

#### Research Bank PhD Thesis

Investigations into a physiotherapy-led vestibular rehabilitation model of care

Parker, Ian Gerard

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# Investigations into a physiotherapy-led vestibular rehabilitation model of care

Submitted by

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Declaration of Authorship and Sources

This thesis contains no material that has been extracted in whole or in part from a thesis that I have submitted towards the award of any other degree or diploma in any other tertiary institution.

No other person's work has been used without due acknowledgment in the main text of the thesis.

All research procedures reported in the thesis received the approval of the relevant Ethics/Safety Committees (where required). See appendices 1 to 3

IAN PARKER

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## Abstract

People with dizziness commonly seek medical solutions through primary contact medical practitioners and Ear Nose and Throat (ENT) outpatient services. Physiotherapists trained in vestibular rehabilitation may independently and safely assess and manage these people. This thesis presents a programme of research undertaken to investigate a standalone physiotherapy-led vestibular rehabilitation service and its management of people with dizziness screened from the wait lists of ENT outpatient services. A systematic review and two clinical studies support the main service investigation.

The published systematic review, Study 1, synthesised vestibular diagnostic proportions reported by the specialties of ENT/Otology, Neurology, Emergency, General Practice and Physiotherapy, enabling comparison with the findings of the clinical studies in this programme of research. A 2020 update found increased awareness for setting-specific differences in diagnostic proportions and for benign paroxysmal positional vertigo (BPPV) diagnostic procedures; however, awareness of correct BPPV management was still deficient.

The Study 2 pilot demonstrated the feasibility of the model of care and informed the extension of the trial into a major study. Sixty-seven participants from an ENT wait list included a 44:23 female to male ratio, a mean age of 55.2 years (SD 17.57) and a diagnostic profile of common diagnoses including BPPV (22%), unilateral vestibular hypofunction (40%), vestibular migraine (10%) and cervicogenic dizziness (6%). Service outcomes included a mean wait of 382.6 days (SD 246.3) with 31(46%) participants receiving one occasion of service. Nine percent of people assessed were returned to ENT for consultant review and no adverse events were recorded. Patient management led to the resolution of BPPV and unilateral vestibular hypofunction clinical signs and significant improvements in the Dizziness Handicap Inventory (34.9/100 to 11.1/100, p< 0.001) and the Activities-specific Balance Confidence scale (78.3/100 to 87.9/100, p= 0.009).

Study 3, an interrater reliability trial between a vestibular audiologist and physiotherapist for diagnostic accuracy and referrals for vestibular rehabilitation included 22 people (82% female) with dizziness from ENT wait lists with a mean age

of 54.9 years (SD 19.44). Clinician diagnoses compared closely for the common forms of vestibular dysfunction: BPPV 100% agreement (Kappa 1.0), unilateral vestibular hypofunction 77.3% (Kappa 0.54), vestibular migraine 95.5% (Kappa 0.78), and cervicogenic dizziness 86.4% (Kappa 0.65). Percentage agreement for referral to vestibular rehabilitation was 95.5% (Kappa 0.89).

Study 4 investigated a cohort of 301 people with dizziness (191 (63%) females) from ENT wait lists averaging 55.5 years (SD 17.23) in age and with a diagnostic profile of BPPV (20%), unilateral vestibular hypofunction (36%), vestibular migraine (15%) and cervicogenic dizziness (8%). Wait times reduced significantly from 390.2 days (SD 243.5) in 2013 to 93.0 days (SD 219.4) (p= 0.004) in 2017, and occasions of service and duration of treatment were skewed positively towards medians of one. Consumer engagement using visual analogue scales showed consistently high median levels of satisfaction for wait time (9.3/10 cm) and service quality (10/10 cm). Clinical effectiveness of the model of care was demonstrated through its treatment of BPPV leading to resolution in 48 out of 50 people (p< 0.001) and its treatment of unilateral vestibular hypofunction leading to compensation in 47 out of 54 people presenting with uncompensated DVA (p< 0.001). Whole cohort Dizziness Handicap Inventory scores improved from 38.1/100 (SD 22.1) to 24.6/100 (SD 21.6) (p< 0.001) and Activities-specific Balance Confidence scale scores from 73.2/100 (SD 21.89) to 81.0/100 (SD 18.94) (p< 0.001).

Investigating the burden of dizziness, initial assessment utility scores calculated from the Assessment of Quality-of-Life 8 Dimensions questionnaire averaged 0.58 (SE 0.01), representing a 30% reduction in quality of life compared with published normal population scores. Treatment saw a significant improvement in the utility by 0.08 (95% CI 0.06, 0.10) (p< 0.001). Using the Work Productivity and Activity Impairment (Dizziness) questionnaire, absenteeism in 2013 participants amounted to potential annualised lost wages of AUD \$16380 per person: reducing to AUD \$4185 by 2017. Presenteeism by people with dizziness at a mean of 30%, represented a considerable potential cost in lost productivity to employers in 2013 at AUD \$20998, reducing with wait reduction by 2017 to AUD \$5308. Cost consequences analysis using decision tree modelling of two models of care, physiotherapy-led and ENT-led, showed dominance in cost by the physiotherapy-led model.

In conclusion, the physiotherapy-led vestibular rehabilitation model of care was shown to be one of high value care; being clinically, service, and cost effective, and safe and satisfactory for people with dizziness referred to an ENT waitlist. Research into the burden of dizziness considering quality of life, absenteeism and presenteeism indicated considerable consequences for people with dizziness and found the physiotherapy-led model improved this burden significantly. In the Australian public hospital setting, independent, primary contact, physiotherapy-led vestibular rehabilitation services provide a safe, effective, efficient and cost-effective pathway for people with dizziness referred to ENT.

## **Chapter 1 Introduction**

Most people mobilise through balanced, upright, bipedal gait. Dizziness, a subjective state of disorientation (Gopinath et al., 2009) including vertigo, a temporary illusion of movement (Baloh, 1998), impacts this balanced movement and leads to preventable sequelae such as falls (Agrawal et al., 2009; Herdman, Blatt, Schubert, et al., 2000; Rubenstein, 2006), physical injury due to falls (Kristinsdottir et al., 2000; Kristinsdottir et al., 2001), and mental dysfunction through associated anxiety (Cheng et al., 2011; Morimoto et al., 2019) and fear of falling (Schlick et al., 2016). As a result, people with dizziness often seek medical solutions to their dizziness (Neuhauser et al., 2008; Newman-Toker, Hsieh, et al., 2008). Clinical reasoning leads primary contact medical practitioners to assess for vestibular, cardiac, respiratory, neurological and systemic causes of the dizziness, in line with the patient history and examination results (Maarsingh et al., 2010; Newman-Toker, Hsieh, et al., 2008). When the medical practitioner suspects vestibular system dysfunction, as is often the case with people experiencing vertigo, they are frequently referred to Ear, Nose and Throat (ENT) or Neurology medical specialists for thorough vestibular assessment and appropriate investigations (Maarsingh et al., 2010). Those referred to public specialist outpatient services are often placed on wait lists categorised on the basis of urgency of need, with the aim of assisting with specialist demand management (Queensland Health, 2013a). This wait lengthens exposure to the dizziness and its sequelae, potentially impacting on the person's overall function within the community (Morimoto et al., 2019).

Dizziness represents a health issue for both people and health systems. As an example, dizziness contributes to patient burden financially (Sun et al., 2014) at the same time as creating demand for health care (Neuhauser et al., 2008). Dizziness potentially contributes to falls (Agrawal et al., 2009; Pothula et al., 2004), which have a consideration impact on health systems (Tinetti, 2003). All dizziness sequelae potentially contribute to people reducing their participation in the community activities (Morimoto et al., 2019; Neuhauser et al., 2008).

This thesis reports the investigations into a physiotherapy-led vestibular rehabilitation model of care and considers whether the service represents one of high value care.

A background into dizziness in general is developed in Chapter 2 followed by a published systematic review with its investigations into the diagnostic proportions of people with dizziness and vertigo, permitting comparison with those of the investigated service. Three clinical studies then follow commencing with the pilot study that investigated the feasibility of the service and the types of outcomes needed for a complete service analysis. An interrater reliability trial considered diagnoses and referrals for vestibular physiotherapy by comparing those produced by a vestibular audiologist and a vestibular physiotherapist. Finally, the thesis describes the full investigation into service, clinical, cost and consumer engagement outcomes as well as describing the burden of dizziness in terms of quality of life, absenteeism and presenteeism. These results are then considered in light of the literature and their clinical significance analysed.

## 1.1 Context

In Australia and England, the use of advanced scope allied health practitioners under suitable clinical governance to manage people with health dysfunction, has been promoted for more than twenty years in moves towards health system modernisation and rationalisation (Allied Health Professions Office Queensland, 2014; Durrell, 1996; Queensland Health, 2013b). People who formerly had to wait to see a specialist as an outpatient, are now managed by allied health services with documented shorter wait times (Queensland Health, 2013a; UK Department of Health, 2000b). This has been well established in the orthopaedic field in both countries (Comans et al., 2014; Desmeules et al., 2012; Durrell, 1996; Oldmeadow et al., 2007). An emerging model of care involves physiotherapists as primary contact, advanced scope practitioners providing support to ENT departments for people with dizziness and associated balance problems (Allied Health Professions Office Queensland, 2014; UK Department of Health, 2000a). This model of care is developed below with background provided by Chapter 2 of this thesis.

An opportunity came about in 2012 at the Royal Brisbane and Women's Hospital in Brisbane, Queensland, Australia to establish a physiotherapy-led service for people with dizziness from low urgency Ear Nose and Throat (ENT) outpatient clinic wait lists. At the time, the hospital's ENT category two and three wait lists included many people whose time on the wait lists exceeded the defined wait times for their category (Queensland Health, 2013a). Within Queensland, category two wait lists require the person to be seen by a consultant within 90 days and category three wait list, within 365 days (Queensland Health, 2013a). An audit of the local ENT category two and three wait lists found referrals for people with symptoms, signs or diagnoses of vestibular dysfunction formed approximately seven percent of the combined wait lists. Of about 100 people a month being added to these two ENT wait list categories combined, the referral of approximately two people with dizziness per week established a reasonable level of demand for a new model of care.

At this point in time, there was professional and political resolve to reduce the numbers of long waits in outpatients services across the state (Queensland Health, 2013b) and to expand the scope of practice of allied health professionals (Young et al., 2015). The doctoral candidate was at the time, the sole vestibular physiotherapy practitioner in the local physiotherapy department and was motivated to develop and investigate a model of care for people referred to ENT with dizziness who could be managed with vestibular physiotherapy.

## 1.2 Model of Care

Proposing to assess and treat people with potential vestibular dysfunction, and to assist the ENT outpatient service with patient throughput and reduction of long waits, a trial of a new physiotherapy-led, multidisciplinary vestibular rehabilitation model of care was supported by stakeholders in the local Queensland Health system. These stakeholders included ENT, physiotherapy, audiology and the Allied Health Office Queensland (Queensland Health, 2013b). The model's pathway commenced with the screening of ENT category two and three outpatient wait lists, initially by the vestibular physiotherapist and then subsequently by audiologists and ENT registrars. Referrals were screened for indications of symptoms, signs, or diagnoses of vestibular dysfunction. As a primary contact model, identified referrals were then transferred to vestibular physiotherapy, a stand-alone physiotherapy service located within the physiotherapy department, for management including initial assessment, treatment, referral onwards if required, and for discharge.

This thesis presents an analysis of the vestibular rehabilitation model of care, comprising the development, collection, and analysis of clinical and service data collected using an observational study design. To demonstrate the high value care provided by the service, analysis uses the framework of the health care Triple Aim goals of Berwick et al. (2008); namely improving the experience of care, improving the health of identified populations, and reducing costs per capita for these populations. The grounds for the use of the Triple Aims of Berwick et al. (2008) is explored in the background chapter.

The thesis commences with a systematic review (Study1) comparing the combined diagnostic outcomes of the pilot and the main study with other models of care internationally. The pilot study of this thesis (Study 2) investigated the model's feasibility in terms of service and clinical outcomes, with a description of the patient profiles.

To determine concurrent diagnostic accuracy and to enable comparison with reported multidisciplinary models of care including audiology in the management of people with dizziness (Kasbekar et al., 2014; Lee et al., 2011; Leong et al., 2008), an interrater reliability trial (Study 3) between a vestibular audiologist and vestibular physiotherapist determined the agreement in diagnoses and in referrals to vestibular rehabilitation after initial assessment.

The main study (Study 4) comprises a prospective case series aiming to formally describe with sufficient cohort size the clinical and service outcomes of patient management by a physiotherapy-led vestibular rehabilitation service. Further, it aimed to explore the cost consequences of the service and to investigate the burden of dizziness as reported by people with dizziness through analysis of quality of life, absenteeism and presenteeism outcomes. See Figure 1.1 below for studies forming this thesis.



Figure 1.1 Flow Diagram of the studies in the thesis project

An analysis of dizziness as a health issue and a contributor to falls, plus the burden that this poses to people with dizziness and health systems follows, providing a background to this model of care.

# Chapter 2 Background

Dizziness represents complex health issues for both people and health systems. This complexity arises from the multiple causes and physiological systems involved, the various diagnostic processes available, the treatment options once a diagnosis is made, and the resultant burden of care experienced by people with dizziness and health systems alike. To enable a broad understanding of concepts involved with the management of dizziness, this chapter provides a background to dizziness and vertigo including prevalence, causes, models of care, the association with falls, and the burden on people and health systems with dizziness. Chapter two concludes with the overall aims of this doctoral programme of research, followed by the aims and research questions for each of the studies reported.

## 2.1 Dizziness: a person's complaint

People with dizziness present frequently to a wide range of clinicians in a wide range of settings. People use the term dizziness, a subjective sense of disorientation (Gopinath et al., 2009), to describe a number of specific experiences that clinicians refine with questioning and assessment. Traditionally, clinicians associate the use of the word dizziness with at least four categories of dysfunction (Drachman & Hart, 1972; Murtagh, 1991; Sloane et al., 2001) as follows:

Vertigo, an illusion of movement (Baloh, 1998), is often reported as spinning, rocking, or veering while walking (Drachman & Hart, 1972). Classically, clinicians make the association between vertigo and vestibular dysfunction where an imbalance exists between the afferent outputs of the two sides of the vestibular system.

Unsteadiness or disequilibrium refers to disorientation in gait with no vertigo (Drachman & Hart, 1972) with associated dysfunction including cervicogenic dizziness, bilateral vestibular hypofunction, peripheral neuropathy and musculoskeletal problems affecting the lower limbs.

Visual Vertigo is the poorly defined sense of dizziness (Drachman & Hart, 1972) associated with visual dependence and resultant hyper-vigilance to movement in the environment, so is often associated with vestibular dysfunction (Bronstein, 1995).

'Light headedness' or 'faintness' are descriptions often used by people when describing presyncopal dizziness associated with orthostatic hypotension (Drachman & Hart, 1972) although the terms are also used to describe dizziness in general.

Other sensations sometimes referred to as dizziness by people with dizziness include but are not limited to oscillopsia - a sense of the world moving that occurs with eyes open in conjunction with head or body movement in people with bilateral vestibular hypofunction and in acute unilateral vestibular hypofunction, a persistent sense of rocking that can be called mal de Debarquement syndrome, diplopia - a sign of a neurological visual split, and the psychological symptoms of floating and swimming (Tusa, 2014a).

## 2.2 Prevalence of dizziness

People experience dizziness frequently, with its prevalence increasing with age (Agrawal et al., 2009; Barin & Dodson, 2011; Jonsson et al., 2004). Senescence of sensory and motor systems (Agrawal et al., 2019), the increased prevalence of many diseases with dizziness as a symptom with increasing age, a greater prevalence in longer lived women, and changes to the environments of older people explain the general increase in dizziness with age (Barin & Dodson, 2011). Table 2.1 below lists a combination of survey and objective testing studies reporting the prevalence of dizziness as a general complaint, demonstrating the increasing dizziness prevalence with age. The relevance to this thesis of increased incidence of dizziness with age will be seen in the analysis of participant demographics.

## 2.2.1 Causes of dizziness

A broad range of aetiologies contribute to dizziness in people presenting to primary care facilities. Analysis of visits to emergency departments by people due to dizziness found that the top four diagnostic groups attributed to the presenting dizziness were otologic/vestibular (32.9%), cardiovascular (21.1%), respiratory (11.5%) and neurological (11.2%) (Newman-Toker, Hsieh, et al., 2008). Proposed diagnostic profiling of the older dizzy person in a primary health care setting included the dysfunction profiles of: frailty, psychological, cardiovascular, presyncope, non-specific dizziness and ENT-disorders (Dros et al., 2011).

Study	Testing Tool	Dizziness prevalence by age group
Sloane (1989)	USA- National Ambulatory Medical Centre Survey	25-34 years 1.8%, 75-84 years 4.0%, ≥ 85 years 6.7%
Colledge et al. (1994)	Scotland- community survey of five general practices	> 65 years 30%
Neuhauser et al. (2005)	German National Telephone Health Interview survey plus concurrent clinic validation study	Lifetime prevalence of moderate to severe dizziness or vertigo 29.5% Lifetime prevalence vestibular vertigo 7.4% Incidence vestibular vertigo 1.4% Prevalence vestibular vertigo: 18-39 years 14%, $\geq$ 60 years 37%
Newman-Toker et al. (2008)	USA- National Hospital Ambulatory Medical Care survey	<ul><li>32.9% of emergency department visits for dizziness due to otologic/vestibular diagnosis,</li><li>3.3% of all emergency department visits associated with dizziness</li></ul>
Agrawal et al. (2009)	USA- National Health and Nutrition Examination Survey- interview with physical examination	35.4% of all adults ≥ 40 years of age had vestibular dysfunction
Gopinath et al. (2009)	Australia- Blue Mountains Hearing Study using DHI questions as part of an audiology interview / assessment	36.2% for dizziness/vertigo, 10% for vestibular vertigo, 14.2% for non-vestibular vertigo
Mueller et al. (2014)	Germany- KORA-Age study	Prevalence of dizziness in past year: mean age 73.6 years (SD 6.1) 26% < 70 years 21% > 80 years 37%
Koo et al. (2015)	South Korean National Health and Nutrition Examination Survey adults ≥ 40 years- interview and physical examination	Prevalence of dizziness in past year in adults ≥40 years old 16.7% Prevalence of vestibular dysfunction 1.84% Prevalence of vestibular dysfunction by age: 40-49 years 0.25% ≥ 70 years 9.19%

#### Table 2.1 A sample of studies examining dizziness prevalence

USA United States of America, DHI Dizziness Handicap Inventory, KORA Cooperative Health Research in the Region of Augsburg, SD standard deviation

Management of dizziness often requires onwards referral to an appropriate medical specialist for review. This process leads to people referred from a primary care service to, for example, ENT, cardiology and psychiatry specialists; differing in their dizziness aetiology due to the filtering effect of primary contact medical practice (Maarsingh et al., 2010). It is helpful to understand the aetiologies expected to be encountered in a list of ENT-referred patients, so a description of these follows.

#### a Dizziness due to vestibular dysfunction- peripheral vestibular dysfunction

This section describes a wide range of disorders associated with vestibular dysfunction, addressing them according to peripheral and central dysfunction, in addition to the non-vestibular causes of dizziness. The role of physiotherapists and other allied health professionals in the management of vestibular disorders is briefly discussed with each cause and the level of evidence of this treatment is explored as available. For this discussion, peripheral vestibular dysfunction can be divided into two categories - vestibular hypofunction and vestibular hyperfunction. Numerous journal articles and texts (for example Agrawal, Ward, et al., 2013; Bronstein & Lempert, 2006; Fetter, 2014) comprehensively describe vestibular dysfunction, thus only a synopsis of key information is presented here to enhance understanding of the model of care that has been developed in this programme of research.

The dizziness literature uses the term nystagmus commonly when describing ocular movement noted in oculomotor assessments specific to different types of dysfunction causing dizziness. It is defined as movement of the eye with alternating slow and fast directional components resulting in a fast direction beat for which it is named (Kerber et al., 2011).

Vestibular activity at rest comprises matched vestibular nerve outputs from the left and right vestibular systems. Vestibular dysfunction often results in one side's vestibular system being less active than the other normally functioning side, or conversely, one side being more active than the other normally functioning side. The term hypoactivity in the following section describes reduced activity of the ipsilateral vestibular system, while hyperactivity refers to increased activity of the ipsilateral vestibular system.

## i Vestibular hypofunction

Vestibular hypofunction occurs when the afferent vestibular output is reduced to the brain stem vestibular nuclei (Fetter, 2014). In an acute occurrence such as due to vestibular neuritis or surgical vestibular deafferentation, the resultant asymmetry in left and right vestibular nucleus resting activity causes the eyes to beat towards the hyperactive side (fast direction of nystagmus) and the person experiences vertigo

(Halmagyi et al., 2010). In chronic settings such as in unilateral vestibular schwannoma and chronic vestibulopathy, vestibular compensation through neuroplasticity leads to an equalisation of vestibular nuclear resting activity (Halmagyi et al., 2010), so people with these conditions do not report dizziness or vertigo at rest.

Vestibular hypofunction is a common diagnosis of dizziness that notably increases in prevalence with age (Grill et al., 2018). Common causes of unilateral vestibular hypofunction include infective (vestibular neuritis - reputedly of viral aetiology), neurodegenerative (senescence of the vestibular system and vestibular schwannoma), traumatic (examples including a stroke of the anterior inferior cerebellar artery, late stage Meniere's Disease, fracture to the temporal bone), toxic (aminoglycoside side effect); and genetic (autoimmune diseases affecting the inner ear, and vestibular paroxysmia) (Fetter, 2014; Grill et al., 2018). Bilateral vestibular hypofunction, typically caused by vestibulo-toxic medications such as gentamicin (Ahmed et al., 2012), sequential vestibular neuritis, presbyvestibulopathy (Agrawal et al., 2019), and a number of systemic pathologies and autoimmune disease (Fetter, 2014), often does not lead to vertigo since there is no imbalance between the two sides of the vestibular system (Curthoys & Halmagyi, 2014). Rather, people experience a sense of feeling off-balance, general dizziness particularly at night, oscillopsia or blurred vision during head movement, and demonstrate loss of balance while standing and walking (Agrawal et al., 2019; Herdman & Clendaniel, 2014).

In the treatment of unilateral vestibular hypofunction and bilateral vestibular hypofunction, vestibular rehabilitation as provided by physiotherapy (Herdman et al., 2007; Herdman et al., 2003) seeks to stimulate central nervous system changes through neuroplasticity, compensating for the imbalance in vestibular outputs. Residual otolithic function has been correlated with improvement in the dynamic visual acuity measure of compensation, as a result of vestibular rehabilitation in these people (Millar et al., 2020). The rehabilitation of people with bilateral vestibular hypofunction in addition needs to include exercises designed to promote the use of alternative strategies to maintain gaze and postural stability (Herdman & Clendaniel, 2014). Notably, the literature provides strong evidence for vestibular rehabilitation of unilateral vestibular hypofunction (Hall et al., 2016; Herdman et al., 2012; McDonnell & Hillier, 2015; Whitney & Rossi, 2000).

Meniere's disease is an uncommon disease in the community, although more common in dizziness clinics due to selection bias arising from the initial screening and referral process conducted by the referring general practitioner. Meniere's disease is commonly misdiagnosed at this point (Neuhauser, 2007, 2016). Classic symptoms include recurrent vertigo episodes of more than 20 minutes up to 12 hours in duration, low frequency hearing loss demonstrated audiometrically, fluctuating hearing, tinnitus and aural fullness (Fetter, 2014; Lopez-Escamez et al., 2015). Vestibular migraine, an example of central vestibular dysfunction, has a significant association with Meniere's disease (Neff et al., 2012; Neuhauser, 2007) and can have similar symptoms, but is much more prevalent (Neuhauser, 2007). In contrast, Meniere's disease usually leads to permanent sensorineural hearing loss and peripheral vestibular hypofunction over time whereas vestibular migraine does not (Lempert et al., 2012; Lopez-Escamez et al., 2015). The differential diagnostic process to separate Meniere's disease from vestibular migraine, particularly in the early stages, often requires the assessment of hearing with serial pure tone audiograms. These hearing tests in the case of Meniere's disease, aim to demonstrate a progressive sensorineural hearing loss - typically in the low to medium frequencies when hearing is still available (Lempert, 2013; Lempert et al., 2012; Lopez-Escamez et al., 2015). Notably, not only do the symptoms of vestibular migraine mimic those of Meniere's disease and benign paroxysmal positional vertigo (Lempert et al., 2012) but the symptoms of Meniere's disease in turn mimic the potentially more serious vestibular schwannoma; another reason for serial pure tone audiograms.

Management of Meniere's disease includes the medical prescription of betahistine and symptom-driven physiotherapy exercises undertaken after each attack (Adrion et al., 2016; Shepard, 2006). Intractable Meniere's disease may require surgical ablation of the vestibular system on the affected side. A Cochrane review of the surgical management of Meniere's disease (Pullens et al., 2013) only included two studies reporting the surgical technique of endolymphatic sac reduction; an example of non-destructive surgery. Papers studying destructive surgical techniques including surgical and chemical labyrinthectomies and vestibular nerve section were not accepted in this Cochrane review due to their study quality. The Cochrane review indicated no statistically significant effect on vertigo, hearing, tinnitus or aural fullness between the intervention and placebo groups of the included randomised controlled trials (Pullens et al., 2013). In a prior Cochrane review of intratympanic gentamicin and its effect on Meniere's disease (Pullens & van Benthem, 2011), only two randomised controlled trials using intratympanic gentamicin vs placebo could be included. The review concluded that intratympanic gentamicin significantly improves vertigo in people with Meniere's disease, although there was a risk of hearing loss (Pullens & van Benthem, 2011).

#### ii Vestibular hyperfunction

Vestibular hyperfunction is not a term usually used but provides a useful contrast in this context, referring to the relative increased activity in the vestibular system of one side compared to the other. An example of this is benign paroxysmal positional vertigo (BPPV), the most common vestibular cause of vertigo (von Brevern et al., 2007). Benign paroxysmal positional vertigo is usually reported as idiopathic but can occur after head trauma (Aron et al., 2015; Pisani et al., 2015) and secondarily to vestibular neuritis (Balatsouras et al., 2014). It is postulated that BPPV occurs due to the movement of otoliths, microscopic-sized crystals of calcium carbonate produced for the utricle and shed from the utricle into the semicircular canals. Changing position of the head causes the otoliths (now referred to as canaliths) to move through the canal and its fluid endolymph, generating a short-lived pressure impulse on the canal's cupula (Brandt & Steddin, 1993; Herdman, 1994), which in turn leads to excitation of the vestibular afferent output. Most often unilateral and involving the posterior semicircular canal (Balatsouras, 2012; Baloh et al., 1987; Bhattacharyya et al., 2008), BPPV leads to an imbalance in vestibular output to the brain stem between sides, resulting in vertigo and its objective correlate, nystagmus. This nystagmus has specific directional components depending on the orientation of the affected canal. Typically the nystagmus has a short latency followed by a short-lived crescendo of intensity matching the duration of the perceived vertigo (Argaet et al., 2019; Fetter, 2014); notably in contrast to the nystagmus of mimicking vestibular migraine (Argaet et al., 2019; Lempert et al., 2012; Polensek & Tusa, 2010). The

literature supports the treatment of BPPV by canalith repositioning and liberatory manoeuvres, with moderate to strong evidence demonstrated (Helminski & Zee, 2010).

Continuing with the theme of vestibular hyperfunction, less common examples of vestibular hyperfunction include the third window syndromes (Ho et al., 2017) of perilymph fistula due to trauma or cholesteatoma, and superior canal dehiscence (Basura et al., 2014). Treatment possibilities by physiotherapy are limited, so when detected, people with these diagnoses are referred back to ENT for consideration of surgical management (Ward et al., 2017).

## b Dizziness due to vestibular dysfunction- central vestibular dysfunction

Dysfunction in the central nervous system leading to vertigo is most commonly represented by vestibular migraines, followed by pathologies with lower prevalence such as central vestibular syndromes, and mild traumatic brain injury. Parkinson's disease, multiple sclerosis lesions of the brainstem, cerebellar paraneoplastic syndrome and genetic disorders such as neurofibromatosis type two and spinal cerebellar ataxia type three, are other disorders of the central nervous system associated with vestibular dysfunction (Bronstein & Lempert, 2006; Tusa, 2014c). This section summarises the more common diagnoses of vestibular migraine, central vestibular syndromes and mild traumatic brain injury.

## i Vestibular migraines

Vestibular migraines are those migraines presenting with attacks of vestibular symptoms including vertigo and head-motion induced dizziness (Lempert et al., 2012). The disorder is diagnosed using the person's history of migraine symptoms in accordance with the International Headache Society's International Classification of Headache Disorders (ICHD)(Lempert et al., 2012). Once determined to be a migraine, the International Classification of Headache Disorders then lists the criteria for diagnosis as a vestibular migraine (Lempert et al., 2012). These comprise temporally associated, recurrent vestibular symptoms. Vestibular migraine occurs frequently in the population, with a lifetime prevalence suggested to be 1% (Neuhauser, 2007), and has been labelled the most common cause of episodic

vertigo (Dieterich et al., 2016). The pathophysiology of migraine can be summarised as genetic sensitivity of neurotransmitter receptors over the four phases of the migraine: prodrome, aura, headache and postdrome (Tusa, 2014b). Vestibular migraines often change in symptoms as people age past 50, frequently with the headache reducing (Obermann & Strupp, 2014; Tusa, 2014b).

Management of vestibular migraine by vestibular physiotherapy includes the coordination of the "3D's": drugs, diary, and diet. Drug therapies can be divided into prophylactic and abortive (Tusa, 2014b), but the research into vestibular migraine management by drugs has been inconclusive to date (Lempert et al., 2012; Obermann & Strupp, 2014). A referral back to the person's general practitioner, perhaps with a recommendation for a neurology review and trial of medication is the only way physiotherapy can intervene from a medication perspective, at least in Australia. By educating people on the use of diaries and diets to understand the triggers of their migraines (Tusa, 2014b), physiotherapists enable clients to identify and then modify exposure to potential triggers, thus increasing their control over the experience.

The effect of physiotherapy on people with vestibular migraine has been researched but needs to be divided into the effect on falls risk versus the migraine or headache experienced. Some studies have shown significant improvement on the risk of falls in people with vestibular migraine either by assessing falls risk through changes in reports of falls (Whitney et al., 2000) or through the effects on outcome measures assessing falls risk such as the patient-reported Activities-specific Balance Confidence scale (Vitkovic et al., 2013; Wrisley et al., 2002) and the Dynamic Gait Index (Whitney et al., 2000) and Functional Gait Assessment (Vitkovic et al., 2013) physical measures. Other studies have found that vestibular rehabilitation provided by physiotherapy can improve the headaches of people with vestibular migraines (Sugaya et al., 2017) although the effect of physiotherapy on migraine through forms of exercise has been graded at a low level of evidence (Luedtke et al., 2016) and requires more research (Alghadir & Anwer, 2018).

#### ii Central vestibular syndromes

Many central vestibular syndromes involve a neural lesion such as that caused by a stroke or tumour leading to an infarction of the brainstem and cerebellum, affecting vestibular pathways, and thus leading to vertigo. The resultant physical signs such as lateropulsion, hearing loss, up or down beat nystagmus, or internuclear ophthalmoplegia relate specifically to the involved neurological structures (Tusa, 2014c). For example, Wallenberg syndrome and downbeat nystagmus syndrome arise from medullary lesions, while upbeat nystagmus syndrome and ocular tilt reaction come from pontomedullary lesions. Many symptoms and signs of central vestibular lesions resolve spontaneously over time. Physiotherapy manages most central lesion disorders such as due to stroke through functional exercise programmes rather than specific vestibular rehabilitation. Medical management, particularly for nausea, is important in the rehabilitation process and is often triggered by physiotherapy need (Tusa, 2014c).

