria, and surveyed health professionals on the information they impart via other means (e.g., verbally) as well as any barriers they face when seeking to provide their patients with information. By surveying emergency department, general practice, and concussion service professionals this study also aimed to show differences between information provision practices and materials between service areas, as well as the potential flow of information patients receive should they require ongoing care.

Design

The study was a survey design that utilised systematic and convenience sampling methods to select participating practices and individuals respectively.

Hypotheses

It was hypothesised that a majority of healthcare providers would provide both written and verbal information, though the content and accessibility of information provided

would vary between service areas. In light of ACC publishing their brochures however, it was hypothesised that the frequency of information provision would have improved since Moore and Leathem's (2004) study and that the ACC publications would be provided by a majority of hospitals and general practices. It was also hypothesised that in line with international research (Peachey et al., 2011), the majority of written information available for health professionals to provide would be limited to the English language and standard print formats, and that both consultation times and the patients' own symptoms (e.g., difficulty concentrating) would be the most frequently reported barriers to providing information.

Participants

Participants were workers from general practices, hospital emergency departments, and concussion clinics. The survey was open to any health professional in a patient-facing position who interacted with people post mTBI . This included doctors, nurses, physiotherapists, occupational therapists, psychologists, other allied health staff and administrative staff.

Measures

Similar to the Moore and Leathem (2004) study data was collected via survey, though rather than via post, the survey was conducted online.

Survey questions. Participants were asked to provide general information such as their profession, the geographic location of their practice, the type of practice they worked in, and the approximate number of mTBI patients they had seen in the last month. This information provided an understanding of how representative the sample was and assisted with dividing the sample for analyses. See Appendix C for the full survey.

Participants were also asked to outline the type of information and advice that was typically provided to patients, by whom this was provided, and in what form this was provided and/or available (e.g., verbal, written, audio, visual). This aimed to assess the type and accessibility of information that survey respondents may provide in forms other than pre-

prepared information sheets, or may have been unable or unwilling to upload to the survey as requested. It also partially addressed the NZGG's advice on the manner in which information should be provided to patients.

Participants were asked about the most frequent symptoms encountered in their practice with mTBI patients and to outline the advice they provided for specific symptoms and treatments. This served to help assess consistency in advice giving as well as whether practitioners were meeting the guidelines for providing information on the risks, benefits, and alternatives to recommended treatments – necessary elements for informed choice.

Perceived barriers to providing information to patients were also queried, and this information aimed to identify reasons for the non-provision of information and any gaps in the current patient literature (e.g., the need for more Te Reo Māori[2] resources).

Assessment of information sheets. Several criteria have been developed for evaluating patient literature both generally and specifically relating to mTBI.

For assessing the accessibility of patient literature more generally, scales of reading ease are frequently used. The Flesch Reading Ease (FRE) scale is perhaps the most widely known and assesses the 'readability' of English language text based on the average sentence length and average word length, which is determined by the number of syllables. Scores range from zero (very difficult) to 100 (very easy) and can be used to estimate the reading grade level. As Jindal and Macdermid (2017) note, the FRE has several limitations when assessing patient literature. It does not account for audience factors (e.g., prior knowledge, health literacy, anxiety); document factors (e.g., tables, figures, spacing, grammar, font colour, layout or legibility); or writing style (e.g., cultural sensitivity, appropriateness for the audience or setting, or comprehensiveness) all of which can alter the accessibility of the information contained in a document.

[2] Te Reo Māori is an official language of New Zealand.

As a means of evaluating the style and usefulness of patient information overlooked by the FRE, Moult and colleagues (2004) created the Ensuring Quality Information for Patients (EQIP) questionnaire. The EQIP assesses the order of information, language use and tone, layout, information about publication (e.g., the publishing date), safety of medications and procedures, and further support. This constitutes general quality guidelines for ensuring patients receive up-to-date and useful information. Moult and colleagues' study showed good preliminary reliability and validity, and this measure may be a useful adjunct for use with readability measures (Jindal & Macdermid, 2017).

Accessibility also refers to the clarity of the actual print, and guidelines for this are often produced by agencies advocating for those with visual impairments. As noted in the previous chapter, Moore and Leathem (2004) and Macdonald et al. (2010) used guidelines produced by the Royal National Institute for the Blind (RNIB) to assess the information sheets received in their respective studies. The Round Table on Information Access for People with Print Disabilities (2011) expanded on the RNIB guidelines to create a handbook of guidelines for producing clear print for use in Australia and New Zealand. This document includes information about clear print, large print, how people with low vision read, font requirements, text layout, contrast, page layout, navigational aids, graphics, tables, printing and reformatting.

Macdonald and colleagues (2010) have combined the above guidelines to form the Patient Literature Usefulness Index (PLUI) that allows for the comparison of patient information sheets. The PLUI is a weighted composite of scores on four different sets of criteria: percentage compliance with content guidelines (e.g., the SIGN leaflet; 45%), average readability score from two or more measures (25%), RNIB compliance percentage (20%) and standard information compliance (e.g., service contact information, date of publication/version number, document name, patient signoff, date seen; 10%).

Ethics

This research project was evaluated by peer review and judged to be low risk. Consequently, review by one of the University's Human Ethics Committees was not required. Ethics approval was sought and granted from several organisations that advised they required this process; their correspondence is available in Appendix D. Four of the responding district health boards required lengthy ethics application and consultation processes; it was decided these would not be pursued due to time constraints.

The survey was securely hosted on the Qualtrics server and jointly managed by the coordinating investigator and the Qualtrics licence holder for the Massey University School of Psychology. The survey was closed manually by the lead researcher after 20 weeks.

All participants provided informed consent by selecting a 'yes' option after reviewing the electronic information sheet. For any participants who elected not to consent, the survey displayed a thank-you message and did not proceed to the question pages.

Hard copy information was stored in a locked file, and all electronic information in password protected files on password protected devices accessible only by the coordinating investigator. No identifying information was collected.

Procedure

In line with Moore and Leathem (2004) all New Zealand hospital emergency departments and every fifth general practice from a public directory were contacted via email with a request to participate in the survey. To expand on this study, all concussion clinics identified by an internet search using the terms 'concussion clinic' and 'concussion service' were also contacted. The directory consulted for general practices was www.healthpoint.co.nz and search terms included 'general practice', 'medical centre', and 'medical clinic'. Results were sorted into alphabetical order before every fifth practice was contacted. Practices that did not list an email address were phoned to introduce the study and request an appropriate email contact. Following a poor response rate from general practices, all Primary Health

Organisations were contacted with a request to forward the survey to the general practices they oversee, thus theoretically requesting participation from every GP practice in the country.

A link to the electronic survey was sent with the initial email to the research, administration, or management email address of the selected healthcare providers. Also included was information about the researcher and the study, and a request to distribute the survey among relevant staff. Where required by certain organisations (i.e., some DHBs), ethics application procedures were begun on receipt of the appropriate request forms and, once approved, organisational procedures were followed for distributing the survey among their staff.

The survey was opened on May 13th, 2019 and closed on September 28th, 2019. Upon the close of the survey all information sheets were downloaded for analysis. These were assessed using the PLUI modified to use only the FRE as the readability measure rather than an average of two, as criteria for other readability measures (such as the number of sentences present) were not met. The PLUI was further modified to include the EQIP as the measure of 'standard information compliance'.

Descriptive statistics were used to compare information sheets' adherence to guidelines, compare practitioners other advice and methods of providing advice, and determine how this differed across regions, services and professions. Data was analysed using version 22 of SPSS for Windows.

Dissemination of Results to Participants

As participation was anonymous, summary reports could not be sent to individuals upon completion of the study. Several participating DHBs required a report of results as part of their ethics approval processes, and these were subsequently forwarded to the respective research offices.

Chapter Seven: Study Two Results

Respondent Characteristics

Of the 125 valid responses to the survey received[3], 56.8% (*n*=71) were from hospital Emergency Department (ED) staff (52.1% nurses, 46.5% physicians, 1.4% unstated), 17.6% (*n*=22) from Community Medical facilities (77.3% General Practitioners), and 25.6% (*n*=32) from ongoing Rehabilitation providers[4] (40.6% occupational therapists). As of June 2019 there were 3671 GPs and 319 ED physicians with a current practicing certificate and vocational scope in New Zealand (Medical Council of New Zealand, 2019), thus only 10% of ED physicians and less than one percent of GPs are represented in the present survey. In addition, it is estimated that over 6000 nurses work within relevant settings, so less than one percent of the nursing workforce is represented (Nursing Council of New Zealand, 2020). No data were available for the number of allied health professionals working within Concussion Services. The majority of responses came from the North Island, with 35.4% of these from the Wellington region. Table 7.1 provides a breakdown of responses by professional group, region and whether rural or urban for the three service areas, as well as the frequency of response from each DHB region.

Most respondents (66.4%) from all groups had seen between one and ten mTBI patients in the previous month. ED staff were most likely to have seen more than this (26.8% had seen 11-20, 8.4% 21-40, and 1.4% over 50 mTBI patients).

[3] 125 respondents consented and provided some responses; not all questions were answered by all participants.
[4] Including concussion services, vocational rehabilitation, sports rehabilitation physicians, and private practice allied healthcare providers.

Table 7.1

Number of Health Professionals and Regional Distributions of Respondents in each Service Area

	Hospital ED[5] N (% total sample)	Community[6] Medical N (% total sample)	Rehabilitation N (% total sample)	Total
Professional Group				
Administrator		1 (0.8)	2 (1.6)	3 (2.4)
Nurse	37 (29.6)	2 (1.6)		39 (42.2)
ED Physician	33 (26.4)			33 (36.4)
General Practitioner		17 (13.6)		17 (13.6)
Other Medical Specialist			4 (3.2)	4 (3.2)
Physiotherapist		1 (0.8)	6 (4.8)	7 (5.5)
Occupational Therapist			13 (10.4)	13 (10.4)
Psychologist		1 (0.8)	3 (2.4)	4 (3.2)
Other Allied Health			4 (3.2)	4 (3.2)
Regions[7]				
Wellington/Kāpiti	34 (27.2)	1 (0.8)	5 (4.0)	40 (32)
Auckland	10 (8.0)	2 (1.6)	5 (4.0)	17 (13.3)
Waikato	9 (7.2)	1 (0.8)	5 (4.0)	15 (12)
Whanganui	8 (6.4)			8 (6.4)
Southern District		7 (5.6)	1 (0.8)	8 (6.4)
BOP	1 (0.8)	1 (0.8)	3 (2.4)	5 (4.0)
Lakes	3 (2.4)		2 (1.6)	5 (4.0)
Waitemata		3 (2.4)	2 (1.6)	5 (4.0)
Northland	2 (1.6)		2 (1.6)	4 (3.2)
Taranaki	3 (2.4)	1 (0.8)		4 (3.2)
Hawkes Bay		1 (0.8)	2 (1.6)	3 (2.0)
Manawatū/Horowhenua			3 (2.4)	3 (2.0)
Nelson/Marlborough		2 (1.6)		2 (2.0)
Counties Manukau			2 (1.6)	2 (2.0)
Tairāwhiti	1 (0.8)			1 (0.8)
Wairarapa		1 (0.8)		1 (0.8)
South Canterbury		1 (0.8)		1 (0.8)
North Island Total	71 (56.8)	11 (8.8)	31 (24.8)	113 (90.4)
South Island Total		10 (8)	1 (0.8)	11 (8.8)
Urban	67 (53.6)	15 (12)	27 (21.6)	109 (87.2)
Rural	4 (5.6)	7 (31.8)	4 (12.5)	15 (12)

Note. No responses were received from the Canterbury, West Coast, or Otago regions.

[5] One respondent from this group did not state their profession.

[6] This category combined both general practice medical clinics and the one responding accident and medical facility.

[7] One respondent from the Community Medical group did not state their region; one respondent from the Rehabilitation group did not state whether urban or rural.

Provision of Written Information Sheets

The vast majority of respondents (92.8%) provided information in some format. Written Information was provided by 84.8% (*n*=106) of respondents (93% ED; 75% Rehabilitation and 72.7% Community Medical) usually accompanied by verbal information (81%). In 43.2% (*n*=60)of cases, the written information was personalised (42.3% ED, 18.2% Community Medical, 62.5% Rehabilitation). Of the 13.6% (*n*=17) of respondents (5.6% ED, 27.3% Community Medical, 21.9% Rehabilitation) who did not provide written information, most (*n*=10) provided verbal information (1.4% ED, 18.2% Community Medical, 15.6% Rehabilitation), some (*n*=4) did not provide information at all (4.2% ED, 3.1% Rehabilitation) and others (*n*=3) did not answer the format of information question (9.1% Community Medical, 3.1% Rehabilitation).

Non ACC information sheets were routinely supplied by 60.8% (*n*=76) of respondents (70.4% ED, 22.7% Community Medical, 65.6% Rehabilitation). ACC information sheets were routinely supplied by 48% (*n*=60) of respondents, including 'Caring for yourself after a Head Injury' (ACC 572), 42.4% (*n*=53); 'Knowing about your Mild Traumatic Brain Injury' (ACC 4154), 17.6% (*n*=22); 'Returning to activity from Concussion or Mild Traumatic Brain Injury' leaflet for children (ACC 7639), 16.8% (*n*=21); 'Caring for your child after their Head Injury', (ACC 6009), 2.4% (*n*=3); and the 'Going head to head with TBI' poster (ACC 7953) was cited as an available resource by one respondent. Further information about the leaflets provided by the three services is shown separately on Figure 7.1 below.

Most respondents (71.2%) advised that any information sheets provided were handed to the patient by their healthcare practitioner.

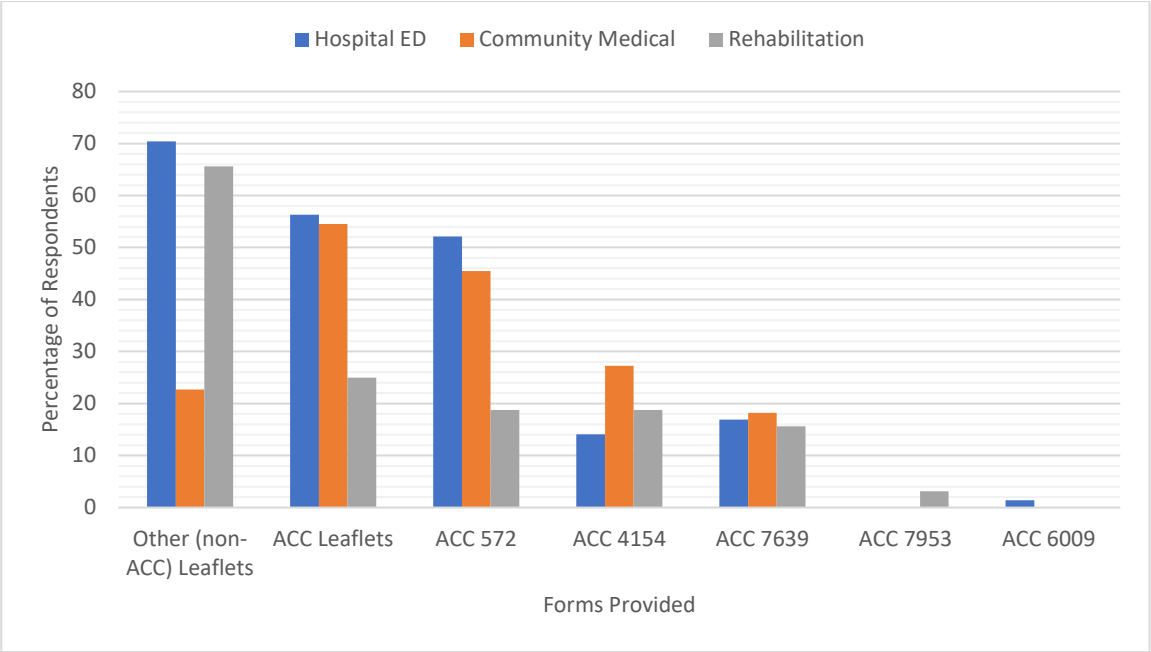

Figure 7.1. Percentage of respondents from each service area providing written information to mTBI patients.

Information specific to children was provided by 44% (*n*=55) of respondents; for adults 32.8% (*n*=41), while few had information specific to infants, adolescents, older adults or caregivers. See Figure 7.2 below for population-specific information.

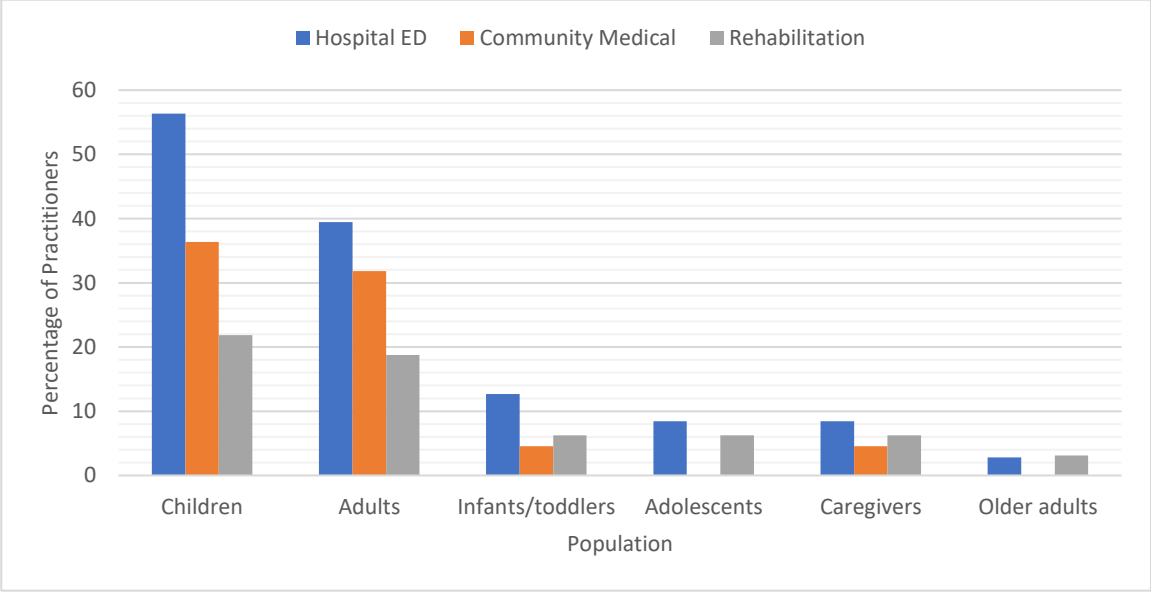

Figure 7.2. Percentage of respondents from each service area providing written information for specific groups of mTBI patients.