#### iii Mild traumatic brain injury

Mild traumatic brain injury is a common neurological presentation in blast injuries and blunt trauma; both of which have a high incidence of associated dizziness (Morris & Gottshall, 2014), but with distinctly different aetiologies and different neuro-pathophysiological effects (Hoffer et al., 2009). It has been reported that dizziness is the most common post injury symptom in military blast mild traumatic brain injury (Hoffer et al., 2010) owing to a large prevalence of benign paroxysmal positional vertigo, vestibular migraine and spatial disorientation. Further, these blast injuries occur in a setting of multiple system involvement resulting in fatigue, cognitive changes, psychological changes, burns, fractures and intestinal injuries (Herdman, 2013). In acute sports-related concussion injuries due to blunt trauma, the incidence of dizziness has been reported to be between 23 and 81% (Alsalaheen et al., 2010), while on-field dizziness has been found to be predictive of protracted recovery post-concussion (Lau et al., 2011). Interestingly, concussion, a term used interchangeably with mild traumatic brain injury, is viewed as metabolic dysfunction rather than a structural injury (Lovell et al., 2004; Morris & Gottshall, 2014).

The approach of physiotherapy to the complex injuries associated with mild traumatic brain injury requires an evidence-based and multi-focal approach (Morris & Gottshall, 2014; Quatman-Yates et al., 2020). Research suggests caution in assessment is needed since objective signs of cerebellar dysfunction in blast injuries can resolve quickly, and may not be evident using normal vestibular oculomotor assessment protocols in sub-acute timeframes (Akin et al., 2017). The therapist applies vestibular rehabilitation to obvious vestibular dysfunction such as benign paroxysmal positional vertigo, and otolith organ dysfunction (Quatman-Yates et al., 2020). Studies investigating systemic dysfunction leading to postural instability in people with mild traumatic brain injury have followed a holistic approach beyond just vestibular rehabilitation (Murray et al., 2016). This includes a combination of vestibular, balance, strength and cardiovascular rehabilitation, and medications, plus consideration of psychological aspects and musculoskeletal pain experienced frequently by this cohort (Akin et al., 2017; Morris & Gottshall, 2014; Quatman-Yates et al., 2020). Evidence from improvements in the Dizziness Handicap Inventory has shown that vestibular rehabilitation contributes to a reduction in a person's response to dizziness post-concussion (Nagib & Linens, 2019). The evidence for efficacy of physiotherapy conducting vestibular assessments and rehabilitation with people with mild traumatic brain injury has been found to be promising and needing more research (Murray et al., 2016; Quatman-Yates et al., 2020; Whitney & Sparto, 2019).

#### c Dizziness due to non-vestibular dysfunction

Forms of non-vestibular dizziness commonly reported by people on ear nose and throat wait lists include unsteadiness, visual vertigo and faintness. These are often due to non-vestibular dysfunction such as cervicogenic dizziness, visual vertigo, orthostatic hypotension, functional, and psychiatric disorders and are outlined below. Just as it is important to identify signs and symptoms of central vestibular dysfunction, due to the frequency of non-vestibular dizziness in this population, clinicians need to be aware of diagnostic criteria, treatment of these symptoms and when to refer the person with non-vestibular dizziness on to a more appropriate health professional. The following section provides a brief description of the common forms of non-vestibular dizziness expected in a primary contact, vestibular rehabilitation clinic.

#### i Cervicogenic dizziness

Joint and muscular dysfunction in the upper cervical spine often leads to complaints of dizziness (Reid et al., 2008; Treleaven, 2008; Wrisley et al., 2000) or more specifically, a sense of unsteadiness. The cervical spine has a rich innervation responsible for cervical afferent information affecting posture, and head and eye movement via three reflexes: the cervico-ocular reflex, the cervico-collic reflex and the tonic neck reflex (Treleaven, 2008). Somatosensory dysfunction resulting from cervical trauma and degeneration, changes to cervical afferent signals, and cervical pain can lead to changes in cervical joint position sense (Treleaven, 2008) and may contribute to the perception of unsteadiness. Diagnostic criteria have been outlined concisely (Reid et al., 2008; Reiley et al., 2017) but the diagnosis remains one of exclusion with no known diagnostic outcome measures (Reiley et al., 2017). Manual therapy to the upper cervical spine (e.g., C2 sustained natural apophyseal glides) has been found to be clinically effective in treating cervicogenic dizziness (Quatman-Yates et al., 2020; Reid, Callister, Katekar, et al., 2014; Reid et al., 2008).

#### ii Visual vertigo

People with a history of vestibular dysfunction often develop sensitivity to visual environmental situations, such as walking down supermarket aisles, driving or experiencing movement of objects in the visual environment; particularly when the experience of vestibular dysfunction is prolonged. It is postulated that this experience of unsteadiness/dizziness results from visual dependence arising from a challenged vestibular system. As a result, these people demonstrate an inability to resolve visual conflict (Bronstein, 1995; Guerraz et al., 2001). Treatment for visual vertigo often only needs successful treatment of the initiating vestibular dysfunction. Other means of management include desensitization using opto-kinetic targets (Heusel-Gillig & Hall, 2014) and repeated exposure to identified stimuli, in the context of a positive experience. The more chronic visual vertigo often forms part of persistent postural perceptual dizziness, formerly known as chronic subjective dizziness (Staab et al., 2017).

#### iii Persistent postural perceptual dizziness

Persistent postural perceptual dizziness is considered to be a state of classical operant conditioning to an initial dizziness stimulus (Staab, 2012) and has been classified as a chronic functional vestibular disorder (Staab et al., 2017). Persistent postural perceptual dizziness diagnostic criteria comprise an initial triggering episode of dizziness of any cause, subsequent experience of dizziness for greater than three months, a waxing and waning experience of dizziness throughout the day often improved by lying down or walking but worst in standing, and sensitivity to moving visual stimuli such as computer screen scrolling, action on television and visually stimulating environments such as shopping centres (visual vertigo) (Staab, 2012; Staab et al., 2017). Persistent postural perceptual dizziness is often diagnosed and successfully treated by vestibular physiotherapists through concomitant vestibular rehabilitation and referral to their general practitioner for pharmacological management using anti-depressant medications (Staab, 2012).

#### iv Orthostatic hypotension

Orthostatic dizziness or presyncope is a common cause of dizziness (Maarsingh et al., 2010; Radtke et al., 2011) typically triggered by sitting up or standing up quickly and resolved by lying down. The resultant light-headedness is caused by orthostatic / postural hypotension. Objectively, assessment of blood pressure demonstrates orthostatic hypotension when systolic blood pressure drops by  $\geq$  20 mmHg or diastolic pressure drops by  $\geq$  10mm Hg once having changed position; provided the test is done within a minute of changing position (Juraschek et al., 2017). A study of Dutch people older than 65 years (n= 417, mean age 78.5 years, age range 65-95, female 75%) presenting to their general practitioner with persistent dizziness (and with a clinically significant Dizziness Handicap Inventory mean score of 36.3/100) found that the cohort's main cause of dizziness was presyncope (69%) with 24% of people testing positive in orthostatic hypotension testing (Maarsingh et al., 2010). In another study (Radtke et al., 2011) using data from the German National Health Interview Survey of 2003, reported the one-year prevalence of orthostatic dizziness to be 10.9%, with a lifetime prevalence of 12.5%.

Presyncopal dizziness is often detected in the initial assessment of a person by their general practitioner (Dros et al., 2011). Since the general practitioner would be expected to filter out and treat such examples of dizziness before referring to ENT specialists, logically this type of dizziness is unlikely to have the same prevalence in a dizziness specialist outpatient setting (Maarsingh et al., 2010). Indeed, this is seen in reports of diagnostic proportions of dizziness for people attending tertiary dizziness centres (for example Abdul-Baqi et al. (2004); Nedzelski et al. (1986); Taura et al. (2010); Trinidade and Yung (2014)), where orthostatic hypotension forms a much lower frequency of diagnoses (< 6%) than encountered in the community. As a result, physiotherapists need to differentiate orthostatic hypotension from benign paroxysmal positional vertigo (BPPV) routinely both in the interview and examination. In the examination, orthostatic hypotension is separated from BPPV by the resolution of dizziness on lying the person down. If the physiotherapist detects orthostatic hypotension, the person is referred back to their general practitioner for medical management.

#### v Psychiatric disorders

Anxiety, panic and somatoform disorder symptoms include dizziness, either as vertigo or light-headedness. People presenting to neurotological clinics with dizziness frequently experience psychological disturbance (McKenna et al., 1991) while the comorbidity of psychiatric and vestibular disorders has shown to be high (Best et al., 2006). Demonstrating the prevalence of this comorbidity, psychiatric disease was a major contributory cause of persistent dizziness in 10% of Dutch people older than 65 years, with 24% having depressive disorder and 18% anxiety (Maarsingh et al., 2010). Anxiety and panic disorders are reported in people after the onset of vertigo. For example, panic disorder has been shown to arise in people after having vestibular neuritis (Godemann et al., 2006), while an association between anxiety and vestibular migraine has been observed (Best et al., 2009). A longitudinal study of 68 people (48.5% female) with vestibular dysfunction found that those with psychiatric syndromes before having their vestibular condition, had a greater prevalence of psychiatric disorders afterwards, compared to those who did not have a psychiatric disorder previously (Best et al., 2009). From the perspective of a specific vestibular disorders, the same study found that only those people with
vestibular migraine had an increased risk of developing psychiatric disorders (Best et al., 2009). Considering specific psychiatric disorders, the study reported that anxiety incidence increased significantly to approximately 30% of people with vestibular migraine at one year after onset of the vestibular disorder (Best et al., 2009). In summary, people presenting to a physiotherapy-led vestibular rehabilitation service can have comorbid psychiatric and vestibular causes of dizziness that may need to be addressed together. The model of care described in this thesis facilitated the management of these psychiatric aspects through normal physiotherapy practice of either referral direct to the hospital's psychology outpatient's department or to the person's general practitioner.

The above section has described the diagnoses for dizziness expected in a population of people derived from ENT outpatient wait lists for management by physiotherapists. What was not clear were the proportions of diagnoses expected and the differences in proportions when compared to those of other specialties. These unknowns supported a systematic review exploring the diagnostic proportions of people with dizziness, reported in Chapter 3.

Consequences of dizziness alluded to above include falls and the burden of dizziness. Intervention in vestibular dysfunction by a physiotherapy service such as the studied model of care, potentially could improve these outcomes. The following section considers falls resulting directly from different diagnoses of vestibular dysfunction and then explores the literature reporting on burden of dizziness.

# 2.3 Vestibular dysfunction and falls

Falls are a significant cause of morbidity and mortality (Centre for Disease Control, 2017) with approximately one third of adults older than 65 years reporting falls annually and with falls leading to approximately 10% of emergency visits (Tinetti, 2003). Risk factors for falls include conditions associated with the ageing experience such as arthritis, depression, postural hypotension, impairment in balance and gait, loss in muscle strength, and polypharmacy (Tinetti, 2003). Illustrating the prevalence of falls and vestibular dysfunction, an analysis of a population-based survey and balance testing of adults over the age of 40 years, reported that adults with vestibular dysfunction had a 12-fold increase in the odds of falling (Agrawal et al., 2009). As

described earlier in this chapter, the incidence of dizziness increases with age (Agrawal et al., 2019), thus falls and their sequelae are likely to be of concern particularly in older people with vestibular dysfunction. The relationship between falls and different conditions of vestibular dysfunction has been described through typically non-randomised, observational studies.

Methodological issues with the research into the falls and vestibular dysfunction relationships should be noted. The report of falls is known to be unreliable due to both recall bias and the interpretation of what constitutes a fall (Mackenzie et al., 2006; Peel, 2000). For example, one prospective study of older women compared the daily falls calendar recording of falls over 12 months to a subsequent 12 monthly falls recall questionnaire (Sanders et al., 2015). This study reported older women who fell more frequently showed reduced agreement between their 12-month recall of fall numbers and the daily calendar number of falls; whereas those who reported no falls had better agreement with their calendars. The researchers agree with previous reports that injury due to a fall is likely to affect recall as well (Peel, 2000; Sanders et al., 2015). Interestingly, higher levels of pride have been found using successive waves of a British longitudinal health survey to lead to lower reported falls in older adults (McMinn et al., 2017). The study findings of Sanders et al. (2015) infer preferred use of prospective calendars but even then, to expect underreporting of falls. Further, they calculated that when using 12-month recall questionnaires, categorising fall frequencies beyond fallers and non-fallers increased the sample size numbers required from 400 person years to 2000, to accurately detect differences between falls categories. These are some factors leading to difficulty in accurately tracking falls histories of the people older than 65 years; a group both at high risk of falls (Hannan et al., 2010; Lawson et al., 2008) and at high risk of vestibular dysfunction (Agrawal et al., 2009; Lawson et al., 2008).

Another methodological factor to consider, is how the vestibular dysfunction is determined clinically. It has been suggested there is a lack of clarity about the relationship between reported vestibular dysfunction and falls due to the differences in vestibular testing conducted in research; particularly in the case of the two most common forms of vestibular dysfunction, benign paroxysmal positional vertigo and vestibular hypofunction (Jacobson et al., 2008). In the case of benign paroxysmal

positional vertigo, reported testing using head position testing (the Dix Hallpike and Supine Roll Tests) may include the use of infrared goggles that enhance the peripheral nystagmus and improve the diagnostic rate (Kerrigan et al., 2013), while other reports do not use goggles (for example Abbott et al., 2016). In studies investigating vestibular hypofunction, some researchers used clinical tests of vestibular function such as the headshake test (Kristinsdottir et al., 2001) or the head impulse test (for example Agrawal, Davalos-Bichara, et al., 2013). These practical and easily conducted, 'bedside' tests are inherently interpretive in nature; providing reasonable sensitivity when vestibular hypofunction is larger (Jacobson et al., 2008; Mahringer & Rambold, 2013). In contrast, studies using quantitative testing techniques (Grill et al., 2018; Herdman, Blatt, Schubert, et al., 2000; Whitney et al., 2006) such as video-oculography (video head impulse) and calorics tests, are reporting tests whose sensitivity is greater. Demonstrating this, Mahringer and Rambold (2013) compared results of bedside head impulse and video head impulse to calorics test findings of vestibular weakness, in a cohort of people with vestibular hypofunction, all with calorics weakness greater than 25% which is considered to represent pathological vestibular weakness. They found bedside head impulses to have a sensitivity of 33% vs. 41% for video head impulses, although noting calorics was not necessarily an appropriate comparison standard for head impulse testing. This increased diagnostic accuracy could result in reporting greater proportions of vestibular hypofunction and therefore different relationships with falls.

Differences between the two groups of testing for vestibular hypofunction is displayed between the interpretive bedside head impulse test (bHIT) and the quantitative video head impulse test (vHIT) or video-oculography. Both tests induce corrective eye saccades - movements of the eyes initiated by the subject either during (covert) or after (overt) a rapid passive head movement or impulse. In the absence of central dysfunction, the presence of a corrective saccade shows that the gain of the vestibular ocular reflex on that side, the gain being the ratio of eye speed to head speed, is less than normal. This indicates the presence of a unilateral vestibular hypofunction on the impulsed side. The interpretive bHIT involves the examiner only detecting overt corrective saccades of the subject's eyes occurring after the head impulse movement, missing covert saccades occurring during the impulse. The more sensitive quantitative vHIT detects both covert and overt saccades, displays the External review thesis 7/2/21

results of each passive impulse graphically, calculates the gain ratio between eye and head velocities, and compares the observed gain with normative values (Jorns-Haderli et al., 2007; MacDougall et al., 2009). Studies using the more sensitive vHIT effectively could identify more cases of vestibular dysfunction, altering the reported incidence.

Lastly, the diagnostic criteria in the area of vestibular dysfunction have evolved over the last sixty years. As an example, many diagnoses of Meniere's disease made from the 1950's (Cawthorne & Hewlett, 1954) to the 1990's (for example Kroenke et al., 1992; Nedzelski et al., 1986; Wells & Yande, 1987) probably would meet the current criteria of vestibular migraine (Burrows et al., 2017; Lempert et al., 2012).

### 2.3.1 Benign Paroxysmal Positional Vertigo

The association of falls with benign paroxysmal positional vertigo (BPPV) has been reported in a number of studies based on people presenting to emergency and falls clinics with falls. For example, in a prospective observational study of 37 people (mean age 82.4 years) admitted due to a fall, 20 (54%) of these had BPPV on testing (Abbott et al., 2016). This association does not allow the reader to deduce whether the BPPV caused the falls or was the result of the falls, due to a lack of comparative controls. In another study, the team retrospectively recorded the number of falls charted for 121 people older than 65 years one year before and then one year after BPPV was identified and treated with canalith repositioning manoeuvres (Gananca et al., 2010). This study reported a highly significant reduction in falls rate with 398 falls recorded before treatment and 139 after (p< 0.001) was reported; suggesting a BPPV association with falls. Again, no controls were used. Similarly, a prospective assessment of case series of 100 people seen consecutively in a geriatric clinic found nine percent had BPPV and that these people reported a higher prevalence of falls in the previous three months (75% compared with 35% non-benign paroxysmal positional vertigo) (Lawson et al., 2008). These studies due to their lack of controls were unconvincing for causality of falls by BPPV.

#### 2.3.2 Vestibular hypofunction

In the case of unilateral vestibular hypofunction, short duration vertigo is experienced due to an imbalance in afferent signals from the two peripheral vestibular systems. An increased risk of falls would be a logical result. People with bilateral vestibular hypofunction have been shown to have a high risk of falling (Dobbels et al., 2020; Hermann et al., 2018). Perusal of the literature for studies assessing the association between unilateral vestibular hypofunction and falls are tabulated below in Table 2.2. Note that in this table, the studies have been separated out based on falls concept reported with actual falls, patient-reported falls and calculation of falls risk with no falls recorded. As with benign paroxysmal positional vertigo, the evidence for falls causality due to unilateral vestibular hypofunction is unconvincing. Factors reducing the strength of findings of the listed studies include the the reliability of falls reportingusually using retrospective participant reported falls, the sensitivity of the method of assessing vestibular dysfunction- often using bedside testing rather than relevant quantitative testing techniques, and the lack of controls in the reported studies with the exception of the two studies reporting associations between hip and wrist fracture with actual falls and unilateral vestibular hypofunction.

#### 2.3.3 Meniere's disease

Crises of Tumarkin are known falls events in some people with Meniere's disease; believed to represent a sudden change in the vestibular spinal reflex tone (Ishiyama et al., 2003). Reports of falls in people with Meniere's disease vary in incidence. For example, a retrospective study of people with Meniere's disease found only 12 people out of a total of 175 (5.7%) reported falls (Baloh et al., 1990). In contrast, a prospective study into falls in a group of 40 people with Meniere's disease over the course of one year reported that 32.5% had falls (Morales Angulo & Gallo-Teran, 2005). Recent research explains some of the differences in reports about falls incidence, suggesting those people with Meniere's disease with otolith organ dysfunction are more at risk of balance dysfunction than those without; otolith organ function being measured by vestibular evoked myogenic potentials (Zhou et al., 2019). Not all falls with Meniere's disease experience vertigo which has an effect on balance and contributes to falls. Further, there is research into Meniere's disease that External review thesis 7/2/21

demonstrates people experiencing Crises of Tumarkin can also experience syncope due to an altered effect of the vestibular sympathetic reflex on the cardiovascular system (Pyykko et al., 2017). Syncope or a temporary loss of consciousness due to a reduction in blood pressure, could then also lead to a fall.

### 2.3.4 Vestibular migraine

Evidence from studies using the report of falls and using tools with increased falls risk cut-offs such as the Activity-specific Balance Confidence scale, the Dynamic Gait Index and the Functional Gait Assessment suggests people with vestibular migraines can be at an increased risk of falling. Several small studies have considered either directly or indirectly falls risk in people with vestibular migraine, however these studies did not consistently control for other variables such as the use of anti-migraine medication, the presence of vestibular dysfunction and the assessment of people in the inter-critical period between migraines.

Two recent, small-sized, prospective observational studies indicated increased falls risk in people with vestibular migraine. The first, a small sized, prospective investigation into the effect of vestibular rehabilitation on a group of people with vestibular migraine (n= 20) and a group with vestibular impairment (n= 16) (Vitkovic et al., 2013) found the mean Activities-specific Balance Confidence scale (ABC) score at baseline for the vestibular migraine group (mean 58/100 standard error 4.5) scored below the increased falls risk 76/100 cut off of Lajoie and Gallagher (2004) and similarly the Functional Gait Assessment (FGA) score of 21.5 (SE 1.4) fell below the 22/30 cut off (Wrisley & Kumar, 2010) for increased falls risk. On discharge, both the ABC and FGA mean scores improved to above their respective clinical falls risk cut-offs with an ABC mean of 72.1/100 (SE 4.5) and an FGA mean of 26.5 (SE 0.7) (Vitkovic et al., 2013).

The second more recent, prospective, controlled case series considered the falls risk of 31 consecutive people (29 females) diagnosed with vestibular migraine, using posturography to assess static balance measures while in the between-migraine inter-critical period (Gorski et al., 2019). In this again small sized study, migraineurs had significantly greater falls risk overall (p= 0.002) and had significantly greater

Falls concept reported	Study	n	Study design	Mean Age (range) Females %	Findings	Falls Percent
Actual falls	Kristinsdottir et al. (2000)	19	Cross- sectional actual falls	72.5 (64- 79) 83%	<ul> <li>Hip fracture related to vestibular hypofunction compared with 28 age and sex matched controls.</li> <li>12 of the 19 people with falls-related fractures had UVH, 9 of these 12 had fallen towards and fractured the side of the UVH</li> </ul>	63% people with fractures had UVH p= 0.04 compared to controls
	Kristinsdottir et al. (2001)	66	Case series actual falls	67.8 (50- 86) 90.9%	<ul> <li>66 people with fractures compared to</li> <li>49 healthy community senior citizen controls</li> <li>50 (76%) of people with wrist fractures had a UVH.</li> <li>30 (60%) of people with wrist fractures with UVH had fracture on same side as the UVH</li> </ul>	76% people with fractures had UVH p< 0.001
Patient reported falls risk	Herdman, Blatt, Schubert, et al. (2000)	70 UVH	Prospective case series patient reported falls	63.0 (25 to 89) 54.3%	People with UVH / BVH compared to a similarly aged community sample. Concluded UVH did not have > falls risk compared with community controls	30% UVH < 51.1% BVH fallers p= 0.02

# Table 2.2 Evidence of increased risk of falls with vestibular hypofunction

	45 BVH		63.2 (30- 80) 49.1%	65-74-year-old group with BVH had increased risk of falling compared with community controls p < 0.001	
Whitney et al. (2006)	100	Retrospective chart audit using participant reported falls	59 (14-90) 62%	No relationship between people with vestibular dysfunction reporting falls and their vestibular testing results. No controls used	30% fallers, 70% non-fallers
Jacobson et al. (2008)	185	Retrospective chart audit patient reported falls	75 70%	73% of the people reporting falls demonstrated evidence of vestibular dysfunction. No controls used	61% falls
Agrawal, Davalos- Bichara, et al. (2013)	50	Prospective cross sectional case series volunteers >70 years using participant reported falls	77 (70 to 84) no female % reported	Increased falls history and reduced gait speed found in people with a positive head impulse test No controls used	Positive HIT associated with increased falls report over last 5 years 80% vs 48% normal HIT p= 0.02 Reduced mean gait speed by 0.23 m/s p= 0.046
Dobbels et al. (2020)	119	Prospective case series using patient reported falls	59 46%	People with BVH experiencing falls in the previous year had significantly higher DHI scores No controls used	39% falls

Falls risk factor calculation	Hall et al. (2004)	47	Retrospective chart audit using DVA and DGI falls risk (<19/24). No report or actual falls considered	65 (28 to 86) 65.6%	Paired DGI analysis showed people with UVH were initially at increased risk of falling and that rehabilitation improved risks- a greater proportion of older people remained at risk of falling on discharge compared with younger people. No controls used Regression modelling identified age, DVA initial and DGI initial as variables significantly associated with increased falls risk on discharge. Degree of hypofunction affects rehabilitation outcome.	Falls risk improved with rehab - improved DGI to clinically normal mean of 19.3/24 p< 0.001
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ABC Activities-specific Balance Confidence Scale, BVH bilateral vestibular hypofunction, DGI Dynamic Gait Index, DHI Dizziness Handicap Inventory, DVA Dynamic Visual Acuity, HIT Head impulse test, UVH unilateral vestibular hypofunction

number of people with moderate to high falls risk (p= 0.003) compared with the 31 gender and age-matched healthy controls without migraine (Gorski et al., 2019).

An older, retrospective observational case series study compared the effect of physiotherapy on a small cohort of people with vestibular migraine (n= 14) to those with vestibulopathy and migraines (n= 25) (Whitney et al., 2000). Improvement in the frequency of falls in the 20.5% of people reporting falls before treatment was found, with the Dynamic Gait Index improving significantly in this group from a baseline mean score of 18/24, below the 19/25 increased falls risk cut off (Shumway-Cook & Woollacott, 1995), to a normal mean discharge score of 20/24. The Activities-specific Balance Confidence scale score improved non-significantly from 47/100, well below the increased falls risk cut-off of 67/100, to a discharge score of 70/100 but that was still below the normal 80/100 cut-off of Myers et al. (1998) (Whitney et al., 2000). This study did consider differences between people using medication, noting those using medication improved with greater change.

Not only do people with vestibular migraine appear to have an increased risk of falling, but those with vestibular migraine and vestibular dysfunction also do not improve in their balance outcomes with treatment as well as those people with only vestibular dysfunction (Wrisley et al., 2002). This effect can also be seen in the Activities-specific Balance Confidence, Dynamic Gait Index, and Functional Gait Assessment outcomes of the studies of Whitney et al. (2000) and Vitkovic et al. (2013) described above. Finally, as mentioned with the Meniere's disease falls risk analysis, researchers reported an association of migraine with syncope in people with Meniere's disease; the loss of consciousness potentially leading to falls (Pyykko et al., 2017).

### 2.3.5 Non-vestibular dizziness and falls

Orthostatic hypotension, a pathological drop in blood pressure on sitting up or standing, is a common cause of non-vestibular dizziness in people attending primary care (for example Maarsingh et al., 2010; Radtke et al., 2011; Spiegel et al., 2017), and is associated with increased risk of falls, fracture and mortality (Juraschek et al., 2017; Radtke et al., 2011). A systematic review and meta-analysis of 63 studies investigating the relationship between orthostatic hypotension and falls (Mol et al.,

2019) found a significant positive association between orthostatic hypotension and falls with an odds ratio of 1.73 (95% CI 1.5 to 2.0). Orthostatic hypotension is reported in ENT/neurotology case studies, albeit at low percentages due to selective referrals by primary care practitioners (Maarsingh et al., 2010). For example orthostatic hypotension has been reported as the primary diagnosis in: Nedzelski et al. (1986) 1.6%, Taura et al. (2010) 1.8% and Trinidade and Yung (2014) 5.8%, and therefore needs consideration by physiotherapists practicing in an ENT-referral model of care.

In summary, research supports the logical observation that dizziness increases the risk of falls, and that both dizziness and falls increase with age. This in turn underlines the importance of assessing and treating these groups of people. Anecdotally from the experiences of the reported vestibular rehabilitation service, often the main reason for referral of people with dizziness by GP's and by ENT surgeons is the perceived increased risk of falling. This thesis presents a model of care that through its routine use of falls risk assessment tools considers the clinical risk of falling from initial assessment to discharge. A description of patient-reported measures and physical outcome measures used to determine falls risk is addressed in the methodology (Chapter 4) with the analysis of results interrogated initially within the pilot data Study 2 (Chapter 5), and then more fully analysed as part of the main study, Study 4 (Chapter 7).

# 2.4 Burden of dizziness

The burden of dizziness in this thesis is defined as the impact of dizziness measured in a quantifiable way. Table 2.3 below provides an outline of the chronological development of inquiry into patient burden from dizziness. The table highlights the progression in the understanding of the burden of dizziness and the progression in the tools used to measure burden including quality of life and loss in wages from the perspective of a person with dizziness and healthcare utilisation and direct costs from the perspective of a health care system.

The use of quality of life questionnaires in the exploration of dizziness impact first immerged in 1995 in Sweden (Grimby & Rosenhall, 1995) and in 1998 in England (Yardley et al., 1998). Both studies investigated dizziness impact in association

# Table 2.3Summary of studies investigating patient burden due to dizziness

author	n	age years Female%	measure	impact
Grimby and 565 Rosenhall (1995)	565	All participants 76 years old 55.4%	Nottingham Health Profile (NHP)	29% of people reported experiencing dizziness, significantly higher scores in all six NHP distress categories
				People with dizziness had more co-morbidity (2.7 diagnoses vs. to 1.7, p< 0.001)
				People with dizziness had reduced functional performance vs. non-dizzy (p< 0.01)
Yardley et al. 2064 (1998)	2064	18-64 years	Questions from previously validated questionnaires on dizziness, anxiety and avoidance behaviour in the last month	Prevalence of dizziness in last month 23%
		59.3%		46% of people with dizziness reported anxiety and/or avoidance behaviour vs.13% of people without dizziness
				21% of people with dizziness off work due dizziness
				Dizziness caused occupational difficulties in 41% of those wishing to work or working,
				Dizziness in people working led to absenteeism (12%) and presenteeism (25%)
Neuhauser et al. (2008)	4869 + follow up interviews of 1003	18-80+ years 54%	Health burden related questions attached to the 2003 GNTHIS	Of the 1003 people reporting dizziness and vertigo, 21% people took sick leave, 12% avoided leaving the house, and 19% experienced interruptions in their daily activities
				Odds ratio of medical consultation due recurrent attacks of vestibular dizziness 2.8 (95% CI 0.9 to 8.3) and of non-vestibular dizziness 2.3 (95% CI 0.9 to 5.7)
				People with dizziness scored lower in all categories of the SF8 than non-dizzy controls.
Gopinath et al. (2009)	2751	All 50 years+	SF-36 DHI	Compared to non-dizzy participants, people with dizziness and vertigo scored significantly lower (p< 0.0001) in all dimensions of the SF36
				People with Vestibular Vertigo reported statistically increased DHI scores than those with non-vestibular dizziness (p< 0.0001 for total DHI score)

Mueller et al. (2014)	4117	All > 65 years old with mean 74 years (SD 6) 51.2%	Mailed health surveys and follow-up telephone interviews of KORA-Age Study HAQ-DI	1-year prevalence for vertigo or dizziness 26%
				Attribution modelling found vertigo and dizziness were the greatest contributors to the burden of disability in participants at ~ 16% attributed.
				Odds ratio of the association of dizziness and vertigo with disability 1.66 (95% CI 1.4 to 2.0)
				HAQ-DI scores > 0 indicate disability- people with dizziness had mean HAQ-DI 0.32
				HAQ-DI higher in people with dizziness and vertigo than those without and higher in women than men
Grill et al. 23 (2014)	2374	mean 55 years 59.8%	Health care utilisation survey of people with dizziness referred to a tertiary dizziness clinic	Duration of symptoms > 3 months to 2 years 42.0% of people with dizziness (95% CI 44.1 to 48.3)
				People with dizziness had undergone a mean number of diagnostic measures of 3.2 (MRI and ECG being the most common), received mean of 1.8 therapies (medication and physiotherapy the most common) and received mean of 1.8 different drugs
Sun et al. (2014)	BVD 15 UVD 22 Controls 23	mean 65 years (SD 10)	DHI HUI3 questionnaire on health care utilisation and lost productivity	Annual economic burdens (95% confidence intervals) for BVD USD \$13,019 (\$0
		mean 52 years (SD 12)		to \$48,830) and for UVD USD \$3,531 (\$0 to \$48442)
		50%		Notably small sample sizes used, particularly when annualising burden
Pyykko et al. (2015)	183	mean 62 years (SD 11)	EQ-5D Index and VAS	EQ-5D Index score 0.75 (SD 0.19) for Meniere's Disease
		no female %		EQ-5D VAS score 71.2 (SD 17.1) for Meniere's Disease
Tyrrell et al (2016)	2719	no demographics	UK Biobank and Hospital Episode Statistics	Meniere's disease 2016 mean total cost per person of GBP£3341 to £3757

BVD bilateral vestibular deficiency, DHI Dizziness handicap inventory, ECG electrocardiogram, EQ-5D European quality of life, GBP Great Britain Pound, GNTHIS German national telephone healt interview survey, HAQ-DI Health Assessment Questionnaire disability index, HUI3 Health utilities index, KORA Cooperative health research in Augsburg, MRI magnetic resonance imaging, QOL qu of life, SD standard deviation, SF8 short form 8 question health survey, SF36 Short form 36 question health survey, UVD unilateral vestibular deficiency, UK United Kingdom, USD United States do UVD unilateral vestibular dysfunction, VAS visual analogue scale

with comorbidities, while importantly the effect on work was considered by the English study (Yardley et al., 1998) who found that dizziness impacted work for those off work, wishing to work, or working. This important finding informed the subsequent tangible measurement of burden of dizziness through total, direct and indirect costs. Population-based surveys exploring the burden of dizziness have reported on the health care utilisation. Analysis of data from the population-based, 2003 German National Health Interview Survey data, found 22.9% of those people surveyed reported dizziness or vertigo in the previous year (Neuhauser et al., 2008). People with vestibular vertigo compared to those with non-vestibular dizziness were significantly more likely to take sick leave (40.6% vs. 14.7% of those who worked, p< 0.01) and were more likely to reduce their daily activities due to their symptoms (40.3% vs. 11.5%, p< 0.001). Recurrent vestibular vertigo was associated with more visits to medical practitioners (OR 2.92 (95% CI 1.11 to 7.7) p= 0.03) (Neuhauser et al., 2008).