Format of Information

Most information was provided in English (98.8% of those who responded to this question [8], 68% total sample; *n*=85), and 7.2% respondents (*n*=9) had information available in Te Reo Māori. Four respondents across the three service areas had other languages available, (usually to be downloaded as required) one of whom did not provide English language information, though downloaded ACC information sheets "as appropriate".

Audio (e.g., sound recordings) or visual (e.g., pictures) information was available in a few cases (6.4%; *n*=8) the majority (87.5%; *n*=7) from the Rehabilitation group and one from ED. No respondents provided information in Braille. Approximately one fifth (20.8%) of the total sample said they directed patients to mTBI related websites e.g., ACC, Brain Injury Association New Zealand, Centres for Disease Control and Prevention (CDC), Ministry of Health, and Health Navigator.

Content and Accessibility of Written Information

Thirty-eight information sheets were uploaded to the survey by 22 respondents (17.6%). Five from the same ED setting were almost identical and yielded identical scores across measures; they were all included in the results as they were submitted by five separate treatment providers. Two 'information sheets' were not analysed because they were not patient literature (one was an assessment measure and the other a set of guidelines, both made for sports physicians). The remaining 36 forms were assessed on their accessibility using the Roundtable Guidelines for Clear Print, their general quality using the EQIP and their readability using the FRE.

[8] 32% survey respondents (*n*=40) skipped this question.

Content was evaluated where applicable [9] against the NICE recommended information sheets for adults, (although scoring for those made for children was altered to avoid artificially low scores due to lack of advice for avoiding alcohol, driving, sleeping pills and operating machinery). Sheets that had scores for all four elements were assessed with the mPLUI, for overall usefulness. ACC acute care information sheets were also assessed with these measures for comparison.

As shown on Table 7.2, ED information sheets scored the highest on content, readability and overall mPLUI for acute care forms. Interestingly the ACC information sheets, which state they are based on the NZGG (2006) recommendations, scored lowest on the content measure but highest on the EQIP across all service areas, suggesting they are logical, respectfully worded, and easy to follow.

The forms provided by the Community Medical group rated lowest for readability, indicating that the language used was difficult to understand, and highest for clarity, indicating that they adhered closely to the Roundtable clear print guidelines. However, this group provided only two sheets for evaluation both produced by outside organisations – one a joint publication between ACC and the Starship Foundation and the other a poster from New Zealand Rugby. Information sheets provided by the Rehabilitation group scored the lowest on the EQIP and second lowest on both the clarity and readability measures. These 'sheets' tended to be longer and contain more in-depth information about specific symptoms and rehabilitation targets than those provided by other groups.

[9] As the content recommendations from the NICE guidelines related to acute care services, this was not analysed for all sheets; the two information sheets provided by Community Medical services and most of the sheets provided by Rehabilitation professionals did not meet the acute care criteria. Whether an information sheet qualified as 'acute care' depended on whether it contained any information relating to symptoms requiring immediate medical assessment or reassessment, as this typically relates to the first day to week post-injury.

Of the three service areas, ED information sheets yielded the highest scores for both clarity and readability, while Community Medical forms scored highest for general quality of layout and wording. Compared with ACC leaflets, ED information sheets were deemed more useful for patients, overall.

Table 7.2

Mean Content, Clarity, EQIP, FRE and mPLUI Scores for each Service area

	Content	Clarity	EQIP	FRE	FRE Descriptor	mPLUI
ACC	52.7 (8.5)	75.7 (15.5)	74.0 (3.6)	65.5 (5.0)	Standard	62.6 (6.3)
Hospital ED	67 (12.1)	81.6 (5.0)	65.4 (3.1)	67.0 (3.3)	Standard	66 (4.9)
Community	n/a					
Medical		81.3 (6.2)	68.8 (6.4)	46.8 (1.1)	Difficult	n/a
Rehabilitation	n/a	74.3 (24.8)	52.5 (18.3)	59.3 (9.6)	Fairly Difficult	n/a

Notes. Mean scores are presented first, with standard deviations in parentheses. All measures have a possible score range of 0-100. EQIP = Ensuring Quality Information for Patients, FRE = Flesch Reading Ease, mPLUI = modified Patient Literature Usefulness Index. Content scores were not provided for the Community Medical and Rehabilitation service areas as the provided forms did not meet 'acute care' criteria.

General Advice Provision

Specific areas of concern. As shown on Figure 7.3 the three service areas provided similar amounts of information on each area queried except for substance use and symptoms requiring medical attention. Rehabilitation respondents more frequently advised on substance use, while Community Medical and ED respondents more frequently advised on symptoms requiring medical attention. This is perhaps unsurprising, given that Rehabilitation providers are likely to be consulted after the acute injury phase when patients are less likely to suffer life threatening adverse events. Those that did provide this information largely outlined the same advice as provided on the standard information sheets, or simply stated "as per leaflet".

Some also stated that certain activities such as driving or returning to sport needed to be assessed by the individual's GP, while others discussed the individual nature of mTBI and advised they could not generalise about the information they provide.

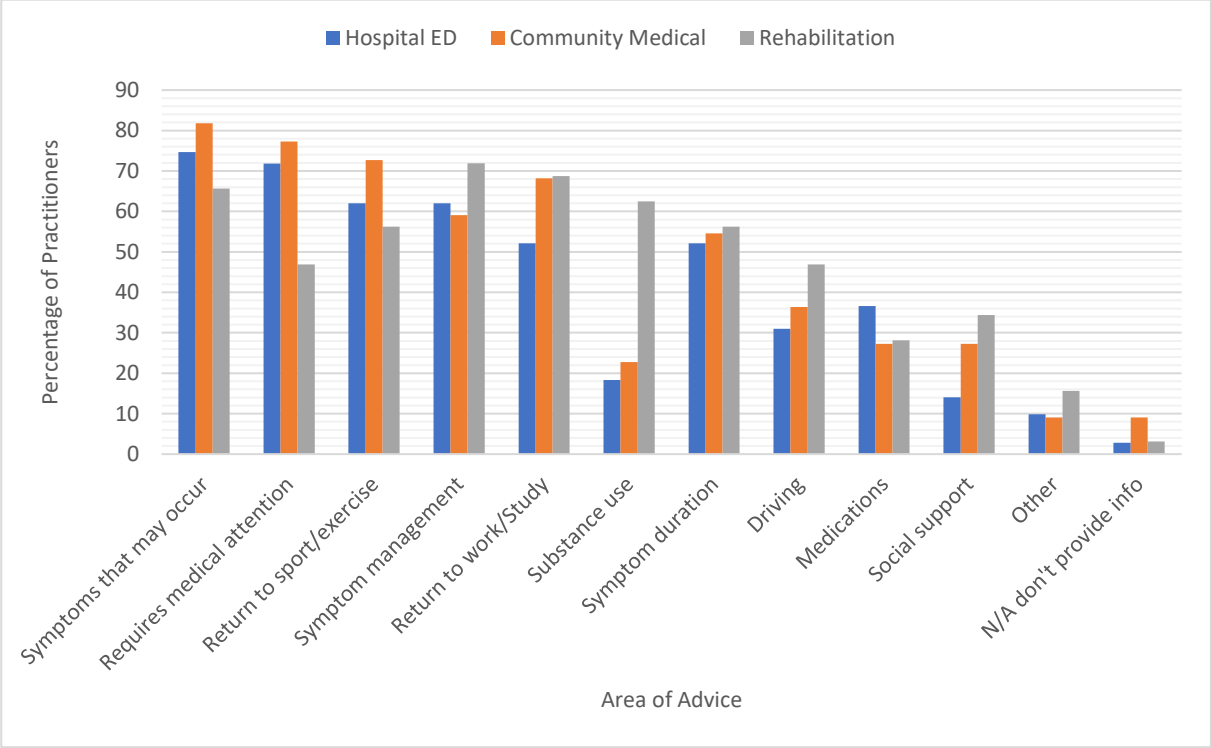

Figure 7.3. Percentage of respondents in each service area providing information on specific areas of concern.

The symptom most frequently reported as most concerning to patients was headache, (56% of total respondents) followed by fatigue (10%) and nausea/vomiting (6%). See Figure 7.4 for the frequency of most concerning presenting symptoms by service group.

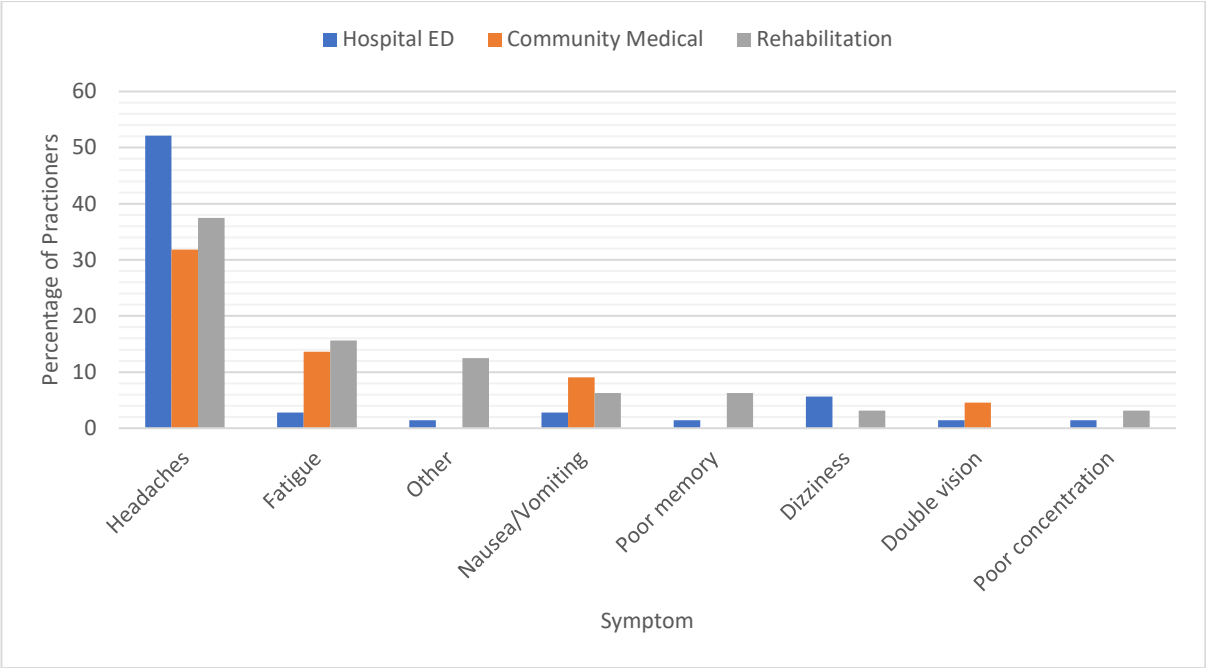

Figure 7.4. Symptom reported by patients as most concerning in each service area. 'Other' included a range of issues such as anger, lack of appetite, word finding difficulties and sexual dysfunction.

Medications & Supplements. ED and Community Medical respondents were more likely to advise on medication (60.6% and 54.5% respectively) than Rehabilitation respondents (37.5%). ED and Community Medical respondents most frequently endorsed paracetamol and non-steroidal anti-inflammatory drugs (NSAIDS) as the advised medications for mTBI. Rehabilitation providers were more likely than the other two service groups to recommend dietary supplements (fish oil and magnesium) or 'other' medications (most commonly anti-emetics and melatonin). See Figure 7.5 for further information.

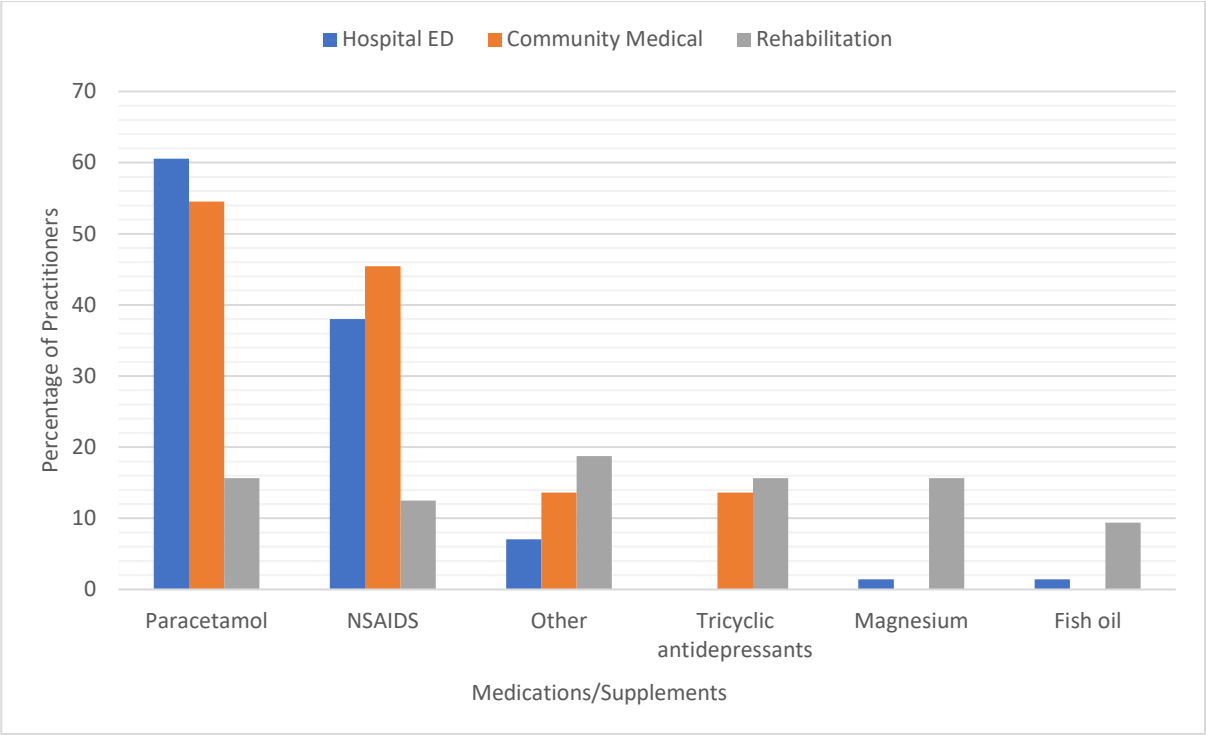

Figure 7.5. Medications and supplements advised by each service area.

Referral to concussion service. ED staff were least likely to refer patients to Concussion Services (32.4% did not do so; 19.7% did if symptoms continued for several weeks; 22.5% made a Concussion Service referral upon a patient's initial presentation and 25.4% did not answer this question). Qualitative information suggested that the acute nature of the ED service meant they are not likely to know who will recover without further assistance, patient intoxication or other injuries potentially mimicking or masking mTBI, and a lack of understanding of the process for making such a referral.

Of the Community Medical respondents, 59.1% referred patients to the Concussion Service if symptoms persisted for several weeks, 9.1% did so upon initial presentation, 4.5% did not refer, and 27.3% did not answer this question. As 50% of the Rehabilitation respondents already worked for a Concussion Service the question was not applicable for them. However, seven others working in the rehab sector made a referral ranging from initial presentation (*n*=2) to several weeks (*n*=4) or months (*n*=1) of symptoms post injury.

Barriers to Providing Information

The most frequently reported barrier to providing information for the overall sample was *time constraints during consultation*, (42.4% of respondents) followed by *lack of appropriate materials* and *patient concentration difficulties* (20.8%), *lack of patient interest in the materials* and *patient distress during consultation*, (12.8%). Most respondents who selected patient distress as a barrier belonged to the Rehabilitation group. Figure 7.6 further outlines these barriers faced by healthcare practitioners across the three service areas.

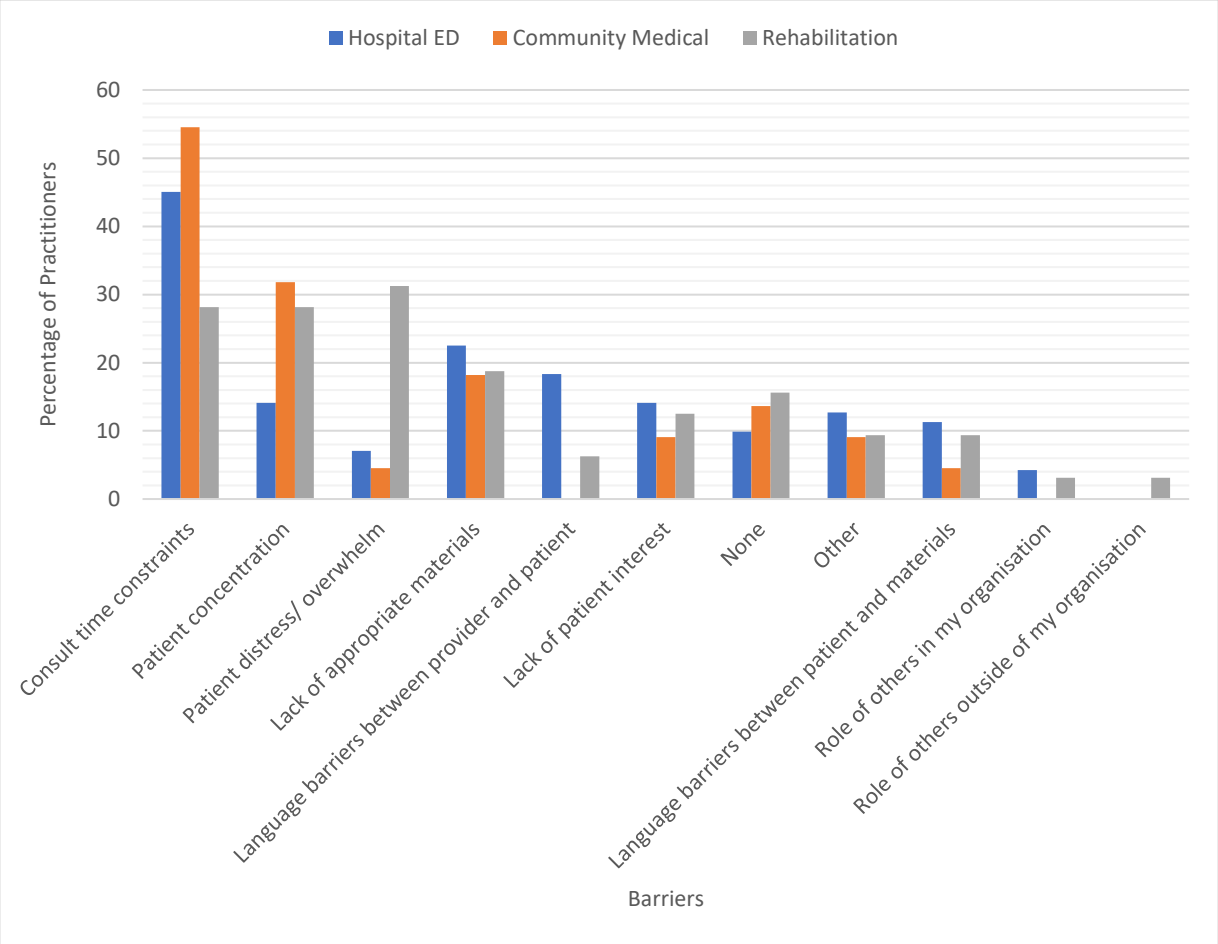

Figure 7.6. Barriers to providing information reported by each service group.