In another population-based cohort, people 65 years or older were assessed for disability using the Health Assessment Questionnaire Disability Index (HAQDI) (Mueller et al., 2014). The HAQDI increased with age as expected, but it was found that the people with vertigo and dizziness had higher average HAQDI scores, and that females with vertigo and dizziness had higher scores than men with the same. Regression analysis of this data found that dizziness and vertigo were associated with disability (Odds Ratio 1.66) and that, similar to joint disease and hospitalisation, the impact of dizziness and vertigo was entry into a spiral of falls, fear of falling, reduced mobility and deconditioning (Mueller et al., 2014).

A revealing study using a retrospective, purpose-made questionnaire considered healthcare utilisation prior to people being referred to a tertiary vertigo clinic (Grill et al., 2014). The collective results from these participants showed they had received on average 3.2 instrumental diagnostic procedures such as magnetic resonance imaging and computed tomography scans, with 71% of people diagnosed with benign paroxysmal positional vertigo (BPPV) having magnetic resonance imaging (MRI) and 79.1% of people with a psychology referral having MRI. In terms of therapy, the participants received on average 1.8 therapies, with for instance physiotherapy and psychology being used in the same proportions to treat people

diagnosed with BPPV. The use of medications came in at an average of 1.8 different medications per patient (Grill et al., 2014).

Tangible costs for dizziness have been calculated. The cost of investigations and diagnosis for people shown to have BPPV was reported to be United States Dollar (USD) \$2009 in 2000 (Li et al., 2000) (using 2000 mid-exchange rate of 0.6 Australian Dollar (AUD) to 1 USD (<u>www.rba.gov.au</u>) converts to 2017 AUD\$5208)(https://www.rba.gov.au/calculator/annualDecimal.html). Similarly, costs per emergency department visit for people with dizziness in American hospitals expressed in 2011 US dollars was calculated to be USD \$1004 (Saber Tehrani et al., 2013) (2011 mid-exchange rate of 1.03 AUD to 1 USD (www.rba.gov.au) converts to 2017 AUD \$1092 (https://www.rba.gov.au/calculator/annualDecimal.html). In contrast, the mean cost to hospitals in Ontario, Canada of combined admitted and emergency people with dizziness in general has been calculated to be much lower at Canadian Dollar \$450 (SD \$1334)(Le et al., 2019); perhaps reflecting the uptake and use of the diagnostic criteria for people with dizziness that have been developed in the last decade. Again in contrast to the American costs, an English nurse follow up clinic for people with dizziness diagnosed by doctors with BPPV showed savings of British pounds (GBP) £3800 over the course of treatment of 200 people with dizziness (2010 mid-exchange rate of 0.59 AUD to 1 GBP (www.rba.gov.au) converts to 2017 AUD \$7450 (https://www.rba.gov.au/calculator/annualDecimal.html), with reviews by ENT nurse practitioners costing £57 (2017 AUD \$112) compared with those by doctors costing £76 (2017 AUD \$149)(Reddy et al., 2011).

Loss of work time and giving up work were reported in a study of 400 people with dizziness in London and Siena (Bronstein et al., 2010). In this study, 27% of people with dizziness reported changing their jobs, 21% stopped working and the London participants reported up to 11 days off work in the last six months due dizziness (Bronstein et al., 2010). Similarly, a Belgian study into dizziness-related absenteeism found 51% of a cohort of 400 people referred to a tertiary centre for dizziness reported attending work less than normal, while 12% found they were totally disabled and unable to go to work (van der Zaag-Loonen & van Leeuwen, 2015).

By 2014 the most significant evidence of dizziness burden - lost wages - had been calculated for people with Mal de Debarquement (Macke et al., 2012), bilateral

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vestibular dysfunction and unilateral vestibular dysfunction (Sun et al., 2014) and Meniere's disease (Tyrrell et al., 2016). For the sake of this summary, direct costs are assumed to be those costs borne by public health systems whereas indirect costs are those incurred on people with dizziness. Thus, lost wages are examples of indirect costs. Mal de Debarquement syndrome, as with other forms of disease, leads to both direct costs of getting a diagnosis and being treated and the indirect costs due to lost wages if working (Macke et al., 2012). In total, Mal de Debarquement syndrome annual indirect costs ranged from USD \$11493 (SD \$2341) to USD \$14561 (SD \$2778) depending on employment status. Converted to 2012 Australian dollars with a mid-exchange rate of 1.04 AUD to 1 USD (www.rba.gov.au) and then converted to 2017 AUD

(<u>https://www.rba.gov.au/calculator/annualDecimal.html</u>), this amounts to a loss in earnings of 2017 AUD \$12161 (SD \$2476) to AUD \$15408 (SD \$2939).

In an analysis of burden due to unilateral vestibular dysfunction and bilateral vestibular dysfunction in the United States, the Dizziness Handicap Inventory and the Health Utility Index Mark 3 were used to measure health status, together with a questionnaire on health care utilisation and lost productivity for costs (Sun et al., 2014). From small-sized diagnostic groups compared with controls, annual economic burdens on people with dizziness were calculated in 2013 USD of \$13019 (95% CI \$0, \$48830) for bilateral vestibular hypofunction and \$3531 (95% CI \$0, \$48442) for unilateral vestibular hypofunction. Using a 2013 mid-exchange rate of 0.95 AUD to 1 USD (www.rba.gov.au), these indirect costs convert to 2017 AUD \$14720 (95% CI \$0, 55212) and AUD \$3989 (95% CI \$0, \$54773) (Sun et al., 2014) respectively (https://www.rba.gov.au/calculator/annualDecimal.html ). The small sizes of the diagnostic groups used in this study probably limit the accuracy of the estimated burdens and limit applicability of these results to other populations, but the results serve as a comparative indication of burden.

Costs for Meniere's disease in the United Kingdom have been calculated using the National Health Service Hospital Episode Statistics data and that from the UK Biobank (Tyrrell et al., 2016). Indirect costs, primarily lost wages, strongly outweighed direct costs with indirect costs per year amounting to British pounds (GBP) £2940 to £3306 per person and direct costs totalling GBP £451 (Tyrrell et al.,

2016). Converted to Australian dollars with a 2013 mid-exchange rate of 0.6 AUD to 1 GBP (www.rba.gov.au) and then converted to 2017 AUD respectively (https://www.rba.gov.au/calculator/annualDecimal.html), the indirect costs amounted to AUD \$5263 to \$5919 and direct costs AUD \$808. In contrast to this UK study, a large retrospective, epidemiological audit of otological cases in emergency departments of American hospitals between 2009 and 2011 (Kozin et al., 2015) found the direct costs of diagnosis and treatment of inactive Meniere's disease to be USD \$5344 (SE \$147). This cost converts using a 2010 mid-exchange rate of 1.05 AUD to 1 USD (www.rba.gov.au) to 2017 AUD \$5888 (SE \$162) (https://www.rba.gov.au/calculator/annualDecimal.html ).

No Australian studies have investigated the costs incurred by dizziness; either direct or indirect. A cost consequences analysis, a cost effectiveness analysis outlying the costs and benefits for the reader to interpret, would be ideal to investigate this burden, combining both clinical costs and a measure of change in health-related quality of life for these people. The goal of such an analysis is to determine the maximum gain for the person with dizziness within a given budget.

# **2.5** Economic analysis of healthcare interventions

Economic evaluation of health care enables the systematic analysis of resource use in the health setting (Drummond, 2005). Decision makers are empowered by cost effectiveness analyses with the information permitting the judicious funding of health services, ensuring maximal use of limited healthcare budgets. A cost effectiveness analysis specific to health care, a cost utility analysis, incorporates the cost of healthcare interventions with utility, a quality of life outcome (Torrance, 1986). When quality of life data is not available for a particular model of care, another form of cost effective analysis, a cost consequences analyses can still identify dominant options and guide policy makers in budgetary decisions (Brazier et al., 2017). A cost consequence analysis does not aggregate outcomes into quality adjusted life years (QALYs) as in a cost utility analysis (Russell et al., 1996) but provides a table of cost and effect outcomes from which the decision maker draws their own conclusions (Mauskopf et al., 1998). To date, no cost utility analysis or cost consequence analysis have been reported for the management of people with dizziness.

#### **2.6** Assessment of People with Dizziness

The subjective differences in the common experiences of dizziness such as vertigo, unsteadiness, faintness or light-headedness (Drachman & Hart, 1972), together with objective findings of oculomotor, vestibulo-oculomotor reflex, head position, neurological, balance and gait testing, plus vestibular investigations and radiographic imaging, have traditionally been used by experienced clinicians to diagnose the causes of dizziness vestibular dysfunction.

In a first contact, vestibular screening and rehabilitation service, an important aspect of the model of care's vestibular assessment process is the identification of nonvestibular conditions and central causes for dizziness. Neurological signs indicating central cause of dizziness are detectable in the oculomotor assessment (neurootologic signs) (Tarnutzer et al., 2011) and, when combined with an extensive history, serve to provide assistance to the assessing clinician. Examples of central signs include sudden hearing loss, direction changing gaze-evoked nystagmus, abnormal skew deviation (Newman-Toker et al., 2015; Tarnutzer et al., 2011), pure torsional or pure up going nystagmus, saccadic pursuit, ocular hypermetria in saccades testing, dysfunctional vestibular ocular reflex suppression (Bronstein & Lempert, 2006), and intra nuclear ophthalmoplegia (Rosengren & Colebatch, 2011) on gaze testing. In cases of hypermetria or overshooting of eye saccades, saccadic pursuit, and pure torsional and vertical nystagmus, these central signs are related to cerebellar dysfunction (Bronstein & Lempert, 2006) and require a neurologist to effect a diagnosis. Intranuclear ophthalmoplegia detected in the oculomotor assessment often indicates a multiple sclerosis lesion or a stroke of the medial longitudinal fasciculus (Rosengren & Colebatch, 2011), again necessitating a referral to a neurologist.

A new approach to this process of diagnosis in emergency departments has been argued in the last decade (Edlow et al., 2018; Kattah et al., 2009; Newman-Toker & Edlow, 2015; Tarnutzer et al., 2011), aiming to reduce missed diagnoses of dangerous acute central causes of vertigo such as cerebellar strokes, but also to help clinicians in their diagnostic processes. A combination of dangerous signs in oculomotor and vestibulo-ocular reflex testing has been promoted in the literature and is referred to by its acronym of HINTS (Head Impulse negative, direction External review thesis 7/2/21

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changing Nystagmus in gaze testing, and positive Test of Skewness) (Kattah et al., 2009; Tarnutzer et al., 2011). From this literature has developed a new focus on categorising dizziness timings and triggers for emergency department settings of hospitals (Edlow et al., 2018; Newman-Toker & Edlow, 2015) and bears noting by all clinicians diagnosing dizziness causes in people.

Once central causes of the person's dizziness are excluded in the examination, the physiotherapist includes tests of the vestibular system's vestibular ocular reflex and head position testing plus tests of balance and gait in their examination (Whitney & Herdman, 2014). For the person with dizziness, the combination of the interview results and their objective examination outcomes leads the therapist to create a differential diagnostic list from which the formal diagnosis or diagnoses is/are made. However, this programme of research does not involve the assessment or management of people presenting to the Emergency Department with acute onset dizziness or vertigo.

The resultant primary diagnoses for people with dizziness referred to ENT outpatient services form a small group of common diagnoses arising from vestibular dysfunction plus some less common ones and an 'other' group of diagnoses (see for example (Isaradisaikul et al., 2010; Kasbekar et al., 2014; Taura et al., 2010). The current doctoral research programme related to primary contact physiotherapy management of people with sub-acute dizziness in a hospital outpatient context.

# 2.7 Service evaluation framework

An evaluation framework was sought to organise the PhD project's analysis of the physiotherapy-led model of care using coherent, relevant sections. Healthcare analysis frameworks in the literature considered included those of the Institute of Medicine (Institute of Medicine (US) Committee on Quality of Health Care in America, 2001), Ferlie and Shortell (2001) and Berwick et al. (2008) for the United States (US), the United Kingdom's (UK) Government's NHS Plan from 2000 (UK Department of Health, 2000b) the Australian government's National Health Performance Framework (National Health Performance Committee, 2001) and the Queensland Governments blueprint for better health (Queensland Health, 2013a).

The Institute of Medicine for American healthcare reform in the early 2000's, proposed six specific aims for improvement of the American health system including: safety, effectiveness, patient-centredness, timeliness, efficiency and equity (Institute of Medicine (US) Committee on Quality of Health Care in America, 2001). There were too many aims in this framework for use as a guiding theme for study analysis in this thesis. The framework of Ferlie and Shortell (2001) considered four levels of quality improvement including individual, team, organisation, and larger system. Focussing on the team level, they listed five examples of actual activities being used at the time in both the USA and UK; these being team development, task redesign, clinical audits, breakthrough collaboratives and guideline / protocol / pathway implementation. All five activities were used in the implementation of the model of care for Studies 2, 3, and 4, however these activities didn't serve as themes to describe the model of care studies by, so were not adopted. Reviewing the aims of the Institute of Medicine, Berwick et al. (2008) proposed reformation of health care by taking a utilitarian approach to population health with three inter-linked aims, their Triple Aims, of improving the experience of care, improving the health of identified populations, and reducing the costs per capita of these populations.

In contrast, the modernisation of the National Health System in the United Kingdom commencing in 2000 with the National Health Plan (UK Department of Health, 2000b), aimed to develop the system into one designed around the client using a health system performance framework comprising six domains: health improvement, fair access, effective delivery of appropriate health care, efficiency, client/carer experience, and capacity and capability (Arah et al., 2003). The government refined its offering of a better service to the public by improving user choice, system responsiveness and user equity (UK Department of Health, 2004) (UK Department of Health, 2004).

In Australia, the federal government developed the National Health Performance Framework using the three domains of health status, determinants of health, and health system indicators. Six indicators measure health system performance including effectiveness, continuity of care, safety, accessibility, responsiveness, and efficiency and sustainability (National Health Performance Committee, 2001). The Queensland Government published a blueprint for better healthcare in 2013 similar to that of the UK government with four themes of: centring health services around people, empowering the health workforce, providing value in health, and investing in health for the future (Queensland Health, 2013a). Initial funding for the physiotherapy-led model of care this thesis explores came under this government initiative (Queensland Health, 2014).

The Triple Aims of Berwick et al. (2008) fit with an utilitarian approach to health care. Utilitarianism proposes the adoption of actions that create happiness and oppose actions that harm, or in other words, actions that promote the 'greater good'. Berwick's proposed Triple Aims interlink as goals, aiming to produce the greatest good for the largest amount of people, producing this desired utilitarian, greater good outcome. Notable in these Triple Aims is the reduction of per capita costs to populations. Cost reduction for health care is key to utilitarianism. In any community, there is a fixed budget allocated to health care with competing demands for this money within the health sector. Demonstrating cost effectiveness in a service analysis gives money-spending, decision makers more information about how to spend a fixed budget for the greatest good of the community. From a utilitarian perspective, cost dominant options, those models of care with cheaper +/- greater quality / clinical outcomes, should be funded over those non dominant options. The latter option, models of care with either more expensive +/- lower quality / clinical outcomes or both, offer the least utilitarian approach and should be avoided. The noted quality / clinical outcomes include clinical benefits of health care for the population and measures of patient experience such as quality of life in the form of utility. Combining cost and quality of life measures produce cost effectiveness analyses specific to healthcare called cost utility and cost consequences analyses. These analyses provide useful information for decision makers when adopting desired models of care for a population's needs.

Berwick's utilitarian schematic was considered an appropriate model to undertake the service analysis of the physiotherapy-led vestibular rehabilitation service and was adopted.

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#### **2.8** Models of care for the management of outpatients with dizziness

Given the high demand on, and low density of specialists in Australian hospitals (Productivity Commission, 2005), people referred with dizziness and without red flags (UK Department of Health, 2000a) usually are triaged at less urgent category two and three levels. This has led to long waits, well beyond the recommended waitlist category time frames (Queensland Health, 2013a). Policy developers within Australian commonwealth and state health services have reviewed models of healthcare provision for some time. A key recommendation by the Australian Government's Productivity Commission review of the healthcare workforce (Productivity Commission, 2005) was the expansion of allied health practitioners practice to achieve full scope of practice (Young et al., 2015). With political and professional support available, the scene in Australia was set for the development of, and investigation into an allied health-led specialist outpatients' model of care managing people referred with dizziness.

Waits for people with dizziness referred to ENT outpatient services can be long if demand for ENT time is high, or supply of ENT time/specialists is low. As an example, an pre-study audit of an ENT wait list at a quaternary referral Queensland public hospital in 2012, found on average, people with dizziness would wait for more than a year before being seen by an ENT Specialist (and thence be referred for conservative management by physiotherapy) (Queensland Health, 2013b). Allied health professionals such as physiotherapists and audiologists, when working at their full scope of practice (Young et al., 2015), can routinely manage people with dizziness including conditions of vestibular dysfunction, since the majority referred to ENT do not require surgery (Department of Health, 2009; Kasbekar et al., 2014). In 2012, in line with the Queensland Government's Ministerial Taskforce into innovative, full scope, allied health practice, it was proposed that an physiotherapy-led vestibular screening and rehabilitation service operating independently to (i.e. not co-located) an ENT specialist outpatient department, could effectively and efficiently fast-track these people (Queensland Health, 2013b, 2014). The overall aim of this research programme was to determine whether this model of care represented a high value care service; one that improves the experience of care, improves the health of

identified populations, and reduces costs per capita for these populations (Berwick et al., 2008).

# 2.8.1 The United Kingdom experiences

In Australia in 2012, there were no allied health-led public sector models of care for people with dizziness to compare with the physiotherapy-led model of care described in this thesis. A review of the literature showed allied health-led models of care for people with dizziness only came from the United Kingdom (UK). Comparison with UK health system was appropriate due to the similarities in conceptual frameworks between the two nationalised/federalised public systems of the two countries (Arah et al., 2003). Objectively, current published funding similarities demonstrate the similarities in two health systems using that of the pluralistic, private sector driven United States of America (USA) in contrast:

- current health expenditure as %gross domestic product Australia 9.91, UK 10.15, USA 16.77
- general government health expenditure as % of total government expenditure Australia 16.25, UK 19.68, USA 22.35
- household out of pocket health expenditure (\$US/capita)
   Australia 867.4, UK 736.4, USA 1235
- domestic private health expenditure (\$US/capita)
   Australia 1537, UK 884.9, USA 5368

(World Health Organisation, 2022)

Similarities exist in professional practice of physiotherapists with similar registration requirements and in the density of specialist medical practitioners between the two countries (Australia 1.5/1000 people, UK 2.3/1000 and USA 1.7/1000) (World Health Organisation, 2022).

In the United Kingdom, the discussion about allied health-led models of care for people with dizziness commenced at the turn of the century (Department of Health, 2009; UK Department of Health, 2000b) with the modernisation of the National Health Service. In 2000, the Action on ENT programme initiated modernisation in ENT services within the National Health Service, leading to updates in the operations

of balance clinics (UK Department of Health, 2000a). As a result, over the next decade ENT clinics in the UK saw a reduction in the average wait times for balance service access across the country from 24 weeks to potentially less than three weeks (Kasbekar et al., 2014; Leong et al., 2008). To achieve this, local ENT departments used the Action on ENT programme's Balance Service Framework to tailor their balance rehabilitation services to the needs of the people in that trust (Department of Health, 2009; Leong et al., 2008). Different multidisciplinary models were created using the existing local capacity, aiming to reduce ENT wait lists through the assessment and treatment of people with dizziness by physiotherapists and audiologists (UK Department of Health, 2000a).

Since the commencing the research programme detailed in this thesis, three multidisciplinary balance services involving physiotherapists and established in response to the NHS initiative, have published the results of their models of care (Burrows et al., 2017; Kasbekar et al., 2014; Lee et al., 2011). The ENT-guided model described by Lee and colleagues in 2011 started with an initial screening of referrals for people with dizziness and/or vertigo by senior ENT registrars who had been trained for the task by consultants (Lee et al., 2011). People with dizziness demonstrating red flags, as listed in Box 1 below (UK Department of Health, 2000a), were selected for immediate specialist review, while those without were sent to the balance assessment clinic run by audiologists and physiotherapists 'with an interest in vestibular rehabilitation'. At this balance clinic, people with dizziness were assessed by physiotherapists before having selected audio-vestibular tests administered by audiologists. Once assessed, cases were discussed at a weekly meeting with an ENT consultant to decide on treatment. Wait times with this model reduced from 21 to 15 weeks (Lee et al., 2011).

Subsequently, a multidisciplinary balance clinic was described (Kasbekar et al., 2014). In this model, screening of ENT referrals was conducted by the hospital's head of audiology, who directed those referrals reporting dizziness but without red flags to physiotherapy for assessment and intervention. Physiotherapists conducted clinics in parallel to ENT vestibular clinics to permit good communications and ease of consultant review. Wait times for the balance clinic reduced from nine to three weeks (Kasbekar et al., 2014). The non-medical prescription of medications for

people with dizziness by a consultant vestibular physiotherapist was added to an ENT-based model of care (Burrows et al., 2017). Prescription of medications by physiotherapists is not current practice in Australia.

Box 2.1 Red flags for people referred with dizziness to ENT services

The Action on ENT document listed red flags that screening clinicians needed to consider in triaging referrals, to determine wait list categorisation. These were:

- Unilateral, sudden, new development or progression of hearing loss
- Incapacitating dizziness for more than six weeks
- Severe tinnitus
- Any neurological symptoms or signs
- Discharging ears
- Ear pain
- Progressive unsteadiness or falls
- Extreme cases of social, occupational or emotional stress

(UK Department of Health, 2000a, p. 37).

A range of audiology investigations were used by these English models: routine video-nystagmography (Leong et al., 2008), diagnostic-specific, selected tests (Lee et al., 2011), and routine otoscopy / pure tone audiogram / tympanometry (Kasbekar et al., 2014) (Burrows et al., 2017). All models of care reported safe outcomes through a combination of clinical governance and multidisciplinary teamwork.

2.8.2 Physiotherapist-led vestibular rehabilitation model of care

The model of care developed in this doctoral research programme, incorporating the physiotherapy-led screening, management, and discharge of people with dizziness who had been referred to an ENT outpatient service, represents a different approach from the three UK models involving physiotherapy described above and from the traditional ENT and neurology medical specialist models functioning world-wide. Notably, the key allied health member in this model of care, a vestibular physiotherapist, practiced independently of the traditional medical referral source of people with dizziness, in this case ENT. Thus, this thesis investigates independent

physiotherapy practice in the vestibular rehabilitation model of care, determining if it is safe, clinically effective, cost effective and consumer acceptable; meeting the high value health care Triple Aim goals of Berwick et al. (2008) namely of improving the experience of care, improving the health of identified populations, and reducing the costs per capita of these populations.

Feasibility of study into the service was investigated through a pilot study of the model of care and followed by a full-scale study for an additional four years. These studies used observational design to collect data. Feasibility was based on analysis of patient profiles comprising demographics and diagnostic proportions, analysis of service outcomes including wait times, occasions of service, rates of dropout and safety outcomes, plus analysis of repeated measures of both physical and patient reported outcomes.

#### 2.8.3 Members of a multi-disciplinary vestibular rehabilitation service

Although the independent clinical practice of the vestibular physiotherapist is notable in this proposed model of care, it is important to highlight that the multi-disciplinary nature of the model reflects current best practice approaches in managing people with dizziness. Multi-disciplinary vestibular screening and rehabilitation services include key service provision by physiotherapy and audiology, working with a team of health practitioners including ENT surgeons, GP's, neurologists and psychologists as required. Models including these team members have previously been described (Burrows et al., 2017; Department of Health, 2009; Kasbekar et al., 2014; Lee et al., 2011) and include the model explored by this thesis. Vestibular physiotherapy manages people with balance and vestibular dysfunction, providing them with vestibular, balance and gait rehabilitation and thus, has the potential to be pivotal in addressing the needs of people with dizziness (Ribeiro et al., 2017). Audiology contributes with a comprehensive suite of assessments of the vestibular system and can conduct the initial assessment of general practitioner referrals for vestibular causes of dizziness with appropriate training and supervision (Leong et al., 2008). Often co-located with ENT, audiology is an integral part of many hospital-based ENT services. ENT surgeons remain an important part of this allied health-led model of care, ultimately retaining responsibility for the referred people with dizziness and

providing consultation and management of a small number of complex presentations (Burrows et al., 2017; Kasbekar et al., 2014).

Some people with vestibular dysfunction develop or already have secondary psychological conditions and associated disability (Holmberg et al., 2006; Yardley, 1994), which are best addressed by clinical psychology. Vestibular migraines and operant conditioning in the form of persistent positional perceptual dizziness, require both vestibular rehabilitation and pharmaceutical management by their general practitioners (Staab, 2012). General practitioners are a critical component of the model as the referring medical officers with continuing, overall responsibility for general patient health care coordination. Many people are referred back to their GP's particularly for pharmacological management of vestibular migraine, but also for co-morbid issues such as non-vestibular migraine, stroke risk, postural hypotension, and polypharmacy detected in the initial assessments.

### 2.8.4 Research programme aims

The overall goal of this research programme was to determine whether the physiotherapy-led vestibular rehabilitation model of care represented high value care by determining if it was safe, clinically effective, cost effective and consumer acceptable and thus meeting the Triple Aims of Berwick et al. (2008); namely improving the experience of care, improving the health of identified populations, and reducing the costs per capita of these populations. To accomplish this, three clinical studies using observational design were undertaken. Study 2, a pilot study, aimed to determine the feasibility of studying the model by describing initial service and clinical outcomes. Service outcomes included wait times and occasions of service while clinical outcomes included demographics, diagnoses, repeated measures of patient reported outcomes including dizziness handicap inventory and activities-specific balance confidence scale, and repeated measures of physical outcomes including dynamic gait index, and dynamic visual acuity.

In addition, the pilot identified the need to compare the model of care's diagnostic proportions with those of pooled populations in international reports by established clinical practice from different settings, specialties, and decades. Change over time was described enabling a full appreciation of comparability between the 2012 to 2017

era physiotherapy-led model of care and clinical models evolved since the 1950's. Study 1 presented in Chapter 3 was the resultant systematic review of diagnostic proportions.

To enable comparison with the reported outcomes of multidisciplinary teams led by audiologists and to determine an indication of concurrent accuracy in diagnoses and referral practice, a reliability trial conducted between a vestibular physiotherapist and a vestibular audiologist is reported as Study 3. With these preparatory studies informing the methodology and aims of the large case series study, Study 4 prospectively collected key data to investigate the clinical, cost, service, and consumer effects and to describe the burden of dizziness. The specific aims of each study were as follows.

a Aims of the systematic review - Study 1

To determine whether the proportions of diagnoses reported for people with dizziness or vertigo depended on the clinical specialty making the diagnosis.

To investigate whether diagnostic proportions have changed over time given the advances in technology and diagnostic criteria that have become available in the last decade to assist in diagnosis.

### b Aims of the pilot study - Study 2

To determine the feasibility of studying the physiotherapy-led vestibular rehabilitation service in terms of its process and its results though the collection and analysis of patient demographic and diagnostic proportion data, service outcomes of wait times and occasions of service and repeated clinical measures.

To inform the methodology of further investigation into the physiotherapy-led vestibular rehabilitation service.

c Aim of the reliability study - Study 3

To establish the interrater reliability in diagnoses and referral patterns for vestibular rehabilitation between audiology and physiotherapy initial assessors of people with dizziness.

d Aims of the main study - Study 4

To conduct an analysis of the physiotherapy-led vestibular rehabilitation service model of care including the collection and analysis of patient demographics and diagnoses, service outcomes including wait times, duration of treatment and occasions of service, repeated clinical outcomes where possible down to the level of common diagnoses, consumer engagement outcomes, measures of burden of disease for treated people with dizziness, and outcomes necessary to conduct a cost consequences analysis.

To compare the patient demographics and diagnostic proportions, service and clinical outcomes, and measures of burden of dizziness generated by the model of care with those reported in the literature.

Specific research questions for each study were:

e Research question for Study 1

Are the diagnostic proportions for people with dizziness dependent on the specialties reporting them and have they changed over recent decades?

f Research question for Study 2

Is the proposed study into the physiotherapy-led vestibular rehabilitation model of care feasible when considering the demographics, diagnostic proportions, service outcomes and clinical outcomes collected from people attending the service?

#### g Research question for Study 3

What is the interrater reliability between a vestibular physiotherapist or vestibular audiologist in the diagnosis of vestibular dysfunction and referring on for vestibular rehabilitation in people with dizziness from ENT wait lists?

#### h Research questions for Study 4

What effects does the physiotherapy-led vestibular rehabilitation model of care have on the service outcomes of wait time and occasions of service?

Does the physiotherapy-led vestibular rehabilitation model of care generate satisfaction for consumers?

What are the clinical effects of the physiotherapy-led vestibular rehabilitation model of care, described down to the level of common diagnoses?

What is the burden of dizziness for people managed by the vestibular rehabilitation model of care measured by change in quality of life, productivity and clinical costs?

What are the cost consequences of the physiotherapy-led vestibular rehabilitation model of care in terms of clinical costs compared with other models of care, burden costs in terms of lost productivity to people with dizziness, and diagnosis specific costs in terms of clinical treatment costs and outcomes in quality of life?

# Chapter 3 Systematic Review: Study 1

The systematic review provides a basis for comparison of diagnostic proportions between traditional specialist medical services and those of the physiotherapy-led vestibular rehabilitation service. Given the number of specialist services reporting case series of people with dizziness, it was a logical enquiry to determine whether the proportions reported were dependent on the clinical specialty making the diagnosis and if so, what differences were expected. This makes the comparison between specialties and with the physiotherapy-led service outcomes more meaningful. Further, it was relevant to determine the changes in diagnostic proportions over time given the advances in diagnostic criteria and technology over the last decade. This knowledge will help the reader to understand the diagnostic validity of the physiotherapy-led service when considering its effect. The systematic review was published in January 2019 and is included below as reported in the Journal of Otology and Neurotology. An updated literature search was undertaken in 2020 using the same search terms and results are discussed in this chapter after those of the published systematic review.

A Systematic Review of the Reported Proportions of Diagnoses for Dizziness and Vertigo

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# 3.1 Abstract

The objectives of the systematic review were to determine the typical proportions of diagnoses for people presenting with dizziness or vertigo based on clinical speciality and to assess the change in proportions of diagnoses over time. Following PRISMA

guidelines, systematic searches of PubMed and CINAHL databases and follow-up reference searches were performed for articles published in English up to October 2016. Analysis of searches yielded forty-two studies meeting the criteria of case series of adult people with dizziness and/or vertigo presenting to general practice, emergency departments or specialist outpatient clinics. Data comprising demographics, diagnostic cases, and the total number of cases were recorded and independently tested, followed by a risk of bias analysis. Sample size weighted proportions expressed as percentages with confidence intervals were calculated and compared using chi squared analysis and a reference proportion formed by the combination of Ear Nose and Throat (ENT) and Neurotology case series published between 2010 and 2016. Analysis of diagnostic trends over time employed Poisson regression with consideration for overdispersion. This systematic review of case series demonstrated significant differences in the proportions of diagnoses for people presenting with dizziness or vertigo, depending on the specialty making the diagnosis. ENT proportions were dominated by benign paroxysmal positional vertigo, psychogenic and Meniere's disease diagnostic categories, whereas emergency proportions were dominated by other, cardiac, and neurological categories. Analysis of case series proportions over time revealed increases in diagnoses such as benign paroxysmal positional vertigo and vestibular migraine, and a corresponding decrease in the diagnoses of Meniere's disease.

### 3.2 Introduction

Case series of diagnoses for people presenting with dizziness or vertigo have been published since the mid-19<sup>th</sup> century (Cawthorne & Hewlett, 1954). Combined, these studies provide a rich source of data to understand both the typical proportions of diagnoses clinicians experience and the change in these diagnostic proportions over time. When making diagnoses today, clinicians naturally benefit from the development over time of knowledge about conditions causing dizziness or vertigo. The last decade in particular has been marked by the publication of definitive diagnostic criteria for most common causes of dizziness including benign paroxysmal positional vertigo (von Brevern et al., 2015), vestibular migraine (Lempert et al., 2012), unilateral vestibulopathy (Strupp & Magnusson, 2015), persistent postural perceptual dizziness (Staab, 2012), and Meniere's disease (Lopez-Escamez et al., 2015). In addition, clinical tools have been developed to aid in diagnosis including infrared goggles, Frenzels glasses, and video-oculography, while new investigations such as vestibular evoked myogenic potentials and new clinical decision rules for acute vestibular syndrome such as HINTS (<u>H</u>ead <u>I</u>mpulse negative, gaze evoked <u>Nystagmus direction changing, <u>T</u>est of <u>S</u>kewness positive) and ATTEST (Associated symptoms, Timing and Triggers, Examination Signs and additional Testing) (Edlow et al., 2018; Newman-Toker et al., 2015; Tarnutzer et al., 2011) have been promoted.</u>

Presentation of standardised diagnostic proportions for different clinical settings will enable clinicians to conduct clinical benchmarking for their local population of people with dizziness or vertigo. Therefore, the first aim of this review was to determine whether the proportions of diagnoses reported for people with dizziness or vertigo depended on the specialty making the diagnosis. The second aim was to investigate whether diagnostic proportions have changed over time as advances in technology and diagnostic criteria have become available to assist in diagnosis. The research question posed was:

• How do the diagnostic proportions of the physiotherapy-led vestibular rehabilitation service compare with those reported in the literature?

It was hypothesized that there would be broad similarities between physiotherapyreported diagnostic profiles and that profiles would differ both between specialties and over time.

# 3.3 Methodology

This systematic review analysed the data of case series by considering a number of factors: the diagnoses themselves; the specialties involved; the chronological time of publication; the study design; and state of national development. The review was registered with the Prospero Database, International Prospective Register of Systematic Reviews (Booth et al., 2012). The analysis and the findings are presented in accordance with PRISMA guidelines (Moher et al., 2009). Two databases, PubMed and CINAHL, were searched using a Boolean phrase search strategy to explore patient case series from different settings and different medical specialties. The nested Mesh search strategy included: ("Primary Health

Care"[Mesh]) OR "General Practice"[Mesh]) OR "Emergency Service, Hospital"[Mesh]) OR "Outpatient Clinics, Hospital"[Mesh]) OR "Ambulatory Care Facilities"[Mesh]) AND "Diagnosis"[Mesh]) OR "Epidemiology"[Mesh]) AND ("Dizziness"[Mesh] OR "Vertigo"[Mesh]). The review included papers published up to October 2016. Inclusion criteria for the search included (1) retrospective chart reviews or prospective case series of adult people with dizziness and/or vertigo presenting to general practice, emergency departments or specialist outpatient clinics and (2) an English abstract. Exclusion criteria included adolescents and children under the age of 17 with dizziness and/or vertigo and articles not published in English.

### 3.3.1 Search strategy and data extraction

Two researchers (IP and JP) screened the two database searches for title and abstract relevance, before accepting papers for full text reading. Disputed paper abstracts were resolved by a third reviewer (AR), before reading full papers. Reference lists from full text papers were searched and further papers identified and reviewed. All three researchers agreed upon a final list of papers and then the doctoral candidate commenced data extraction. The data were tabulated by the principal researcher. Data were extracted from a random selection of included articles by the third reviewer to confirm the accuracy of the principal researcher's data extraction. Statistical analysis was then undertaken on the completed data set (GH). Analysis considered the age of the papers, the age of the participants, the medical setting or specialty, the nationality of publication, and the retrospective or prospective nature of the study design. The doctoral candidate assessed each included paper for Risk of Bias using the Risk of Bias Tool for Prevalence Studies (Hoy et al., 2012).

Initial analysis grouped the data into ten clinical diagnostic categories: Benign Paroxysmal Positional Vertigo; Bilateral Vestibulopathy; Cardiac; Cervicogenic Dizziness; Meniere's Disease; Neurological; Other; Psychogenic; Unilateral Vestibulopathy; and Vestibular Migraine. The 'Other' category comprised the combination of 'Unknown Diagnosis' with 'Medical' categories (medical, metabolic, infections, medications) and 'Other Vestibular' pathologies (less frequent diagnoses such as perilymph fistula and vestibular paroxysmia). 'Unilateral Vestibular

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Hypofunction' comprised vestibular neuritis, chronic vestibulopathy and episodic vestibulopathy amongst other diagnoses.

Papers from the Ear Nose and Throat (ENT) and Neuro-Otological specialties contributed to a combined category the reviewers called ENT. Only combined ENT case series from 2010 to 2016 were used in an attempt to produce a contemporary ENT diagnostic proportion for use as the reference standard by this review.

### 3.3.2 Statistical analysis

Sample size weighted proportions expressed as percentages with confidence intervals were calculated using JMP Pro® v 14.0 software (2018, SAS Institute) and tabulated. Generalized linear models with binomial distribution and logit link were used to demonstrate the change in proportions of diagnoses over time, the differences between the combined ENT category and other specialties. Confidence intervals for binomial variables were calculated using the Wilson score method (Agresti & Coull, 1998; Wilson, 1927). Poisson regression with overdispersion was used to analyse trends over time in the proportion of people with dizziness receiving specific diagnoses.

### 3.4 Results

# 3.4.1 Literature search

In total, 263 abstracts were collected by the doctoral candidate including 186 from PubMed and 77 (after 15 duplicates were removed) from CINAHL. After screening the titles and abstracts, 141 papers were rejected from the PubMed search of which 34 were not in English and 107 did not meet other specified inclusion criteria. Only one additional paper was identified from the CINAHL search after 15 duplicates, one non-English paper and 75 papers not meeting specified inclusion criteria were excluded. Once the 46 papers identified in both searches were read, a further 29 papers were excluded for not meeting inclusion criteria, resulting in a total of 16 papers. Review of the reference lists in the initial 46 papers, yielded a further 45 potentially suitable papers. Of these, another 26 were accepted after reading in full. In total 42 papers from 1954 to 2016 were identified and included in this systematic review (see Figure 3.1 below). Synthesis of the literature enabled the results to be

presented under a number of themes: demographics, speciality, country of origin (developed or developing country), and the type of studies.

### 3.4.2 Demographics

As listed in Table 3.1, six papers reported neither a measure of sample age, nor of gender proportion (Cawthorne & Hewlett, 1954; Cutfield et al., 2011; Drachman & Hart, 1972; Jayarajan & Rajenderkumar, 2003; Trinidade & Yung, 2014; Wells & Yande, 1987); three of which were also noted for being at moderate or high Risk of Bias (Cutfield et al., 2011; Hoy et al., 2012; Jayarajan & Rajenderkumar, 2003; Wells & Yande, 1987). The overall percentage for female subjects, when stated in 36 of the 42 papers, averaged 59.0% (95% CI 58.3%, 59.7%). For the 27 papers in which the mean age was stated, a mean age of 55.8 years (SD 8.39) with an age range from 17 to 95 years was found. Four papers considered only geriatric populations (Chau et al., 2015; Davis, 1994; Katsarkas, 1994; Lawson et al., 1999) with an overall female percentage of 57.8% (95% CI 55.3%, 60.4%) from three of the papers; one (Davis, 1994) being a male-only study. The mean age for the geriatric studies was significantly older (p <0.001) at 74.6 (SD 1.94) years.

The specialties from the reported papers included ENT or otology (n=16), neuro otology (8), general practice (6), neurology (6), emergency or internal medicine (3), and physiotherapy (3). Thirty two papers originated from 12 developed countries (Australia, Canada, Denmark, Germany, Hong Kong, Ireland, Japan, Netherlands, Spain, Switzerland, UK, USA) and 10 papers reported from five (5) developing countries (Jordan, Malaysia, Nigeria, Thailand, Turkey), in accordance with United Nations economic guidelines (UN Department of Economic and Social Affairs, 2018). There were 22 prospective observational case series studies and 20 retrospective chart audit studies included. Only one of the prospective studies was case controlled.

The ratio of extractable reported diagnoses to cases varied from less than one (i.e., more cases than diagnoses) for six studies (minimum of 0.89), 19 had one diagnosis per case, and the remaining 17 reported more than one diagnosis for their study cases (maximum of 1.25). Table 3.2 below details the diagnostic proportions for each specialty expressed as percentages with confidence intervals. The 'Other'
category included a combination of diagnostic categories for both vestibular and nonvestibular related dizziness, so often presented as a large proportion. Each specialty is described below.

# 3.4.3 Combined ENT and Neuro Otology

Eleven ENT and neuro-otological papers published from 2010 to 2016 (Cutfield et al., 2011; Grill et al., 2014; Isaradisaikul et al., 2010; Luscher et al., 2014; Olusesi & Abubakar, 2016; Ozono et al., 2014; Somefun et al., 2010; Taura et al., 2010; Trinidade & Yung, 2014; Tungvachirakul et al., 2014; Wahat et al., 2013) were combined, reporting the diagnoses for a total of 4266 people. After assigning a high risk of bias to one study, (Cutfield et al., 2011), analysis indicated changes to diagnostic proportions and confidence intervals with and without this paper were only at the 0.1 % level, permitting the paper to remain in the analysis.

Overall, for the combined ENT group, the four dominant categories in descending order comprised ere benign paroxysmal positional vertigo (BPPV) (29.1%), unilateral vestibular hypofunction (6.9%), psychogenic (15.3%) and Meniere's disease (12.8%). The components of the Other category (20.4%) comprised in order of size, unknown diagnoses, Other vestibular diagnoses and medical diagnoses.

# 3.4.4 Emergency

Three emergency department papers accepted (Cheung et al., 2010; Kroenke et al., 1992; Navi et al., 2012) reported a total of 1420 people with dizziness. The dominant group in the emergency context was the Other group at 50.4%.





study	year	n	mean age years	% female	specialty	country	study design	bias	ratio of diagnoses to cases
Cawthorne et al	1954	1902	nr	nr	ENT	England	retro	low	1:1
Drachman et al	1972	104	nr	nr	Neuro	USA	pro	low	1.01:1
Ahmed	1984	100	55	nr	Neuro	USA	pro	low	1:1
Nedzelski et al	1986	2222	48	52.9	NeuroOt	Canada	retro	low	0.89:1
Wells et al	1987	86	nr	nr	ENT	England	retro	medium	1.01:1
Kroenke et al	1992	100	61.7	59	Medicine	USA	pro	low	0.97:1
Davis	1994	117	70.2	0	Neuro	USA	pro	low	1.1:1
Katsarkas	1994	1194	75.4	62.8	NeuroOt	Canada	retro	low	1.25:1
Alvord et al	1994	93	49.9	58.2	ENT	USA	pro	low	1.02:1
Krishnan	1994	107	nr	43	ENT	Malaysia	retro	low	1:1:1
Sloane et al	1994	140	58.6	71.8	GP	USA	pro	low	1.01:1
Lawson et al	1999	50	74	74	GP	England	pro	low	1.18:1
Heaton et al	1999	400	50.7	59.6	ENT	Canada	pro	low	1.15:1
Bath et al	2000	812	50.4	63.2	NeuroOt	Canada	pro	low	1.19:1
Hanley et al	2002	70	52	60.5	GP	Ireland	pro	low	1:1
Jayarajan et al	2003	313	nr	nr	GP	UK	retro	medium	1:1
Abdul-Baqi et al	2004	108	45.6	51.9	NeuroOt	Jordan	pro	low	1:1
Guilemany et al	2004	591	61	61.4	ENT	Spain	pro	low	1.12:1
Arya et al	2008	91	52.6	65.9	NeuroOt	England	pro	low	1:1
Uneri et al	2008	677	nr	64.4	NeuroOt	Turkey	retro	low	0.94
Philip et al	2009	100	nr	51	ENT	Malaysia	retro	low	1:1
Yin et al	2009	2169	nr	64.9	ENT	Japan	retro	low	1.01:1
Cheung et al	2010	413	nr	64.9	Emerg	Hong Kong	pro	low	0.96:1

Table 3.1Included studies: demographics, study design, risk of bias and ratio of diagnoses to cases

Isaradisaikul et al	2010	547	49.9	72.2	ENT	Thailand	retro	low	1:1
Somefun et al	2010	102	52	54.9	ENT	Nigeria	pro	low	1:1
Taura et al	2010	612	56	66	ENT	Japan	retro	Low	1:1
Cutfield et al	2011	90	nr	nr	NeuroOt	England	retro	high	1;1
Lee et al	2011	194	54	72	Physio	England	retro	low	0.99:1
Royl et al	2011	475	nr	60	Neuro	Germany	retro	low	1.05:1
Navi et al	2012	907	59	58	Emerg	USA	retro	low	1:1
Geser et al	2012	951	nr	53.2	GP	Switzerland	retro	low	1.14:1
Geser et al	2012	951	nr	53.2	Neuro	Switzerland	retro	low	1.04:2
Wahat et al	2013	777	nr	55.2	ENT	Malaysia	retro	low	0.98:1
Grill et al	2014	2374	58	67	NeuroOt	Germany	retro	low	1:1
Kasbekar et al	2014	200	58	67	Physio	England	retro	low	0.98:1
Luscher et al	2014	1034	nr	69.8	ENT	Denmark	pro	low	1:1
Ozono et al	2014	120	64.1	59.2	ENT	Japan	pro	low	1.01:1
Trinidade et al	2014	242	nr	nr	ENT	England	pro	low	1.26:1
Tungvachirakul	2014	167	52	69	ENT	Thailand	pro	low	1.04:1
Chau et al	2015	76	69	57.9	Neuro	Australian	pro	low	1:1
Stewart et al	2015	114	67.4	57	Physio	Australian	pro	low	1:1
Wada et al	2015	121	65.5	66.2	GP	Japan	pro	low	1:1
Olusesi et al	2016	575	44.7	47.1	ENT	Nigeria	pro	low	1:1

2020 Update	year	n	mean age years	% female	specialty	country	study design	bias	ratio of diagnoses to cases
Obermann et al	2015	1272	61.1	61.0	NeuroOt	Germany	pro	Low	1:1
Roland et al	2015	429	54.0	62.5	NeuroOt	USA	pro	Low	1.32:1
Muellemann et al	2017	2079	56.0	66.2	NeuroOt	Germany	retro	Low	1.19:1
van Leeuwen et al	2017	621	56.0	67.0	NeuroOt	Netherlands	pro	Low	1.3:1
Feil et al	2018	610	58.1	51.2	NeuroOt	Germany	retro	Low	1:1
Pan et al	2018	392	52.4	69.4	Neuro	China	pro	Low	1:1
Strupp et al	2018	749	62.9	45.9	NeuroOt	Germany	pro	Low	1:1
Staibano et al	2020	211	61.0	64.9	NeuroOt	Canada	retro	low	1:1

ENT ear nose and throat, GP general practice, Neuro neurology, NeuroOt neuro otology, Physio physiotherapy, pro prospective, retro retrospective, nr not reported

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Diagnosis	ENT combined	Emergency	GP	Neurology	Physiotherapy
-	% (95% CI)				
BPPV	29.1 (28.0, 30.2)	7.4 (6.1, 8.9)	16.3 (14.6, 18.2)	24.6 (22.6, 26.8)	27.8 (24.0, 31.8)
BVH	2.6 (2.2, 3.0)	0.0 (0.0, 0.3)	1.0 (0.6, 1.6)	3.1 (2.3, 4.0)	1.0 (0.4, 2.3)
cardiac	1.5 (1.3, 1.8)	18.8 (16.9, 20.9)	0.9 (0.6, 1.5)	4.9 (4.0, 6.1)	0.0 (0.0, 0.8)
CD	2.2 (1.9, 2.6)	0.8 (0.5, 1.5)	0.0 (0.0, 0.2)	0.0 (0.0, 0.2)	0.8 (0.3, 2.0)
MD	12.8 (12.0, 13.6)	0.8 (0.5, 1.5)	2.9 (2.2, 3.9)	4.7 (3.7, 5.8)	5.3 (3.7, 7.6)
neuro	2.1 (1.8, 2.5)	9.3 (7.9, 10.9)	5.6 (4.6, 6.8)	14.5 (12.9, 16.3)	4.3 (2.9, 6.5)
other	20.4 (19.5, 21.4)	50.4 (47.8, 52.9)	54.7 (52.3, 57.2)	28.3 (26.1, 30.5)	25.8 (22.2, 29.8)
psych	15.3 (14.5, 16.2)	3.3 (2.5, 4.4)	1.8 (1.3, 2.6)	8.1 (6.9, 9.5)	3.1 (1.9, 5.1)
UVH	6.9 (6.3, 7.5)	4.9 (3.9, 6.1)	18.6 (16.8, 20.6)	12.4 (10.9, 14.1)	23.2 (19.8, 27.1)
VM	7.9 (7.3, 8.5)	2.9 (2.1, 3.9)	0.8 (0.4, 1.3)	9.9 (8.6, 11.5)	7.5 (5.5, 10.1)

Table 3.2	Diagnostic	proportions	by specialty
	0		

BPPV benign paroxysmal positional vertigo, BVH bilateral vestibular hypofunction, CD cervicogenic dizziness, ENT ear nose and throat, GP general practice, MD Meniere's disease, neuro neurological, pysch psychological UVH unilateral vestibular hypofunction, VM vestibular migraine

Benign paroxysmal positional vertigo formed a low 7.4% proportion of cases. Unknown diagnoses were the largest contributor to the other group, forming 26.6% of the emergency total, followed by medical (15.7%). There were no other vestibular diagnoses registered in the emergency studies. Cardiac, neurological, and unilateral vestibular hypofunction followed in descending order.

#### 3.4.5 General practitioners

General practitioner studies comprised six papers (Geser & Straumann, 2012; Hanley & T, 2002; Jayarajan & Rajenderkumar, 2003; Lawson et al., 1999; Sloane et al., 1994; Wada et al., 2015) from 1994 to 2015 including 1645 people with dizziness. Dominant categories in descending order comprised other (54.7%), unilateral vestibular hypofunction (18.6%), and BPPV (16.3%). The other diagnostic category was high in one study, reporting 662 cases of its total of 951 (69.8%) as unknown (Geser & Straumann, 2012). This contrasted with a mean for the unknown categories of the other five studies of 7.7%. With this outlier study removed, the proportions of diagnoses changed to unilateral vestibular hypofunction, BPPV and then Other, in descending order.

#### 3.4.6 Neurology

The review accepted six neurology studies (Ahmed, 1984; Chau et al., 2015; Davis, 1994; Drachman & Hart, 1972; Geser & Straumann, 2012; Royl et al., 2011) from 1972 to 2015 including 1823 people with dizziness. Dominant categories in descending order comprised other (28.3%), BPPV (24.6%), unilateral vestibular hypofunction (12.4%), and neurological (14.5%). The other category in neurology included all the subcategories of other vestibular, unknown, non-diagnosed and medical diagnoses at approximately equal proportions. The diagnosis of vestibular migraine occurred most often (9.9%) in the neurology studies, compared with other specialities in this systematic review.

## 3.4.7 Physiotherapy

Three Physiotherapy studies accepted (Kasbekar et al., 2014; Lee et al., 2011; Stewart et al., 2015) were all published after 2010 and included 508 people with dizziness. Two dominant categories included BPPV (27.8%) and unilateral vestibular hypofunction (23.2%) of cases.

#### 3.4.8 Geriatric studies

The review included four Geriatric studies published from 1994 to 2015 and including 1437 people with dizziness. One study was from an ENT service (Katsarkas, 1994), one from a GP setting (Lawson et al., 1999) and two from neurology services (Chau et al., 2015; Davis, 1994). The ENT and neurology papers reported similar percentages with BPPV the dominant diagnosis followed closely by other. In the GP study, cardiac formed the dominant diagnostic category (46.0%) followed by unilateral vestibular hypofunction (24.0%) and then Other (22.0%).

# 3.4.9 Developed vs. developing country and prospective vs. retrospective comparisons

Geographically and economically, 32 papers came from institutions in developed countries and 10 (Abdul-Bagi et al., 2004; Cheung et al., 2010; Isaradisaikul et al., 2010; Krishnan, 1994; Olusesi & Abubakar, 2016; Philip & Prepageran, 2009; Somefun et al., 2010; Tungvachirakul et al., 2014; Uneri & Polat, 2008; Wahat et al., 2013) from developing; the latter either ENT/neuro otology or emergency studies. There were 20 retrospective and 22 prospective studies with the following breakdown: ENT/neuro otology, the 11 studies from 2010 to 2016, five retrospective (Cutfield et al., 2011; Grill et al., 2014; Isaradisaikul et al., 2010; Taura et al., 2010; Wahat et al., 2013) and six prospective (Luscher et al., 2014; Olusesi & Abubakar, 2016; Ozono et al., 2014; Somefun et al., 2010; Trinidade & Yung, 2014; Tungvachirakul et al., 2014); ENT, eight studies before 2010 with five retrospective (Cawthorne & Hewlett, 1954; Krishnan, 1994; Philip & Prepageran, 2009; Wells & Yande, 1987; Yin et al., 2009) and three prospective (Alvord & Herr, 1994; Guilemany et al., 2004; Heaton et al., 1999); emergency department one retrospective (Navi et al., 2012) and two prospective (Cheung et al., 2010; Kroenke et al., 1992); GP two retrospective (Geser & Straumann, 2012; Jayarajan & Rajenderkumar, 2003) and four prospective (Hanley & T, 2002; Lawson et al., 1999; Sloane et al., 1994; Wada et al., 2015); neurology two retrospective (Geser & Straumann, 2012; Royl et al., 2011) and four prospective (Ahmed, 1984; Chau et al., 2015; Davis, 1994; Drachman & Hart, 1972); neurotology, six studies before 2010 with three retrospective (Katsarkas, 1994; Nedzelski et al., 1986; Uneri & Polat, 2008) and three prospective (Abdul-Baqi et al., 2004; Arya & Nunez, 2008; Bath et al., 2000) and all three physiotherapy studies prospective (Kasbekar et al., 2014; Lee et al., 2011; Stewart et al., 2015). Inspection of Table 3.3 demonstrates that most proportions follow the diagnostic pattern of the specialty, regardless of country economic status or study design.

#### 3.4.10 Analysis of diagnostic trends over time

Figures 3.2 and 3.3 demonstrate percentages for each of the 10 diagnostic categories over time with a smoothed regression trend added. Using Poisson Regression and considering for overdispersion, Table 3.4 demonstrates the percentage change per year over the period 1954 to 2016 for each of the diagnostic categories. Statistically significant increases (p < 0.05) occurred in several diagnostic groups including BPPV, bilateral vestibular hypofunction, vestibular migraine and other, with reported Meniere's disease (p < 0.01) displaying a significant decrease over time.

## 3.4.11 Comparison of specialties with ENT using diagnoses

Figure 3.4 shows the graphical representation of the difference in diagnostic proportions of GP studies compared to ENT considering each diagnostic category over time. All specialties differed significantly to ENT (p < 0.001) using Chi Square analysis. Table 3.3 reports percent diagnosis (95%CI) for developed vs developing countries, retrospective vs prospective studies, and geriatric studies.

# 3.5 Discussion

Human disease understanding has developed remarkably over time from 1954 to 2016 and the changes in the diagnostic proportions for people with dizziness produced by this systematic review reflect this change. The rapid change experienced during the last decade, particularly with the advances in diagnostic criteria and tools applied to the diagnostic practice of the combined ENT specialities, justifies this review's use of a standardised combined ENT grouping calculated from ENT and neuro otology case series published between 2010 and 2016.

The main findings of this systematic review are that the diagnostic proportions differ significantly both between settings/specialties and over time. For example, the proportions for GP and ENT differ statistically with a p < 0.0001 and demonstrate

clear separation when plotted graphically (Figure 3.4). Similarly, both statistically and graphically, the review demonstrated changes in diagnostic proportions over time, e.g., increases in BPPV and vestibular migraine and a decrease in Meniere's disease (Figures 3.2 and 3.3).

Differences in diagnostic proportions between specialties are expected and are multifactorial. The initial differences between specialties results from the basic systemic screening and referral practice of primary medical care (Maarsingh et al., 2010). This process samples the whole population of people with dizziness and vertigo, in which those due to vestibular dysfunction occur at a minor proportion (Newman-Toker, Hsieh, et al., 2008). People diagnosed with likely vestibular dysfunction are then referred to specialists such as ENT, while those diagnosed with, for example, cardiac dysfunction are not.

Diagnostic bias might be expected between specialties for several reasons. Clinician understanding of the vestibular eye exam has been reported to be low in the Emergency Department setting (Newman-Toker et al., 2015). This, together with lower experience levels of clinicians in training hospital settings, may add to the inaccuracy of diagnoses explaining the 22% of 'you have vertigo' diagnoses offered people with vertigo presenting to emergency departments as reported by Newman-Toker, Hsieh, et al. (2008). Diagnostic criteria and tools used, leading to more accurate diagnoses, have developed dramatically in the last decade- for example, see the timeline provided by Newman-Toker et al. (2015). Perhaps these novel approaches are more likely taken up early after initial development by specialist outpatient services, such as those provided by ENT and neuro otology, in contrast to primary medical care settings. In time, as technology becomes more accepted and tested in different settings (e.g., video head impulse testing in emergency

Specialty	Dx	Developed	Developing	Retrospective	Prospective	Geriatric
		% (95% CI)				
ENT	BPPV	28.8 (27.5, 30.2)	29.6 (27.7, 31.5)	22.0 (20.8, 23.2)	43.0 (41.0, 45.1)	44.4 (41.6, 47.2)
	BVH	3.8 (3.3, 4.4)	0.0 (0.0, 0.2)	3.9 (3.3, 4.5)	0.0 (0.0, 0.2)	2.2 (1.5, 3.2)
	cardio	2.2 (1.8, 2.7)	0.0 (0.0, 0.3)	0.3 (0.2, 0.6)	3.8 (3.1, 4.7)	0.0 (0.0, 0.3)
	CD	2.1 (1.7, 2.6)	2.5 (1.9, 3.2)	0.7 (0.5, 0.9)	5.4 (4.5, 6.4)	0.0 (0.0, 0.3)
	MD	12.0 (11.0, 12.9)	14.6 (13.2, 16.1)	13.4 (12.4, 14.4)	11.7 (10.4, 13.0)	4.6 (3.6, 5.9)
	neuro	2.8 (2.4, 3.3)	0.6 (0.4, 1.0)	1.6 (1.3, 2.0)	3.1 (2.4, 3.9)	16.8 (14.8, 19.1)
	other	9.7 (8.9, 10.7)	42.4 (40.4, 44.5)	22.1 (20.9, 23.4)	17.1 (15.6, 18.7)	44.2 (41.4, 47.1)
	psych	22.7 (21.4, 23.9)	0.2 (0.1, 0.5)	22.2 (21.0, 23.4)	1.9 (1.4, 2.5)	7.0 (5.6, 8.5)
	UVH	7.7 (6.9, 8.5)	5.1 (4.3, 6.1)	5.4 (4.8, 6.1)	9.6 (8.5, 10.9)	6.1 (4.9, 7.6)
	VM	9.6 (8.8, 10.5)	4.3 (3.6, 5.3)	8.0 (7.2, 8.8)	7.7 (6.6, 8.9)	0.1 (0.0, 0.5)
Emerg	BPPV	9.3 (7.7, 11.3)	2.7 (1.5, 4.7)	8.6 (6.9, 10.6)	5.3 (3.6, 7.5)	
	BVH	0.0 (0.0, 0.4)	0.0 (0.0, 0.9)	0.0 (0.0, 0.4)	0.0 (0.0, 0.7)	
	cardio	18.1 (15.8, 20.6)	20.6 (17.0, 24.7)	19.4 (17.0, 22.1)	17.7 (14.7, 21.3)	
	CD	0.2 (0.1, 0.7)	2.4 (1.3, 4.4)	0.0 (0.0, 0.4)	2.3 (1.3, 4.0)	
	MD	0.4 (0.2, 1.0)	1.9 (1.0, 3.8)	0.0 (0.0, 0.4)	2.3 (1.3, 4.0)	
	neuro	6.5 (5.1, 8.1)	16.2 (13.0, 20.1)	7.2 (5.7, 9.0)	13.1 (10.4, 16.3)	
	other	53.7 (50.6, 56.8)	42.1 (37.5, 46.9)	55.5 (52.2, 58.7)	41.3 (37.1, 45.6)	
	psych	3.9 (2.8, 5.3)	1.9 (1.0, 3.8)	2.4 (1.6, 3.6)	4.9 (3.3, 7.1)	
	UVH	4.0 (2.9, 5.4)	7.0 (4.9, 9.9)	3.0 (2.1, 4.3)	8.2 (6.1, 10.9)	
	VM	3.8 (2.8, 5.1)	0.7 (0.2, 2.1)	4.1 (3.0, 5.6)	0.8 (0.3, 2.0)	

Table 3.3Diagnostic proportions by country status and study design

Specialty	Dx	Developed	Developing	Retrospective	Prospective	Geriatric
		% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
GP	BPPV	16.3 (14.6, 18.2)		16.5 (14.5, 18.6)	15.7 (12.2, 20.0)	8.0 (3.2, 18.8)
	BVH	1.0 (0.6, 1.6)		0.8 (0.4, 1.5)	1.8 (0.8, 3.9)	0.0 (0.0, 7.1)
	cardio	0.9 (0.6, 1.5)		0.0 (0.0, 0.3)	4.5 (2.8, 7.3)	46.0 (33.0, 59.6)
	CD	0.0 (0.0, 0.2)		0.0 (0.0, 0.3)	0.0 (0.0, 1.1)	4.0 (1.1, 13.5)
	MD	2.9 (2.2, 3.9)		2.9 (2.1, 4.0)	3.0 (1.6, 5.5)	2.0 (0.4, 10.5)
	neuro	5.6 (4.6, 6.8)		4.9 (3.8, 6.2)	8.2 (5.7, 11.6)	10.0 (4.3, 21.4)
	other	54.7 (52.3, 57.2)		62.6 (59.9, 65.2)	24.8 (20.4, 29.7)	22.0 (12.8, 35.2)
	psych	1.8 (1.3, 2.6)		0.7 (0.4, 1.3)	6.0 (3.9, 9.1)	0.0 (0.0, 7.1)
	UVH	18.6 (16.8, 20.6)		13.9 (12.1, 15.9)	36.6 (31.5, 41.9)	24.0 (14.3, 37.4)
	VM	0.8 (0.4, 1.3)		0.9 (0.5, 1.7)	0.0 (0.0, 1.1)	2.0 (0.4, 10.5)
Neurol	BPPV	24.6 (22.6, 26.8)		26.4 (24.2, 28.8)	11.8 (8.0, 16.9)	30.6 (24.5, 37.4)
	BVH	3.1 (2.3, 4.0)		3.3 (2.5, 4.4)	1.5 (0.5, 4.2)	4.1 (2.1, 8.0)
	cardio	4.9 (4.0, 6.1)		5.0 (4.0, 6.2)	4.4 (2.3, 8.2)	4.7 (2.5, 8.6)
	CD	0.0 (0.0, 0.2)		0.0 (0.0, 0.3)	0.0 (0.0, 1.8)	0.0 (0.0, 2.0)
	MD	4.7 (3.7, 5.8)		4.6 (3.7, 5.8)	4.9 (2.7, 8.8)	2.6 (1.1, 5.9)
	neuro	14.5 (12.9, 16.3)		14.4 (12.7, 16.4)	14.7 (10.5, 20.2)	6.2 (3.6, 10.6)
	other	28.3 (26.1, 30.5)		28.5 (26.3, 30.9)	26.5 (20.9, 32.9)	37.8 (31.3, 44.8)
	psych	8.1 (6.9, 9.5)		5.6 (4.5, 6.9)	25.5 (20.0, 31.9)	2.1 (0.8, 5.2)
	UVH	12.4 (10.9, 14.1)		11.9 (10.3, 13.7)	15.7 (11.3, 21.3)	18.1 (13.3, 24.2)

	VM	9.9 (8.6, 11.5)		11.4 (9.8, 13.1)	0.0 (0.0, 1.8)	0.0 (0.0, 2.0)
Specialty	Dx	Developed	Developing	Retrospective	Prospective	Geriatric
		% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Physio	BPPV	27.8 (24.0, 31.8)		24.1 (20.2, 28.6)	40.4 (31.8, 49.5)	
	BVH	1.0 (0.4, 2.3)		0.5 (0.1, 1.8)	2.6 (0.9, 7.5)	
	cardio	0.0 (0.0, 0.8)		0.0 (0.0, 1.0)	0.0 (0.0, 3.3)	
	CD	0.8 (0.3, 2.0)		1.0 (0.4, 2.6)	0.0 (0.0, 3.3)	
	MD	5.3 (3.7, 7.6)		6.1 (4.1, 8.9)	2.6 (0.9, 7.5)	
	neuro	4.3 (2.9, 6.5)		5.6 (3.7, 8.3)	0.0 (0.0, 3.3)	
	other	25.8 (22.2, 29.8)		25.4 (21.3, 29.9)	27.2 (19.9, 36.0)	
	psych	3.1 (1.9, 5.1)		4.1 (2.5, 6.5)	0.0 (0.0, 3.3)	
	UVH	23.2 (19.8, 27.1)		23.4 (19.4, 27.8)	22.8 (16.1, 31.3)	
	VM	7.5 (5.5, 10.1)		8.4 (6.0, 11.5)	4.4 (1.9, 9.9)	

BPPV benign paroxysmal positional vertigo, BVH bilateral vestibular hypofunction, cardio cardiac, CD cervicogenic dizziness, Dx diagnosis, ENT ear nose and throat, Emerg emergency, GP general practice, MD Meniere's disease, neuro neurological Neurol neurology, Physio physiotherapy, pysch pyschological, UVH unilateral vestibular hypofunction, VM vestibular migraine

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Figure 3.2 Change in diagnostic percentages over time

External review thesis 7/2/21





BPPV Benign Paroxysmal Positional Vertigo

External review thesis 7/2/21



Figure 3.4 Comparison of ENT and GP proportions by diagnosis over time

BPPV Benign Paroxysmal Positional Vertigo, BVH Bilateral Vestibular Hypofunction

diagnoses over time	percent change per year (95% Cl)	Poisson regression p
BPPV	1.48 (0.1, 3.11)	0.035
BVH	6.06 (0.91, 14.88)	0.014
cardiac	3.75 (-0.81, 11.86)	0.125
cervicogenic dizziness	5.56 (-0.88, 19.33)	0.109
Meniere's disease	-3.43(-4.4, -2.43)	< 0.001
neurological	-0.42 (-1.7, 1.05)	0.558
other	1.90 (0.12, 4.12)	0.035*
psychogenic	0.99 (-1.5, 4.42)	0.472
UVH	-1.00(-2.1, 0.24)	0.110
vestibular migraine	21.40 (10.0, 38.97)	< 0.001

#### Table 3.4 Poisson regression versus year with overdispersion

BPPV Benign Paroxysmal Positional Vertigo, BVH Bilateral Vestibular Hypofunction, UVH Unilateral Vestibular Hypofunction

departments) (Newman-Toker et al., 2013), other specialties may move to using these tools for diagnosis.