Further Information

At the conclusion of the survey respondents were provided with space to make general comments about their work with mTBI patients. Many of these comments came from

ED respondents who did not refer patients to the concussion service but provided advice upon discharge and recommended they follow up with their GP if symptoms persist.

Some respondents expressed concern over the prevalence of concussion and/or the way in which their mTBI patients present, for example

> "…I worry about the amount of people that come in with concussion… I find patients are not very knowledgeable with what they are dealing with…",
> "many of our presentations are students, related to sport and/or alcohol consumption – this age group presents challenges of their own in their feeling of invincibility… still some pressure on key players to get back [into sport], and hence they can minimize symptoms to fit the criteria for doing so"
> "difficult problem to deal with".

Others outlined the necessity of correct diagnosis and provision of correct and useful information as key for setting recovery expectations. Expressions of need for further information and/or resources included

> "I would like to have a better understanding of what is available for those with ongoing symptoms",
> "it would be useful to have more resources available in easy read format…"
> "it would be great to have a system in which we could generate documents with information based on the client's specific symptoms and concerns…".

Summary

One hundred and twenty-five valid survey responses were received, the majority of which came from ED staff, the North Island, and urban areas. Three service groups – Hospital ED, Community Medical, and Rehabilitation – were compared. The majority of respondents from each group provided both written and verbal information to mTBI patients, the content and quality of which varied across groups. Hospital ED and ACC information sheets obtained the highest scores on the FRE, achieving a 'standard' readability score while the Rehabilitation and Community Medical groups scored 'fairly difficult' and 'difficult', respectively. The ACC forms scored highest (74) on the EQIP and the Rehabilitation group scored lowest (52.5); clarity scores were similar across groups. Of the acute care forms, the ED group adhered most

closely to the NICE guidelines. Of those who responded to the language and formatting question, 98.8% provided written information in English, while just 10.2% provided information in Te Reo Māori. Time constraints, a lack of appropriate materials, and patient symptom factors were the most frequently cited barriers to providing information to this population.

Chapter Eight: Information Provision Discussion

The majority of respondents gave their mTBI patients both verbal and written information, as recommended by the NZGG (2006). According to the written responses provided within the survey, most advice was in line with the content guidelines, though some was tailored to each individual patient's symptoms or to specific recovery targets. Like Moore and Leathem's (2004) study, Study Two showed that more hospital EDs than Community Medical practices provided written information to mTBI patients, however the information provided by both of these services was less varied in both content and length than the 2004 study; and a considerably higher percentage of Community Medical respondents (72.7%, compared with 42.8% in 2004) provided some form of written information.

Usefulness of Information Provided

The mPLUI scores for the acute care forms were comparable across the Hospital ED, ACC, and all acute care groups. The mean mPLUI for all acute care forms was very similar to Kempe and colleagues' (2014) findings (mean mPLUI scores of 65.93 and 65.86, respectively). Because no composite measure similar to the mPLUI was used in Moore and Leathem's 2004 study, no comparison of the overall content and accessibility in New Zealand mTBI literature over time can be made.

Content guidelines. The NZGG and NICE both recommend that those with TBI and their caregivers should be made aware of the possibility of ongoing symptoms and be provided with the details of support services as part of their written discharge advice, as well as being informed of the warning signs for medical emergency and common symptoms that need not cause concern. Aspects of this recommended information however, were often not included with written discharge advice. The content items most frequently missed from acute care forms included: the warning signs of loss of balance or problems walking, clear fluid leaking from the ear or nose, and bleeding from one or both ears; the common symptoms of a lack of appetite and insomnia; and advice to stay within reach of a telephone or medical help, that

some symptoms may appear after an initial period of seeming relatively well, and information about further support. In addition, the ACC forms tended to miss both nausea as a common symptom and advice not to drive or operate machinery until symptoms subside. It was also noted that advice specific to driving was highly varied, as per both Moore and Leathem (2004) and Baker et al. (2015). Driving advice included set periods of no driving, advice to wait until certain symptoms such as dizziness subside, driving only short distances with a responsible passenger and/or on quiet roads, and consulting one's GP prior to returning to driving.

Survey responses for advice provided in any format indicated that 62.9% of practitioners provided advice about returning to sport or exercise, 59.2% about driving, and 36% work or study. This was similar to the written information collected by Moore and Leathem (2004) in which 58.3% advised about sport/exercise, 61.7% driving, and 40% returning to work. While any differences in the specific content of the information provided in these domains cannot be determined, it appears that little may have changed regarding how frequently patients are advised in these areas.

Accessibility guidelines. Similar to Moore and Leathem (2004) the present research noted a higher proportion of readable information from ED services than Community Medical services. However, the accessibility of information did not always meet recommended standards. This was indicated by the low mean FRE scores for both the Community Medical and Rehabilitation groups. The readability scores for these groups were classified as difficult and fairly difficult respectively, suggesting that a considerable proportion of the population may struggle to read and understand the materials. Regardless of the quality of the information contained in an information sheet, if it cannot be read, it cannot communicate the information so is not useful to the patient. While this represents an apparent decrease in readable information from Moore and Leathem's 2004 research, the small Community Medical sample in the present study and the provision of the ACC sheets (two out of three of which were a 'standard' level of readability) prevent meaningful comparison.

The EQIP also provides an indication of how understandable patient information is, and this was somewhat varied between groups. Frequently missed items on the EQIP included information about whether patients or families were consulted, space for patients to take notes, and details of other information sources. The rehabilitation group scored lowest on this measure, where points were lost for missing the points above as well as for not using everyday language, ensuring illustrations and diagrams were relevant and easily understood, or directly addressing quality of life issues such as mobility and school/work attendance. Where quality of life issues were not addressed by this group, the information tended to discuss symptoms (e.g., fatigue) that may impact the patient in numerous ways, but not specifically outline how this may affect certain activities of daily living or strategies for dealing with the symptoms in specific situations. It is likely that such information would be tailored to individual patients and be covered during a consultation, however providing concrete written advice, or a section for the patient or practitioner to record advice in written form, is likely to assist with retention and adherence and was frequently not included. Given that the Rehabilitation group tend to treat patients with ongoing symptoms and thus are likely to have working knowledge of the information processing, attention and memory difficulties associated with mTBI, it was surprising to see lower levels of clarity and readability from this group.

Most information sheets across all groups adhered well to the clear print guidelines. Like MacDonald and colleagues' (2010) study, mean compliance was 78% and the most commonly overlooked recommendation was for font size to be at least 12 point, with text justification recommendations sometimes also neglected. While 91.9% of information sheets assessed by Moore and Leathem (2004) adhered to the 12 point font recommendation, just 25.7% of those assessed in the present study did the same. The same percentage of information sheets (74.3%) adhered to the text justification recommendation in 2004 and 2019. As visual disturbances are common symptoms in both acute and ongoing mTBI, text that

is large enough to be easily seen is an important element of ensuring written information is accessible and thus useful.

Advice for Different Populations

Few practitioners had available information for specific populations aside from adults and children, and 20% stated that everyone received the same information. Given the potential for symptoms to present differently and the varied needs of other populations, it would seem pertinent to have more specific information available. For instance, it is likely necessary to provide more information regarding behavioural signs of distress and impairment for the caregivers of pre- or minimally verbal infants and toddlers (Gagner, Dégeilh, Bernier, & Beauchamp, 2019). As per Gagnon and colleagues' (2008) participants, information for adolescents needs to account for this population's emerging independence and academic and sporting commitments, as well as both the internal and external pressures they face which may lead to returning to these pursuits too soon (Swain et al., 2008) and the possibility of ongoing emotional and behavioural symptoms (Connolly & McCormick, 2019). Regarding older adults, there may be a need to provide more information about the possibility of ongoing symptoms, their impact on day to day functioning, and future injury prevention, particularly relating to falls (Abdulle & van der Naalt, 2019).

Less than half of practitioners provided personalised information, though the majority stated that information was provided to patients directly by the healthcare practitioner. This may allow for discussion of how generic information relates to the specific patient, and as per the NZGG's recommendations, allow time for patients and their support people to consider the information and ask questions, however this was not assessed by the current study. Where any personalised information is provided verbally, this may be easily forgotten by mTBI patients struggling with attention and memory difficulties, or the shock of the incident that led to injury.

Similarly, few practitioners had information available in languages other than English. Just 7.2% of respondents had information available in te reo Māori, New Zealand's other official written language. Two practitioners stated they downloaded other-language resources from the ACC website as necessary, however a search of this website revealed that the te reo Māori and other language information available related to more severe TBI and more specific sequelae rather than symptoms and advice for mTBI. No respondents had information available in Braille, and few could supply information in audio format. This lack of different formatting places the onus on visually impaired patients to either supply their own technology or support person to record information, or to recall it themselves. During a time of injury in which both physical and emotional trauma can impair memory and information processing, this may not be feasible. This lack of other language and other format information, perhaps more than difficult readability and general quality statistics, points to inequities in our healthcare system that disadvantage our indigenous and visually impaired populations and goes against recommendations from the NZGG. As information regarding the availability of other formats and languages was not collected by Moore and Leathem (2004), it cannot be determined whether the present results represent change.

Barriers to Providing Information

Time constraints during consultations and a lack of appropriate materials were identified as significant barriers to providing information in all three service areas. Together, this could mean that information is provided in a format not suited to the patient and there is little time to help the individual apply this information to his or her own context, thereby making the information less useful for the patient. Considering the patient comments made regarding the need for timely, reputable and coherent information in Snell and colleagues' (2016) Christchurch based study, such a situation is likely to lead to confusion and distress, which has the potential to exacerbate symptoms. Patient concentration difficulties and distress were also endorsed as significant barriers by the rehabilitation group and as several

researchers (Paniak et al., 1998; Paniak et al., 2000; Ponsford et al., 2002; Matuseviciene et al., 2013) have shown, these barriers could potentially be reduced with accurate and understandable information earlier in the post-injury period.

Flow of Patient Information Across Services

The majority of hospital ED respondents provided verbal and written information and the sheets provided for analysis suggest that this is accurate and understandable. However, this only holds for populations with an adequate understanding of English who are not visually impaired. Many ED respondents stated they referred patients to their GP for any ongoing symptoms, for assessment relating to driving, work, school and sport, and for further referral to concussion services if necessary. The small sample of GPs that responded to the survey outlined similar concerning symptoms, treatments, information available and barriers to providing this information as the ED group, indicating similar management of acute mTBI and similar information provided to patients throughout this period.

Sixty-eight percent of the responding community medical staff stated they referred mTBI patients to concussion services. The high rate of non-response to this survey question (27.3%) prevents inference regarding whether some patients who could benefit from this service miss out. Rehabilitation respondents tended to provide more in-depth information tailored to patients' symptoms and social needs. The written elements of this information however, tended to be less accessible in terms of readability and general quality than that provided by acute care practitioners. While the rehabilitation respondents provided a more specialised service, they faced similar barriers to providing information and some of the information provided may be difficult for patients to comprehend, thus less likely to assist recovery.

Several rehabilitation providers stated they referred patients back to their GP for certain issues such as clearance for driving and medication/supplement advice. While this is understandable, it highlights the responsibility placed on GPs to provide care at various points

of recovery while not necessarily having a clear understanding of a patient's full range of difficulties. It is evident there is a need for clear communication between services as a means to prevent the lack of information or contradictory information that Snell and colleagues' (2016) participants found distressing.

Conclusion

Several authors have noted that the timely provision of useful information is beneficial for mTBI sufferers and their caregivers. Written and verbal information relating to symptoms indicative of medical emergency, common symptoms that need not cause concern, the potential for ongoing symptoms, rehabilitation advice, support services, and reassurance that a quick and full recovery is likely is recommended for all mTBI patients upon discharge from acute care settings. Although ED staff in the present study tended to provide accurate and accessible information for the majority of mTBI patients, there are clear gaps in this service for non-English speaking and visually impaired populations, as well as areas of improvement for all populations across all service areas (Hospital ED, Community Medical, and Rehabilitation).

The NZGG recommendations for allowing time during consultation to provide and explain written information and answer questions about it, providing written information regarding ongoing symptoms and supports, and for providing information in various languages and formats are frequently overlooked. This may lead to increased anxiety, distress, and service use for patients. The barriers to providing information identified by healthcare practitioners included consult time constraints, patient distress and difficulty concentrating, and a lack of appropriate materials. This suggests information provision difficulties may be due to systemic issues such as the fast paced and high pressured nature of both acute care and recovery services, and lack of understanding regarding other services available.

The present results indicate that while some elements of information provision may have improved since Moore and Leathem's 2004 study, others have not. Driving and other return to activity advice remains varied, as does the length of information sheets and the type

of information they include (e.g., acute symptom, ongoing symptom, returning to activity advice). The same percentage of information sheets adhered to text justification recommendations, but fewer adhered to the 12 point font advice, making these sheets less accessible for patients with visual impairments. A similar percentage of ED respondents provided written information to mTBI patients, and a larger percentage of Community Medical respondents did the same (76.8% in the present study, 42.8% in 2004). Almost a quarter (23.2%) of respondents in the present study stated they do not have any ACC information sheets available for their patients. While considerable variation still exists between patient information forms for mTBI sufferers, the ACC brochures may provide a degree of consistency in the information available across services and is an easy, readily available method for practitioners to provide sound information.

Recommendations

Given the time constraints healthcare practitioners face and the complex nature of mTBI, a wider variety of easily accessible information for mTBI patients seems to be required. It is recommended that information sheets outlining the acute and ongoing symptoms of mTBI and strategies and support for dealing with these are created in various languages and formats, and for different populations. Similarly, as per a suggestion in the free-answer section of the survey, a repository of information for specific symptoms and their management available for practitioners to compile for individual needs may prove useful and minimally time consuming for busy health professionals.

Limitations

With 125 responses and slightly more than a quarter of these (27.2%) coming from ED staff in the Wellington/Kāpiti region, the survey results are based on a small sample and may not be generalisable to the wider mTBI care system in New Zealand. However, many of the main centres in the North Island were represented by both ED and rehabilitation staff and likely can provide valuable insight. It may be that due to a larger sample and more

standardised resources within emergency departments, more can be extrapolated from this group's responses than the other two groups. The rehabilitation group was the most diverse in relation to professions and organisational settings represented, and this was evident in the responses collected, particularly the qualitative information. As such, while it may be difficult to determine whether the responses given by this group represent the information provided by rehabilitation professionals more generally, it is likely that the nature of the information – in-depth, individualised and geared towards post-acute care – is. A very low response rate from general practitioners likely prevents generalisation of the data obtained from the Community Medical group, particularly as they may have fewer shared patient resources than a typical Emergency Department. However, responses from this group and qualitative remarks from the other groups provide insight into both the expectations and limitations of this area of the medical workforce. Responses to requests for participation in the study suggested that reasons for the low response rate include a high volume of requests for research participation, general busyness of healthcare professionals, and particularly for the GP practices, the survey period coinciding with flu season when time and resources were already stretched.

Chapter Nine: Overall Discussion

Terminology

Studies One and Two both encountered similar terminology confusion to that mentioned in prior research. Terms such as minor/mild head injury, concussion, mild traumatic brain injury, minor brain injury, post-concussive disorder, and post-concussion syndrome are common throughout the literature. However, the NZGG (2006) recommended 'head injury' or 'head trauma' to describe the injury to the head, rather than the brain, prior to a diagnosis of traumatic brain injury with a specifier for severity if necessary. The NZGG acknowledged that the mild severity specifier may not be agreeable for the injured party, but that it is necessary for treatment planning and resource allocation. While most Study One practitioners used both concussion and mTBI, the 'mild' element of mTBI was at times upsetting to participants struggling with their symptoms. Participants tended to use the terms 'concussion', ' head injury' and 'head knock' when referring both to their initial injury and the ongoing effects.

Responses collected for Study Two reflected varied terms such as head injury, minor head injury, traumatic brain injury (TBI), and brain injury as well as concussion and mTBI. Only the ACC leaflets explained that a head injury involved trauma to the head which could then lead to an injury to the brain, as per the NZGG guidelines these information sheets were based on. Several of the materials stated "also known as concussion" to explain the use of other terminology, which given the name of the ACC 'Concussion Service' is likely a useful clarification. Variation may also be present in the verbal information provided to patients, as indicated by the qualitative information received through the survey, e.g., "…most are mTBI without concussion…" and "I don't refer patients with very minor head injury/TBI…".

Receiving information with multiple differing terms is likely to confuse and distress patients as was noted by Snell and colleagues' (2016) participants, and in a Study Two survey comment:

> "use of terminology and confusion for clients e.g. Dr advises client they have had a concussion, Clinical Psychologist then completes a Neuropsych Screen and advises based on DSM criteria that 'mild traumatic injury' and now resolved – real dilemma for clients hearing this when they are still experiencing significant symptoms. Then the Drs start talking about 'post concussion'…".

As such, keeping with the terms mTBI and concussion as well as providing clear and understandable explanation of injuries, as per the NZGG guidelines, is recommended.

Diagnostic Difficulties

Peripheral injuries, intoxication and psychological trauma can all cause similar symptoms, potentially masking or mimicking mTBI and confounding diagnosis. Several Study Two survey respondents outlined that they see patients too soon after injury to know whether they will experience concussion symptoms for more than a few days, so may not diagnose mTBI at that time. As noted in Chapter One, the WHO and ACRM definition of mTBI requires that symptoms not be due to intoxication or other injuries (Carroll et al., 2004), so acute care providers may have little choice but to refer such a diagnosis to the individual's GP, which many stated they do. Delaying a diagnosis in this manner may be necessary, however it may also lead to a delay in the patient receiving useful information about their injury and delays in seeking or obtaining treatment. This was a situation that participants in Study One found confusing and frustrating, perhaps indicating a need for more effective communication from healthcare providers.

Flow of Information Through Services

A lack of diagnosis at the acute stage may lead to frustration for other providers when patients experience ongoing symptoms, as indicated by the following Study Two survey remark "correct diagnosis an issue. GPs do not seem to be able to determine if someone has had a concussion or bump to the head". Many ED professionals advised they referred patients to their GP if symptoms persisted, and the majority provided patients with some form of written

information relating to mTBI symptoms which usually reiterated this, but the timeframe varied from a few days to two weeks making it likely that some patients do re-present too early for accurate diagnosis.

If diagnosis is not confirmed by a subsequent ED or GP visit, this can preclude access to ACC concussion services and necessitate further medical appointments that cost a patient time and money, likely causing some degree of stress. The operational guidelines for ACC's Concussion Service (ACC, 2019) state that they require the correct referral form or a referral letter with medical notes proving that a medical professional has seen the patient and either diagnosed concussion/mTBI or recommended a concussion service referral. However, as several survey respondents noted being unsure about referral processes and pathways this necessity may not be widely understood. It could be that more detailed note-taking or more frequent sharing of notes with ACC and/or patients' GPs could expediate the referral process. This may prevent the frustration, stress and confusion experienced by Study One participants and the participants in Snell and colleagues' (2016) qualitative study.

In addition, more information about the concussion service may be of use to acute care providers, as indicated by comments such as "lack of clarity of what concussion services are available in our area" and "I would like a better understanding of what is available for those with ongoing symptoms". Not only would this potentially enhance the referral process, but allow healthcare providers to advise patients of the support available to them should they require it, something frequently missing from acute care information sheets. Given the busyness evident in the concussion services from Study One however, it may not be feasible to increase the volume of referrals without further straining the system and increasing wait times.

Treatment

Due to the cancellation of Study One it remains to be seen whether DHA supplements can reduce the severity or shorten the duration of ongoing mTBI symptoms. The unsuccessful

trial did, however, produce several lessons to inform future work. These mostly related to the time and effort required to be part of the study. For recruiting clinicians, the time required to determine eligibility, discuss the study, and complete the requisite paperwork added strain to their already full session plans and caseloads. In future trials, it may be necessary to reduce the pressure on clinicians' time. For participants, the time and effort required to complete testing, take the supplements and record fish consumption, side effects and missed doses proved too much. Future researchers will need to decrease barriers and increase motivation for participation. This is discussed further in the following section.

Despite the lack of empirical data, anecdotal reports suggested a number of practitioners recommended DHA and other nutritional supplements for mTBI patients. This was not, however, frequently seen from the health professionals surveyed. This may be due to practitioners genuinely not recommending nutrition based treatments, or due to a non-representative sample consisting mainly of acute care practitioners from EDs. One dietician responding to the survey expressed a wish for ACC to include dietetic care within the Concussion Service to allow the consideration of dietary treatment. Because registered healthcare professionals are bound by their disciplines' scopes of practice and evidence-based practice guidelines, rates of DHA supplementation are unlikely to increase without further evidence of clinical effectiveness.

Early educational intervention begins at the first point of contact for most mTBI sufferers – the ED or their GP. While the information provided by ED services may be more consistent than prior New Zealand based research (Moore & Leathem, 2004) has found, it is not clear whether information provided by GPs is of equally high quality, and rehabilitation services may benefit from adhering more closely to patient literature accessibility and quality guidelines. To assess whether supplementary treatment with DHA could form part of the more intensive intervention provided by rehabilitation services for ongoing mTBI symptoms, further research is required.

Recommendations for Future Research

Key recommendations for future research were outlined in Chapter Four. These include randomised controlled trials of an algae based DHA supplement with adequate time, personnel, and financial resources to allow for an appropriately sized sample to be recruited and supported. In order to attract the necessary funding for this, it is likely that beginning with a small pilot study and working very closely with, or perhaps even working as part of, a concussion service would improve processes and outcomes. Working closely with all stakeholders from funders to potential participants and beginning with focus groups and other qualitative studies, could lead to the collection of data meaningful to all parties, earlier identification of barriers to recruitment and retention, and could inform decisions about scaling up the study to multiple centres if feasible. To prevent encountering the same recruitment issues as Study One however, a pilot study would need to be funded well enough to compensate clinicians for their time, or perhaps be run from a DHB where time issues seemed less prevalent.

With regard to the provision of information, the previous chapter suggested a repository of resources be created for diverse populations including different languages and accessibility requirements, as well as information regarding treatment for certain symptoms able to be compiled according to patient needs. If this was done, a survey of healthcare practitioners and patients could assess its uptake and provider satisfaction, while trials of new information in comparison with the services' 'treatment as usual' information may ascertain its effectiveness at preventing the development of ongoing symptoms and/or further service use. If DHA was found to be an effective treatment for ongoing symptoms, it would likely be a useful inclusion in acute care patient literature due to being considered generally safe and well tolerated by most people.

Researcher Reflections

Over the course of conducting the two presented studies I learned a great deal about the world of research. With a keen interest in nutrition and a background in professional cookery, I began Study One excited to combine my long standing passion for food and nutrition with my burgeoning interest in the human brain. With minimal prior research experience I was initially somewhat daunted by the scale of the project, but remained enthusiastic and optimistic that I could contribute meaningful research to the field of neuropsychology. This was fuelled further by the positive reception from several Concussion Services approached for participation. Building relationships with the staff in these services and sharing the aspirations for the study was a rewarding element of the research process. It was this optimism that led me to persevere with Study One when the initial plan was not working. It was perhaps also this optimism, coupled with my inexperience, that initially clouded my vision from some of the practical realities of research participation for both individual and organisational participants.

Large organisations such as hospitals and some GP practices receive numerous requests to participate in research. Due to this, many require time-consuming application processes or simply decline if a high volume of requests has been received, and even when initially eager to help may not have time to do so. This applied mostly to Study Two, however likewise because most Concussion Services are funded entirely by ACC, who restrict the number of hours providers may claim payment for, some Study One services likely did not have the time to participate. Perhaps I was naïve to not have realised that time is money in our private healthcare services, just as it is in other industries. For both studies, the busyness of organisations that agreed to participate meant they could not always provide the assistance they initially agreed to, regardless of how enthusiastic they were about the research.

I learned to allow plenty of time for organisations to consider requests, and to ensure that all important information was presented in a concise and easily accessed manner. Polite

follow-up of organisations' progress with requests was also necessary. It quickly became clear that follow up calls and emails provided reminders and encouraged feedback from healthcare providers about difficulties with recruitment and participation. For some practitioners however, reminders appeared to increase stress. It was important to remember that they were assisting out of good will rather than being employed for the study, and those in Study One were accountable to ACC for their time. I often felt a slight sense of guilt for adding to an already high workload with little to offer in return. Using a friendly tone, conveying understanding of their situation and attempting to avoid putting pressure on the individual practitioner was important for maintaining valuable collegial relationships. I did sometimes wonder though, whether this made me – and consequently the study – easier to brush aside.

Individual service users from Study One also tended to be very busy, or significantly impaired. In both circumstances they had little time and energy to devote to participating in research and declined, withdrew, or struggled to adhere to the protocol because of this. In addition, some potential participants were uncomfortable with the possibility of being in the control group, opting instead to simply purchase fish oil supplements. I learned the importance of ensuring involvement in research is as easy as possible for participants – after all, they gain little for their considerable efforts while I stand to gain much. A more personal communication style was necessary with these participants, as enquiring in-depth about their wellbeing was necessary both for the research and for building and maintaining rapport. For each participant and each telephone call I had to find a balance between 'data-collector' and 'counsellor' to allow the timely collection of information while ensuring each individual felt cared for. I had a great deal of appreciation for these participants and toiled with feeling like I had let them down when the study couldn't continue – I felt that all their efforts had come to nothing, thus I had wasted their precious time and energy.

The cessation of Study One was a low point in my doctoral journey. Although I thought I had expended as much energy and effort as possible within the project's constraints, I still felt

disappointed in myself. I kept asking myself what I had missed, what I should have done differently, and wondering how I could come back from such a setback. It was with the support of supervisors, classmates and the Concussion Service practitioners that I was able to look forward and find another path. I was reminded to treat myself as I would treat a client – with empathy, creativity and openness, and without judgement. I am thankful to have been able to use participant experiences to guide me in a new direction, which helped to alleviate negative feelings around Study One's cessation. This was a valuable lesson in observation and flexibility, as well as self compassion. After ending Study One wondering whether I was capable of high level research, I found renewed vigour through Study Two. It was not without challenges, but I felt better able to handle these after my Study One experiences.

An overarching lesson from this experience was that clinical research is dynamic, and so a researcher must be too. As outlined above, I learned how important adjustments and accommodations for different organisations, processes, and individuals are to developing research relationships. I learned that as with clinical practice, the relationships built throughout the research process are essential to both morale and research outcomes. I learned that regardless of how well research is pitched and received, how strong relationships are, or how well planned processes are, there is no guarantee of research success. Flexibility in the face of disappointment, however, can lead to valuable learning, growth and inspiration.

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Appendix A

Study One Contact Log

Date	Mode	Direction	Organisation/ Designation	Outcome
7/02/2017	Email	Outbound	Taranaki Psychologist	Providing study information
7/02/2017	Email	Outbound	Wai/Bop Director	Providing study information
7/02/2017	Email	Outbound	Well/Auk Psychologists	Providing study information
13/02/2017	Email	Thread	Taranaki Psychologist	Arranged locality assessment
14/02/2017	Email	Thread	Wai/Bop Manager	Arranged conference call
23/02/2017	Web conference	Outbound	Concussion Service Team	Presented study information to Wai/Bop team
1/03/2017	Email	Thread	Wai/Bop Manager	Organised ethics locality assessment
6/03/2017	Email	Outbound	Christchurch Psychologist	Providing study information
9/03/2017	Email	Thread	Wai/Bop Manager	Discussion of expectations - 24 participants by the end of June possible
20/03/2017	Email	Outbound	Wai/Bop Manager	Forms with 0800 number finalised and provided
23/03/2017	Email	Thread	Wai/Bop Manager	Organised 18 packs of supplements to be distributed to 4 clinicians
27/03/2017	Email	Thread	Wai/Bop OTs	Check to ensure supplements received and if any questions. 3x replies of received.
7/04/2017	Email	Inbound	Wai/Bop OT	Replied that supplements received

10/04/2017	Email	Inbound	Wai/Bop Manager	Request for remaining 6 supplement packs to be sent to 2 clinicians
19/04/2017	Email	Outbound	Wai/Bop OTs	Follow up on receipt of supplements. Supplements received
26/04/2017	Email	Inbound	Wai/Bop OT	Recruitment of participant
26/04/2017	Call	Outbound	Participant 121	Voicemail x2- message left
28/04/2017	Email	Outbound	Participant 121	Introduction and requesting a time to call
3/05/2017	Call	Outbound	Participant 121	Introduction and Baseline testing calls
31/05/2017	Email	Thread	Participant 121	Prescribed 10 mg/d Amitriptyline and queried need to withdraw, I advised Ok to continue
5/06/2017	Email	Outbound	Participant 121	Queried good time for a catch up call
9/06/2017	Call	Outbound	Participant 121	Catch up, no problems with supplements, still experiencing many symptoms
10/05/2017	Email	Outbound	Wai/Bop OTs	Discussed slow recruitment and queried any barriers to participation or presenting study
10/05/2017	Email	Reply	Wai/Bop OT	Has had 'odd' referrals and clients not meeting criteria
10/05/2017	Email	Reply	Wai/Bop OT	Clients haven't met criteria due to age or severe mental health difficulties that affect cognitive testing
10/05/2017	Email	Reply	Wai/Bop OT	Had few new concussion referrals. Of two, one already on supplements, one too young.
12/05/2017	Email	Reply	Wai/Bop OT	Clients too young, severe mental health difficulties, and vegetarian.
15/06/2017	Email	Outbound	Wai/Bop OTs	Group email asking specific questions about barriers to recruitment
19/06/2017	Email	Reply	Wai/Bop OT	7 new referrals, 3 not concussion, 2 on supplements already, 1 child, 1 too severe to discuss study with
19/06/2017	Email	Outbound	Waikato Psychologist	Providing study information
21/06/2017	Email	Outbound	Taranaki Psychologist	Update on project - continuing as normal. Queried participation and whether it would be useful to recruit via local concussion service OTs
21/06/2017	Email	Thread	Wai/Bop Manager	Discussed recruitment issues and few clinicians replying. Manager advised the contract changed this year and offers less time but more paperwork, so clinicians are feeling stretched. Advised one OT away and two accepting more child clients. Discussed changing the eligibility questionnaire to a self-administered form, manager thought this was a good idea
23/06/2017	Call	Outbound	Wai/Bop OT	Voicemail-message left

23/06/2017	Call	Outbound	Wai/Bop OT	Voicemail-message left
23/06/2017	Call	Outbound	Wai/Bop OT	Full case load but has two clients to ask next week. Barriers = busy, neurologist prescribing fish oil, mental health diagnoses
23/06/2017	Call	Outbound	Wai/Bop OT	Voicemail-message left
23/06/2017	Email	Reply	Wai/Bop OT	12 concussion clients - 4 children, 2 severe MH problems, 2 on fish oil already, 1 no cognitive problems, 3 to ask about study next time
29/06/2017	Email	Inbound	Wai/Bop OT	Had asked 2 clients about the study, one no cognitive problems, the other trying to conceive
29/06/2017	Call	Outbound	Taranaki Psychologist	Unavailable, call back
29/06/2017	Call	Outbound	Taranaki Psychologist	Voicemail-message left
29-Jun	Call	Inbound	Taranaki Psychologist	Office manager will phone past referrals next week to ask if they'd like an info pack, I will email new questionnaire to post out, psychologist thinks own service better placed to recruit than local OT service
3-Jul	Email	Thread	Waikato Psychologist	Follow up on information. Has been sent to management who are busy
3-Jul	Email	Outbound	Taranaki Psychologist	Provided new eligibility questionnaire to be sent out to potential participants
3-Jul	Email	Outbound	Wellington Psychologist	Providing study information. Forwarded to research management team
6/07/2017	Call	Outbound	Participant NYR	Discussed symptoms and situation. Will call and hang up or text before calling to give time to get to a reception area. Set time of 8:30am 7/7 for baseline testing
6/07/2017	Email	Thread	Taranaki Psychologist	Advised neurologist with concussion service prescribes all concussion patients fish oil, organisation of pre-paid envelopes
7/07/2017	Email	Inbound	Taranaki Psychologist	Advised 4 info sets sent out
7/07/2017	Call	Outbound	Participant NYR	Called and hung up as requested. Called again 3x no answer.

12/07/2017	Email	Thread	Well/Kāpiti research manager	Advised of receipt of info, asked questions and provided research sign off forms. Replied with answers and advised of supervisor's absence therefore a delay in completing the forms
20/07/2017	Call	Outbound	Participant 121	Voicemail - no message left x2
20/07/2017	Call	Outbound	Wai/Bop OT	Voicemail stated unavailable until 24th July
20/07/2017	Call	Outbound	Wai/Bop OT	Caseload full with other contracts, also many child cases. One client may be interested
20/07/2017	Call	Outbound	Participant NYR	Voicemail - no message left x2
25/07/2017	Call	Outbound	Participant 121	Voicemail - no message left
25/07/2017	Call	Outbound	Participant NYR	Call back at 12 please
25/07/2017	Call	Outbound	Participant NYR	1st call unanswered. 15 mins later answered. Too stressed to take part, forgetting appointments and having trouble with OT, ACC, and work. Return to work difficult and exacerbating symptoms. Discussed benefits and costs, decided on withdrawal. Hasn't started supplements, will attempt to have OT collect them
25/07/2017	Email	Outbound	Taranaki Psychologist	Follow up on information packs - no information received back.
1/08/2017	Call	Inbound	Waikato Psychologist	Information went to wrong person, has forwarded to correct person who is interested in participation. Will hopefully hear in 2 weeks
2/08/2017	Call	Outbound	Participant 121	Testing call as previously agreed - receiver lifted and hung up, next 2 calls unanswered - message left
4/08/2017	Email	Inbound	Taranaki Psychologist	Information for potential participant received, with verbal consent to contact him as the consent form hadn't been returned
7/08/2017	Call	Outbound	Potential Participant Taranaki	Discussed fish consumption - determined ok to participate. Discussed requirements and possibility of being in placebo group. Will think about participation and talk to partner before deciding
7/08/2017	Email	Outbound	Wai/Bop OT	Follow up regarding a potential participant - received consent form
7/08/2017	Email	Outbound	Wai/Bop OTs	Check in. Reply from one OT: caseload full, no new clients
8/08/2017	Call	Outbound	Potential Participant	Discussed symptoms, medications, and requirements of participation. Agreed, and set time for baseline testing - 14/8/17 10am

14/08/2017	Email	Outbound	Well/Kāpiti research manager	Sign off forms sent
14/08/2017	Call	Outbound	Potential Participant Taranaki	Voicemail-message left
14/08/2017	Call	Outbound	Participant 121	Voicemail-message left
14/08/2017	Call	Outbound	Participant 146	Baseline testing and discussion. Will have OT deliver supplements at appt. 16/8/17.
15/08/2017	Call	Outbound	Potential Participant Taranaki	Voicemail - no message left
15/08/2017	Call	Outbound	Participant 121	1st 2 calls no ring or VM, 3rd call child answered by child, participant unavailable
15/08/2017	Email	Outbound	Participant 121	Request for good time to call for second test session
15/08/2017	Call	Outbound	Wai/Bop OT	Reminder to take supplements to participant 146 tomorrow
16/08/2017	Email	Reply	Participant 121	Explained she had work last week so missed the session. Advised she wants to withdraw as she has missed too many of the capsules and this is unfair for me and the study.
16/08/2017	Call	Outbound	Potential Participant Taranaki	Keen to participate in trial and can drop into clinic to collect supplements. Set baseline testing for 18/8 at 9:30am.
16/08/2017	Call	Outbound	Participant 121	Voicemail - message left requesting call back or email
16/08/2017	Email	Outbound	Participant 121	Advised she could possibly continue with the study, or if withdrawing it would be good to do second testing. Asked about barriers to taking the supplements.
18/08/2017	Call	Outbound	Potential Participant Taranaki	Called for testing at set time. No answer. Called twice more at 15 minute intervals, no answer, message left.
18/08/2017	Call	Outbound	Participant 121	Voicemail, no message left.
21/08/2017	Call	Inbound	Waikato Psychologist	Project given OK by branch manager, just need to check with local ACC, invitation to team meeting tomorrow to give a talk and have Q&A.
21/08/2017	Email	Thread	Waikato Psychologist	Provided letter from ACC. Psychologist called her and will hear back tomorrow.