The trends over time demonstrate the effect of development of knowledge in the areas of vestibular dysfunction, neurology and psychology. Examination of the data from the Cawthorne and Hewlett (1954) study, the first of the systematic review's case series reveals a strong influence on the resultant temporal regression trends of the psychogenic, Meniere's disease and unilateral vestibular hypofunction categories. Although key criteria for Meniere's disease were known at this time, in particular the low frequency changes demonstrated on pure tone audiograms, it seems that aural symptoms were attributed by these researchers to the hydrops of Meniere's disease rather than to other diagnoses such as vestibular migraine and unilateral vestibular hypofunction. Similarly, Cawthorne and Hewlett (1954) reported no psychogenic-related cases, in sharp contrast to the following studies up to the 1990's, plus the current understanding of the prevalence of persistent postural perceptual dizziness (Staab, 2012; Staab et al., 2017).

At the other end of the time scale, as new diagnoses are developed, changes in diagnostic proportions will continue. More recently, Neuhauser et al. (2001),

wrestling with the diagnostic criteria of vestibular migraine, noted the condition was more prevalent than suspected previously and that its symptoms had been attributed to other diagnoses in the past. With established diagnostic criteria in play, increasing accuracy of diagnoses has been promoted through the use of new technology for investigations such as video-oculography (Newman-Toker et al., 2013). Further, diagnoses in primary care are likely to have been improved through a broader understanding of the importance of vestibular eye exams in the assessment of people with dizziness or vertigo (Newman-Toker et al., 2015) plus the adoption of related protocols designed to help reduce missing dangerous diagnoses of acute cerebellar and brain stem stroke as summarised by the acronyms HINTS (Tarnutzer et al., 2011) and ATTEST (Edlow et al., 2018).

#### 3.6 Limitations

This systematic review excluded non-English articles, where in fact there may be a considerable literature base of case series from researchers in Asia, Europe, and South America. It would be interesting to see the effect of this literature on an inclusive set of diagnostic proportions.

#### 3.7 Conclusions

Using published case series since 1954, this systematic review demonstrates significant differences exist in the proportions of diagnoses for people presenting with dizziness or vertigo, depending on the specialty making the diagnosis. Analysis of case series proportions over time demonstrates increasing specificity in diagnoses, with this review showing an increase in diagnoses such as BPPV and vestibular migraine in recent years, and a corresponding decrease in the diagnoses of Meniere's disease. This change in diagnostic proportions over time is likely due to improved diagnostic criteria and the use of well-informed protocols and newly developed technology in the initial assessment process. This review provides valuable information for clinicians working in different contexts about the likely proportions of diagnoses common in similar settings. However, the review also reinforces the need for clinicians to consider the era in which research was published

before making direct comparisons with the prevalence of different disorders in their own clinical context.

# 3.8 2020 Update to Systematic Review

A search of the PubMed and CINAHL databases conducted in July 2020 using the same Boolean search strategy yielded 68 papers for consideration of title and abstract from the PubMed database and 119 papers from the CINAHL database. Four papers from PubMed and 10 from CINAHL where then read, with two selected for review plus six more selected from reading references. The eight reviewed reports originated from seven neurotology (Feil et al., 2018; Muelleman et al., 2017; Obermann et al., 2015; Roland et al., 2015; Staibano et al., 2019; Strupp et al., 2018; van Leeuwen et al., 2017) and one neurology (Pan et al., 2018) specialist outpatient services.

Demographics included a mean study female percentage of 61.0% (95% CI 54.3, 67.7) and a mean study age of 57.7 years (95% CI 54.6, 60.7). The reviewed studies were conducted between the years 2010 to 2017 with three being retrospective (Feil et al., 2018; Muelleman et al., 2017; Staibano et al., 2019). Risk of bias assessment using the risk of bias tool for prevalence studies (Hoy et al., 2012) indicated low risk for all studies. Table 3.5 below reports the mean proportions for the review update studies and for the Study 4 physiotherapy-led vestibular rehabilitation service from 2012 to 2017 expressed using the systematic review's diagnostic categories.

Psychogenic, BPPV, vestibular migraine and Meniere's disease formed the top four diagnostic categories, accounting for two thirds of diagnoses. This proportion compares most closely with that of ENT studies from developed countries reported in the original review (see Table 5.3). Notably, none of the update reviewed studies reported cervicogenic dizziness.

Interestingly, the proportion for Meniere's disease in the 2020 update was relatively high at 11.7% (95%CI) (6.2, 17.2) comparing closely with the ENT proportion of the 2016 review of 12.8% (12.0, 13.6). This despite the reports all coming from neurology case series. The 2016 review physiotherapy and neurology Meniere's

disease proportions show much lower prevalence at 5.3% (95%Cl) (3.7, 7.6) and 4.7% (95%Cl) (3.7, 5.8) respectively. The 2016 review showed that Meniere's disease is likely a rare disease that is more likely to be diagnosed by ENT's and probably the subject of misdiagnosis in the last half of last century. Caution in making a diagnosis of Meniere's disease is encouraged by this review.

In line with this systematic review's message of differing diagnostic proportions for differing settings or specialities, the more recent literature also supports this. For example, it was reported that emergency department-fed, rapid access dizziness clinics who logically see acute presentations of people with dizziness, differ notably in diagnostic proportions from those of dizziness clinics servicing more chronic cases (Staibano et al., 2019).

Diagnosis	Review 2016-2020 (Study 1) % (95% CI)	RBWH Physio (Study 4) % (95% CI)
BPPV	21.2 (14.9, 27.4)	20.4 (16.2, 25.3)
BVH	7.4 (0.9, 13.9)	5.1 (3.1, 8.3)
cardiac	2.7 (1.0, 4.4)	2.8 (1.4, 5.4)
cervicogenic dizziness	nr	8.3 (5.8, 12.2)
Meniere's disease	11.7 (6.2, 17.2)	2.8 (1.4, 5.4)
neurological	8.9 (5.2, 12.6)	1.2 (0.4, 3.3)
other	9.8 (5.0, 14.6)	7.1 (4.7, 10.6)
psychogenic	22.4 (15.7, 29.2)	2.8 (1.4, 5.4)
UVH	11.5 (6.4, 16.7)	35.6 (30.4, 41.2)
vestibular migraine	12.4 (7.6, 17.3)	15.1 (11.5, 19.6)

Table 3.5	Diagnostic proportions – 2020 update and RBWH vestibular
	rehabilitation service

BPPV benign paroxysmal positional vertigo, BVH bilateral vestibular hypofunction, nr not reported, UVH unilateral vestibular hypofunction

Again supporting the original systematic review's discussion, a recent report (Dunlap et al., 2019) found medical practitioner awareness of the evidence behind the diagnosis and management of people with dizziness had increased over the last decade. Retrospective analysis of the American National Ambulatory Medical Care showed an increase in adherence to guidelines for the management of BPPV from 43.4% in 2005 to 79.5% in 2015, ending in similar to the rates shown by neurology and otolaryngology specialists (Dunlap et al., 2019). This reported increase in awareness of BPPV reflects the original systematic review's findings of increasing BPPV diagnostic proportions leading up to 2016, shown in figure 3.3, and reflects the high BPPV diagnostic proportions reported by the studies reviewed in this update.

However, the improvement in overall management of people with dizziness is not universal. Current literature notes the importance of the use of highly sensitive HINTS testing over computed tomography and magnetic resonance imaging investigations for people presenting with acute vestibular syndrome (Edlow et al., 2018; Kattah et al., 2009; Newman-Toker & Edlow, 2015; Newman-Toker, Kattah, et al., 2008). Despite this, the use of computed tomography and magnetic resonance imaging, combined with the lack of use of the HINTS assessment protocol and the use of medications for BPPV treatment rather than canalith repositioning manoeuvres, still are features of the diagnostic and management processes reported by recent studies considered by this review (Garneau et al., 2018; Hanna et al., 2019; Pan et al., 2018; Quimby et al., 2018; Staibano et al., 2019). Culture change is characteristically slow and no more so than in the diagnosis and management of people with dizziness.

# Chapter 4 Methodology

This chapter describes the methods used for the three clinical studies in the doctoral programme of research.

# 4.1 High value service criteria

In establishing a new hospital-based model of health care, it has been proposed that a service should seek to demonstrate six key characteristics; namely the model should be safe, effective, equitable, patient-centred, timely, and efficient (Committee on quality health care in America, 2001). Berwick et al. (2008) refined these characteristics into their Triple Aim goals of improving the experience of care, improving the health of identified populations, and reducing costs per capita for these populations. This research programme adopted this Triple Aim framework to describe each study and to determine whether the model of care met the Triple Aim goals of high value care.

Longitudinal collection of measures of service and consumer engagement outcomes were chosen to show an improved experience of care for the new service. Repeated measures of clinical outcomes were collected and analysed to outline clinical effectiveness, informing the improvement in health of the identified population goal; where the identified population were those people with dizziness referred to an ENT outpatients service. Controlled and/or randomised study designs were not used, either through a wait list control design or randomisation between ENT and physiotherapy. Wait list controls were considered unethical given the long waits being experienced by people with dizziness on the ENT wait lists as shown by a prestudy audit in 2012. Randomisation between ENT and physiotherapy was ruled out on the grounds of being inappropriate given the clinical and political imperatives at the time to reduce the size of the ENT wait lists and the length of waits being experienced.

The measurement and analysis of the effect of the vestibular rehabilitation service on the dizziness burden of disease and cost effectiveness addressed the reduction of cost goal. A summary of each high value characteristic follows, before outlining the specific study methods employed.

- Improved experience of care: Service outcomes were collected throughout the research programme. For example, wait times from initial referral to initial assessment point not only to the service effect of the new model of care but directly relate to other aspects such as burden of disease and consumer satisfaction with care. Satisfaction of people with dizziness with their wait times and with the service provided as a measure of consumer engagement was collected using visual analogue scales in the main study. Satisfaction is believed to relate to the patient-centred, timely and efficient health-care characteristics of high value care (Committee on quality health care in America, 2001; Prakash, 2010). Safety of the service was determined through the collection and reporting of complaints by study participants in hospital safety databases, reports of adverse events from other health care professionals and the recording of adverse events during physiotherapy.
- Improving the health of identified populations: In terms of clinical effectiveness, the scientific literature concludes there is moderate to strong level of evidence supporting the treatment for the two of the most common peripheral vestibular pathologies; benign paroxysmal positional vertigo (Helminski & Zee, 2010) and vestibular hypofunction (Hillier & McDonnell, 2011; Whitney & Rossi, 2000). Clinical measures were used to demonstrate the physical effect of treatment and outcomes from the perspectives of people with dizziness. Other clinical aspects considered included the effect of therapy on balance, gait and the risk of falls.
- Reduction in costs per capita of identified populations: Direct service costs in a vestibular rehabilitation service include a combination of labour, consumable, and hotel costs. Direct costs for this programme of research were calculated

by the Queensland Health Metro North Hospital and Health Service District Clinical Costings department considering all three sources of costings. Indirect costs, the tangible burden to working people with dizziness including absenteeism, or the cost of time away from work, and presenteeism, the cost of reduced productivity to the workplace employing people with dizziness, was derived from the Work Productivity and Activity Impairment Questionnaire (Reilly et al., 1993).

An eight dimension, multi-attribute utility quality of life instrument, the Assessment of Quality of Life 8 Dimensions (AQOL8D) (Richardson et al., 2013) informed the analysis of burden on the person with dizziness. The AQOL8D was chosen over other quality of life multi-attribute utility quality of life instrument's such as the Short Form Health Survey 12 questions (SF-12) used in conjunction with the Short Form Health Survey 6 Dimensions algorithm (SF6D) and the European Quality of Life 5 Dimensions (EQ5D) (Brazier et al., 2004). The AQOL8D aims at small sample number surveys (Brazier et al., 2007), permits analysis of the sensory dimension, and has been validated with Australian populations (Richardson et al., 2013). Multi-attribute utility quality of life instruments enable the measurement of change in quality of life over time using an output called a utility, which in this case was related to the effect of the vestibular rehabilitation delivered to each person with dizziness (i.e. change in quality of life from admission to discharge).

As part of the cost consequences analysis, decision trees were developed to model possible service variations with patient outcomes and the associated costs.

#### **4.2** Ethical and site-specific approval

The Royal Brisbane and Women's Hospital Human Research Ethics Committee and the Australian Catholic University approved Studies 2, 3 and 4 (see Appendices 1, 2, and 3)

- HREC/13/QRBW/92 and ACU 2013 293Q for Study 4,
- HREC/15/QRBW/141 for Study 2, and
- HREC/15/QRBW/142 for Study 3

Site specific approvals were granted by the research governance offices of the Royal Brisbane and Women's Hospital, Metro South (SSA/14/QPAH/460), Logan Hospital (SSA/15/QPAH/592) and the Mater Hospital (RG-14-279) (see Appendices 1, 2, and 3).

Methods for the three clinical studies in the doctoral programme of research followed the physiotherapy-led model of care with individual variations in data collected. A description of each clinical study's methodology is found below, together with descriptions of the outcome measures used.

# **4.3** Study 2 methodology: Pilot study

With the aim of Study 2 to investigate feasibility of a study into the physiotherapy-led service and to determine whether the model of care was safe and having a positive clinical and service effects, repeated measures were collected on admission and on discharge. The pilot study was designed as a prospective, observational, case series, sourcing participants from people waiting on the ENT category two and three wait lists for an appointment. Wait list control or ENT/physiotherapy treatment randomisation designs respectively were not considered ethical or clinically/politically appropriate. People were screened from the wait lists, and if they gave permission, were assessed and treated by the doctoral candidate, a physiotherapist providing care for vestibular clients in the physiotherapy department's outpatient area. This pathway represented a primary contact, hospital-based model of care with the initial assessment and treatment decisions made by the physiotherapist in the hospital setting, instead of by a consultant ENT surgeon or audiologist.

When required, the physiotherapist referred internally to other health professionals including audiology and psychology and on discharge, a letter was written by the physiotherapist to both the ENT Director and the person's referring medical officer. Cases identified as needing ENT assessment were discussed between the physiotherapist and ENT Director or proxy before returning the person to the ENT wait list.

In terms of the conduct of the study, the pilot started prospectively with standardised verbal participant information and verbal consent gained from people with dizziness for admission. A retrospective opt-out participant information and consent process conducted after the pilot had finished met the demands of ethical approval for the study. The pilot study commenced before the candidate was accepted into the PhD programme but was reviewed by the Primary Supervisor and deemed valid to continue as the first clinical study for the PhD programme. Ethics for the pilot study and its additional retrospective opt out consent process was gained once the pilot study finished but by the time the candidate had met PhD candidature requirements.

The pilot commenced in November 2012 once stakeholders had agreed to the assessment protocol and to the vestibular pathway proposed. Participants were included if on the wait list up to the end of June 2013. A retrospective ethical application applied for and granted in 2015 (Queensland Health HREC 15 QRBW 141 and ACU 2013 293Q - Appendix 1) permitted applicable use of Study 2 data. To gain consent for inclusion of Study 2 patient data, participants were sent an opt-out participant information and consent form newsletter by post.

#### 4.3.1 Settings and participants

The pilot study, Study 2 was conducted at the Royal Brisbane and Women's Hospital, a quaternary referral hospital located in the Metro North Hospital and Health Service district of Queensland Health. Participants came from ENT outpatient category two and three wait lists. Where category two referrals were meant to be seen by an ENT consultant within 90 days of receipt and category three within one year.

#### 4.3.2 Procedures: Participant inclusion criteria

Referrals of people with dizziness were screened from the ENT category two and three outpatient waiting lists. Inclusion criteria included a category two or three referral to ENT noting:

Signs of vestibular dysfunction

- Symptoms of vestibular dysfunction
- Diagnosis of vestibular dysfunction
- Person aged 17 years or older
- And providing signed consent after reading the participant information and consent form

All referred people with dizziness meeting these screening criteria were offered an initial assessment and treatment if they agreed. These criteria for the admission of people with dizziness to the study were continued across each of the studies.

Exclusion criteria included those people who, once contacted, refused to be assessed by physiotherapy, people younger than 17 years of age, those people incapable of giving informed consent, and those people not from the ENT wait lists.

4.3.3 Procedures: Participant screening, recruitment, and administration

After screening, those people who were not contactable or who refused an appointment, were removed from the physiotherapy and ENT wait lists and a discharge letter written to the ENT Director and GP/referring medical officer. People were informed of the study on arrival for their initial appointment and if consenting to participate verbally, completed a questionnaire battery before initial assessment. On discharge, participants were given the opportunity to complete a similar questionnaire battery.

#### 4.3.4 Initial assessment

On presentation for initial assessment, people with dizziness were interviewed using a vestibular assessment form (Royal Brisbane and Women's Hospital Physiotherapy Department, 2013) (see Appendix 4) purposively created for this programme of research. Interviews included history of the complaint, dizziness triggers, general health, hearing red flags, medications, and headache questions. Participants completed a battery of questionnaires both on admission and on discharge; the Activities-specific Balance Confidence Scale (Powell & Myers, 1995), the Dizziness Handicap Inventory (Jacobson & Newman, 1990), and the Short Form 12 question quality of life questionnaire (Ware et al., 1996). The Screening Test for Hearing Problems (Demorest et al., 2011) was completed on admission in Study 2, to assist with the physiotherapy management of participants.

Physical performance measures included

- cervical active range of motion as a measure of cervical motion and in testing for vertebrobasilar insufficiency,
- oculomotor testing to test for central dysfunction,
- VOR assessments to assess the peripheral vestibular system,
- head position testing assessing for benign paroxysmal positional vertigo,
- static and dynamic balance assessments plus gait assessment to assess people's function.
- neurological assessments including manual muscle strength tests, light touch sensation testing, reflex testing and tone testing were included if central dysfunction was suspected from the interview or preceding physical assessment
- palpation of cervical spine in supine

#### 4.3.5 Management of identified dysfunction

Treatment commenced at the end of the initial assessment for those people identified with dysfunction treatable by physiotherapy and progressed in accordance with normal vestibular dysfunction treatment protocols: benign paroxysmal positional vertigo (BPPV) (Bhattacharyya et al., 2008; Reid, Rivett, et al., 2014), unilateral vestibular hypofunction (Hall et al., 2016), and cervicogenic dizziness (Reid, Rivett, et al., 2014). People with migraine and Meniere's disease were managed for treatable vestibular conditions (often BPPV or unilateral vestibular hypofunction) and referred back either to their referring medical practitioner for migraine pharmacological management (Tusa, 2014b) or back to ENT for Meniere's disease management.

#### 4.3.6 Internal referrals

In Study 2, people with dizziness assessed as needing a pure tone audiogram and / or vestibular investigations were referred internally to the hospital's audiology department. When the physiotherapist identified or suspected central neurological dysfunction or other systematic disorders, the person with dizziness was referred back to their GP or was discussed with either a consultant neuro otologist, consultant ENT or the consultant ENT Director. If an ENT review was subsequently required, the person with dizziness was returned administratively to the ENT wait list with an appropriate categorisation ensuring no loss of place in the wait list. Such disorders included evidence of central neurological dysfunction, increased stroke risk, vestibular migraine, intractable Meniere's disease, autoimmune disorders, sudden sensorineural hearing loss, unilateral hearing loss, and other hearing disorders.

#### 4.3.7 Patient reported outcome measures for Study 2

Participants completed patient-reported measures prior to the initial assessment and on discharge. The physiotherapist entered the results of service and clinical outcomes into the study database for analysis.

Physiotherapists assess the impact of conditions on balance and gait through analysis of validated self-reported questionnaires and objective clinical testing. Hall and Herdman (2006) concluded from a review of outcome measures assessing risk of falls and the effect of falls on people with peripheral vestibular disorders, that several questionnaires demonstrated validity and reliability. These included the Activities-specific Balance Confidence scale measuring the fear of having a fall and the risk of falling in people older than 65 years, the Dizziness Handicap Inventory measuring the impact of dizziness on quality of life, and the Short Form-36 question health-related quality of life instrument. Each of these tools were used as measures of clinical effectiveness in this programme of research and are considered in more detail.

Clinicians use health-related quality of life questionnaires such as the Short Form-36 or its shortened derivative, the Short Form-12 (SF-12)(Ware et al., 1996), to measure

quality of life. Some health-related quality of life questionnaires calculate utility, a measure of quality of life between 0 and 1 where 0 represents death and 1 full quality life (Torrance, 1986). For the SF-12, use of the Short Form-6 Dimensions algorithm (Brazier et al., 2002) enables conversion of SF-12 scores into utility scores. With repeated measures of utility, an impression of change in utility can be gained and attributed to a specific health care intervention. This process is important as it both expresses the magnitude of quality of life, typically for comparison with other conditions, and when the change in utility is combined with the cost of the health service, it produces the variable of quality adjusted life years (QALYs). Heath economists when conducting cost effectiveness studies into health care interventions in terms of cost and quality. This combination of repeated measures of SF-12 and use of the SF-6D to produce the utility was introduced into the pilot study.

#### a Dizziness Handicap Inventory

The Dizziness Handicap Inventory (DHI) assesses self-perception of handicap from dizziness by considering daily activities (Jacobson & Newman, 1990). Dizziness Handicap Inventory scores greater than 26/100 represent significant self-report handicap of dizziness (Jacobson et al., 2008), while those less than 50/100 have been suggested to predict benign paroxysmal positional vertigo (Saxena & Prabhakar, 2013). The DHI was found to be the most responsive (i.e. sensitive to change) of a battery of self-reported measures including the Activities-specific Balance Confidence scale and Global Rating of Change, for people with balance and vestibular dysfunction (Friscia et al., 2014). A minimum significant change of 18/100 has been reported for the DHI (Jacobson & Newman, 1990). A number of investigations into the DHI have shown it scores higher in females and in the people older than 65 years (Formeister et al., 2020; Maarsingh et al., 2011; Ten Voorde et al., 2012).

Reliability in the DHI has been demonstrated for people with dizziness (Jacobson & Newman, 1990) and replicated for people with both peripheral and central vestibular dysfunction (Enloe & Shields, 1997; Kammerlind, Larsson, et al., 2005). The

questionnaire developers showed construct validity of the DHI with its high correlation between perceived handicap and emotional response to the dizziness (Jacobson & Newman, 1990). Similarly, the DHI correlates significantly in a strong, inverse relationship with the SF-36 health-related quality of life survey (linear correlation coefficient adjusted  $R^2 = 0.59$ , p< 0.001) (Formeister et al., 2020). Other indications of validity include high correlation with the Sensory Organisation Test (Jacobson et al., 1991), significant, strong positive correlation between physical component scores with posturography outcomes (rho= 0.72, p= 0.02) (Kaufman et al., 2006), and moderately strong, inverse correlation between the DHI and the Activities-specific Balance Confidence (ABC) scale (rho= -0.635, p< 0.001) in people attending balance and vestibular clinics (Whitney et al., 1999). Responsiveness to treatment is seen as change in DHI scores correlating well with the Global Rating of Change (rho= 0.61, p< 0.001) (Friscia et al., 2014), and in people with vestibular dysfunction through health-related quality of life surveys such as the Short Form-36 (Enloe & Shields, 1997; Lopez-Escamez et al., 2003). Thus, it was deemed suitable for the three clinical studies of the doctoral programme of research.

In order to compare the DHI outcomes from this thesis with that of the literature, a brief review of DHI outcomes by diagnosis was conducted with Figure 4.1 below demonstrating the resultant forest plot of mean initial assessment DHI values by diagnosis. The review used the PubMed database and the search term of 'dizziness handicap inventory' in abstracts from January 2011 to May 2019. The PubMed search retrieved 374 abstracts, from which 53 papers in English were read in their entirety. Initial assessment DHI Pre sum values were recorded including a measure of variation by specific diagnosis, from papers reporting DHI scores in people over the age of 17.





#### Figure 4.1 Initial assessment Dizziness Handicap Inventory scores by diagnosis

BPPV benign paroxysmal positional vertigo, BVH bilateral vestibular hypofunction, CD cervicogenic dizziness, CI confidence interval, MD Meniere's disease, PPPD persistent postural perceptual dizziness, SCDS superior canal dehiscence syndrome, UVH unilateral vestibular hypofunction, VM vestibular migraine

Initial assessment DHI values were extracted, and reference lists consulted, adding a further four papers for a total of 57 papers read. Data were extracted from 18 papers for benign paroxysmal positional vertigo, 22 papers for unilateral vestibular hypofunction, 12 papers for vestibular migraine, and 5 papers for cervicogenic dizziness, with analysis producing weighted confidence intervals. No risk of bias assessment nor blinded testing of data extraction was conducted.

#### b Activities-specific Balance Confidence Scale

The Activities-specific Balance Confidence (ABC) scale assesses the confidence / fear of falling during functional everyday activities in a population of people older than 65 years (Powell & Myers, 1995). Subsequent studies found the ABC scale can discriminate between fallers and non-fallers (Beninato et al., 2009; Lajoie & Gallagher, 2004). The ABC scale generates a percentage score with greater scores indicating greater confidence. Scores ranging from 50 to 80% indicate reduced community participation - comparable to retirement home / no exercise groups with moderate levels of functioning. Scores of less than 50% represent home care-level people with low levels of functioning, while those scoring > 80% represent high level functioning older adults (Myers et al., 1998). Scores less 67% have been shown to represent increased risk of falling in the people older than 70 years (Lajoie & Gallagher, 2004) while in people with stroke, a small study reported a cut-off of 81% below which multiple falls were likely (Beninato et al., 2009).

Reliability, internally consistency and validity has been demonstrated for the ABC with older adults (Powell & Myers, 1995). The ABC has been found to have a moderately strong, inverse correlation (rho = -0.64) with the Dizziness Handicap Inventory when used with a group of people referred to physiotherapy for balance and / or vestibular dysfunction (Whitney et al., 1999). Adding to this correlation, people with dizziness presenting due to an acute unilateral vestibulopathy demonstrated a moderate inverse correlation between the ABC and Dizziness Handicap Inventory (rho = -0.403) (Son et al., 2015). As an indication of repeated measures effect, people attending a vestibular disorders clinic and receiving physiotherapy showed significant improvement in their ABC scores (mean increase of 25/100 p< 0.001) (Wrisley et al., 2002). Further, a clinically significant improvement of 10 points (p= 0.04) has been reported when using the ABC scale with people with bilateral vestibular hypofunction (Brown et al., 2001). This tool was used by all three clinical studies.

#### c Screening Test for Hearing Problems

As there are known relationships between hearing loss and vestibular dysfunction (for example Cawthorne & Hewlett, 1954; Leong et al., 2008; Man et al., 1980; Manabe et al., 1995; Niu et al., 2016), the Screening Test for Hearing Problems (STHP) was selected and applied to aid the identification of people appropriate for referral to audiology for hearing testing. This 20-question, two-factor instrument was derived from and cross-validated against the 163 question, five-factor Communication Profile for the Hearing Impaired (Demorest & Erdman, 1987; Demorest et al., 2011). Participants who scored abnormally in the STHP, plus had not had a recent review by audiology were referred to audiology. The STHP was deemed valid for inclusion in the doctoral project for Studies 2 and 4. Study 3 included a pure tone audiogram for all participants, negating the need for the STHP.

d Short Form-12 health related quality of life questionnaire and the Short Form-6D algorithm

To investigate the cost utility of the vestibular rehabilitation model of care in the pilot study, the Short Form-12 (SF-12) health-related quality of life questionnaire (Ware et al., 1996) was completed before initial assessment and on discharge by participants recruited from May to June 2013. Using these results, a measure of utility was then calculated by the Short Form-6 Dimensions (SF-6D) algorithm (Brazier et al., 2002).

Based on the Short Form-36 question Health Survey (SF-36) (Ware & Sherbourne, 1992), the SF-12 is a one page, 12-question, population-level, health-related quality of life survey tool. As with the SF-36, the SF-12 produces two summary measures of physical and mental health. These summary measures were used in the validation of the SF-12, when it was compared successfully with the SF-36 (Ware et al., 1996). The SF-6D algorithm was developed to create a utility output from the SF-12 and considers six dimensions of health state (Brazier et al., 2002). This SF-12 / SF-6D were only used in Study 2, the pilot study.

# 4.3.8 Physical outcome measures and the clinical examination

The clinical examination (see Text Box 4.1 below) commenced with a series of tests for the central and then peripheral nervous systems to inform a diagnosis. With the participant sitting, cervical spine active range of motion was determined followed by an oculomotor examination, and vestibular ocular reflex testing.

Box 4.1 Oculomotor assessment steps (Bronstein & Lempert, 2006)

Oculomotor assessment comprises observations of:

- spontaneous nystagmus in neutral eye position
- range and speed of ocular motion horizontally and vertically in gaze
- gaze-evoked nystagmus at sustained limits of gaze
- pursuit considering smoothness of pursuit / presence of saccades / presence of nystagmus at sustained limits of gaze
- saccadic testing for speed of ocular movement and presence of hyper- / hypo-metria
- presence of skewness in the cover / cross cover test
- vestibular ocular reflex suppression

Following standing balance and gait testing, head position testing was undertaken in supine. This sequence of testing enabled progressive interpretation of the objective findings. Each step is briefly discussed below.

a Standardized oculomotor examination

The bedside assessment using oculomotor testing (Text Box 4.1) considered central dysfunction before that of the peripheral vestibular system.