21/08/2017	Email	Outbound	Well/Kāpiti research manager	Follow up and provided ACC letter.
21/08/2017	Call	Outbound	Participant 121	Voicemail, no message left.
21/08/2017	Call	Outbound	Potential Participant Taranaki	Voicemail, no message left.
22/08/2017	Meeting	Face to Face	Waikato team	Gave talk to full team and fielded questions.
22/08/2017	Email	Thread	Waikato Psychologist	Organised and completed locality assessment for HDEC
22/08/2017	Email	Thread	Well/Kāpiti research manager	Hospital sign off forms hadn't been received despite being correctly attached, happened twice. Converted to PDF and sent again.
23/08/2017	Email	Outbound	Wellington Psychologist	Follow up to advise what has been happening with DHB application.
24/08/2017	Call	Outbound	Potential Participant Taranaki	Advised he didn't want to go ahead with the study as too busy with work and wedding planning and has improved greatly over the last few months. Stated he is a “yes man" and needs to say no more often, so he will say no this time. He apologised several times for "leading me on"
24/08/2017	Email	Inbound	Well/Kāpiti research manager	Questions from medical team
25/08/2017	Email	Thread	Well/Kāpiti research manager	Answered questions, manager advised nothing further would be needed.
25/08/2017	Call	Inbound	Wellington Psychologist	Advised it looks like we can go ahead, invited to MDT meeting to give a talk and field questions
28/08/2017	Email	Outbound	Wellington Psychologist	Advised I could attend this Wednesday's MDT
28/08/2017	Call	Outbound	Participant 121	Voicemail, left message

28/08/2017	Call	Outbound	Wai/Bop OT	Voicemail, left message re withdrawn participant
28/08/2017	Call	Outbound	Wai/Bop OT	Voicemail, left message re catch up
28/08/2017	Call	Outbound	Wai/Bop OT	Voicemail, left message re catch up
28/08/2017	Call	Outbound	Wai/Bop OT	Answered but busy and will call back. Full case load and no luck with recruitment
28/08/2017	Email	Outbound	Taranaki Concussion Service #2	Sending study information
28/08/2017	Email	Inbound	Wai/Bop OT	Withdrawn participant's case closed, send courier to collect supplements
30/08/2017	Meeting	Face to Face	Well/Kāpiti team	Attended MDT. Delivered supplements and cleared up confusion around recruitment process. Team Leader spoke with Research Manager who said OK to proceed
30/08/2017	Email	Inbound	Taranaki Psychologists	Office manager advised unable to find further participants and “no longer sustainable to hold onto supplies”, requested pick up
1/09/2017	Email	Thread	Wellington Psychologist	Confirmed there would be no overlap of verbal fluency measures
1/09/2017	Email	Thread	Taranaki Concussion Service #2	Following up study information. OT thanked for opportunity and advised it was run past team who were interested, now with psychologist for checking of measures
18/09/2017	Call	Outbound	Participant 146	Difficulty with compliance and experienced nausea, advised to try taking 2x twice per day or try taking in the evenings after dinner, as she's not a 'breakfast person'. Long discussion about RTW and difficulties in the office
1/09/2017	Email	Outbound	Taranaki Concussion Service #2	Following up study information with psychologist
22/09/2017	Email	Inbound	Waikato OT	Consent forms for participant
25/09/2017	Email	Thread	Taranaki Psychologists	Confirming arrangements and final pick-up of materials by freight-forwarding courier
25/09/2017	Call	Outbound	Participant 107	Call to introduce and organise baseline test
25/09/2017	Call	Inbound	Participant 140	Returned my voice message from same day, introduced and organised baseline testing
25/09/2017	Email	Thread	Wellington Psychologist	Follow up for Well/Kāpiti service recruitment and any barriers, psychologist unsure but advised one potential participant

26/09/2017	Call	Outbound	Participant 140	Baseline testing
27/09/2017	Call	Outbound	Participant 107	Baseline testing
28/09/2017	Email	Thread	Well/Kāpiti team	1x participant consent, advised barriers are fatigue at end of session making it hard to review study info, not wanting to take the placebo, and concern about time requirements when not managing daily life
29/09/2017	Email	Inbound	Participant 146	Advised she suffered another GI reaction and would now withdraw. Requested no phone call and offered journal for review. Replied apologising for the distress and thanking for her time and consideration
4/10/2017	Email	Inbound	Well/Kāpiti OT	1x participant consent
5/10/2017	Email	Inbound	Well/Kāpiti OT	1x participant consent
6/10/2017	Call	Outbound	Participant 142	Intro and discussion of symptoms, organised baseline testing for 20/10
9/10/2017	Email	Inbound	Well/Kāpiti OT	1x participant consent
10/10/2017	Email	Inbound	Well/Kāpiti OT	1x participant consent with additional background info - client suffers bipolar I disorder and alcohol dependence, though is reportedly no longer drinking.
10/10/2017	Email	Inbound	Waikato OT	1x participant consent
11/10/2017	Call	Outbound	Participant 147	Voicemail – message left
11/10/2017	Call	Outbound	Participant 189	Voicemail – message left
11/10/2017	Call	Outbound	Participant 145	Intro and discussion of symptoms, will take some time to consider participation
16/10/2017	Call	Outbound	Participant 147	Intro and arranging baseline testing
16/10/2017	Call	Outbound	Participant 189	Intro and arranging baseline testing
16/10/2017	Call	Outbound	Participant 145	Voicemail – unnamed so no message left
20/10/2017	Call	Outbound	Participant 142	Baseline test call to voicemail – message left
21/10/2017	Call	Outbound	Participant 145	Decided not to participate as too busy and stressed, and cognitive symptoms much better
24/10/2017	Call	Outbound	Participant 142	Voicemail, no message. Followed up with email.
25/10/2017	Email	Inbound	Participant 142	Apologies, lost phone. New number provided and baseline scheduled for 6/11
26/10/2017	Call	Outbound	Participant 140	Catch up call went to voicemail – message left
26/10/2017	Call	Outbound	Participant 107	Catch up call, doing well but still experiencing some symptoms, working more this month.
27/10/2017	Call	Outbound	Participant 140	Voicemail – no message left

31/10/2017	Email	Outbound	Participant 140	Check-in email and request for a good time to call
3/11/2017	Email	Thread	WAI/BOP OT	Not taking further referrals so cannot continue to recruit. Organised collection of materials
3/11/2017	Call	Inbound	Participant 140	Returning call/email. Doing well, no issues with supplements, working full time hours
6/11/2017	Call	Outbound	Participant 142	Baseline testing
7/11/2017	Email	Thread	Participant 125	Organising a time to talk and then conduct baseline testing after several failed attempts at phone contact
11/11/2017	Call	Outbound	Participant 147	Baseline testing
22/11/2017	Call	Outbound	Participant 189	Baseline testing
23/11/2017	Email	Thread	Well/Kāpiti team	1x participant consent and discussion of potential trial changes
24/11/2017	Call	Outbound	Participant 125	Baseline testing
29/11/2017	Call	Outbound	Participant 139	Intro and discussion of symptoms, organised baseline testing for tomorrow
29/11/2017	Call	Outbound	Participant 140	Catch up call to voicemail – message left
29/11/2017	Call	Outbound	Participant 107	Catch up call to voicemail – message left
29/11/2017	Call	Outbound	Participant 147	Catch up call to voicemail – message left
29/11/2017	Call	Outbound	Participant 189	Catch up call to voicemail – message left
29/11/2017	Call	Outbound	Participant 142	Catch up call to voicemail – message left
29/11/2017	Call	Outbound	Participant 125	Catch up call returned after several attempts. Discussed trial changes and participant happy to receive fish oil supplements and continue. Organised courier for active treatment
30/11/2017	Call	Outbound	Participant 139	Child answered, not available, left message to phone back on 0800 number
1/12/2017	Call	Outbound	Participant 140	Catch up call to discuss progress and trial changes. Advised 140 is placebo and provided options, participant decided to remain as a control and advised doing much better
1/12/2017	Call	Outbound	Participant 107	Catch up call to discuss progress and trial changes. Advised 107 is placebo and provided options, participant decided to withdraw without receiving fish oil
1/12/2017	Email	Thread	Wai/Bop team	Advised of changes to trial and requested any recruitment efforts paused, team happy with this – no potential participants currently
4/12/2017	Call	Inbound	Participant 139	Apologised for missing session, was working. Rescheduled for 12/12
4/12/2017	Email	Outbound	Participant 147	Advised of study changes and active group status, provided options and requested a call back

4/12/2017	Email	Outbound	Participant 189	Advised of study changes and active group status, provided options and requested a call back
4/12/2017	Email	Outbound	Participant 142	Advised of study changes and active group status, provided options and requested a call back
4/12/2017	Email	Thread	Waikato psychologist	Discussion of proposed trial changes - Waikato would be happy to continue once provided with updated materials. Stated her OTs found several clients were taking supplements already.
12/12/2017	Call	Outbound	Participant 147	Voicemail, message left
12/12/2017	Call	Outbound	Participant 142	Voicemail, message left
12/12/2017	Call	Outbound	Participant 139	Answerphone for numerous people, no message left
12/12/2017	Call	Outbound	Participant 189	Voicemail, message left
15/12/2017	Call	Outbound	Participant 139	Rescheduled baseline testing for 3/1. Participant advised he's busy at work, going away, and feeling better though still experiencing some symptoms
18/12/2017	Email	Thread	Participant 125	Supplements received and started, some GI upset including nausea and vomiting, changed to 2x twice a day and this stopped. Agreed to catch up call in January and to contact ASAP if any further side effects or other issues
19/12/2017	Email	Thread	Well/Kāpiti team	Provided participant consent and details of supplements still held at the DHB
28/12/2017	Call	Outbound	Participant 140	Time 2 testing call to voicemail, message left
28/12/2017	Email	Outbound	Participant 140	Request to organise time 2 testing
3/01/2018	Call	Outbound	Participant 139	Baseline testing
3/01/2018	Call	Outbound	Participant 107	Time 2 testing to voicemail, message left
17/01/2018	Call	Outbound	Participant 125	Voicemail, message left
17/01/2018	Call	Outbound	Participant 147	Voicemail, message left
17/01/2018	Call	Outbound	Participant 142	Voicemail, message left
17/01/2018	Call	Outbound	Participant 189	Voicemail, message left
23/02/2018	Email	Outbound	Remaining participants	Notification of cancellation of trial, thanked for participating
23/02/2018	Email	Outbound	Remaining organisations	Notification of cancellation of trial, thanked for participating

17/04/2018	Email	Thread	Wai/Bop	Organising return/disposal of materials

Notes: OT= Occupational Therapist, Wai/Bop = Waikato/Bay of Plenty based service, Well/Kāpiti = Wellington/Kāpiti coast based service, NYR= Not Yet Received (referring to supplements and associated participant number).

Appendix B

Study One Self-Report Eligibility Questionnaire

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Eligibility Questionnaire

If you answer yes to any of the following questions, you ***may not*** be eligible to participate. If you wish to discuss any of the questions, please phone Brylee on 0800 279 533.

	Yes	No
Do you take a fish oil supplement already, or have you regularly taken one in the last 6 months?		
Do you eat *more than* 3 servings of oily fish or shellfish (e.g. salmon, sardines, mackerel, fresh tuna, herring, kahawai, scallops, oysters) per week?		
Do you have an allergy to fish or shellfish?		
Are you vegetarian or pescatarian (eat fish but no other meat)?		
Are you pregnant or breastfeeding?		
Have you been diagnosed with any neurological or learning disorders?		
Are you taking any blood thinning medications?		
Do you have any hearing difficulties that make it hard to hold a telephone conversation?		

If you answered no to all of these questions, you may be eligible to participate in the study. If you wish to discuss your participation further please phone 0800 279 533 or email Brylee.Cresswell.1@uni.massey. ac.nz. If you have decided to participate, please complete the additional information form and the consent form, and return them to your occupational therapist/keyworker.

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Additional Information Form

If you have decided to participate in the study, please return the following information form, along with your signed consent form and your questionnaire, to your occupational therapist/keyworker.

Name **Sex**

Date of Birth **Ethnicity**

Level of Education (total years at school/polytech/university)

Date of Injury

Mechanism of Injury (how it happened)

Are you taking any medications? If so, please list:

***Are you taking any other (non-fish oil) supplements? If so, please list:**

*It is important that you avoid beginning any new supplements while taking part in the trial, but it is ok to continue with any that you are already taking.

Appendix C

Study Two Information Sheet and Survey

We are seeking to assess the information that is provided to people who have suffered a mild Traumatic Brain Injury (mTBI), sometimes also known as concussion. Our aims are to find out what information is made available to mTBI sufferers by their healthcare providers and in what form that information is provided, and compare written information with recommended patient information guidelines.

What is involved?

Completing the survey will take approximately 10 minutes. If you provide patients/clients with a non-ACC information sheet we request that you upload a copy of this to the survey when prompted. Your responses will contribute to research evaluating the provision of information to patients who have suffered a mild Traumatic Brain Injury.

Click on the next button at the bottom of this page which will take you to the survey. Thank you for taking the time to complete this survey.

Who is doing this research?

My name is Brylee Cresswell, I am a Doctor of Clinical Psychology candidate at Massey University, under the supervision of Professor Janet Leathem.

Who can participate?

You need to be a staff member in an organisation that treats patients who have suffered mTBI/concussion. Multiple staff members from the same organisation are welcome to participate.

Your rights as a participant:

You are under no obligation to accept this invitation. If you decide to participate, completion and submission of the questionnaire implies consent. You have the right to decline to answer any particular question. In order to protect your privacy the survey is anonymous.

Data resulting from this research will be securely stored at Massey University for 5 years, after which it will be destroyed. The information you provide will be used in my doctoral thesis and submitted for assessment, and the findings may be published in scientific journals or presented at scientific conferences in New Zealand and overseas.

Contact information:

If you have any further questions please feel free to contact the researcher or supervisor. A detailed report outlining the findings of this research study will be available to all participants, on request, once the study is complete.

Brylee Cresswell – Doctoral Candidate and Lead Researcher
Email: Brylee.Cresswell.1@uni.massey.ac.nz

Professor Janet Leathem – Supervisor
Email: J.M.Leathem@Massey.ac.nz

This project has been evaluated by peer review and judged to be low risk. Consequently it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with

someone other than the researcher(s), please contact Dr Brian Finch, Director (Research Ethics), email humanethics@massey.ac.nz.

Survey Questions

First, we'd like to know a little about your practice and profession

What is your profession?

General Practitioner
Medical Specialist (please state)
Nurse
Physiotherapist
Occupational therapist
Psychologist
Administrator
Other (please state)

What type of organisation do you work in?

Hospital Emergency Department
Accident and Medical Centre
General Practice
Concussion Service
Other: (please state)

In which part of New Zealand is your organisation located?

Northland	Whanganui
Auckland	Manawatū/Horowhenua
Waitematā	Wairarapa
Counties Manukau	Hutt Valley
Waikato	Wellington/Kāpiti
Bay of Plenty	Nelson/Marlborough
Lakes district	West Coast
Tairāwhiti	Canterbury
Hawkes Bay	South Canterbury
Taranaki	Otago

Is your service in an urban or rural location?

Urban
Rural

The remaining questions focus on your practice with mTBI/Concussion patients. You may feel as though you cannot answer some questions if you do not work directly with the patients. If this is the case, feel free to skip any questions that do not apply to you.

In the last month, approximately how many patients with confirmed or suspected mTBI/concussion have you seen?

0
1-10
11-20
21-30
31-40
41-50
50+

Do you provide patients with confirmed or suspected mTBI/concussion with written information about their injury?
Yes
No

Do you provide ACC leaflets? If yes, tick all that apply
ACC 572: Caring for yourself after a… Head Injury
ACC 4154: Knowing about your Mild Traumatic Brain Injury (TBI)
ACC 7639: Returning to Activity from a Concussion/Mild Traumatic Brain Injury
Other: (please state)
No, we do not supply these

Do you provide any other information sheets? If yes, please upload here
Yes
No

Do you have separate sheets available for the following? Tick all that apply
Babies/toddlers
Children
Adolescents
Adults
Older adults
Caregivers

Do you have information available in the following formats? Tick all that apply
English
Te Reo Māori
Languages other than Te Reo Māori and English
Audio format
Braille

How are your information sheets provided? Select all that apply
Handed to patient by consulting healthcare provider
Handed to patient by reception staff
Available for patients to take from the waiting room if they wish

Do you routinely include personalised written information?
Yes
No

Do you routinely provide mTBI/concussion patients information relating to the following, in any format (e.g., written, verbal, audio)? Please tick all that apply and outline the advice you provide
Symptoms that may occur (please state)
Symptom management (please state)
Symptom duration (please state)
Indicators of an emergency (please state)
Driving (please state)
Returning to work/study (please state)
Returning to sport/exercise (please state)
Substance use (please state)
Social support (please state)

Medications (please state)
Other: (please state)

Do you direct patients to health-related websites for their mTBI/concussion symptoms?
Yes (please state)
No

Which symptoms tend to be the most concerning for the patients you see. Please prioritise the list from the most frequently presenting symptom to the least.

Headaches	Frustration/impatience
Dizziness	Forgetfulness/poor memory
Nausea/vomiting	Poor concentration
Noise sensitivity	Taking longer to think
Light sensitivity	Blurred vision
Fatigue	Double vision
Sleep disturbance	Restlessness
Depression/tearfulness	Other (please state)

If you prescribe or advise the use of certain medications or supplements, please tick all that apply and outline the advice you provide for their use (e.g., nightly for sleep until symptoms subside; as required for headaches)
Paracetamol
Non-Steroidal Anti-Inflammatory Drugs
Tricyclic Antidepressants
Omega 3s/Fish Oil
Magnesium
Other: (please state)
N/A I do not recommend medications or supplements

What barriers do you face when it comes to providing your patients with information about mTBI/concussion? Please select as many as necessary and prioritise your selections in order of significance.
Lack of appropriate materials
Time constraints during consultations
It is the role of others within my organisation to pass on information (please state)
It is the role of others outside of my organisation to pass on information (please state)
Lack of patient interest in information
Patients have difficulty concentrating on what I tell/give them
Patient distress or feeling overwhelmed during consultations
Language barriers between myself and my patients
Language barriers between the information available and my patients
Other (please state)
Other (please state)
Other (please state)

Do you routinely refer patients with confirmed or likely mTBI to concussion services?
No, don't refer to concussion service
Yes, refer upon initial presentation
Yes, refer if symptoms continue for several weeks
Yes, refer if symptoms continue for several months

N/A I work for a concussion service

Any further comments about your practice with patients who have suffered mTBI/concussion? (please state)

Thank you for taking part in this survey! Your contribution is greatly appreciated.

Appendix D

DHB Research Approval Communications

13 June 2019

Brylee Cresswell
Doctoral of Clinical Psychology Candidate
Massey University

Dear Brylee

I refer to your application for research titled "Information Provision for Mild Traumatic Brain Injury". The other researchers involved are listed as Janet Leathem and Ross Flett. Carla O'Keeffe has agreed to be you clinical site lead for this research. For any clinical information you require please contact Carla Carla.okeeffe@wdhb.org.nz

The application has been approved by the Whanganui District Health Board's Clinical Board.

The Clinical Board would appreciate a copy of the research paper once completed.

Ngā Mihi

Rebecca Moody

Quality Coordinator, Patient Safety & Quality

Bay of Plenty
CLINICAL SCHOOL

BAY OF PLENTY
DISTRICT HEALTH BOARD
HAUORA A TOI

11 June 2019

Dear Brylee Cresswell

RE: Information Provision Following Mild Traumatic Brain Injury

I am pleased to advise that this research application has been authorised.

As a condition of this authorisation you are required to:

(i) inform the Research Office of the start and stop dates of your project;
(ii) contact the Research Office if there are any changes to your study protocol; and
(iii) provide a copy of the final study outcomes or report once your research has been completed.

Please contact the Research Office by email at research@bopdhb.govt.nz.

Please don't hesitate to contact the Research Office for further information about your application. We wish you all the best for your study.

Yours sincerely,

Charlie Stratton
Clinical Research Development Manager

Bay of Plenty Clinical School. Ground Floor Pohutukawa House, Tauranga Hospital, Cameron Road, Tauranga 3143 New Zealand. DDI + 64 7 5798797 | M + 64 27 546 6129 | F + 64 7 5780895 |

23 July 2019

Institutional Approval

Brylee Cresswell
[redacted]
Brylee.cresswell.1@uni.massey.ac.nz

Dear Brylee,

Re: Information Provision following Mild Traumatic Brain Injury.
The MidCentral DHB Research Support Office would like to thank you for the opportunity to review your study and has given approval for your research project. Your Institutional approval is dependent on the Research Office having up-to-date information and documentation relating to your research and being kept informed of any changes to your study. It is your responsibility to ensure you have kept Ethics and the Research Office up to date and have the appropriate approvals.
MDHB approval may be withdrawn for your study if you do not keep the Research Office informed of the following:

- Any communication from Ethics Committees, including confirmation of annual ethics renewal
- Any amendment to study documentation
- Study completion, suspension or cancellation

If you have any questions please do not hesitate to contact the Research Support Office.
Yours sincerely

Kelly Butler
Research Support Officer
MidCentral District Health Board

18 July 2019

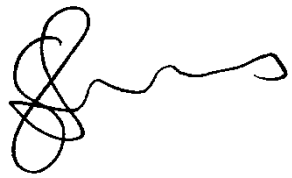
Brylee Cresswell
Doctoral Candidate and Lead Researcher
Massey University

Dear Brylee

Research proposal

I am pleased to advise you that your research proposal, Mild Traumatic Brain Injury, has met the requirements of the Taranaki DHB research policy and has been approved.

Yours sincerely



Dr Greg Simmons
Chief Medical Advisor

Project Description (300 words max – background, aim, methods):
Start Date: 17/05/2019
End Date: 31/05/2019
Sample Size: All patient facing Emergency Dept Staff : 200+

Providing patients and their support peoples with appropriate information after mild Traumatic Brain Injury (mTBI, also known as concussion) is important for safety, anxiety reduction, and symptom management. Several studies have shown that providing written information upon discharge from acute settings can reduce an individual's overall health service use, may help to prevent ongoing symptoms, and can be as effective as more intensive treatment for many mTBI sufferers. A recent Christchurch based qualitative study found that former mTBI patients considered information as a necessary element of their treatment, but despite this, many individuals lacked understanding of their injury and recovery.

International studies have shown substantial variability in the written information provided to patients after an mTBI. A 2004 New Zealand study found that only 45.9% of the survey respondents from New Zealand Emergency Departments and General Practitioners provided written information to patients who had a confirmed or suspected mTBI. These ranged from one to ten pages in length, and just over half met the criteria for being able to be read by 70% of the population. Since this study took place, at least two patient leaflets have been produced by the Accident Compensation Corporation (ACC) and treatment guidelines have been updated. It is not yet known if the ACC leaflets are routinely provided to patients by their healthcare providers, or whether other information sheets follow the current guidelines for mTBI treatment and patient information.

The goals of this research include; to compare the content of the information provided with current mTBI guidelines, to compare the accessibility of any written information with guidelines for patient materials, and to gain an understanding of any barriers or concerns that healthcare providers have regarding their work with this population. The results may assist with future practice recommendations and resource development.

I would like to invite staff from your Emergency Department who work with mTBI sufferers in any capacity to complete the survey. It will take approximately 5 to 10 minutes and includes an option to upload any written information sheets that are provided to patients.

Management and Resource Sign-offs

This study does not require HDEC review.

Locality Review – *the undersigned agree to the following statements:*

- The study protocol and methodology are ethical and scientifically sound.
- This researcher has identified that this study does not require Health & Disability Ethics Committee (HDEC) review.
- The local lead investigator is suitably qualified, experienced, registered and indemnified.
- Resources, facilities and staff are available to conduct this study, including access to interpreters if requested.
- Cultural consultations have occurred or will be undertaken as appropriate

Waikato DHB Approval of Research

RD019053	Information Provision for Mild Traumatic Brain Injury

Project Personnel

Principal Investigator:	Brylee Cresswell Massey University Brylee.cresswell.1@uni.massey.ac.nz
Waikato DHB named investigators:	
Primary contact name and contact details (email and phone):	Brylee Cresswell
Date Submitted:	17/05/2019
Type of Project:	Observational: qualitative/epidemiological
Multisite?	Multi-centre, Waikato DHB sub-site
Department:	Emergency Department
Service:	Medicine
% of Māori with condition of interest	According to one 2010-11 Waikato based study 31% of mTBI sufferers were Māori.
What are your plans for recruiting Māori?	All patient-facing ED staff will be invited to participate, no specific plans to recruit Māori practitioners.
Is ethnicity a variable in your study? (Māori c.f. non-Māori)	No
Will your study involve collecting tissue samples?	No
Will you expect to publish your results?	Yes
Finance/Resource Requirements: (eg staff time, extra clinics, extra procedures, consumables)	The required resources are email lists of ED staff or a staff member to disseminate the survey link on behalf of the researcher, and 5-10 minutes of respondents' time.

- Appropriate confidentiality provisions have been planned for.
- Appropriate arrangements are in place to notify other relevant local health or social care staff about the study, and for making available any extra support that might be required by participants, where relevant.
- Conducting this research will have no adverse effect on the provision of publicly funded healthcare.
- There is a stated intent that the results of the study will be disseminated and where practical and appropriate the findings of the study will be translated into evidence based care.

Queries about this research must be made to the Primary Contact person listed.

Dept/Service /Org	Role	Name (print clearly)	Signature	Date signed
Emergency Department	Clinical Nurse Director	Hayley Colmore-Williams	See attached email	
Emergency Department	Clinical Director	Ian Martin	See attached email	
Emergency Department	Operations Director	Barbara Garbutt		
~~Te Puna Oranga~~	~~Māori Research Review Cttee~~	~~Nina Scott~~		

Clinical Support Services Sign-offs

CROSS OUT/ADD SIGN-OFFS APPLICABLE TO THIS PROJECT

SIGNATORIES DECLARATION: We agree that appropriate resources are available in our service to support this project

Clinical Support Service	Name (print clearly)	Signature	Date signed
~~DHB Pharmacy~~	~~Rajan Ragupathy AND~~		

~~DHB Pharmacy~~	~~Marinda van Staden OR Jan Goddard~~
~~Laboratory~~	~~Kay Stockman~~
~~Radiology~~	~~Glenn Coltman~~
~~Medical Records~~	~~Marilyn Hunt~~

Please return to the Research Office (via Sarah Brodnax, 13 Ohaupo Road) along with required documents as identified in the checklist for final approval.

Office use only:
Quality & Patient Safety, Waikato DHB

Signature: [signature] **Date:** 24/5/17

Name: Mo Neville
Director
Quality & Patient Safety

Position:

RE: Massey University MTBI Survey Research Request

Jim Green <Jim.Green@tdh.org.nz>
Tue 18/06/2019 18:13
To: Cresswell, Brylee <Brylee.Cresswell.1@uni.massey.ac.nz>

Kia ora Brylee
I am giving the staff a reminder. See if we can increase participation for you.
I hope that is successful.
Jim

From: Cresswell, Brylee <Brylee.Cresswell.1@uni.massey.ac.nz>
Sent: Tuesday, 18 June 2019 10:38 AM
To: Jim Green <Jim.Green@tdh.org.nz>
Subject: Re: Massey University MTBI Survey Research Request

Kia ora Jim,

Thank you for your response to my request. It has been difficult to attract respondents from the Tairāwhiti region, so DHB participation would be hugely valuable and appreciated. If you or any other staff have questions or concerns not addressed in the materials already provided, please don't hesitate to get in touch.

Ngā mihi mahana,
Brylee Cresswell
02102269087

From: Jim Green <Jim.Green@tdh.org.nz>
Sent: 07 June 2019 18:15:35
To: Cresswell, Brylee
Subject: FW: Massey University MTBI Survey Research Request

Kia ora Brylee
I am responding to your request for participation in your study.
I am the Research Coordinator at Hauora Tairāwhiti.
I will process this through our research approval protocol.
You have provided all the required information for that so that all that remains is checking on staff agreement to participate which is underway.
I will advise if there is agreement and that will trigger staff accessing your reporting tool.
Thank you for the opportunity to participate in your research.
Ngā mihi
Jim Green
Research Coordinator
Hauora Tairāwhiti

From: Cresswell, Brylee [mailto:Brylee.Cresswell.1@uni.massey.ac.nz]
Sent: Friday, 7 June 2019 3:08 p.m.
Subject: Massey University MTBI Survey Research Request

Tēnā koe,

My name is Brylee Cresswell and I am a candidate on the Doctor of Clinical Psychology programme at Massey University. My doctoral research focuses on mild Traumatic Brain Injury (mTBI, also known as concussion) and as part of this I am looking into the information provided to patients who have suffered mTBI.

Re: Concussion Survey Invitation

Cresswell, Brylee
Wed 05/06/2019 17:55
To: saptarshi Mukerji <sapimuk09@gmail.com>

Kia ora Sapi,

Thank you kindly for your response. The deadline has been extended so I would be most appreciative if you could disseminate the survey to the relevant staff.

I understand they are very busy and may not be interested in completing a survey, but every response counts! Currently I have a lot of responses from around the Auckland region, so it would be great to get a decent sized sample from the Wellington region too.

If you or other ED personnel have any further questions, please don't hesitate to get in touch.

Warm regards,
Brylee.

From: saptarshi Mukerji <sapimuk09@gmail.com>
Sent: 05 June 2019 16:01:04
To: Cresswell, Brylee
Subject: Concussion Survey Invitation

Hi Brylee,

I just received your email from Marina at the CCDHB research office about your survey. I can disseminate the survey link to our doctors, nurses and allied health if you want. Traditionally, these people are very difficult to get to fill forms. Most ED personnel have rather short attention spans! But I can pester them.

From your email it looks like we may have already missed the deadline of 31st May? Let me know if you still want to go ahead.

Cheers
Sapi Mukerji
Advanced Trainee, Emergency Medicine
Clinical Research Emergency department Wellington (CREW)
[redacted]

RE: Massey University Concussion Research Invitation

Peter Jones (ADHB) <PeterJ@adhb.govt.nz>
Tue 21/05/2019 13:59
To: Cresswell, Brylee <Brylee.Cresswell.1@uni.massey.ac.nz>

Hi Brylee

We discussed your study at our research group meeting today and the group was happy to support it. I will ask our administrators to forward this email to our staff across medical; nursing; admin; allied health staff today. Good luck with your research!

Kind regards

Peter

Peter Jones
MBChB, MSc (Oxon), FACEM
Associate Professor of Emergency Medicine, Department of Surgery, University of Auckland
Director of Emergency Medicine Research, Auckland City Hospital
Chair NZEM Network

From: Cresswell, Brylee [mailto:Brylee.Cresswell.1@uni.massey.ac.nz]
Sent: Thursday, 16 May 2019 2:54 p.m.
To: Peter Jones (ADHB)
Subject: Massey University Concussion Research Invitation

Tēnā koe Dr Jones,

My name is Brylee Cresswell and I am a candidate on the Doctor of Clinical Psychology programme at Massey University. My doctoral research focuses on mild Traumatic Brain Injury (mTBI, also known as concussion) and as part of this I am looking into the information provided to patients who have suffered mTBI. Professionals in both primary and secondary care services are being invited to participate in a brief survey relating to their work with these patients, with a focus on the information they provide.

I would like to invite those in your organisation who work with mTBI sufferers in any capacity (this includes medical, allied health, support and administration staff) to complete the survey. It will take approximately 5 to 10 minutes and includes an option to upload any written information sheets that are provided to patients. I aim to collect as many responses as possible before the 31st of May and would be most appreciative if the survey could be forwarded to the appropriate teams and/or individuals within your DHB. Alternatively, I would be happy to make contact directly if the appropriate contact details could be provided to me.

The goals of this research include; to compare the content of the information provided with current mTBI guidelines, to compare the accessibility of any written information with guidelines for patient materials, and to gain an understanding of any barriers or concerns that healthcare providers have regarding their work with this population. The results may assist with future practice recommendations and resource development.

To see the official information sheet and consent form, and to begin the survey if you wish, please click here: Information Provision for Mild Traumatic Brain Injury

survey

Marysha Gardner (NDHB) <Marysha.Gardner@northlanddhb.org.nz>
Tue 14/05/2019 11:28
To: Cresswell, Brylee <Brylee.Cresswell.1@uni.massey.ac.nz>

Hi Brylee, I would be happy to complete your survey and also pass on to other members of our emergency department.

Regards,

Dr Marysha Gardner

FACEM
Clinical Director Emergency Department
Whangarei Hospital

Appendix E

Case Study

The Neuropsychological Assessment of a 33-year-old Male with Historic Traumatic Brain Injury:

How my doctoral research contributed to my work with this individual

Massey University Doctor of Clinical Psychology Candidate

Intern Psychologist at the Department of Corrections

This case study represents the work of Brylee Cresswell during her internship in 2018. Clinical supervision was received during the assessment of this individual. All names and identifiable information within the case study have been changed to protect the anonymity of the client.

Candidate: Brylee Cresswell……..Date:……

Supervisor: Sharlene Murdoch……..Date:…….

Abstract

The present case study outlines the effects that my doctoral research has had on my work as an Intern Psychologist. To demonstrate this I have discussed a client from the Department of Corrections Prison Service, whose assessment benefitted from learning that I took from the theoretical and practical components of my research with individuals who have suffered from Mild Traumatic Brain Injury. The case study begins with a summary of my research, followed by the assessment report for my client, and concludes with a discussion of how my research contributed to my work with this client, and as an intern clinician in general.

Summary of Research

Mild Traumatic Brain Injury (mTBI) represents 70-90 percent of all TBI in New Zealand. Key mechanisms of injury include motor vehicle accidents, falls, and assaults. Typical symptoms in the acute phase of mTBI include headache; dizziness; nausea; confusion; focal neurological signs such as tinnitus; and cognitive symptoms such as memory, attention, and executive function difficulties. These symptoms usually abate within days or weeks post-injury, however 20-30% of sufferers develop ongoing symptoms that can persist for months or years (Barker-Collo et al., 2015; Heitger et al., 2009) and delay an individual's return to normal functioning. Ongoing symptoms are also associated with increased rates of anxiety and depression (Macleod, 2010; McCauley et al., 2008; Mickeviciene et al., 2002; Styrke et al., 2013).

Post-concussion syndrome (PCS) is the common term for the experience of ongoing symptoms after mTBI, however debate exists about both the classification and causation of post-concussion symptoms. There are no symptoms unique to PCS, frequently reported symptoms such as headache and fatigue are common in the general population, and individuals experience similar symptoms after other forms of trauma, therefore, some argue, it should not be a diagnostic entity specific to brain injury (Meares et al., 2011; Rathbone et al., 2015). Personality and psychological factors, rather than direct injury related phenomena, are commonly considered the cause of PCS. Various phenomena such as premorbid anxiety or depression (Meares et al., 2011), negative injury beliefs and attributions (Hou et al., 2012; Kay, Newman, Cavallo, Ezrachi and Resnick (1992); Macleod, 2010; Snell, Hay-Smith, Surgenor, & Siegert, 2013), low cognitive reserve (Oldenburg et al., 2016), all or nothing behaviour after injury (Hou et al., 2012), or iatrogenic factors (Broshek et al., 2015; Macleod, 2010) increase the odds of developing PCS.

Omega 3 polyunsaturated fatty acids (*n*-3 PUFA) have been found to have many health benefits and recent research suggests that they may have a role to play in the recovery of

cognitive function following brain injury. The *n*-3 PUFA are essential fatty acids – they must be obtained through the diet. Alpha-linolenic acid (ALA) is obtainable from many plant sources, while both Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are more commonly found in marine sources (Lunn & Theobald, 2006). DHA comprises the majority of the brain's lipids; while EPA is less abundant within the brain, it exerts important effects peripherally (Dyall, 2015; Mueller et al., 2015). Supplementing the diet with *n*-3 PUFA in the form of fish oil capsules has been effective for both enhancing cognitive performance in healthy individuals low in DHA (Stonehouse, 2014) and attenuating decline in those with mild cognitive impairment (Otaegui-Arrazola, Amiano, Elbusto, Urdaneta, & Martinez-Lage, 2014).

The study aimed to evaluate whether *n*-3 PUFA supplementation was an effective adjunct to standard treatment following mTBI. Further aims included assessing whether any cognitive effects were moderated by changes in mood, and whether illness perceptions and coping mechanisms predict outcomes. Participants were randomly assigned to receive either a *n*-3 PUFA supplement containing 1988 mg of DHA + 468 mg of EPA per day, or the placebo supplement containing 4000 mg of sunflower oil per day. Supplements were in the form of fish oil capsules. The trial duration was intended to be six months and consist of telephone based testing sessions at baseline, three and six months. To maximise the sensitivity of testing it was essential to assess the domains of functioning most commonly impaired after mTBI. Particular attention was given to memory and executive function as studies have found that speed and ease of processing (Kay et al., 1992), learning and remembering (Shanmukhi & Panigrahi, 2003), executive ability, complex attention, cognitive flexibility and memory (Barker-Collo et al., 2015) may be affected in the first 12 months post-injury. In addition, depression, anxiety, and stress are frequent mood-related post-injury difficulties (Barker-Collo et al., 2015; Bay et al., 2009; J.-K. Chen et al., 2008; Styrke et al., 2013) that may benefit from fish oil supplementation (Jacka et al., 2012; Meyer et al., 2013; Sarri et al., 2008)

During the course of recruitment and data collection for this study, it became apparent that individuals with mTBI had little understanding of their injury, symptoms, or prognosis. As it proved difficult to recruit an adequate sample for the initial study, a further survey style study was generated to consider the provision of information to patients who have suffered mTBI.