#### b Vestibular ocular reflex testing: Dynamic Visual Acuity (DVA)

The Dynamic Visual Acuity (DVA) test acts to diagnose the compensation status of a vestibular hypofunction, serving as a primary outcome measure for vestibular rehabilitation (Herdman et al., 2003; Millar et al., 2020). The bedside DVA test (Rine & Braswell, 2003) is based on the Dynamic Illegible E Test (Longridge & Mallinson, 1987). Validity of both tests is based on the correlation of DVA score deterioration (increasing difference in lines read statically and dynamically) and worsening caloric function (a measure of mainly lateral semicircular canal function, compared between sides as a percentage difference and expressed as percent canal paresis) and often validated through the testing of people with bilateral vestibular hypofunction (Grossman & Leigh, 1990; Hillman et al., 1999).

In the bedside version of the DVA, the person being assessed sits two metres from a Snellen Eye Chart and reads down to the level of their first reading mistake. This represents the static visual acuity. In the dynamic test of acuity, the client's head is rotated in a sinusoidal pattern at two hertz in a small arc of at least 30 degrees each side of neutral, recording the reading chart line at which the client either makes a mistake in reading the chart or when the client resists the two hertz rotation (Rine & Braswell, 2003). This two hertz frequency for passive head rotation of the client while sitting was confirmed by Lee et al. (1997). Results of the DVA are recorded as categorical data, based on the difference between the dynamic and static tests, e.g., if the static test scores eight and the dynamic test scores six, the result is two lines lost. A normal result occurs with one or two lines lost (called grade one or two respectively) and an abnormal result with a score of three lines or more (grade three). With high sensitivity, specificity and reliability being reported in adults with vestibular hypofunction (Rine & Braswell, 2003), the DVA serves as an important tool to assess and monitor the treatment of people with unilateral and bilateral vestibular hypofunction (Herdman et al., 2007; Herdman et al., 2003); hence its use in this programme of research.
#### c Head impulse testing

A key step in the vestibular assessment process is to establish the presence of dysfunction in the peripheral vestibular system. Until the demonstration of head impulse testing in the 1980's, vestibular hypofunction was detected by head shake testing at the bedside, followed by calorics irrigation testing by audiologists. However, since then, an interpretive, functional clinical assessment of the lateral semicircular canal has been introduced, the bedside head impulse test (bHIT) (Halmagyi & Curthoys, 1988) which has been shown to be valid and reliable. This test is done with the person being assessed in sitting with the assessor sitting in front. With the person focussing on the assessor's nose, the assessor rotates the person's head in a low-speed low-amplitude sinusoidal fashion and then without warning induces a high-speed low-amplitude impulse, noting whether their eyes remain fixed on the assessor's nose (normal) or shows a movement with the person's head and then back to focus on the assessor's nose (abnormal with the side of vestibular hypofunction being in the direction of the head impulse)(Halmagyi & Curthoys, 1988). The importance of this test merits a thorough understanding of its validity through analysis of sensitivity and specificity calculations.

Importantly, bHIT validity depends on the completeness of unilateral vestibular hypofunction. At complete unilateral vestibular loss, the bHIT obtains excellent 100% sensitivity and specificity (Halmagyi & Curthoys, 1988). These values drop to 34% and 95-100% respectively (Beynon et al., 1998; Harvey et al., 1997) in generalised populations of people with vestibular hypofunction and using calorics irrigation test results of greater than 25% canal paresis as the comparator. Employing receiver operating curves of bHIT sensitivity vs. 1-bHIT specificity, the minimum cut-off canal paresis value (as determined by calorics testing) was found to be 43%, at which point a reasonable bHIT sensitivity and specificity of 78% and 87% respectively, was obtained (Perez & Rama-Lopez, 2003). In contrast, using the research 'gold standard' of search coils as the comparator test instead, 70% sensitivity and 67% specificity for the bHIT was obtained (Jorns-Haderli et al., 2007). It has been noted that bHIT sensitivity and specificity varied with the experience of the tester. Expert testers show reduced sensitivity and increased specificity (Jorns-

Haderli et al., 2007); suggesting they are more conservative to interpreting a bHIT positive result. The bHIT acts as an important clinical means of assessing for vestibular hypofunction and was used in all clinical studies.

## d Postural stability in standing and walking

People with a range of vestibular disorders can show changes in their balance and mobility when assessed with tests of performance such as the modified Clinical Test of Sensory Interaction in Balance (Cohen et al., 2014) and the Dynamic Gait Index (Wrisley et al., 2004). The modified Clinical Test of Sensory Interaction in Balance test can be used as a screening test for vestibular dysfunction (Agrawal et al., 2009; Cohen et al., 2014; Koo et al., 2015) and was selected for the same function in the doctoral study.

Static standing balance was assessed using a single timed position test for each of the bases of support on a firm surface from feet apart, feet together, and stride stance, and all with eyes open and then in eyes closed, finishing with single leg standing, eyes open. All tests were completed with shoes on (Bohannon et al., 1984) and without head movement. One, timed, modified Clinical Test of Sensory Interaction in Balance condition four test was conducted involving the person standing on 10 cm thick, medium density foam, eyes closed, feet together, shoes on (Whitney & Wrisley, 2004; Wrisley & Whitney, 2004). Pass / fail outcomes were recorded with a pass assessed as no fall with eyes closed for 30 seconds in adults up to the age of 64, and between 12.5 to 18.5 seconds in people aged 65-85 years (Horn et al., 2015; Shumway-Cook & Horak, 1986). Static standing balance tests were conducted in all three clinical studies.

The Dynamic Gait Index (Shumway-Cook & Woollacott, 1995) tests dynamic balance in people walking. The DGI includes eight walking tasks, each scored from zero (unable) to three (normal); the lower the score, the worse the dynamic balance. Validity is demonstrated through DGI cumulative scores of less than 19 associating the person with increased falls risk / reported falls in last 6-months (Shumway-Cook et al., 1997; Whitney, Wrisley, et al., 2004). Sensitivity and specificity of the falls cutoff score of <19 has been reported to be moderate at 70% and 51% respectively (Whitney, Marchetti, et al., 2004). A clinically significant improvement of three points for the DGI has been reported (Romero et al., 2011). The DGI was used in all three clinical studies of the programme.

## e Positional testing for benign paroxysmal positional vertigo (BPPV)

Specific positional testing for BPPV was required and included the Dix-Hallpike and supine head roll tests. These tests diagnose BPPV and guide its immediate management (Bhattacharyya et al., 2008; Halker et al., 2008; Hilton & Pinder, 2014). The tests have established high levels of sensitivity and specificity; with 79% and 75% respectively for the Dix-Hallpike, and 90% and 75% respectively for the supine head roll (Halker et al., 2008). Since activation of BPPV has symptomatic effects causing dizziness and frequently nausea (Bhattacharyya et al., 2008) (and to a less degree headache and migraine), to achieve a full objective examination, these tests were always applied last in the objective examination of a person with dizziness. Benign paroxysmal positional vertigo was diagnosed if the tests elicited diagnostic nystagmus, plus a complaint of vertigo (Bhattacharyya et al., 2008). Testing in the clinical studies used live visual signs of nystagmus from the person without routine infrared / Frenzel goggles or recordings thereof, except for cases of doubt. The latter included the presence of unusual nystagmus or evidence of vertigo without obvious nystagmus in the testing position or in sitting on return from the BPPV testing position. Head position testing was conducted in all three clinical studies of the doctoral programme of research.

### f Cervicogenic dizziness testing and treatment

Cervicogenic dizziness remains a diagnosis of exclusion with no definitive test (Reiley et al., 2017). In Study 2, cervicogenic dizziness was suspected when the person being interviewed denied vertigo but preferred the word unsteadiness to describe their dizziness. The assessment of cervicogenic followed the stepwise process suggested by (Reiley et al., 2017) but did not use their final stage of clinical tests such as cervical neck torsion testing. In the objective examination, cervical active range of motion assessment was always the first step for all people with dizziness, including those suspected of having cervicogenic dizziness. Then, the

therapist conducted oculomotor, vestibular ocular reflex, and BPPV testing in accordance with normal vestibular assessments (Reiley et al., 2017). The characteristic report of unsteadiness was often made during Dix-Hallpike testing for posterior canal BPPV, notably in the absence of BPPV-diagnostic report of vertigo and of canal-specific nystagmus. To confirm cervicogenic dizziness, the results of the seated cervical spine active range of movement testing were then combined with findings of a detailed cervical spine examination when the therapist conducted passive physical movements and palpation of the person's cervical spine in supine. If a diagnosis of cervicogenic dizziness was made, areas of hypomobility/muscle spasm noted in palpation in the upper cervical spine were then treated with manual therapy in accordance with literature studies (Reid, Callister, Snodgrass, et al., 2014) and the person reviewed for improvement within a week.

# **4.4** Study 3 methodology: Interrater reliability trial

Study 3 examined interrater reliability between two allied health initial assessors of people with dizziness referred to an ENT outpatient services. The trial was conducted between November 2015 and May 2016.

# 4.4.1 Design

A prospective interrater reliability trial compared levels of agreement in diagnoses and referrals between two allied health professionals following initial assessments of people with dizziness. Vestibular physiotherapists and vestibular audiologists have reported lead roles in allied health -led models of care for the management of people with dizziness in ENT settings in the UK (Kasbekar et al., 2014; Lee et al., 2011) so the level of concurrence between the two professions was sought in Study 3. If concurrent findings indicated need for vestibular rehabilitation, the person with dizziness was referred to another vestibular physiotherapy service for treatment. Further, the analysis of Study 3 demographics and diagnostic proportions results permitted comparison with the same of Study 4 when considering their inclusion in Study 4 analyses.

# 4.4.2 Setting and participants

Study 3 was conducted at Logan Hospital, a tertiary referral public hospital located in the Metro South Hospital and Health Service district of Queensland Health. Participants came from ENT outpatient category two and three wait lists using the traditional, medically led model of care.

4.4.3 Procedures: participant inclusion criteria, screening, recruitment, and administration

Referrals of people with dizziness were screened from the ENT category two and three outpatient waiting lists by the study vestibular audiologist. Inclusion criteria included a referral noting:

- Signs of vestibular dysfunction
- Symptoms of vestibular dysfunction
- Diagnosis of vestibular dysfunction
- Person aged 17 years or older
- And providing signed consent after reading the participant information and consent form

All referred people with dizziness meeting these screening criteria were offered an initial assessment.

Exclusion criteria refusal to be assessed by physiotherapy or audiology, being younger than 17 years of age, and being incapable of giving informed consent.

After the audiologist screened ENT category two and three wait lists referrals for people with dizziness, potential participants were offered assessments and mailed out a participant information and consent form with their appointment letters. On arriving for the initial assessment, people with dizziness had the study described verbally, consented by signing the participant information and consent form, and were given a copy.

## 4.4.4 Outcome measures

Before commencing the assessment, completed Dizziness Handicap Inventory, Activity-specific Balance Confidence and Assessment of Quality of Life 8 Dimensions questionnaires were collected from the participant for post assessment analysis and for repeated measures analysis if the participant attended subsequent vestibular rehabilitation. Initial assessment used a form developed from the Royal Brisbane and Women's Hospital Vestibular Assessment form used in the other studies. Physical performance measures included:

- cervical active range of motion as a measure of cervical motion and in testing for vertebrobasilar insufficiency,
- oculomotor testing to test for central dysfunction,
- VOR assessments to assess the peripheral vestibular system,
- head position testing assessing for benign paroxysmal positional vertigo,
- static and dynamic balance assessments plus gait assessment to assess people's function.
- neurological assessments including manual muscle strength tests, light touch sensation testing, reflex testing and tone testing were included if central dysfunction was suspected from the interview or preceding physical assessment

Assessment results were recorded on the vestibular assessment form (see Appendix 4) and inserted into the hospital record as in the pilot and main studies. Using a computer-generated random number generator, assessments were randomised between the physiotherapist or audiologist. The assessment burden on people with dizziness is often large due to nausea and dizziness evoked by physical tests. Rather than both clinicians conducting the assessment separately which would increase the assessment burden unacceptably and unethically on the person with dizziness, the non-assessing clinician observed the assessment by the randomised clinician, recording their assessment findings blindly on a separate vestibular assessment form. At the end of the assessment, both clinicians recorded assessment interpretations blindly on a data collection form (see Appendix 5) and

together with pre assessment questionnaires were sealed for post session analysis. Analysis of the tabulated answers computed both percentage agreement and Kappa statistics using SPSS Version 27.

# 4.4.5 Analysis

The clinical bedside testing results were recorded on the data form in a nominal scale format (present or absent, left or right). Calculation of a Kappa coefficient permitted testing of assessor diagnosis and referral reliability with Kappa values of 0.41 to 0.60 indicating moderate agreement, 0.61 to 0.8 substantial and 0.81 to 1 almost perfect agreement (Sim & Wright, 2005). A sample size of 41 was calculated on the basis of statistical testing for a significance level of < 0.05 in a two-tailed test with the null hypothesis being that the Kappa value was < 0.40, at a power of 0.9, a Kappa to detect of 0.9, and a 0.7 proportion of positive findings (Sim & Wright, 2005). In other words, if the Kappa value was found to be 0.9, it would have a confidence interval hypothesised to exclude at least a test value of Kappa of 0.4.

Since the Cohen's Kappa coefficient conducted to measure agreement between two clinicians often produces lower indications of agreement than are suggested by percentage agreement, percentage agreement of the data was also analysed (O'Leary et al., 2014).

# 4.4.6 Interrater reliability protocol quality review

The testing protocol was reviewed with respect to the 11-item, Quality Appraisal of Reliability Study (QAREL) criteria; a diagnostic reliability trial quality checklist (Lucas et al., 2010) used to appraise the quality of this interrater reliability trial. Table 4.1 below summarises the results of the QAREL interrogation, indicating adherence to all but two check list items, ensuring the rigour of Study 3's conduct.

# **4.5** Study 4 methodology: Main study

Study 4 continued the pilot study investigation of the physiotherapy-led vestibular rehabilitation model of care. Results of Study 2 informed the adjustment of outcome. Changes in measures collected by Study 4 included:

- changing the quality-of-life tool to the Assessment of Quality of Life 8 Dimensions questionnaire,
- changing the Dynamic Gait Index to the Functional Gait Assessment to provide a more rigorous tool to assess gait and indicate fall risk,
- adding a burden of dizziness assessment questionnaire, the Work Productivity and Activity Impairment questionnaire, and

adding a consumer engagement assessment tool in the form of a visual analogue scale measuring satisfaction, as well as incorporating video Head Impulse Test video-oculography results into the examination of people with dizziness.

With knowledge of feasibility of the model of care from the pilot trial results, a multidisciplinary vestibular pathway for people with dizziness referred to the ENT specialist outpatient service was developed in early 2015. Jointly developed by ENT, physiotherapy and audiology, this pathway commenced at triage with the initial categorisation of referrals by the screening ENT registrar, using normal red flag criteria (UK Department of Health, 2000a). People with dizziness formerly triaged onto the category two or three wait lists for later review by ENT, were now sent directly to the physiotherapy department for wait list categorisation with the initial assessment then undertaken by the vestibular physiotherapists involved in the service

4.5.1 Procedures: Participant inclusion criteria, screening, recruitment, and administration

Study 4 used the same inclusion and exclusion criteria as Study 2. Screening, administration, and management of people with dizziness from the ENT wait list was undertaken as per Study 2 until 2015 when screening of referrals of the wait lists was taken over by ENT registrars and the audiology team leader. On presentation for initial assessment to the physiotherapy service, people with dizziness were managed with the same processes as for Study 2 including initial assessment, treatment, referrals, and discharges.

# Table 4.1 QAREL check list for Study 3

Item	Yes	No	Unclear NA	
1 Was the test evaluated in a sample of subjects who were representative of those to whom the authors intended the results to be				
applied?	Yes			
2 Was the test performed by raters who were representative of those to whom the authors intended the results to be applied?	Yes			
3 Were raters blinded to the findings of other raters during the study?	Yes			
4 Were raters blinded to their own prior findings of the test under evaluation?	Yes			
5 Were raters blinded to the results of the accepted reference standard or disease status for the target disorder (or variable being				
evaluated?	Yes			
6 Were raters blinded to clinical information that was not intended to be provided as part of the testing procedure or study design?		No		
7 Were raters blinded to additional cues that were not part of the test?		No		
8 Was the order of the examination varied?	Yes			
9 Was the stability of the variable being measured considered when determining the suitability for the time-interval between				
repeated measures?	Yes			
10 Was the test applied correctly and interpreted appropriately?	Yes			
11 Were appropriate statistical measures of agreement used?	Yes			

## 4.5.2 Outcome Measures

Patient-reported measures and clinical measures were collected in the same manner as Study 2. The additional measures included in Study 4 are described below.

# a Assessment of Quality of Life 8 Dimensions (AQoL8D)

Key characteristics of the AQoL8D include:

- The AQoL8D built on the original Assessment of Quality of Life 4 Dimensions (Hawthorne et al., 1999).
- Designed and tested on Australian population by Monash University (Richardson et al., 2013)
- Designed using the World Health Organisation definition of health, impairment, disability and handicap (Hawthorne et al., 1999)
- Describes eight dimensions including sensory, so relevant to people with dizziness.
- As a full sized HRQoL with 35 questions, the AQOL8D is aimed at small samples of populations in contrast with short questionnaires like the SF-12 with 12 questions, which target population-sized studies (Brazier et al., 2007).
- The AQOL8D is valid and comparable to other multi-attribute utility instruments in use (Hawthorne et al., 2001; Richardson et al., 2013).

Assessment of Quality of Life 8 Dimensions utility scores behave in accordance with gender and age. Considering the original Assessment of Quality of Life 4 Dimensions, female scores decrease after the age of 50, male scores decrease between 40 and 80 years, and the utility scores of both sexes decrease further after the age of 80 (Hawthorne & Osborne, 2005). An average utility across all ages and genders was determined to be 0.83 (SD 0.20) with a minimal detectable change of 0.06 (95% CI 0.03, 0.08)(Hawthorne & Osborne, 2005). Reliability was also determined with a Cronbach alpha coefficient of 0.81 (Hawthorne & Osborne, 2005). Subsequent analysis of the AQOL8D has shown high reliability with a Cronbach alpha coefficient of 0.96 plus demonstrated convergent, predictive and content validity through comparison with other multi-attribute utility instruments including the

EuroQol-5 Dimensions, Health Utilities Index 3, Short Form-6D, 15D, and Quality of Wellbeing (Richardson et al., 2013).

# b AQOL8D Questionnaire Components

The AQOL8D reports as both a weighted utility measure and an unweighted psychometric measure (Monash Business School, 2018). Weighted utilities were calculated for this study's AQOL8D results. As well as the utility, the AQOL8D reports weighted values for eight dimensions, and two super dimensions. These include independent living, pain, and senses (combined into the physical super dimension) and mental health, happiness, coping, relationships, and self-worth (combined into the psycho-social super dimension). Each dimension is scaled from 0 to 1 but the components are not comparable to each other e.g. 0.8 in pain does not equate to 0.8 in independent living (Richardson et al., 2012).

The concept of a minimally important difference represents a measure of clinical change. A minimally important difference of 0.06 (95% CI 0.03- 0.08) has been reported for change in utility using the Assessment of Quality of Life 4 Dimensions (AQOL4D) (Hawthorne & Osborne, 2005), however no minimally important difference has been reported for the AQOL8D. In their analysis of Australian population norms for the AQOL4D and AQOL8D, Richardson et al. (2012) found close similarity in outcomes between the two. As a result, a minimally important difference of 0.06 will be used as a guide to the interpretation of utility change in Study 4.

# c Work Productivity and Activity Impairment: Specific Health Problem (WPAI:SHP) questionnaire

Measuring burden of disease informs decision-making and planning processes in health. Knowledge of the burden of dizziness assists decision makers to understand the demand for services that address the problem of dizziness. Since the ability to work or to conduct activities of daily living for people with dizziness is a serious concern for people, community and health services, the Work Productivity and Activity Impairment Questionnaire: Specific Health Problem (WPAI:SHP) (Reilly et al., 1993) was used to assess this issue. The WPAI:SHP uses patient report to quantitatively measure absenteeism (loss of wages), presenteeism (impairment at work) and activity impairment due to a specific health condition, in this case dizziness. Using time in the last 7 days to measure dysfunction, the WPAI:SHP produces an overall work productivity score with higher percentages indicating improved performance. The specific health problem version has been shown to be reliable and validated against numerous disease-specific measures, although not yet with dizziness. For example, work productivity correlated with severity of depression (Asami et al., 2015) and irritable bowel syndrome (Reilly et al., 2004).

The WPAI:SHP (Dizziness) groups people with dizziness into either working or nonworking groups. People in working groups are then questioned about:

- Hours missed in last week due dizziness
- Hours missed in last week due to other reasons
- Hours in last week actually worked
- A rank of how much dizziness effected work productivity
- A rank of how much dizziness affected ability to do regular activities

Non-working people only had to answer the last question about effect on regular activities; reducing the WPAI:SHP usefulness for unemployed populations since no tangible result such as lost wages can be calculated. Whereas cost utility analyses outline direct costs to the health service, the WPAI:SHP (Dizziness) informs the economic analysis about the indirect costs to the person with dizziness in terms of lost wages or absenteeism and to the employer in terms of lost productivity or presenteeism, adding to the richness of the analysis and hence its inclusion in the main study.

# d Wait list and vestibular rehabilitation service satisfaction surveys

Consumer engagement assessment comprised two visual analogue scales (VAS) to assess ratings of satisfaction for time on the ENT wait list and with the rehabilitation service. The wait list survey used the phrase "Please place a mark on the line below corresponding to how satisfied you feel right now about your time on the wait list before having an appointment made to assess your dizziness" with Very Satisfied and Very Unsatisfied as the VAS line end phrases. The service satisfaction survey used the phrase "Please place a mark on the line below corresponding to how satisfied you feel right now about the management of your dizziness by your Physiotherapy service" again with Very Satisfied and Very Unsatisfied as the scale line end phrases. Participants marked the level of satisfaction with a line across the vertical VAS, which was measured using a ruler; the length in centimetres being recorded in the database. With appropriate anchor phrasing, VAS have been shown to be valid, reliable and responsive for assessing quality of life related concepts (de Boer et al., 2004). To account for potential bias due to the researcher also being a service therapist, people with dizziness completed the VAS wait list as part of the mailed out, pre-assessment questionnaire. Similarly, the service VAS was completed in private on discharge either at the hospital or at home and mailed back.

e Tests of gait-related activities- the Dynamic Gait Index versus the Functional Gait Assessment

As a measure of gait-related activities in community dwelling older adults, the Dynamic Gait Index was found to have a ceiling effect when used with people with vestibular dysfunction (Wrisley et al., 2004). To mitigate for this effect, a 10-item instrument was developed from the Dynamic Gait Index , the Functional Gait Assessment (Wrisley et al., 2004), particularly to address the needs of older people with vestibular disorders. Reliability plus concurrent, discriminative, and predictive validity was demonstrated with a cut off score of  $\leq$  22/30 predicting increased risk of falls in assessed community-dwelling older adult people (Wrisley & Kumar, 2010). To evaluate unsteadiness in gait, to determine the presence of increased falls risk and to contribute to the assessment of the clinical effectiveness of the service, the Functional Gait Assessment was adopted for Studies 3 and 4.

### f Vestibular Ocular Reflex (VOR) testing with Head Impulse Tests

The vestibular ocular reflex assessment protocol comprised the interpretive bedside head impulse test (Halmagyi & Curthoys, 1988) of the pilot study plus quantitative

video-oculography employing Video Head Impulse Testing (vHIT) (MacDougall et al., 2009; Weber et al., 2009). These two tests were conducted after oculomotor testing had ruled out central dysfunction, improving the diagnostic sensitivity by better identifying involvement of specific canals (MacDougall et al., 2013; MacDougall et al., 2009). The use of vHIT video oculography is important particularly in the assessment of vertical semicircular canal function (MacDougall et al., 2013; Welgampola et al., 2019), as no other clinical test assesses the function of these four canals. Calorics irrigation testing, a test often employed by audiologists to determine canal function, only measures lateral canal function, expressing it as canal paresis percentage. The individual canal contribution to detected nystagmus by calorics testing has been calculated in people without vestibular dysfunction to be in the ratio of 0.3: 0.1: 1.0 for anterior, posterior (the vertical canals) and lateral canals respectively (Aw et al., 1998).

Video head impulse sensitivity and specificity is superior to that of bedside HIT (bHIT) when the canal paresis is greater than 40% (Alhabib & Saliba, 2017). For example, when considering people with acute vestibular neuritis whose paresis was greater than 40%, vHIT sensitivity and specificity has been shown to be 87% and 100% respectively, compared with the bHIT results at 43% canal paresis of 78% and 87% (Bartolomeo et al., 2013). The sensitivity of vHIT reduced to 69% by a 30% canal paresis limit of unilateral vestibular hypofunction (Bartolomeo et al., 2013).

### 4.5.3 Analysis

Service and clinical outcome measure data were entered into the research database, and then imported into the SPSS® statistical software version 27 for analysis. Distribution of data were reviewed for normality prior to analyses being undertaken. Relevant descriptive statistics were used to describe the cohort of people with dizziness and paired statistics used to examine change with treatment, as appropriate. Multiple comparisons of means were investigated using analysis of variance (ANOVA) with adjustments made for Type 1 error using Bonferroni correction when relevant. Missing value analysis to determine the presence of nonrandom factors was conducted in the analysis of dropout of discharge data for the major repeated measures of Dizziness Handicap Inventory, Activities-specific Balance Confidence Scale, and Assessment of Quality of Life 8 Dimensions. This was followed by multiple imputations using SPSS® and its product of pooled imputed means for outcome analysis.

# **4.6** Study 4 methodology: Cost consequences analysis

A cost consequences analysis was conducted in Study 4. Variables used included clinical costs, utility produced by physiotherapy intervention using the Assessment of Quality of Life 8 Dimensions health-related quality of life questionnaire, waits for 2013 and 2017, and the results of the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire.

Direct clinical costs were calculated by Metro North Health and Hospital Service finance department accounting for those physiotherapy, audiology and ENT outpatient appointments occurring within a participant's admission and discharge dates for the vestibular service. Indirect costs borne by the people with dizziness and employers fell under the burden of dizziness due to lost wages and presenteeism respectively and are described separately. Decision trees were generated for the two main pathways or options followed from triage of ENT-referred people with dizziness: either primary contact management by the physiotherapy-led vestibular rehabilitation service or primary contact management by an ENT consultant. The generated costs were used to compare the two models in a cost consequences table.

The following chapters (Chapters 5-8) present the results of the three clinical studies for the doctoral programme of research.

# Chapter 5 Pilot Study: Study 2

Chapter five presents Study 2- the pilot study of this research programme. A brief introduction outlines the need and purpose of the pilot study. The methods used are described followed by the description and analysis of patient profiles including demographics, and diagnostic proportions. In order to demonstrate the service as feasible and as one of high value care, safety, service, clinical and quality of life outcomes were collected both on admission and on discharge. Analysis of repeated measures of service and clinical outcomes lead to an assessment of the feasibility of this model of care.

# 5.1 Abstract

The Study 2 pilot investigated the feasibility of a study into a standalone physiotherapy-led vestibular rehabilitation model of care with the intent of informing an extension of the trial into a major study. The 67 participants from a quaternary referral hospital ENT wait list had a 44:23 female to male ratio, a mean age of 55.2 years (SD 17.57) and produced a diagnostic profile of common diagnoses comprising benign paroxysmal positional vertigo (BPPV) (22%), unilateral vestibular hypofunction (40%), vestibular migraine (10%) and cervicogenic dizziness (6%). Service outcomes analysis yielded a mean wait of 382.6 days (SD 246.3) with 46% of participants receiving one occasion of service. Nine percent of participants were returned to ENT for consultant review, while no adverse events were recorded. Management of people with dizziness led to the clinical resolution of benign paroxysmal positional vertigo and compensation of unilateral vestibular hypofunction and produced significant improvements in the Dizziness Handicap Inventory (34.9/100 to 11.1/100, p< 0.001) and the Activities-specific Balance Confidence scale (ABC) (78.3/100 to 87.9/100, p= 0.009). In summary, the model of care was found to be feasible with the pilot informing the modification of outcome measures for a largescale investigation of the model of care.

## 5.2 Introduction

People with dizziness often seek medical solutions to the dizziness (Neuhauser et al., 2008; Newman-Toker, Hsieh, et al., 2008). Clinical reasoning leads primary contact medical practitioners to assess for vestibular, cardiac, respiratory, neurological, and systemic causes of the dizziness, in line with the patient history and examination results (Newman-Toker, Hsieh, et al., 2008). When vestibular system dysfunction is suspected, as is often the case when people experience vertigo, medical practitioners frequently refer people to ENT or neurology specialists for advanced vestibular assessment and investigations. Referral to a public specialist outpatient service can result in these people being placed on wait lists to assist with demand management (Lee et al., 2011; Leong et al., 2008). This wait lengthens the exposure to the dizziness and its sequelae, having impacts on the overall function of a person with dizziness within the community (Morimoto et al., 2019).

Dizziness represents a health issue for both people and health systems. As an example, dizziness contributes to patient burden financially (Sun et al., 2014) at the same time as creating demand for health care (Neuhauser et al., 2008). Dizziness potentially contributes to falls (Agrawal et al., 2009; Pothula et al., 2004) and both dizziness and falls increase in prevalence with age (Agrawal et al., 2009). Sequelae of falls have a considerable impact on the people falling as well as the health systems (Tinetti, 2003). All dizziness sequelae potentially contribute to people reducing their activity participation in the community (Morimoto et al., 2019; Neuhauser et al., 2008).

By early 2013, a number of multidisciplinary models managing people with dizziness had been reported; two reports on a combined otolaryngology and neurology clinic from Canada (Bath et al., 2000; Heaton et al., 1999), and two ENT-led, combined ENT/audiology/physiotherapy services in England (Lee et al., 2011; Leong et al., 2008). The majority of diagnoses reported for these multidisciplinary models were examples of peripheral vestibular dysfunction; known to be manageable by allied health professionals such as audiologists and physiotherapists (Herdman, Blatt, & Schubert, 2000).

This study investigated the feasibility of the study of a primary contact,

physiotherapy-led vestibular rehabilitation model of care, independently managing people referred to ENT for dizziness. The model of care was proposed as a way of reducing the long waits (Lee et al., 2011; Leong et al., 2008) and costs of medically dominated models, while producing safe, effective management of people with dizziness. The model was also proposed to meet the key requirements of high value care, namely meeting the Triple Aim goals of improved experience of care, improved health of identified populations, and reduced costs per capita of identified populations (Berwick et al., 2008). Thus, the aim of Study 1 was to demonstrate the feasibility of the study into the model of care through analysis of patient profiles, and service, safety, clinical outcomes, and quality of life. The research question posed was:

• Is the study of the proposed physiotherapy-led vestibular rehabilitation model of care feasible?

It was hypothesized that the patient demographics, diagnostic proportions, service outcomes including occasions of service, and repeated measures of clinical outcomes including physical measures and patient reported measures reflected the rehabilitation findings as outlined in the literature, that the patient profile was comparable to published profiles, and that for the main diagnostic categories, the study of the model of care was feasible and worthy of further study.

# 5.3 Methods

The methods initiated in the pilot study for participant recruitment, assessment and management formed the basis of the methodology for the programme of research.

# 5.3.1 Study design

An observational pilot study was conducted to determine feasibility of study of an innovative model of care using repeated service and clinical measures, located in a single public healthcare hospital with separate ENT specialist outpatient and physiotherapy vestibular rehabilitation services.

## 5.3.2 Setting and participants

Study 2 was undertaken at the Royal Brisbane and Women's Hospital, a quaternary referral, public hospital in south-eastern Queensland, Australia. People with dizziness were initially referred to the Royal Brisbane and Women's Hospital ENT department for management. This department is a large ENT service providing inpatient and outpatient care for people from a number of public hospital and health service districts in central to southern Queensland. The pilot study managed people with dizziness between November 2012 and June 2013. Referrals placed on category two and category three ENT wait lists between 2011 and 2012, were screened for suitability for inclusion in the study by the physiotherapist, working in the ENT department. Additionally, people referred with dizziness between November 2012 and June 2013 were included in this study. ENT category two patients are meant to be seen by a consultant within 90 days of receipt of referral and category three within 365 days. Referrals for people with dizziness were screened by the vestibular physiotherapist for signs, symptoms, or diagnoses of vestibular dysfunction.

The pilot study started prospectively in November 2012 with standardised verbal participant information and verbal consent gained from people with dizziness for admission. A retrospective opt-out participant information and consent process conducted after the pilot study had finished met the consent demands for ethical approval for the study. The pilot study commenced before the candidate was accepted into the PhD programme but was reviewed by the Primary Supervisor and deemed valid to continue as the first clinical study for the PhD programme. Ethical approval for the pilot study and its additional retrospective opt-out consent process was gained once the pilot study finished but by the time the candidate had met PhD candidature requirements.

Consent for retrospective consent to use the data was obtained from the Royal Brisbane and Women's Hospital Human Research Ethics Committee (HREC/15/QRBW/141) and Australian Catholic University (2013 293Q) (see Appendix 1).

# 5.3.3 Procedures- Participant inclusion criteria

Inclusion criteria required a category two or three referral to ENT noting:

- Signs of vestibular dysfunction
- Symptoms of vestibular dysfunction
- Diagnosis of vestibular dysfunction
- Person aged 17 years or older

Exclusion criteria comprised those people who once contacted, refused to be assessed by physiotherapy, people younger than 17 years of age, those people incapable of giving informed consent, or those people not from the ENT category two and three wait lists. People not meeting the inclusion criteria but agreeing to be assessed by physiotherapy were seen by the service as part of its normal functions, outside of the research study.

## 5.3.4 Procedures- Participant screening, recruitment, and administration

All referred people with dizziness meeting the screening criteria were offered an initial assessment and treatment (when required). On arrival for the initial appointment, people with dizziness were informed of the study and if consenting to participate, completed a battery of patient reported measures before initial assessment. Clinical and demographic information collected at this stage included patient identification number, date of birth, gender, and referral date. Outcomes collected included the Dizziness Handicap Inventory, the Activity-specific Balance Confidence scale, and the Short Form quality of life 12 question questionnaire (SF-12). On discharge, participants were given the opportunity to complete a similar battery of patient reported measures.

# 5.3.5 Initial assessment

Initial assessments were completed by the doctoral candidate using a purposedesigned vestibular assessment form (Royal Brisbane and Women's Hospital Physiotherapy Department, 2013) (see Appendix 4) which included history of the condition, dizziness triggers, general health, hearing red flag, medication, and headache questions. Physical performance measures included:

- cervical active range of motion as a measure of cervical motion and testing for vertebrobasilar insufficiency
- oculomotor testing to assess for central dysfunction
- vestibular ocular reflex assessments to assess the peripheral vestibular system
- head position testing for benign paroxysmal positional vertigo
- static and dynamic balance assessments plus gait assessment to assess people's function
- neurological assessments including manual muscle strength, light touch sensation, reflex and tone testing, only included if central dysfunction was suspected from the interview or preceding physical assessment.

The report of falls, the Screening Test for Hearing Problems (Demorest et al., 2011) and the modified Clinical Test of Sensory Interaction in Balance (Cohen et al., 2014), were only collected on initial assessment.

# 5.3.6 Management of identified dysfunction

Treatment commenced at the end of the initial assessment for those participants identified with dysfunction treatable by physiotherapy, following protocols described in the literature for benign paroxysmal positional vertigo (Bhattacharyya et al., 2017), peripheral vestibular hypofunction (Hall et al., 2016), and cervicogenic dizziness (Reid, Rivett, et al., 2014). Participants assessed as needing a pure tone audiogram and / or vestibular investigations were referred internally to hospital audiology.

# 5.3.7 Referrals to other health professionals

When the physiotherapist identified or suspected central neurological dysfunction or other systematic disorders, people with dizziness were referred back to their GP or their case was discussed with either a consultant neurotologist or consultant ENT. If an ENT review was subsequently required, the participant was returned

administratively to the ENT wait list, with an appropriate categorisation ensuring no loss of place in the wait list.

# 5.3.8 Outcome measures

From a pilot study perspective, feasibility for the study of the model of care was determined by investigating patient profiles, service outcomes, safety outcomes, and clinical outcomes using repeated patient-reported measures and physical measures. Patient profiles comprised demographic data entered including gender and age to be explored by decade, plus diagnoses. Both the total number of diagnoses and the primary diagnosis were recorded. Service outcome data included wait times, occasions of service, duration of treatment and measures of safety. Safety information included complaints by participants, reports of adverse events from health care providers and the hospital safety database Prime®, and records of adverse events during treatment.

Validated and reliable patient-reported measures included the Activities-specific Balance Confidence Scale (Powell & Myers, 1995), the Dizziness Handicap Inventory (Jacobson & Newman, 1990), the Screening Test for Hearing Problems (Demorest et al., 2011) and the SF-12 (Ware et al., 1996). Validated and reliable physical measures comprised Dynamic Visual Acuity (Herdman et al., 2003; Rine & Braswell, 2003), results of head position testing (Bhattacharyya et al., 2008), Dynamic Gait Index (DGI) (Shumway-Cook & Woollacott, 1995) and one test of condition four from the modified Clinical Test of Sensory Integration in Balance (Cohen et al., 2014). Patient-reported falls were recorded in the interview to enable comparison with diagnoses and instruments reporting falls risk.

# 5.3.9 Analysis

The distribution of data was assessed for normality before selecting the statistics for use in analysis. With normally distributed repeated measures data, descriptive and paired testing of mean values was used. Non-normal data were otherwise described using descriptive statistics and when paired, through nonparametric Wilcoxon Signed Ranks testing. SPSS® statistical package version 27 was used in the analysis of

outcome data. Probability values of less than 0.05 were considered significant, with multiple comparisons such as in analysis of variance (ANOVA) using Bonferroni correction to the p-value to reduce Type 1 errors.

# 5.4 Results

Out of 134 people screened from category two and three ENT wait lists during the pilot study, 67 people completed initial assessments. The other 67 people did not attend for an initial assessment and were excluded. At discharge, 27 participants completed all assessments while others completed some. Thus, various numbers of participants completed the patient reported measures of the Dizziness Handicap Inventory (n= 27) and the Activities-specific Balance Confidence Scale (n= 31), and the physical measure Dynamic Gait Index (n= 36). There were 31 (46.3%) people who attended for a single occasion of service, of which 14 people were discharged needing only the initial assessment for clinical reasons.

# 5.4.1 Patient Profiles: Demographics

Of the 67 people who attended initial assessments; 44 (66%) were females and 23 (34%) males. The average age of participants was 55.2 years (SD 17.57), with males being older by 13.1 years (95% CI 4.8 to 21.4) compared with females at 50.7 years (SD 17.02). Figure 5.1 below shows the age frequency groups by decades.

Sixty-seven (50%) people with dizziness were screened but did not take up the offer This included 37 (55%) females (seven category two and 30 category three referrals) and 30 (45%) males (nine category two and 21 category three referrals). Nonassessed people with dizziness did not differ to those assessed by age.

# 5.4.2 Patient Profiles: Diagnoses

Diagnostic proportions are outlined in Table 5.1 below. Notable proportions include unilateral vestibular hypofunction as the leading proportion and anxiety only occurring as a secondary diagnosis in the total diagnostic cohort.

# a Benign paroxysmal positional vertigo (BPPV)

Seven cases of BPPV were left-sided and eight were right-sided. Six people with BPPV reported falls. All 15 people with BPPV were positive on initial assessment with head position testing and following treatment, 14 out of the 15 were negative on discharge.

## b Unilateral Vestibular Hypofunction

There were 19 people with left-sided and 22 people with right-sided unilateral vestibular hypofunction. Ten people with unilateral vestibular hypofunction reported falls. Using dynamic visual acuity to measure compensation in people with unilateral vestibular hypofunction, of the 39 people with unilateral vestibular hypofunction recording initial assessment Dynamic Visual Acuity scores, 16 had an abnormal grade three, nine had a normal grade two and 13 had a normal grade one. On discharge, all 16 abnormally scoring people with uncompensated unilateral vestibular hypofunction recorded normal, compensated Dynamic Visual Acuity scores of grade two or one; a significant clinical response to treatment (Wilcoxon Signed Rank Test Z = -3.52, p < 0.001).





Diagnosis	total diagnoses n (%)	primary diagnoses n (%)
benign paroxysmal positional vertigo	15 (11.5)	15 (22.4)
unilateral vestibular hypofunction	41 (31.3)	27 (40.3)
bilateral vestibular hypofunction	5 (3.8)	4 (6)
vestibular migraine	13 (10)	7 (10.4)
cervicogenic dizziness	15 (11.5)	4 (6)
anxiety	22 (16.8)	0 (0)
Meniere's disease	2 (1.5)	1 (1.5)
persistent postural perceptual dizziness	1 (1)	1 (1.5)
non-vestibular other	17 (13)	8 (11.9)
combined	131 (100)	67 (100)

# Table 5.1 Study 2 diagnostic proportions

### c Other diagnoses

Four people with cervicogenic dizziness reported associated falls. In the five people with bilateral vestibular hypofunction, two reported falls. The dynamic visual acuity improved with treatment in four of these five people with bilateral vestibular hypofunction to clinically normal levels. Anxiety was a common comorbid diagnosis in 22 (32.8%) out of the 67 participants, however anxiety did not occur as a primary diagnosis. Six people with anxiety reported falls. No clinical screening measure for anxiety was recorded.

# 5.4.3 Service outcomes

People with dizziness combined from both wait lists had a mean wait of 382.6 days (SD 246.3) before initial assessment. Waits ranged from three to 857 days and had a bimodal distribution centred on 100 and 500 days. Non-assessed people were on wait lists significantly longer by 119.4 days (95% CI 76.3 to 162.4).

Thirty-one (46%) of the 67 people with dizziness received one occasion of service. Occasions of service ranged from one to 10. Median duration of treatment was 21 days in a positively skewed distribution (skewness= 3.65) with a mode of one day. Physiotherapy made 21 referrals (31%) to audiology, while six people (9%) were returned to ENT for consultant review after a discussion with the consultant. As a measure of safety, no complaints were received from participants, no complaints were reported by other health professionals, and no adverse events were recorded either in the PRIME® hospital safety database or by the pilot study.

# 5.4.4 Clinical outcomes

Table 5.2 outlines the patient reported and clinical measures for admission and discharge using Wilcoxon Signed Ranks paired data testing.

a Modified Clinical Test of Sensory Integration in Balance and reported falls

Sixty-four of 67 people completed the modified Clinical Test of Sensory Integration in Balance with eyes closed for more than 30 seconds, suggesting a low falls risk in the pilot study cohort. Sixty-five people responded to the initial assessment interview question about whether they had falls associated with their dizziness with 19 (29%) reporting falls and 46 (71%) no falls.

outcome measure	paired n	admission paired mean (SD)	discharge paired mean (SD)	mean difference (95%Cl)	Z	p
DHI	24	34.9 (23.8)	11.1 (14.45)	-23.8 (-13.2 to -34.5)	-3.87	<0.001
ABC	28	78.3 (20.1)	87.9 (13.48)	9.5 (2.6 to 16.4)	-2.65	0.008
DGI	35	22.1 (4.0)	23.3 (1.98)	1.2 (0.1 to 2.2)	-2.41	0.016

Table 5.2 Clinical effect measures

ABC Activities-specific Balance Confidence Scale, CI confidence interval, DGI Dynamic Gait Index, DHI Dizziness Handicap Inventory, SD standard deviation, Z Wilcoxon Signed Ranks testing statistic

b Short Form 12 quality of life questionnaire / Short Form 6 Dimensions algorithm

Using the Short Form 12 quality of life questionnaire / Short Form 6 Dimensions algorithm for 25 people with dizziness to assess feasibility of measuring change in utility, a mean pre-assessment utility of 0.61 (SD 0.10) was found. Accounting for the discharge Short Form 12 drop out of 13 participants, the 12 participants completing

both pre assessment and post discharge measures of Short Form 12 scored a pre assessment mean Short Form 6D algorithm utility score of 0.61 (SD 0.10), increasing to 0.66 (SD 0.13) by discharge. This represented an improvement of greater than the reported minimum importance difference for the Short Form 6 Dimensions utility of 0.041 (Walters & Brazier, 2005).

# 5.5 Discussion

Analysis of Study 2 service patient profiles, service and clinical repeated measures, service safety, and quality of life utility data demonstrated feasibility of the study into the physiotherapy-led vestibular rehabilitation service model of care.

Demographics of the screened cohort before being offered an initial assessment appointment, had an even gender split. However, more females than males attended initial assessment; a dominance reported frequently in the specialist outpatient literature (Arya & Nunez, 2008; Bath et al., 2000; Bronstein et al., 2010; Guilemany et al., 2004; Heaton et al., 1999; Isaradisaikul et al., 2010; Kasbekar et al., 2014; Lee et al., 2011; Luscher et al., 2014; Tungvachirakul et al., 2014; Yin et al., 2009). Females were also younger than males attending the service, reflecting the literature when ages of females vs. male are reported (Bath et al., 2000; Isaradisaikul et al., 2010; Olusesi & Abubakar, 2016; Philip & Prepageran, 2009) and suggesting either an age-related prevalence of dizziness or a lower prospect of working-age males attending assessments during working hours.

In considering service outcomes, the pilot study found waits for participants in Study 2 showed a bimodal distribution reflecting a combination of new referrals and long waits in the cohort. The long waits of between one and two years indicated potentially significant burden for the participants due to dizziness. Of the 31 people who had a one-day duration of treatment, most frequent diagnoses were vestibular migraine (n = 5) and compensated unilateral vestibular hypofunction (n = 9); both of which were managed with one occasion of service intentionally. The majority (67%) of participants requiring treatment duration of more than one day up to three months, had unilateral vestibular hypofunction (n = 24). Duration of treatment reflected the

treatment practice for diagnosed conditions. For example, vestibular migraine was often managed by one session of physiotherapy for diagnosis and education followed by return to the person's general practitioner for pharmacological management. In contrast, management of uncompensated unilateral vestibular hypofunction was based on vestibular rehabilitation (Herdman et al., 2003), incorporating the progression of home exercises with reviews every two weeks until compensation had been achieved. This yielded higher occasions of service and duration of treatment.

A key service element of the model of care displayed by this study was its safety, demonstrated through the recording of no adverse events on the hospital's Prime ® safety register, the reception of no complaints or reports of misdiagnosis, and its multidisciplinary nature with the internal referrals of people with dizziness possible after initial assessment to either audiology or ENT.

The two largest diagnostic groups of benign paroxysmal positional vertigo and unilateral vestibular hypofunction collectively explained 63% of primary diagnoses. Analysis of physical measures known to demonstrate the clinical effect of treatment on these two diagnoses, the head position test and the dynamic visual acuity respectively, showed almost complete resolution and statistically significant improvements on discharge using the small, non-parametric samples. This improvement was in line with the literature (Hillier & McDonnell, 2011; Hilton & Pinder, 2014) and supported a pilot study finding of feasibility for the service investigation. With the model of care showing potential improvement in clinical outcomes for at least the main common diagnostic categories, continuing the study into the model of care was indicated with the aim of generating larger sample sizes and further analysis of clinical outcomes.

The feasibility in the research method of selected patient-reported outcomes was largely supported. The Dizziness Handicap Inventory (DHI) was recommended for continued use as a primary measure of dizziness impact due to the changes observed with treatment and the validity of the DHI in measuring self-perceived symptoms of dizziness (Jacobson & Newman, 1990; Son et al., 2015). To demonstrate clinical effectiveness, the number of participants required to complete

the DHI in the main study was calculated using a sample size and power calculator by G\*Power (http://www.gpower.hhu.de). A strong effect size of 0.95 was sought. Using the DHI means from this current study for a two-tailed paired t-test with an alpha of 0.05 and power (1-beta) of 0.95, 17 participants would be required. Likewise, following the observed improvement in the Activities-specific Balance Confidence (ABC) scale with treatment in this feasibility study, further collection of the ABC scale was recommended to continue the assessment of perceived falls risk in this cohort. Using the same criterion as for the DHI and using the G\*Power calculator, 48 participants would be required to demonstrate clinical effectiveness. Results for the Dynamic Gait Index (DGI) showed most people with dizziness scored normally on initial assessment and in excess of the less or equal to 19/24 cut off for falls. A similar ceiling effect for the DGI for people with dizziness (Wrisley et al., 2004) was previously reported with a more effective measure, the Functional Gait Assessment, developed and tested for validity and reliability (Marchetti et al., 2014; Wrisley et al., 2004). The Functional Gait Assessment was adopted for the subsequent clinical studies.

A majority of people completing the Screening Test for Hearing Problems (STHP) scored abnormally, highlighting the frequency of hearing loss in people with dizziness attributed the pathophysiology of the diagnoses (Polensek & Benton, 2014) and to their older average age. Referrals to audiology for pure tone audiograms were made on a case-by-case basis, in contrast with the routine hearing tests for participants reported by other multidisciplinary clinics (Burrows et al., 2017; Kasbekar et al., 2014; Lee et al., 2011; Leong et al., 2008). Factors considered in the audiology referral included the recency of hearing loss, the results of previous hearing tests, the results of the STHP and in particular, when the differential diagnosis included Meniere's Disease (Agrawal & Minor, 2010; Lopez-Escamez et al., 2015) and Vestibular Migraine (Lempert et al., 2012; Radtke et al., 2002).

When considering whether the cohort was comparable to those of other services, either nationally or internationally, diagnostic proportions represent a useful comparator. The frequency of conditions diagnosed did not reflect the pattern of acute peripheral vestibular disorders associated with dizziness typically reported in the literature (Bath et al., 2000; Heaton et al., 1999; Isaradisaikul et al., 2010; Kasbekar et al., 2014; Katsarkas, 1994; Luscher et al., 2014; Olusesi & Abubakar, 2016). Notably benign paroxysmal positional vertigo, often quoted as being the most frequent acute peripheral vestibular dysfunction (Helminski & Zee, 2010; Parnes et al., 2003), formed only 22% of the primary diagnoses in the model of care trial's cohort, and was a distant second to unilateral vestibular hypofunction's 41%. In association with the long waits these people had experienced, the findings implied a population sample with chronic vestibular dysfunction rather than acute disorders. This indicated the need for further evaluation of the wait-list population's diagnostic proportions through a larger case series and confirmed the need for the systematic review determining comparative diagnostic proportions as reported in Chapter 3.

The Short Form 6 Dimensions algorithm (SF-6D) utility baseline score of 0.61, compared to 0.80 (SD 0.11) for a multi-country analysis of healthy populations utility (Chen et al., 2016), represents a 24% reduction in quality of life. In Study 2, utility improvement due to vestibular rehabilitation represented a 6.6 % increase in quality of life. This increase indicated a need for a cost consequences analysis by Study 4 to explore the cost effectiveness of the model of care and to contribute to the assessment of it as one of high value care. The Short Form-12 question health related quality-of-life questionnaire (SF-12) is a short questionnaire designed for population-sized samples (Marosszeky, 2005; Ware et al., 1996) so a more appropriately sized questionnaire for smaller samples was needed. The longer, Australian-developed, eight-dimensional Assessment of Quality of Life 8 Dimensions questionnaire (AQOL8D) was deemed to be more appropriate. Comprising 35 questions, the AQOL8D suits small sample sizes cohorts with the advantages of being developed on two large samples from the Australian population (Richardson et al., 2012), of being validated against other multi-attribute utility instruments (Richardson et al., 2013), of having a sensory dimension in its matrix (Richardson et al., 2012), and of being free for use once the study was registered with the instrument-developing institution, Monash University.

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Continuing the analysis of the physiotherapy-led vestibular rehabilitation service as one offering high value care using the Triple Aims of Berwick et al. (2008), the model of care's effect on consumer satisfaction and on consumer burden of dizziness needed to be added to the future studies. As a result, Study 4 adopted visual analogue scales to measure consumer satisfaction with the wait list time and with the vestibular service as valid and reliable measures (de Boer et al., 2004). The Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire (Reilly et al., 1993) was added to assess absenteeism and presenteeism for working people with dizziness. Clinical costings were collected from the public health service to contribute with utility from the AQOL8D questionnaire to a cost consequences analysis of the service.

# 5.6 Conclusions

From demographic, service and clinical perspectives, Study 2 demonstrated sufficient *a priori* evidence of clinical safety and effect for the study into the physiotherapy-led vestibular rehabilitation model of care to be considered feasible. Refinement of specific study measures for a larger study was required in order to fully address the concept of high value care. These changes included the addition of a measure of consumer engagement, a change in the quality-of-life questionnaire, the addition of public health service-generated clinical costs, an improved measure of dynamic balance, and the addition of a measure of burden of disease. Note, the methodology of the subsequent Study 4 remained otherwise the same.

# 5.7 Following Chapters

Analysis of the Study 2 pilot outcome measures showed clear improvements using the sample size of the whole cohort. Small diagnostic category case numbers resulting from the division of the whole cohort into six common diagnoses, limited the production of valid, statistically supported conclusions on the basis of diagnosis. This pilot study limitation provided justification for a larger study (Study 4), aiming to increase the confidence in analysis of clinical effectiveness down to diagnostic level. A reliability study (Study 3) was considered necessary to demonstrate that a vestibular physiotherapist and a vestibular audiologist can similarly diagnose and refer on ENT wait listed people with dizziness for vestibular rehabilitation services. Since the studied model of care represented a physiotherapy-led model, in contrast to previous published models which were either medical consultant-led (Lee et al., 2011) or audiology-led (Leong et al., 2008), an interrater reliability trial between an audiologist and physiotherapist investigated the initial assessment process. Study 3 was therefore located in a health system where it was more usual for audiologists to screen category two and three wait lists. A key output of this reliability trial was the determination of level of agreement in diagnoses and referrals for rehabilitation. In addition, should reliability be indicated, and Study 3 demographics be statistically similar to those of Study 4, another output was the determination that the data of assessed people with dizziness could then be combined with the cohorts from Studies 2 and 4 for the main analysis. Furthermore, establishing interrater reliability would contribute to establishing the veracity of the model of care's diagnoses and therefore subsequent physiotherapy management; a key step in demonstrating the clinical effectiveness of the model.

Thus, Studies 1, 2 and 3 were considered necessary preparation for the project's larger study, Study 4. Analysis of the combined clinical results from Studies 2, 3 and 4 aimed to demonstrate service and clinical effectiveness down to the level of common diagnoses, as well as showing the model of care's cost effectiveness, its effect on patient burden of dizziness and describing levels of consumer engagement outcomes. These studies allowed the combined outcomes to be thoroughly investigated and to determine the support for the model's claim to being one of high value care option for people with dizziness.

The next chapter continues the preparation for the project's main analysis with a reliability study between a vestibular audiologist and a vestibular physiotherapist in their conduct of initial assessments for people with dizziness and their subsequent referral patterns.

# Chapter 6 Interrater reliability trial Study 3

Chapter six reports Study 3, an interrater reliability trial considering the initial assessment and referral for vestibular rehabilitation of people with dizziness from ENT category two and three wait lists as conducted by a vestibular audiologist and a vestibular physiotherapist.

# 6.1 Abstract

This study reports the interrater reliability between a vestibular audiologist and vestibular physiotherapist in the initial assessment of 22 people with dizziness screened from ENT wait lists in an Australian public hospital. Using a standardised assessment process, the two practitioners demonstrated perfect agreement in benign paroxysmal positional vertigo diagnosis (Kappa 1.0 and percent agreement 100%), and substantial agreement for other common diagnoses of vestibular dysfunction using the Kappa and percentage agreement statistics (cervicogenic dizziness- Kappa 0.65 (95% CI 0.3, 0.99) and percent agreement 86.4%, vestibular migraine- Kappa 0.78 (95% CI 0.36, 1.0) and percent agreement 95.5%. and unilateral vestibular hypofunction – Kappa 0.54 (95% CI 0.18, 0.89) and percent agreement 77.3%. Comparing the referral of people with dizziness on to vestibular rehabilitation, these practitioners also showed almost perfect agreement with a Kappa statistic of 0.89 (95% CI 0.68, 1.0) with low prevalence (0.41) and bias (0.05) indices, plus a high percentage agreement of 95.5%. These results informed the comparison of the physiotherapy-led vestibular rehabilitation model of care with audiology-led models of care in the management of people with dizziness. They also represent a concurrent check of the diagnostic accuracy as needed for correct management of people with dizziness by the physiotherapy-led service.

# 6.2 Introduction

Previously published international vestibular rehabilitation services were either consultant-led (Heaton et al., 1999; Leong et al., 2008) or audiology-led services (within an ENT department) (Leong et al., 2008), whilst local Queensland health

services employed audiologists to screen category two and three wait lists for suitable patients. As such, the physiotherapy-led model was an innovation needing to demonstrate comparable outcomes in initial assessment findings and referral patterns with other studies and needing to establish its clinical effectiveness; a part of which included establishing the veracity of its diagnoses. The reliability study aimed to demonstrate interrater reliability in the initial assessment diagnoses and the referral for vestibular rehabilitation between a vestibular audiologist and a vestibular physiotherapist. The research question posed was:

• What is the interrater reliability between a vestibular physiotherapist or vestibular audiologist diagnosing vestibular dysfunction and referring on people with dizziness from ENT wait lists for vestibular rehabilitation?

It was hypothesised that experienced physiotherapists and audiologists, trained in the initial assessment of people with dizziness wait listed for an ENT outpatient clinic, make similar diagnoses and refer the same cohort of people with dizziness for vestibular rehabilitation.

# 6.3 Methods

Consent for prospective use of the data was obtained from the Royal Brisbane and Women's Hospital Human Research Ethics Committee (HREC/15/QRBW/142) and Australian Catholic University (2013 293Q) (see Appendix 2).

# 6.3.1 Study design

A prospective observational study was conducted using standardised initial assessments of people with dizziness screened from ENT category two and three wait lists to investigate interrater reliability between two allied health initial assessors of people with dizziness referred to a public healthcare hospital with an ENT specialist outpatient service. The protocol incorporated randomised initial assessments by either an audiologist and a physiotherapist with the other clinician observing and recording nominal testing results.

# 6.3.2 Setting and participants

Study 3 took place at the Logan Hospital, a tertiary referral public hospital in southeastern Queensland. Participants were screened from the ENT category two and three wait lists for signs, symptoms, or diagnoses of vestibular dysfunction by the trial audiologist. The Logan ENT department provides inpatient and outpatient ENT care for people from a large public hospital and health service district in southern Queensland.

People with dizziness on category two and three ENT wait lists between November 2015 and May 2016 were screened for suitability for inclusion by the audiologist, working in the ENT/audiology department. Category two referrals are meant to be seen by an ENT consultant within 90 days of receipt of referral and category three within 365 days. Referrals were screened for signs, symptoms, or diagnoses of vestibular dysfunction. For people requiring vestibular rehabilitation, a referral was made to a physiotherapy-led vestibular rehabilitation service.

# 6.3.3 Procedures: Participant inclusion criteria

Inclusion criteria included a category two or three referral to ENT noting:

- Signs of vestibular dysfunction
- Symptoms of vestibular dysfunction
- Diagnosis of vestibular dysfunction
- Person aged 17 years or older

Exclusion criteria included those people who once contacted, refused to be assessed by physiotherapy, people younger than 17 years of age, those people incapable of giving informed consent, or those people not from the ENT wait lists.

# 6.3.4 Procedures: Participant screening, recruitment, and administration

All referred people meeting the screening criteria were offered an initial assessment and treatment when required. The study audiologist mailed out a participant consent and information form with an appointment notification letter to all prospective participants for completion before attending their initial assessment appointment. After having the study described to them verbally at their initial assessment, participants signed the consent form. Referral options for treatment after the assessment included physiotherapy-led vestibular rehabilitation offered by a nearby hospital, outpatient psychology, returned to their general practitioner, or returned to the ENT wait list.

# 6.3.5 Initial assessment

The interview and examination followed a vestibular assessment form (Royal Brisbane and Women's Hospital Physiotherapy Department, 2013) (see Appendix 4) created for use in the research programme. Interview points included questions on the history of the condition, dizziness triggers, general health, hearing red flags, medication, and headaches. The examination included the following physical performance measures:

- pure tone audiogram
- cervical active range of motion as a measure of cervical motion and for testing of vertebrobasilar insufficiency,
- oculomotor testing to test for central dysfunction,
- VOR assessments to assess the peripheral vestibular system,
- head position testing assessing for benign paroxysmal positional vertigo (BPPV)
- Neurological assessments including manual muscle strength tests, light touch sensation testing, reflex testing, and tone testing, only included if central dysfunction was suspected from the interview or preceding physical assessment.

Using a computer random number generator, assessments were randomised between the physiotherapist or audiologist. The non-assessing clinician observed the assessment by the randomised clinician, recording answers to questions and examination findings blindly on a separate vestibular assessment form. The testing protocol was positively reviewed with respect to the 11-item, Quality Appraisal of
Reliability Study (QAREL) criteria (Lucas et al., 2010) (see Table 4.1 in Methodology Chapter 4).

#### 6.3.6 Diagnosis and referral

On completion of each assessment, clinical interpretations from the interview, examination, and diagnosis, plus decisions about the referral destination were recorded blindly on a data collection form (Appendix 5). This form recorded responses in a nominal fashion, for example as either present or absent, left or right, or yes or no. Four interview outcomes included likely diagnoses of vestibular dysfunction, cervicogenic dizziness, visual vertigo, and vestibular migraine while 19 physical examination points needed to reach a diagnosis included whether the audiogram indicated further assessment by audiology was required, presence of cervical dysfunction, and details of the oculomotor, vestibular ocular reflex and BPPV testing. Finally, six diagnostic categories comprised BPPV, vestibular hypofunction, vestibular migraine, cervicogenic dizziness, other vestibular dysfunction, and central dysfunction, followed by six referral options including vestibular rehabilitation, audiology, psychology, ENT, neurology, and general practitioner.

#### 6.3.7 Analysis

Two statistics were calculated: both using SPSS® version 27 statistical software. Assessor percentage agreement was first calculated using descriptive frequency statistics. Since this statistic does not take into account chance agreement (McHugh, 2012), the Kappa statistic was used to determine reliability between two assessors using nominal data and calculating the proportion of agreement over and above chance (McHugh, 2012; Sim & Wright, 2005), or above that generated by guessing; which in healthcare trials is an important concept (McHugh, 2012). Interpretation of Kappa coefficient values used the following ranges: 0.41 to 0.60 indicating moderate agreement, 0.61 to 0.8 substantial agreement and 0.81 to 1 almost perfect agreement (Sim & Wright, 2005).

Prevalence and bias are two factors that influence the magnitude of the Kappa statistic and should be used to explain Kappa interpretations (Sim & Wright, 2005).

These indices are calculated from a 2x2 contingency table of counts of agreements and disagreements between two assessors for a particular diagnosis where:

prevalence index = [a - d]/n and

bias index = [b-c]/n

(Sim & Wright, 2005).

Diagnosis A	Clinician 2 present	Clinician 2 absent	Total
Clinician 1 present	a	b	
Clinician 1 absent	С	d	
Total			n

A sample size of 41 was targeted using a significance level of p < 0.05 with the null hypothesis being the Kappa value < 0.40. This included a power level of 0.9, a Kappa value to detect of 0.9, and a 0.7 proportion of positive findings (Sim & Wright, 2005). Thus, if the Kappa value was found to be 0.9, it would have a confidence interval hypothesised to exclude at least a test value of Kappa of 0.4. The SPSS® version 27 statistical package was used for statistical analysis with significance set at p < 0.05.