Case Presentation

Reason for Referral

Mr Timothy Sanson was referred for cognitive testing to assess his current functioning across multiple domains. Mr Sanson had expressed difficulties with attention, memory, and clarity of thought, as well as his mental health. While he has suffered numerous injuries during his life, perhaps the most severe was sustained during a car accident in 1997, when Mr Sanson was 11 years old. He sustained a significant coup and contre coup injury to the temporo-parietal area, with the initial force to the left side. Mr Sanson was unconscious for four to five days and spent 19 days in hospital. It was not clear whether neuropsychological testing took place following this injury, and no follow up was received 12 months after the accident.

Sources of Information

The following sources of information were used to inform the assessment:

Date(s)	Information Source	Author/Assessor
26/4/18 2/5/18 9/5/18 17/5/18	Interviews with Mr Sanson	Brylee Cresswell (Intern Psychologist)
26/4/18 2/5/18 9/5/18 17/5/18	Psychometric testing with Mr Sanson[10][11][12][13][14]	Brylee Cresswell (Intern Psychologist)
26/4/18	Psychometric questionnaire[15]	Brylee Cresswell (Intern Psychologist)
2/5/18	List of life events	Mr Sanson
18-27/8/97	Clinical notes	Various, Palmerston North Hospital
27/8/97	Discharge Summary	Palmerston North Hospital
27/8/97	Ophthalmologist report	S. Migde
30/9/97	Social Worker's letter to ACC	Jack Newtown
2/10/97 30/1/98 27/7/98	Paediatrician reports	Marlene Cliffe
8/10/97 9/4/98	Neurosurgeon reports	Marlon Hunt

[10] Wechsler Adult Intelligence Scale, Fourth Edition, Australia and New Zealand Version (WAIS-IV$^{A\&NZ}$)
[11] Delis-Kaplan Executive Function System (D-KEFS)
[12] Rey Auditory Verbal Learning Test (RAVLT)
[13] Rey Complex Figure Test (RCFT)
[14] Logical Memory I and II subtests from the Wechsler Memory Scale, Fourth Edition, Australia and New Zealand Version (WMS-IV$^{A\&NZ}$)
[15] Conners' Adult ADHD Rating Scale (CAARS)

Presentation

Mr Sanson is a 33 year old male of New Zealand European and Cook Island Māori descent. He is of average build, and appeared well groomed. Mr Sanson exhibited psychomotor agitation throughout the interviews, particularly when thinking back to events in his childhood and speaking about his difficulties with anxiety. While this agitation was noted in each interview, it tended to subside with time and when engaged with non-verbal testing tasks. While his mental status was not formally assessed, Mr Sanson appeared oriented to time, place, person, and situation. Mr Sanson struggled with word-finding at times, and frequently repeated the final word from sentences spoken to him; although Mr Sanson was not aware of this tendency, it may be a strategy for attending to and thus recalling the end of sentences. Neither the content nor the pattern of his speech was suggestive of formal thought disorder, and no perceptual abnormalities were apparent.

Current Situation

Mr Sanson currently resides in Waikeria Prison's Kauri unit where he is serving a two year nine month sentence for Aggravated Robbery. Mr Sanson advised that he keeps his cell clean and organised, and often cleans common areas such as the showers. He dedicates time each day to physical training, as fitness and strength are important to him, and undertakes agricultural/horticultural work within the unit compound.

Mr Sanson is a 'returned offender' who was deported from Australia while serving time in prison, and later a detention centre. His key support people reside in Australia and he maintains some telephone contact with them. He has a partner, daughter and step-daughter in Queensland, and his mother in New South Wales. In addition, his father, brothers, and son also live in Australia. Mr Sanson has few support people in New Zealand, though some extended family members reside in his hometown in Manawatū.

Presenting Problem

Mr Sanson reported numerous difficulties with anxiety, clarity of thought, and memory. He reported instances of racing thoughts and struggling to maintain focus or order tasks when too much information is presented to him (e.g., multi-step instructions or a long paragraph of text) which often leads to heightened anxiety, anger, and outbursts. Mr Sanson advised that he sometimes has outbursts of verbal frustration with himself, but no longer lashes out physically at property or people; previously, he would "smash" anyone or anything in his path of escape from an overwhelming situation. However, he also spoke about being able to problem solve with practical work when he did not understand instructions (e.g. constructing an object himself when he did not understand the plans).

Mr Sanson reported beginning new tasks before completing what he was previously working on, then becoming frustrated with the mounting tasks he has to complete, as well as instances of narrow focus, when he will spend however much time is necessary completing a task he is engaged in. He also advised that his mind "goes blank" at times, leading him to forget what he had been doing previously, or what had been said to him.

Mr Sanson stated that his short-term memory is poor, and showed difficulty remembering many elements of his childhood years. He spoke of "flashes" of memories – some traumatic, others ordinary, coming to him both during interviews and everyday life. He advised that at times these have raised his anxiety levels.

Mr Sanson reported that he has taken amitriptyline for approximately 12 years, and has recently begun taking Epilim (sodium valproate) after requesting a mood stabiliser for his anxiety. He advised that this medication regime has helped him to feel calmer and think more clearly, however anxiety remains a significant difficulty.

Relevant Background Information

Developmental and Family History

Mr Sanson raised the possibility that his mother abused drugs during her pregnancy with him, but advised that this may have been a rumour heard from another family member.

He was uncertain if he met his developmental milestones, but had no information to the contrary.

Mr Sanson advised that he lived with his Mother and Father until approximately age eight, when his mother "abandoned" the family and moved to Australia. He has two brothers, approximately two years older and younger than himself; all three children remained in the care of their father. After Mr Sanson's mother left, his father remarried a woman with children of her own; Mr Sanson stated that he did not get along with his stepmother. This reportedly happened twice; Mr Sanson's father divorced and remarried another woman with her own children who Mr Sanson "hated". Over the course of these three marital relationships, the children were reportedly exposed to a considerable degree of domestic violence.

Mr Sanson reported that he and his brothers were frequently beaten by both biological parents, though more so their father, and Mr Sanson wrote "I think he belted fear into us, I do know I remember being really scared and sore". He went on to detail his father then comforting him after physical punishments, telling him that he punished the children like that because he loved them and wanted them to learn. Mr Sanson made a point of saying that despite the abuse, he loves both of his parents, and that he is grateful to his father for teaching him practical skills for daily living (e.g., cooking, home maintenance).

In addition to physical abuse, Mr Sanson reported suffering sexual abuse perpetrated by an older male family member. This included both performing and witnessing sexual acts. In the context of the referral request it was not deemed necessary or appropriate to explore this disclosure in further detail, however Mr Sanson was advised of the sexual abuse specific support available to him and how to access this should he wish. As well as "sexual things" Mr Sanson advised that this family member made him do many other "bad things" such as smoking an entire packet of cigarettes around the age of 10, sneaking out at night, fighting, and using drugs. Mr Sanson spoke about then forcing a younger family member to do the same

things. Aside from both being subjected to and witnessing violence in the home, Mr Sanson advised that he has few memories of his childhood.

Education/Occupation

Mr Sanson had difficulty recalling his school years, though advised that he was "naughty" and may have had learning difficulties after his accident in 1997. He attended 10 years of schooling, mostly in New Zealand and a brief period in Australia. A Social Worker's letter to ACC in October 1997 indicated that Mr Sanson's stepmother had been informed of difficulties at school, and teacher concerns about moving forward to high school the next year, however medical reports from 1998 note that Mr Sanson was reading at his age level, and while his parents believed he was slower to register new information and had more difficulty expressing himself than he had before the accident, he was doing well in school and had no obvious learning difficulties. Mr Sanson advised that he became a bully in school, and was "kicked out" of all of his schools.

Mr Sanson began working at age 14 in Australia. His employment history consists of manual work such as panel-beating and spray-painting, working in an abattoir, concreting, and drain laying. During his prison sentences Mr Sanson has obtained certificates in English, mathematics, health and fitness, and workplace safety. He has worked in prison gyms, laundries, kitchens, and agricultural services.

Medical

Mr Sanson described difficulties sleeping, particularly getting to sleep, as well as a fluctuating appetite. He advised that both of these problems have been alleviated by taking Epilim and believes they are related to anxiety. He stated that he is otherwise healthy, and ensures that he is physically fit and strong by training every day. Mr Sanson spoke of his physical training regime as a kind of meditation for him.

Mr Sanson was not aware of any serious physical or mental health difficulties among his family, though stated that he thinks his older brother had a diagnosis of ADD.

Injury

At age 11 Mr Sanson was an unrestrained back seat passenger in a car vs. power pole motor vehicle accident. Medical notes state that he was found lying unconscious and unresponsive to pain or voice, and on admission was moving to pain but exhibited no spontaneous eye opening. No Glasgow Coma Scale score was provided. Mr Sanson was air lifted to Wellington hospital where he stayed for several days before being transferred to Palmerston North. He remained unconscious for four to five days, and spent a total of 19 days in hospital.

Mr Sanson took the force of the accident on the left side of his body and head; a CT scan showed petechial haemorrhage of the posterior limb of the left internal capsule and blood lying on the tentorium cerebelli. Mr Sanson suffered a period of left hemiparesis and left sided neglect, and recalled that he "had to learn to do everything again". This weakness improved significantly over the following months. Noted ongoing effects included occasional confusion, forgetfulness, and clumsiness, though according to the reports this did not impact his schooling or sporting ability.

Mr Sanson reported receiving many further blows to the head throughout his life. These have come from fighting, including being hit with a pole on one occasion, and falling. He reported vague memories of being "knocked out", though could not detail any of his injuries.

Mental Health

Mr Sanson reported a history of significant anxiety, which he described as racing thoughts, being jumpy (both in body and mind), and an urge to escape. He said he would "smash anything in the way" of his escape, and often finds himself feeling anxious in group situations. Mr Sanson stated that he has had problems with anger, which has led to violence against people and property. He advised that he has suffered from depression in the past for which he was prescribed SSRI medication, however this made him "flip out" and increased his

agitation and anxiety. Mr Sanson reported that his current medication regime of Amitriptyline and Epilim is successfully improving the above difficulties.

Mr Sanson spoke about periods of hearing voices. These voices were sometimes insults and sometimes commands, and were present both with and without the influence of substances. He mused during the interview that while the voices were not the sound of his father, the derogatory comments were similar to what he experienced from him in childhood. Mr Sanson stated that the voices began in his teenage years and were experienced periodically, but he had not heard them for several years. Similarly, he spoke of "seeing weird things" flying past him out of the corner of his eye, then turning to find nothing present; it was not clear if these were illusions or hallucinations or whether they occurred under the influence of substances.

Mr Sanson described having "flashes" of memories during the course of everyday life, as well as during the interview. He advised that they were very intense, and often made him feel anxious. At other times he experienced "mind blanks" which prevented him from engaging with tasks or conversations. When queried about nightmares, Mr Sanson reported that he had experienced recurring nightmares in the past – both as a child and as an adult, but was uncertain of their content.

Social and Emotional

Mr Sanson could not recall much of his social situation from childhood, but remembered having a best friend, whom he saw briefly after his deportation from Australia. He also recalled being a bully at school.

Mr Sanson described romantic relationships involving violence, infidelity, and emotional dependence. He stated that he has had a tendency to become "clingy" with women he is romantically involved with. He also outlined numerous occasions of infidelity, domestic violence, and "rough" sexual encounters. Mr Sanson currently has a partner in Australia who

has provided him with support throughout two of his prison sentences; he wishes to enjoy a healthy relationship with his partner upon release.

Mr Sanson is currently serving his third prison sentence. He received two seven year sentences in Australia – the first for Grievous Bodily Harm with Intent, and the second for multiple Aggravated Robberies. During his second sentence, Australian law was changed to allow for the deportation of offenders who were not Australian citizens. Mr Sanson was moved to a detention centre in Western Australia, where he spent eighteen months. After this time he signed his deportation order and was returned to New Zealand. Mr Sanson obtained work in Palmerston North and later Tauranga, before reoffending with a further Aggravated Robbery leading to his current sentence. Regarding this offence, he stated that he "didn't even need to" as he was earning a comfortable living. Mr Sanson stated that he has spent over 12 years in prison and has had enough; he believes that he is capable of living safely in the community though he worries that he has become "institutionalised".

Although he had seen numerous counsellors and other professionals, and completed several anger management/violence prevention programmes, Mr Sanson had not spoken about his childhood sexual abuse until recently. He also had not disclosed hearing voices, nor the extent of his emotional difficulties. Mr Sanson advised he felt significantly calmer after disclosing these difficulties. He stated that he now understands that asking for help is beneficial for him, so will not hesitate to do this after his release.

Substance Use

Mr Sanson detailed an extensive substance use history, beginning with smoking cigarettes from age 10. He advised that he began using cannabis around the age of 12 or 13, and after leaving school in Australia began growing and dealing cannabis with his mother. He reported becoming dependent on cannabis for daily life, as it made him feel good and his "worries went away". Mr Sanson's heavy use of cannabis ceased with his first prison sentence, and he has now not used it for five to six years. He also outlined his use of amphetamines and

methamphetamine, which included injecting amphetamine at 16 or 17 years old. Mr Sanson advised that he used these substances heavily after his first release from prison; they made him feel "invincible", sometimes "amped up" and other times "level". He described occasionally drinking coffee to help him get to sleep at night, though did not notice calming effects from coffee during the day. Mr Sanson has had periods of heavy alcohol consumption, though drugs were noted as his key substance use problem.

Strengths

Mr Sanson has developed several techniques for coping with his difficulties. He described being orderly and clean, which assists him with structuring his time and activities; he uses physical exercise as a means of focusing his mind and remaining physically healthy; and repeats the end of sentences possibly as a way to help him recall and respond appropriately during conversation. These are strategies that Mr Sanson has developed over the course of his life, and have not been taught to him. This, alongside his numerous recent disclosures and willingness to seek help, indicate significant resilience, capacity to relate to others, and self-preservation.

Psychometric Assessment

Mr Sanson's current levels of cognitive and behavioural function were assessed using the Wechsler Adult Intelligence Scales, fourth edition, Australia and New Zealand version (WAIS-IV$^{A\&NZ}$), selected subtests from the Delis-Kaplan Executive Function System (D-KEFS), the Logical Memory I and II subtests from the Wechsler Memory Scales, fourth edition, Australia and New Zealand version (WMS-IV$^{A\&NZ}$), the Rey Complex Figure Test (RCFT), and the Rey Auditory Verbal Learning Test (RAVLT). Please see below for a description of his results, and the appended table for more concise score information.

Premorbid Functioning

While verbal tests or subtests are frequently used to assess premorbid functioning, this was not deemed appropriate for Mr Sanson given his difficulties with verbal expression and low level of schooling. Reports from after his accident state that he was reading at a 13 year level (at 12-13 years of age) and had no obvious learning difficulties at school. This suggests that Mr Sanson had been functioning at or around the *average* level before his accident.

Test Taking Behaviour

Mr Sanson was eager for testing to take place and appreciative of the opportunity to discover his cognitive strengths and difficulties. At times during testing Mr Sanson became anxious, which was exhibited through psychomotor agitation and tended to occur during verbal subtests when he was uncertain of the answer or numerous pieces of information were presented at once. Mr Sanson frequently initiated discussion between subtests, usually about what he was experiencing during the previous test or about situations from his past that the test had reminded him of. There were no concerns regarding the level of effort Mr Sanson was exerting during testing.

Full Scale Intelligence Quotient

The Full Scale Intelligence Quotient (FSIQ) is a composite score that measures cognitive functioning across multiple domains: verbal comprehension, perceptual reasoning, working memory, and processing speed. The FSIQ score is considered the most reliable indicator of general intellectual functioning. Relative to others of a similar age, Mr Sanson's FSIQ is in the *low average* range (12th percentile). While this is a broad overview of Mr Sanson's cognitive functioning at this time, considering his performance in each individual domain will allow for a more thorough understanding of his abilities.

Verbal Comprehension

The Verbal Comprehension Index (VCI) measured Mr Sanson's verbal reasoning and concept formation. His score on this index fell within the *borderline* range (7th percentile). The

VCI is comprised of three subtests, and Mr Sanson's score across these subtests was varied. He scored higher on the Similarities subtest – which required him to use abstract thinking, concept formation, and verbal reasoning skills to verbalise the similarity between two words – than the Vocabulary and Information subtests. (Similarities – *average* range, 37th percentile; Vocabulary – *low average* range, 9th percentile; Information – *very low* range, <1st percentile). The latter two subtests rely more heavily on cultural and educational experiences, alertness to the environment, and retrieval of information from long-term memory. Given Mr Sanson's low level of schooling and history of trauma during his school years, it is unsurprising that he showed more difficulty with these tasks.

Perceptual Reasoning

The Perceptual Reasoning Index measured Mr Sanson's nonverbal concept formation, visual perception and organisation, and visual-motor coordination. Mr Sanson's score was in the *average* range (61st percentile). His performance on the subtests comprising this index (Block Design, Matrix Reasoning, and Visual Puzzles) were all within the average range thus comparable, suggesting that his skills in this domain are developed to similar levels. Interestingly, his poorest performance was one the Block Design subtest, the only timed test in the PRI.

Processing Speed

The Processing Speed Index (PSI) measures the ability to process simple visual information quickly and effectively. Both the Symbol Search and Coding subtests require visual and motor speed. Mr Sanson's score on this index was in the *low average* range (18th percentile) and his scores on both subtests were comparable.

Working Memory

The Working Memory Index (WMI) is a measure of an individual's ability to sustain attention, concentrate, and exert mental control. Mr Sanson scored in the *borderline* range (3rd percentile) on this index. This indicates that he may have difficulties with auditory recall and

mental manipulation of information. The majority of people can hold seven (plus or minus two) items in their working memory, Mr Sanson was able to hold a maximum of five.

During the Arithmetic subtest, which is a timed test of solving verbally presented mathematical problems without the use of pen and paper, Mr Sanson frequently asked for the question to be repeated. He advised that his mind was "stuck" on previous problems, particularly when he knew he'd given an incorrect answer. He also experienced "mind blanks" that prevented him from attending to the full question. His score on this subtest – *very low* range (<1st percentile) – lowered his score for this index. On the Digit Span subtest, which required Mr Sanson to recall and mentally manipulate strings of numbers increasing in length, he scored in the *average* range (25th percentile).

Attention

The Digit Span Forward subtest is a measure of verbal attention, a skill required for many everyday tasks such as following verbal instructions and holding a conversation. Mr Sanson scored in the *average* range (37th percentile), indicating an ability to attend to simple verbal information.

Visual Memory

The Rey Complex Figure Test required Mr Sanson to copy a novel drawing, and later recreate it from memory. This test requires visual attention, visual-motor coordination, and long term visual memory. He produced an accurate copy of the figure to score in the *high average* range (91st percentile), and a delayed re-creation in the *average* range (50th percentile).

Verbal Memory

The Logical Memory subtest required Mr Sanson to verbally recall two stories immediately after their presentation, and again approximately 30 minutes later. This measures

verbal attention, short-term verbal memory and long-term verbal memory. Mr Sanson scored in the *low average* range (9th percentile) for the immediate recall trial, and in the *low* range (1st percentile) for the delayed trial. This may indicate a difficulty with long term verbal memory, however his score was likely impacted by the degree of anxiety Mr Sanson experienced during this test. He had stated that he struggled when presented with large amounts of information at once, and upon the presentation of the first story, Mr Sanson experienced a memory "flash" of similar story recall tasks in school. He required encouragement to continue his recall after quickly stating he could not remember any further details for the first story. With further encouragement to allow himself time to search his memory and provide his answers, Mr Sanson performed better on the immediate recall trial of the second story. For the delayed recall condition, he could not remember any details of the first story.

The delayed trial of the Rey Auditory Verbal Learning Test (RAVLT) also assessed Mr Sanson's long-term verbal memory, with his score falling in the *low average* range (9th percentile). The discrepancy between this score and his score on the delayed trial of Logical Memory may relate to Mr Sanson's anxiety, the lower amount of information presented in the RAVLT, or the opportunity for repetition and practice with the RAVLT.

Memory and Learning

The Rey Auditory Verbal Learning Test assessed Mr Sanson's ability to retain and integrate more information with repeated presentation of a list of words. Also assessed were proactive and retroactive interference, and his recognition ability. Mr Sanson's recall after the initial presentation of words was in the *average* range (25th percentile), however he learned few further words over successive trials and his total score from learning over trials fell within the *low* range (1st percentile). No proactive interference was evident with Mr Sanson's score on learning a new word list (*borderline* range, 5th percentile), however he was able to recall only two words before stating that he had "lost all of that". This may represent difficulty processing new information whist inhibiting previously learned responses. His immediate free

recall of the initial list (*borderline* range, 2nd percentile) included one instance of retroactive interference from the second list, however this was not a word he had recalled when required to. His delayed recall was in the *low average* range (9th percentile) and recognition in the *borderline* range (2nd percentile). When presented with a page of written words, Mr Sanson was able to recognise most of the words he had consistently recalled from list one, with one list B intrusion. This indicates that he had successfully encoded his consistently recalled words into memory, while the others may not have been attended to.

Verbal Fluency

The Verbal Fluency subtest of the D-KEFS consists of three conditions – Letter Fluency, Category Fluency, and Switching. The Letter Fluency condition required Mr Sanson to name as many words as possible beginning with a particular letter within 60 seconds, while adhering to a set of rules about which type of words were allowed. This measures initiation, simultaneous processing, speed of processing, and vocabulary knowledge. His score on this condition was in the *average* range (63rd percentile). The Category Fluency condition required the production of words within a certain category within 60 seconds, it measures the same skills as the Letter Fluency task, but is supposedly less effortful, as tasks that access semantic knowledge are less novel. Mr Sanson's score on this condition was in the *borderline* range (5th percentile), indicating difficulty accessing semantic knowledge, which is potentially due to focal injury to the left temporal region.

Cognitive Flexibility

Several subtests of the D-KEFS assessed Mr Sanson's cognitive flexibility, including the switching condition of Verbal Fluency, the Number-Letter sequencing trial of the Trail Making Test, and the Inhibition/Switching trial of the Colour Word Interference Test. Cognitive flexibility is necessary for 'higher order' skills such as multi-tasking, simultaneous processing, and divided attention. Significant difficulties with cognitive flexibility can be due to frontal or diffuse brain injury.

Mr Sanson's score for the switching condition of the Verbal Fluency test was in the *very low* range (<1st percentile). This condition required him to name items from alternating categories, and while his switching was accurate it was also slow. His pattern of scores indicates that Mr Sanson had difficulty switching between categories over and above the difficulty he experienced simply naming items based on their semantic properties as in the Category Fluency condition.

The Trail Making Test involves scanning and drawing a line through or between items ordered on a page. Mr Sanson scored in the *average* range for the number sequencing and letter sequencing conditions (75th percentile and 50th percentile, respectively) and the *high average* range for the visual scanning and motor speed conditions (84th percentile for both). On the Letter-Number sequencing condition, which requires switching between numbers and letters with each line connection, Mr Sanson scored in the *low* range (1st percentile). This indicates significant difficulty with flexibility.

The Colour Word Interference Test required Mr Sanson to name colours, read the names of colours, name the colour of the ink a word (which was the name of a colour) was printed in – requiring the inhibition of the automatic task of reading the word as it is written, and finally to switch between naming the colour of words and reading them. His score on the colour naming condition was in the *low average* range (16th percentile) which may represent his difficulty with semantic retrieval. His scores on the word reading and inhibition conditions were in the *average* range (63rd percentile for both), and his score on the switching condition was in the *very low* range (<1st percentile). Midway through the final condition Mr Sanson made an error and stated he thought he was doing it wrong, he paused and appeared uncertain of what to do, but with prompting was able to complete the test.

Problem Solving

Both the Sorting and 20 Questions subtests from the D-KEFS assess problem solving. The Sorting subtest measured Mr Sanson's concept formation and problem solving skills by

asking him to sort sets of cards into two categories and describe the categories. He scored in the *average* range for both the number of sorts made (37th percentile) and for his ability to describe the sorting categories (50th percentile). Mr Sanson did show difficulty describing the sort categories, which seemed related to his ability to find the necessary words, however when allowed sufficient time he was able to provide adequate information.

The 20 Questions subtest required Mr Sanson to identify specific objects on a page using as few yes/no questions as possible. This requires categorical processing and the use of feedback to guide problem solving behaviour. The initial abstraction score indicates how efficient an individual was at eliminating as many objects as possible with their first question, which requires categorical processing. Mr Sanson scored in the *average* range (37th percentile) for this. The weighted total score is an indication of how efficient the individual was with their questioning, while taking into account the possibility of 'lucky guesses', Mr Sanson's weighted total score was in the *high average* range (91st percentile).

Visual-Spatial Skills

The D-KEFS Tower test measured Mr Sanson's visual attention, visual-spatial skills, and spatial planning. It required him to build towers of varying complexity whilst adhering to a set of rules and using as few moves as possible. His score fell within the *average* range (25th percentile) and indicated that Mr Sanson possesses a degree of advanced spatial planning ability.

The Block Design subtest of the WAIS-IV also measures visual-spatial ability and spatial planning, by having the individual copy two-dimensional designs presented in a book, using blocks. Mr Sanson's score for this subtest was in the *average* range (37th percentile).

For both of the visual-spatial tests, Mr Sanson provided some correct responses after the time limit had elapsed.

ADHD Symptoms

Mr Sanson completed the Conners' Adult ADHD Rating Scale, which is a self-report questionnaire of symptoms and behaviours related to Attention Deficit Hyperactivity Disorder. Mr Sanson's scores on all scales fell within the non-clinical range, though there was some inconsistency with his responding that necessitates caution when interpreting the responses. His highest elevated score related to inattentive symptoms, which may be better explained by the sequelae of trauma and injury than a neurodevelopmental disorder.

Summary

Mr Sanson's overall cognitive functioning was in the *low average* range. He exhibited significant difficulties with memory and learning in the verbal domain, as well as cognitive flexibility. He showed difficulty with semantic retrieval and processing on the Verbal Fluency test, which required rapid responses. Mr Sanson had less difficulty with these processes on the Colour Word Interference, Sorting, and 20 Questions tests. This may relate to the visual nature of these tests, as well as the lack of a time requirement with the latter two, on which Mr Sanson scored higher than the Colour Word Interference test. A discrepancy between Mr Sanson's motor speed and processing speed is apparent, which may account for some of the confusion and frustration he reports feeling towards himself. Mr Sanson showed relative strengths in the visual domain, particularly visual memory and problem solving with visual materials.

Formulation

Mr Sanson described difficulties relating to racing thoughts, ordering tasks, verbal recall, thinking 'clearly', completing tasks before moving on, anxiety, psychomotor agitation, 'flashes' of memories, and 'mind blanks'. In addition, he reported a recent history of violent physical and verbal outbursts. These symptoms and behaviours stem from a combination of significant left sided and diffuse brain injury; trauma from emotional, physical, and sexual abuse; and social learning.

Mr Sanson suffered numerous adverse events during his formative years. From a young age he was witness to domestic violence and subjected to excessive physical punishment from both parents; his father provided comfort and affection after beating him. He was also subjected to sexual abuse from his older brother. Mr Sanson felt abandoned when his mother left the family, and witnessed further domestic violence when his father remarried. These events normalised violence and provided Mr Sanson with distorted models of love and relationships, as well as a disorganised attachment style, all of which formed the template for his own romantic relationships. As an adult Mr Sanson's relationships have involved violence, infidelity, and "clinginess".

The turbulent upbringing and physical and sexual abuse Mr Sanson suffered likely led to beliefs about the world being dangerous and unpredictable and a consistently heightened state of arousal. This state is necessary for keeping safe, as it allows the environment to be constantly scanned for danger. However, less energy is then available for other tasks of normal academic and social learning, and thus such learning opportunities are missed. In this way Mr Sanson's childhood trauma may have impaired his ability to attend to information for long enough to commit it to memory. Traumatic memories tend to be encoded in a fragmented rather than sequential form and this accounts for difficulties with recalling a traumatic event in its full detail, intrusive memories, nightmares, and flashbacks. Due to this, Mr Sanson's continued traumatic experiences may have impaired his memory function further, as evidenced by the "flashes" of both traumatic and everyday memories he now experiences. In addition, when a traumatic experience is inescapable many people, especially children, experience dissociative reactions which recur during episodes of re-experiencing. Mr Sanson may continue to have such reactions, which he experiences as brief "mind blanks".

A combination of autonomic hyperarousal and normalised violence may have led to his disruptiveness in the classroom and reputation as a "bully". Mr Sanson is unlikely to have learned to express his emotions verbally, and this ability may have been impaired due to his

traumatic experiences as Broca's area – the brain region responsible for expressive language – often 'shuts down' during traumatic events and traumatic re-experiencing. In addition, he suffered a significant injury to the left temporal and parietal areas of the brain, which have likely further impaired his expressive ability. Rather than verbally expressing his emotions and experiences, Mr Sanson used violence or escape behaviours when situations activated his fear response. As these behaviours were reinforced, either by avoiding difficult situations or discharging his negative emotions, his propensity to use them grew stronger and they became significant difficulties in his life.

On top of the negative emotions associated with polyvictimisation, Mr Sanson also experienced the guilt and shame of subjecting his younger brother to the same antisocial and sexual behaviours he himself had endured. This likely compounded his negative emotional experiences and lead to depression, as well as avoidance behaviours such as substance abuse and thrill-seeking. Mr Sanson's thrill-seeking, violent, and other criminal behaviours may have stemmed from his difficulties with cognitive flexibility and information processing – as he struggled to process the information in his environment and consider the consequences of numerous possible courses of action, he resorted to behaviours that were well learned, or succumbed quickly to peer pressure. Such behaviours likely also reinforced the belief that the world is not safe and one must always be on high alert for danger. As such, he continues to experience significant hyperarousal, sleep difficulties, and other anxiety related sequelae. The combination of trauma, drug use, and his brain injury likely also led Mr Sanson to experience auditory and visual hallucinations.

The injury Mr Sanson suffered at age 11 likely compounded difficulties he was already experiencing due to the effects of trauma. Trauma, drug abuse, and injury all have the ability to impair numerous cognitive domains. Due to the left sided focus of the injury, it is likely responsible for the semantic processing and verbal memory difficulties Mr Sanson showed in the present assessment. Although medical notes at the time indicated a good recovery, it is

also possible that Mr Sanson 'grew into' difficulties as his frontal lobe functions developed in adolescence and early adulthood. This would account for his significant deficits in cognitive flexibility.

Recommendations

- Due to Mr Sanson's difficulties with anxiety and self-reported discomfort in the group environment, any treatment he engages in should occur in an individual setting.
- Cognitive remediation therapy (CRT) can teach many strategies for learning cognitive skills or compensating for cognitive deficits. This may be beneficial for Mr Sanson's difficulties with flexibility, memory, and verbal processing. However, as this approach frequently utilises specialised software, access to CRT may prove difficult, particularly in the prison environment.
- An important support for Mr Sanson may be helping him to understand his functional difficulties and learn to explain them to others in a manner both comfortable and useful to him.
- Mr Sanson has difficulty holding more than five pieces of verbal information in his working memory. The use of simple instructions involving one or two key points may be an effective compensatory strategy to prevent overloading Mr Sanson's working memory and help to remain focused when receiving instructions.
- Mr Sanson's visual skills are better developed than his verbal skills. Using written lists and/or picture cues to help him perform tasks in a step by step fashion may help him to perform tasks without becoming confused or jumping forward in the task sequence before completing all necessary prior steps. Writing down, or otherwise recording, information will also allow him to use this as a form of external recall, rather than relying on his own long-term verbal memory.

- Mr Sanson showed a tendency to provide correct answers after the testing time limits, perform more poorly on timed tests, and perform better once encouraged to take his time on non-timed tests. In addition, his motor speed was assessed as faster than his information processing speed. As such, taking his time when performing tasks will likely be beneficial for the final results and help him to prevent the frustration he experiences towards himself. Strategies that may help with this include mindfulness, verbal self-instruction, and paced breathing during moments of confusion or racing thoughts.
- Mr Sanson experiences considerable anxiety and trauma related symptoms which include psychomotor agitation, emotional dysregulation, and experiential avoidance (e.g., escape behaviours, dissociation). There is an association between cognitive flexibility and self-awareness and the understanding and expression of emotions. In addition, flexibility impairments appear to be higher with greater levels of psychological distress. As such, treating these psychological difficulties will likely enhance Mr Sanson's ability to respond to his surroundings. Numerous treatment modalities may assist with these difficulties; schema therapy operates from an emotional standpoint and may be beneficial for processing emotional trauma without relying too heavily on higher level cognitive functions. Dialectical Behaviour Therapy (DBT) may also be an appropriate treatment modality, due to its focus on psychological flexibility and skills training.
- It is recommended that Mr Sanson be supported to access the ACC sensitive claims service to process the sexual abuse he suffered in childhood. This difficult work should be undertaken with a clinical psychologist, to prevent any delays in his assessment, to allow him to form a trusting relationship with his assessor rather than having to re-tell his story for the assessment process, and due to his complex cognitive and emotional needs.

- It is also recommended that upon release from prison Mr Sanson take part in an assessment with an Occupational Therapist to assess how his difficulties with attention, memory, and cognitive flexibility affect his instrumental activities of daily living.

Effects of my Research on my Clinical Practice

Undertaking research relating to concussion has enhanced my practice as an Intern Psychologist in a number of ways. Firstly, it has deepened my understanding of neuroanatomy and the neurobiological processes that underpin brain injury symptoms; secondly, interacting with the participants has shown me how I need to alter my practice to account for both symptoms and the trauma of the accident itself; and finally, I have seen that clients often have minimal knowledge of what has happened to them, why they are experiencing symptoms, and what this means for their future.

Having an understanding of the anatomy and neurobiological processes that underpin brain injury symptoms has assisted me with test selection, formulation, and explaining difficulties to clients. Due to Mr Sanson's complex history I selected tests to assess a broad range of functioning, but with an emphasis on executive function, memory and language. This was due to the possibility of left focal injury affecting his language processing and verbal memory abilities, and the possibility of executive function deficits becoming apparent as he matured rather than at the time of injury. In addition, the use of subtests from the WAIS-IV, WMS-IV, and D-KEFS in my research test selection meant I was comfortable with administering many of the tests I utilised with Mr Sanson. This allowed me to administer the tests in a more natural and relaxed manner, which Mr Sanson responded to well. As Mr Sanson's case was complicated by significant trauma in childhood, drug use, and potentially further injury, it was not possible to clearly state which events have caused which symptoms. With some knowledge of the anatomy of both brain injury and trauma, I could state that his semantic processing, verbal memory, and cognitive flexibility deficits were likely caused or significantly worsened by the injury. However, it is also likely that the brain injury and trauma symptoms have maintained one another.

Working with my research participants taught me to slow down, and allow clients the space they need to express themselves. I found that many of my research participants had had

little chance to discuss their accident and its sequelae in depth, and allowing them to do so was an exercise in building rapport. As a naturally fast speaker I also found I needed to slow my own speech to allow for constructive conversation with participants' who may have had information processing difficulties. With Mr Sanson, who could not recall any neuropsychological assessment after his injury, had only very recently begun speaking openly about his past, and had a history of "smashing" his way out of stressful situations, I felt that this approach would be imperative to our work together. In our initial session, I was prepared with numerous areas of inquiry, but tried to use open questions and allow him plenty of time to respond as I had suspected that word finding may have been a difficulty for him. Even when responding to injury related questions he frequently returned the conversation to other past traumas, at which times I altered my line of questioning to gather information relating to his history and emotional functioning. Mr Sanson seemed grateful for this, as in that session and future sessions he thanked me for listening, conducting the assessment, and simply showing up for the appointment.

Despite having the professional input of General Practitioners, Occupational Therapists, Physiotherapists, and sometimes Neurologists and Psychologists, many of the injured individuals I spoke to regarding my research did not appear to understand their injury. They were uncertain of whether their injury experience was 'normal' (e.g. if feeling ok the day of the injury, and very unwell the next day was related to the injury or not), which symptoms might relate to the injury, and what their symptoms meant for their recovery. Many stated that they learned more every time they spoke with someone about their symptoms, but it could be weeks between opportunities for such discussions. Due to this, I suspected that Mr Sanson might have a lot of questions about his injury and which of his present difficulties relate to it. This turned out to be correct, and my understanding of injury processes and the need to slow down to deliver information clearly was useful in this situation. He was however, very receptive to the notion that the testing would help us to discern where his difficulties and

strengths lie and which functions may have been affected by the injury. I was sure to repeat this information in each session, and this appeared to put Mr Sanson more at ease with the testing situation.

In conclusion, my doctoral research involved the assessment of individuals who had suffered from a mild traumatic brain injury. This provided valuable experience for my work as an Intern Psychologist by deepening my understanding of the mechanisms of brain injury, experience with cognitive testing, and experience working with individuals who are suffering the effects of brain injury. In my work with Mr Sanson these learnings proved valuable for building and maintaining rapport, conducting the testing, producing the report and helping him understand his difficulties.

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