#### 6.4 Results

The reliability study included 22 people with dizziness screened from ENT category two and three wait lists and assessed from November 2015 through to May 2016. Six males and 16 females had a mean age of 54.9 years (SD 19.44). Table 6.1 below reports the percentage agreement, Kappa statistic, and prevalence and bias

indices for assessment diagnoses and referrals, with the interview and assessment variables listed in Appendix 6.

variable	abnormalit detected	ies	percent agreement	Карра	95% Iower CI	95% upper Cl	prevalence index	bias index
diagnosis	assessor 1	assessor 2						
BPPV	4	4	100	1.00	1.00	1.00	0.64	0
UVH	12	13	77.3	0.54	0.18	0.89	0.14	0.05
VM	3	2	95.5	0.78	0.36	1.00	0.77	0.05
CD	7	4	86.4	0.65	0.30	0.99	0.50	0.14
Other	1	2	95.5	0.65	0.01	1.00	0.86	0.05
Central	1	2	95.5	0.65	0.01	1.00	0.86	0.05
Psych	4	4	90.9	0.69	0.30	1.00	0.64	0
referral								
Audiology	5	2	86.4	0.51	0.06	0.96	0.68	0.14
Physiotherapy	16	15	95.5	0.89	0.68	1.00	0.41	0.05
ENT	4	5	86.4	0.58	0.16	1.00	0.59	0.05
GP	2	4	90.9	0.62	0.16	1.00	0.73	0.09

Table 6.1 Interrater reliability trial assessment

BPPV benign paroxysmal positional vertigo, Central central dysfunction, CD cervicogenic dizziness, ENT referral to ENT, GP referral to GP Other other vestibular dysfunction, Psych psychological dysfunction, UVH unilateral vestibular hypofunction, VM vestibular migraine, note no referrals to neurology or to psychology were made so not included in table

#### 6.5 Discussion

The reliability trial demonstrated good interrater reliability between two trained allied health practitioners for most components of the initial assessment, the examination, interpretation/diagnoses, and the referral to physiotherapy of people with dizziness coming from category two and three ENT wait lists. The percent agreement and Kappa statistics indicated substantial to almost perfect agreement for most components of the interview and examination (see Appendix 6).

Interpreting the outcomes of the trial, the diagnoses and the referrals listed in Table 6.1 below, a number of factors need to be considered to be able to make an informed statement about interrater reliability.

First are the magnitudes of the percent agreement and Kappa statistics. Percent agreement was uniformly high, except for the diagnosis of unilateral vestibular hypofunction, and was higher in all categories than the compared Kappa statistic. Kappa scores for the diagnoses scored through the range from moderate agreement (unilateral vestibular hypofunction) to perfect (benign paroxysmal positional vertigo), but most diagnoses scored in the substantial agreement band (0.61 to 0.8 Kappa). Practically, although the diagnoses achieved a substantial level of agreement, the referral to physiotherapy compensated for this by being almost perfect agreement.

Secondly, the 95% confidence interval for the Kappa statistic indicates whether the planned null hypothesis of Kappa < 0.4 can be rejected. Only the variables of benign paroxysmal positional vertigo (BPPV) diagnosis and referral for physiotherapy achieved a 95% confidence interval, excluding a Kappa test score of 0.4 and rejecting the null hypothesis of Kappa < 0.4. All others included a Kappa of 0.4 but excluded zero. SPSS conducts tests of significance for Kappa using a one-tailed null hypothesis of Kappa < 0, which for this trial, was rejected for all variables. The weakness in the Kappa results arises from the wide confidence intervals for Kappa, many of which extend to almost zero, reducing the power of findings considerably. Clinical reliability trials need to exclude a high Kappa test score, such as 0.7, to generate confidence in the statistics, and this trial with its reduced case numbers and high standard errors did not achieve this.

Third is the level of prevalence (Sim & Wright, 2005), or the proportion of the sample with a specific characteristic: for example, the diagnosis BPPV is known to have a prevalence in cohorts of people with dizziness in ENT outpatient settings of about 30% and this frequency may influence the Kappa calculation. Table 6.1 lists the prevalence index calculated for each variable between the two assessors using 2x2 contingency tables. A high prevalence reduces the Kappa value as it represents an increased risk of chance agreement (Sim & Wright, 2005). Inspection of the data indicates for BPPV, its prevalence index was moderate, but it had little effect on the Kappa statistic since there was perfect agreement. On the other hand, the prevalence index of unilateral vestibular hypofunction was low, indicating the

accuracy of the moderate level of agreement shown by the Kappa statistic in the diagnosis of unilateral vestibular hypofunction. Considering the referral to physiotherapy, the prevalence index was low to moderate in level, suggesting the almost perfect agreement indicated by the Kappa statistic was accurate. The other referrals show higher prevalence, contributing to lower Kappa levels of agreement.

The last factor to consider is the bias or the rate at which the raters disagree on the proportion of positive cases for a particular variable being rated (Sim & Wright, 2005). Using a two assessor 2 x 2 contingency table for each variable, the bias index results are listed in Table 6.1. Considering these results, the bias is notable for being low in all variables, indicating a low level of disagreement for positive cases when they are seen.

Thus, the trial showed high reliability between the two assessors in the diagnosis of BPPV and the referral to physiotherapy. Despite the Kappa differences, percentage agreement was greater than 85% for all diagnoses, except unilateral vestibular hypofunction, and for all referrals.

This reliability trial was between two allied health practitioners trained in and practicing the assessment of people with dizziness. Factors explaining the differences between the two practitioners' interpretations of data in the trial might include training, experience, current practice, and the professional's view of their actions in the traditional medical hierarchy or their sense of independence. As an example, the experience both in the assessment and interpretation of signs and symptoms elicited from cervical spine assessment was widely different, seen in the low Kappa and relatively low percent agreement for the cervicogenic dizziness interpretation of the differences between the two professionals needs to consider the normal working practices. As such, there was a tendency for the audiologist to refer to ENT, while the physiotherapist, used to treating people with dizziness independently, referred less to ENT but more to audiology.

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The design of the trial can be criticised on a number of fronts. Firstly, two independent assessments of the same person with dizziness were not undertaken due to perceived unacceptable patient burden. Thus, one randomised therapist observed the interview and examination by the other which could have led to biased interpretation of results. Further, the two therapists if assessing independently, may not have conducted the assessment in a similar manner to the other therapist, leading to differing results. Drawing conclusions about the interrater reliability therefore requires careful analysis of the results. Study 3 has sought to reduce statistical uncertainty with the use of two primary statistics, Kappa and percentage agreement, and two secondary means of analysing the Kappa statistic, the prevalence and bias indices.

Secondly, drawing firm conclusions about the interrater reliability of other trained audiologists and physiotherapists is difficult from the small amount of data collected and the resultant size of the Kappa 95% confidence intervals.

Thirdly, this involved a trial between two clinicians educated and practising in Queensland. Their training and experience levels may be quite different to a similar pairing from elsewhere in Queensland, in another state in Australia or another country, so extrapolation of the study results should be done cautiously. Note that, audiologists and physiotherapists screen ENT wait lists for people with dizziness both locally and in internationally reported models and have been trained to conduct assessments and treatments under supervised ENT outpatient settings (Burrows et al., 2017; Kasbekar et al., 2014; Lee et al., 2011; Leong et al., 2008).

Establishing interrater reliability for the referral to vestibular rehabilitation in Study 3 indicates comparability of referred people with dizziness for this study at least, and most likely with multidisciplinary studies such as those cited above. Although the rest of the diagnoses were not agreed upon as highly as BPPV, this reduced agreement was compensated for by the agreement in referral for vestibular rehabilitation. As a result, it was deemed valid to include the data of the Study 3 participants in the overall analysis. Overall, diagnostic agreement was high and ultimately, the results validated the diagnostic process followed by the assessing clinicians in Study 4.

Correct diagnoses ensure correct treatment and referrals are subsequently applied, an important element in the demonstration of the model's clinical effectiveness.

# 6.6 Conclusions

Comparison of diagnoses and referrals showed high agreement indicating interrater reliability for most areas of an initial assessment between a vestibular audiologist and vestibular physiotherapist. Concurrent agreement in diagnoses indicated correct treatment was likely to be applied in subsequent vestibular rehabilitation. Importantly, in the referral of people with dizziness by the audiologist and the physiotherapist to vestibular rehabilitation, the high percent agreement and the almost perfect agreement in Kappa statistic without notable prevalence or bias effects demonstrated interrater reliability between the two professionals. With the perfect agreement in the diagnosis of BPPV aside, the substantial level of agreement in the interpretation of assessment results was tempered by large confidence intervals due to reduced subject numbers. This was acceptable given the high likelihood of the people with dizziness being appropriately referred for vestibular rehabilitation.

With interrater reliability established between the study's audiologist and physiotherapist, comparison with other multidisciplinary clinics employing both audiologists and/or physiotherapists was supported. This reliability also enabled data from people with dizziness referred by the audiologist in Study 3 to vestibular physiotherapy to be included with the data of Studies 2 and 4 for combined analysis. Finally, the agreement in diagnoses between two health professionals validated the diagnostic process undertaken for participants of Study 4; contributing to the measure of the model's clinical effectiveness. The following chapters present the main study - Study 4. The results are presented as: patient profiles and service and clinical outcomes in Chapter 7, followed by burden of dizziness to working people with dizziness and cost consequences for the health system in Chapter 8.

# Chapter 7 Study 4: Physiotherapy-led vestibular rehabilitation service- patient profiles, service, and clinical outcomes

This chapter presents the patient profiles, and service and clinical outcomes for the main study, Study 4. The following chapter presents the burden of dizziness for working people with dizziness from Study 4 and conducts a cost consequences analysis of the service.

# 7.1 Abstract

Study 4 investigated a cohort of 301 people with dizziness for service, clinical and cost effectiveness. This cohort included all participants recruited in Studies 2, 3 and 4 and comprised 191 females (63%) with an average age of 55.5 years (SD 17.23); females (53.5 years (SD 17.47) being significantly younger than males by 5.4 years (95% CI 1.4, 9.3) (p= 0.008). The diagnostic profile included the primary diagnoses of benign paroxysmal positional vertigo (BPPV) 20%, unilateral vestibular hypofunction 36%, vestibular migraine 15% and cervicogenic dizziness 8%. Service effectiveness was demonstrated through service outcome analysis which showed wait times significantly reduced from 2013 of 390.2 days (SD 243.5) to 2017 of 93.0 days (SD 219.4) (p= 0.004), and occasions of service and duration of treatment both being skewed positively towards a mode of one occasion of service and one day's duration of treatment. Further service analysis through consumer engagement demonstrated high levels of satisfaction for both wait time (visual analogue scale median 9.3/10 cm) and service quality (visual analogue scale median 10/10 cm). Clinical effectiveness was shown through significant improvements in patientreported measures of dizziness or vertigo and objective measures of dysfunction. The Dizziness Handicap Inventory improved significantly both from a whole cohort perspective (from 38.1/100 to 24.6/100, p < 0.001) and for individual common diagnoses. The Activities-specific Balance Confidence scale improved significantly with a whole cohort improvement from an abnormal 73.2 (SD 21.89) to a normal 81.0 (18.94), p < 0.001). Paired analysis of the Assessment of Quality of Life 8 Dimensions health utility indicated that the quality of life in people with dizziness

improved significantly by a utility value of 0.063 (95% CI 0.037, 0.088) (p < 0.001) from a combined cohort, initial assessment paired mean utility of 0.63. Objectively, BPPV head position testing and unilateral Dynamic Visual Acuity (DVA) testing both improved significantly towards complete resolution of these common disorders. Of the paired 50 people with BPPV, 48 resolved (Wilcoxon Signed Ranks Test p < 0.001). Of the 54 people who completed paired DVA scores and who had an uncompensated unilateral vestibular hypofunction with abnormal grade three DVA scores on initial assessment, 47 were discharged with normalised DVA scores (Wilcoxon Signed Ranks Test p < 0.001).

# 7.2 Introduction

The pilot study found *a priori* indication of service and clinical benefits, providing support for a larger case series for further investigation of service and clinical effectiveness plus cost effectiveness. In order to support the physiotherapy-led vestibular rehabilitation model of care as one of high value care, the programme of research needed to investigate the improvement in the health of the population of people with dizziness, to assess whether the provision of a service is acceptable to people with dizziness, and to assess the costs incurred by the model of care. This chapter examines service and clinical effectiveness, safety, and consumer engagement outcomes. The service and clinical effectiveness and the consumer engagement research questions for Study 4 were:

 What effects does the physiotherapy-led vestibular rehabilitation model of care have on service outcomes?

It was hypothesised that the vestibular rehabilitation model of care would reduce wait times, treat people with dizziness efficiently, and be safe.

 Does the physiotherapy-led vestibular rehabilitation model of care provide a satisfactory service for people with dizziness?

It was hypothesised that people with dizziness would be satisfied with the physiotherapy-led vestibular rehabilitation service.

 What is the clinical effectiveness of the physiotherapy-led vestibular rehabilitation model of care, described down to the level of common diagnoses?

It was hypothesised that the model was effective for improving clinical outcomes for the common diagnoses experienced by people with dizziness attending the physiotherapy-led vestibular rehabilitation service.

# 7.3 Methods

The pilot study analysis found indications of service and clinical effectiveness from a whole cohort perspective. In order to delve deeper into this cohort so as to provide an analysis by common diagnosis, a larger case series was required. Ethical approval permitted the retrospective consent for the data collected in Study 1 to be used in combination with Study 4 data - Royal Brisbane and Women's Hospital Human Research (RBWH) Ethics Committee (HREC/15/QRBW/141) and Australian Catholic University (2013 293Q). In addition, ethical approval was gained to combine data from those people with dizziness initially assessed by an audiologist from the service assessed for interrater reliability in Study 3, and then referred for vestibular physiotherapy- RBWH Human Research Ethics Committee (HREC/15/QRBW/142) and Australian Catholic University (2013 293Q) (see Appendices 1, 2, and 3).

# 7.3.1 Study Design

Study 4 continued with the prospective, observational, repeated measures design of the pilot study, collecting service, and clinical data, plus expanding to include clinical cost data (reported in the following chapter) for the now recurrently funded physiotherapy-led vestibular rehabilitation service. Design of the study analysis comprised combining the data from Studies 2, 3, and 4.

# 7.3.2 Setting and Participants

Study 4 was undertaken at the Royal Brisbane and Women's Hospital; a large urban quaternary-referral, public hospital, located in south-eastern Queensland. A large

ENT department in the hospital provides both inpatients and outpatients care for the population from the central region of the state. Commencing in the second half of 2013 upon receipt of ethical approval from the RBWH Human Research Ethics Committee, the RBWH ENT category two and three wait lists continued to be screened for people with dizziness by the doctoral candidate. Screening went through all retrospective referral lists for ENT category two and three referrals, and since the referrals were stored by month and year of referral, this screening covered all held years of referrals. By early 2015, screening had covered all retrospective wait lists, with prospective referrals being triaged thereafter by ENT registrars and a vestibular audiologist. Concomitantly, a vestibular physiotherapy pathway had been created for the ENT department to be activated on receipt of appropriate referrals by the triaging ENT registrar. This pathway facilitated the quick transfer of identified category two and three referrals of people with dizziness straight to a physiotherapy department wait list, where they were then categorised by the vestibular physiotherapist as either category one to be seen within 30 days or category two to be seen within 90 days.

#### 7.3.3 Procedures: Participant inclusion criteria

Inclusion and exclusion criteria for Study 4 were the same as the pilot study. Inclusion criteria comprised a category two or three ENT referral with:

- Symptoms of vestibular dysfunction or
- Signs of vestibular dysfunction or
- Diagnosis of vestibular dysfunction, and
- Persons aged 17 years or older

Exclusion criteria comprised those people refusing to be assessed by physiotherapy, those younger than 17 years of age, those people incapable of giving informed consent, or those people not from the ENT wait lists.

#### 7.3.4 Procedures: Participant screening, recruitment, and administration

All referred people with dizziness meeting the screening criteria were offered an initial assessment and treatment as required. People accepting an appointment for physiotherapy were either sent a participant information and consent form plus the initial assessment questionnaire battery by mail or, on arrival for the initial assessment appointment, were informed of the study and if consenting to participate, completed a battery of patient reported measures before initial assessment. Clinical and demographic information collected included date of birth, gender, the Dizziness Handicap Inventory, the Activity-specific Balance Confidence scale, the Assessment of Quality of Life 8 Dimensions, and the Screening for Hearing Problems questionnaires, plus a visual analogue scale to assess satisfaction with the wait. On discharge, participants were given the opportunity to complete a similar battery of patient reported measures; with the visual analogue scale assessing the satisfaction with the service and there being no Screening Test for Hearing Problems.

#### 7.3.5 Initial assessment

In keeping with the Study 2 protocol of initial assessment, a vestibular assessment form (Appendix 4) was used to record the results of an interview, and the results of the clinical examination comprising cervical spine active range of motion, oculomotor testing, vestibular ocular reflex testing including the results of video-oculography (video head impulse test), head position testing, static and dynamic balance testing, and neurological assessment results. A clinical reasoning space was made in the form for problem and differential diagnosis lists, followed by the diagnosis, and treatment plan.

#### 7.3.6 Management of identified dysfunction

For participants needing treatment, a treatment plan was outlined, and treatment commenced at the end of the initial assessment. Those needing a pure tone audiogram and / or vestibular investigations were referred internally to audiology. Referrals to other allied health professionals included clinical psychology and neuropsychology.

Identified central neurological dysfunction or other systematic disorders necessitated a referral back to their GP or a discussion with either a consultant neurotologist, or consultant ENT. When the need for an ENT review was identified, the person with dizziness was returned administratively to the ENT wait list, with an appropriate categorisation ensuring no loss of place in the wait list.

#### 7.3.7 Outcome measures

Data collected in the pre-assessment, initial assessment, treatment, and discharge phases of a participant's management included patient profile (demographics and diagnoses), service outcomes, repeated measures of patient-reported and clinical outcomes, participant satisfaction data, and clinical costs incurred for the person with dizziness. Patient profiles included demographics of gender with age to be explored by decade and diagnoses. Since people with dizziness are often diagnosed with more than one diagnosis, total diagnoses and the primary diagnosis were recorded. Benign paroxysmal positional vertigo, unilateral vestibular hypofunction, vestibular migraine and cervicogenic dizziness are the primary diagnoses reported in this thesis. Anxiety, a diagnosis only occurring in the total diagnosis category as a secondary diagnosis, is also reported. Service outcome data included wait times, occasions of service, duration of treatment and measures of safety. Analysis of wait included the time from the date of referral by the initiating medical practitioner to ENT to the date of initial assessment by physiotherapy, i.e., the whole wait and in Study 4, examined the change over the period from 2013 to 2017.

Participant-reported measures with established validity and reliability recorded included the Activities-specific Balance Confidence (ABC) scale (Powell & Myers, 1995), the Dizziness Handicap Inventory (Jacobson & Newman, 1990), the Screening Test for Hearing Problems (Demorest et al., 2011), the Assessment of Quality of Life 8 Dimensions (Hawthorne, 2009), and the Visual Analogue Scale (de Boer et al., 2004). The Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire was also included in the participant-reported repeated measure to assess patient-specific burden (Reilly et al., 1993) and is reported in the following chapter. People with dizziness offered an initial assessment

by the service completed patient-reported measures before attending for initial assessment and after discharge, to avoid potential bias given the doctoral candidate was often the treating physiotherapist.

Physical measures with established validity and reliability comprised the Dynamic Visual Acuity (Herdman et al., 2003; Rine & Braswell, 2003), results of head position testing (Bhattacharyya et al., 2017), the Functional Gait Assessment (Wrisley et al., 2004) and modified Clinical Test of Sensory Interaction in Balance (Cohen et al., 2014). Patient-reported falls were recorded in the interview to enable comparison with diagnoses and the ABC, Functional Gait Assessment and modified Clinical Test of Sensory Interaction in Balance instruments reporting falls risk. Safety information included complaints by participants, reports of adverse events from health care providers, evidence of misdiagnosis, and records of adverse events during treatment recorded on the hospital's Riskman® and Prime® health and safety incident databases.

Analysis by diagnosis allowed clinically meaningful description of demographics, service measures and change in repeated measures for later discussion.

#### 7.3.8 Analysis

Data was imported from a spreadsheet into SPSS® version 27 for statistical analysis. Initial analysis involved inspecting the distribution of the data before deciding on nonparametric or parametric analysis. Description of non-normal data used descriptive statistics and when paired, nonparametric Wilcoxon Signed Ranks testing. Description of normally distributed, repeated measures data employed descriptive and paired t testing of means. Analysis of variance (ANOVA) using Bonferroni-adjusted probabilities to counter type one errors was used when comparing greater than two categories.

To account for discharge questionnaire participant dropout, missing data analysis and multiple imputations using SPSS produced pooled imputed mean discharge data for paired t-testing with the initial assessment, total diagnosis cohort data. Total diagnosis data included all diagnoses made, in contrast to primary diagnosis data, as there was often more than one diagnosis per person with dizziness. Missing value analysis sought to identify non-random factors leading to missing data. Once these factors were identified, a multiple imputation model analysed Dizziness Handicap Inventory (DHI), ABC scale and Assessment of Quality of Life 8 Dimensions (AQOL8D) utility incorporating the variables of age, length of stay, wait, and pre- and post-treatment DHI, Activities-specific Balance Confidence scale, and AQOL8D scores. The SPSS ® multiple imputation algorithm used a linear regression method (IBM, 2020), automatically accounting for non-randomness of missing data when calculating the imputations.

## 7.4 Results: Patient profiles and service outcomes

The following results present combined data from Studies 2, 3 and 4.

#### 7.4.1 Patient profiles: Demographics

Patient profiles comprise the demographics and diagnostic proportions of study participants. Service outcomes of waits, occasions of service, duration of treatment, and wait and service satisfaction are then reported.

A total of 301 people with dizziness attended initial assessment between November 2012 and December 2017, following the screening of referrals for people with dizziness from the Royal Brisbane and Women's Hospital category two and three ENT wait lists (Study 1 n= 67 and Study 4 n = 204) and Logan Hospital (n = 30). Table 7.1 below details the age and gender breakdown of the three studies contributing to this total. Considered as a whole cohort, the ratio of female to male participants was significantly biased towards females (total 191:110, binomial test of test proportion 0.5, p < 0.001). All three clinical studies showed similar significant bias using binomial testing (Study 1 44:23, Study 3 22:8, and Study 4 125:79). Mean ages by study did not differ significantly, being for Study 2 55.2 years (SD 17.57), for Study 3 57.1 years (SD 18.28), and for Study 4 before combining with other studies-55.3 years (SD 17.03).

Study	f n	m n	total n	female mean age years (SD)	male mean age years (SD)	mean difference years (95% CI)	Mann Whitney U p
2	44	23	67	50.74 (17.57)	63.87 (15.61)	13.1 (21.6, 4.6)	0.003
3	22	8	30	57.7 (17.79)	55.44 (20.74)	2.3 (15.9, 20.4)	0.963
4	125	79	204	53.8 (17.54)	57.8 (15.99)	4.0 (8.7, 0.7)	0.146
Total Cohort	191	110	301	53.5 (17.47)	58.9 (16.32)	5.4 (9.3, 1.4)	0.01

Table 7.1Ages of participants by study

CI confidence interval, f female, m male, n cases, SD standard deviation

Combined studies mean age of participants was 55.5 years (SD 17.23). The age histogram by gender below in Figure 7.1 shows approximately symmetrical distribution with a reduction in attendance by the fifth decade group in both females and males. Age did not differ significantly over the period between 2013 (mean age 55.9 years (SD 17.69)) and 2017 (mean age 58.9 years (SD 14.27)) with a mean difference of 3.0 years (95% CI -9.4 to 3.4).



Figure 7.1 Histogram of age in decades by gender

#### 7.4.2 Non-Assessed Patient Demographic Analysis

Two hundred and twenty-four people did not attend an initial assessment: 112 females and 88 males. These people were significantly younger by 5.8 years (95% CI 3.8 to 7.9 years) than the mean age of those attending.

#### 7.4.3 Flow of patients

There were 104 people who attended for a single occasion of service, leading to a positively skewed duration of treatment (skewness = 3.4) towards a mode of one day and with a median of 41.0 days. The single OOS frequency also led to a large dropout of discharge questionnaires completed; as an example, the single occasions of service plus the drop out in the Dizziness Handicap Inventory of 58 questionnaires led to 162 non completed discharge Dizziness Handicap Inventory's.

#### 7.4.4 Patient profile: Diagnostic proportions

Table 7.2 below reports both primary and total diagnostic proportions for the doctoral programme of research. Primary diagnoses were those representing the main cause of a person's dizziness. Many people presented with a number of conditions contributing to the dizziness experience, so these were recorded as well and included in a total diagnosis format. The primary diagnostic proportions reported in descending order of size were benign paroxysmal positional vertigo, unilateral vestibular hypofunction, vestibular migraine and cervicogenic dizziness. Diagnoses of smaller proportions included bilateral vestibular hypofunction, Meniere's disease, and persistent positional perceptual dizziness.

Diagnosis	Primary n (%)	Total n (%)
BPPV	61 (20.3)	62 (15.9)
UVH	107 (35.5)	146 (48.5)
BVH	15 (5.0)	19 (6.3)
VM	45 (15.0)	67 (22.3)
Anxiety	0 (0)	98 (32.6)
CD	25 (8.3)	70 (23.3)
MD	8 (2.7)	12 (4.0)
PPPD	9 (2.7)	10 (3.3)
Minor	32 (10.6)	61 (20.3)

Table 7.2 Diagnostic proportions

BPPV benign paroxysmal positional vertigo, BVH benign vestibular hypofunction, CD cervicogenic dizziness, MD Meniere's disease, PPPD persistent positional perceptual dizziness UVH unilateral vestibular hypofunction, VM vestibular migraine Anxiety was not recorded as a primary diagnosis but occurred commonly as a secondary diagnosis, so is reported in the total diagnosis format. In Table 7.2, the category of minor diagnoses included the infrequent diagnoses of non-vestibular diagnoses, superior canal dehiscence, postural hypotension, mal de Debarquement syndrome, postural orthostatic tachycardia syndrome, glomus tumour, vestibular schwannoma, auto-immune Chiari malformation, sudden sensorineural hearing loss, vertebrobasilar insufficiency, cochlear implant, otolithic organ dysfunction, resolved benign paroxysmal positional vertigo, and compensated unilateral vestibular hypofunction. The minor diagnosis category occurred within both primary and total diagnoses and is not reported routinely unless relevant.

#### 7.4.5 Service outcomes: Wait list times

Measurement of the change in mean wait for people with dizziness over the duration of the doctoral programme of research forms a direct measurement of service effectiveness and this is shown in Table 7.3 below.

Year of assessment	n	Wait mean days (SD)	95% CI days
2012	6	371.2 (223.03)	(137.11, 605.23)
2013	65	390.2 (243.54)	(329.81, 450.5)
2014	54	434.6 (460.61)	(308.85, 560.3)
2015	63	181.4 (447.67)	(68.64, 294.12)
2016	47	247.7 (482.31)	(106.11, 389.34)
2017	36	93.0 (219.38)	(18.74, 167.2)
ANOVA F	р	post hoc year pairs	p (Bonferroni)
5.34	< 0.001	2013 / 2015	0.04
		2013 / 2017	0.004
		2014 / 2015	0.008
		2014 / 2017	0.001

Table 7.3	Study 2 and 4	Wait duration	analysis of	variance
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ANOVA analysis of variance, Bonferroni correction used in ANOVA, CI confidence interval, n cases, SD standard deviation

The mean waits shown are from the date of initial referral to ENT to the date of initial assessment by physiotherapy. These waits reduced significantly over the time of the doctoral programme of study from outside the 365-day criteria for category three waits to just inside the criteria for category two waits of 90 days. Waits on the physiotherapy wait list, once transferred over from ENT, were calculated for 2016 demonstrating a highly responsive mean of 20.1 days (SD 18.60) while for 2017 this was calculated to be a mean of 27.7 days (SD 29.10).

#### 7.4.6 Service outcomes: Occasions of service

Occasions of service (OOS) for participants dropping out from discharge questionnaire completion (n=137) were positively skewed (skewness of 11.1) with a mode of one. Occasions of service for paired data (n= 165) were more evenly distributed between one and four OOS. The distribution of OOS for the whole cohort was positively skewed (skewness= 2.0) by the large number of single occasions of service (n=104) with a median OOS of 2.0. Occasions of service remained constant over the duration of the programme of research from 2013 with a mean OOS of 2.7 (SD 2.24) to 2017 with a mean OOS of 2.9 (1.49) with a mean difference of 0.3 occasions (95% CI -1.0 to 0.5). Table 7.4 below reports occasions of service and duration of treatment by common total diagnoses.

Table 7.4	Occasions of	of service	and duration	of treatment b	v total	diagnoses
				•••••••••••••••••••••••••••••••••••••••	,	

diagnosis	n	median occasions	mode occasions	median duration days	mode duration days
BPPV	62	3	3	35	1
UVH	146	3	1	47.5	1
VM	45	2	1	41	1
CD	25	3	1	37.5	1
А	98	3	1	40	1

BPPV Benign Paroxysmal Positional Vertigo, CD Cervicogenic Dizziness, CI confidence interval, n cases, SD standard deviation, UVH Unilateral Vestibular Hypofunction, VM Vestibular Migraine

#### 7.4.7 Service outcomes: Duration of treatment

The median duration of treatment was 41.0 days, with a positively skewed distribution (skewness of 3.36) and mode of one day. Seventy-five participants had a duration of one day. Duration of treatment remained constant between the two years of 2013 (n= 65, mean 50.8 days (SD 94.82)) and 2017 (n=36, mean 51.7 days (SD 45.11)) with a non-significant mean difference of 0.9 days (95% CI -34.2 to 34.4 days) (p= 0.95).

7.4.8 Service outcomes: Visual analogue scale measure of wait and service satisfaction

Both visual analogue scale (VAS) scoring distributions for wait list satisfaction and service satisfaction were negatively skewed (skewness wait list = -1.4, skewness service = -3.0) towards a high satisfaction score of 10/10 with a median wait list VAS = 9.3 and a median vestibular service VAS = 10. Table 7.5 below reports the VAS scores by total diagnosis.

# Table 7.5Wait and Service satisfaction visual analogue scale results by total<br/>diagnosis

	Wait S	atisfaction		Servio	ce Satisfaction	on
Diagnosis	n	VAS median cm	mode cm	n	VAS median cm	mode cm
BPPV	29	8.4	10	25	10	10
UVH	70	9.2	10	69	9.9	10
VM	37	9.1	10	23	10	10
CD	26	9.3	10	33	10	10
Anxiety	56	8.6	10	39	9.8	10

BPPV Benign Paroxysmal Positional Vertigo, CD Cervicogenic Dizziness, n cases, SD standard deviation, UVH Unilateral Vestibular Hypofunction, VAS visual analogue scale, VM Vestibular Migraine

#### 7.4.9 Service outcomes: Safety and ENT referrals

The safety review drew from the hospital safety reporting databases Prime® and Riskman® for the duration of the programme of research between November 2012

and December 2017. In these systems, no adverse events were recorded for physiotherapy during vestibular rehabilitation nor reported by other health professionals, and no complaints were recorded from study participants. No reports of misdiagnoses were reported either in the safety databases or direct to the vestibular rehabilitation service.

Sixteen people with dizziness (5.3%) were referred back to ENT. These referrals included discussions with consultants about ongoing physiotherapy management, ENT taking over the management of people with non-responsive vestibular dysfunction, and ENT management of comorbid non-vestibular dysfunction identified either in the referral or by the physiotherapist.

## 7.4.10 Audiology Referrals

Forty-eight people (17.7%) with dizziness (of the 271 participants of Study 2 and 4 cohorts, not including the Study 3 cohort) were referred to the hospital audiology department for assessment; all receiving pure tone audiograms (PTA) plus other appropriate investigations as indicated by the diagnosis. Eighty-seven people (32.1%) had already attended private or public audiology for pure tone audiograms by the time of the physiotherapy initial assessment. Eight people with dizziness were referred for repeat pure tone audiograms after having had one with the hospital audiology service prior to initial physiotherapy assessment. All 30 people with dizziness participating in the interrater reliability trial had a pure tone audiogram as part of their initial assessment. Results of pure tone audiograms were discussed with audiologists to gain further insight into the participants' conditions and management.

# 7.5 Results: Self-report Questionnaires and Tests of Physical Performance

This section describes the combined results for Studies 2, 3, and 4 of the selfreported questionnaires (Dizziness Handicap Inventory and Activities-specific Balance Confidence scale) and the tests of physical performance undertaken (Functional Gait Assessment, Dynamic Visual Acuity, Head position test and modified Clinical Test of Sensory Interaction in Balance).

#### 7.5.1 Dizziness Handicap Inventory

Participants completed the Dizziness Handicap Inventory (DHI) before the initial assessment and on discharge. Out of 301 participants, 286 people completed the DHI (15 missing) on initial assessment. On discharge, 134 people completed a DHI (53.8% of those initially assessed); a reduction in discharge questionnaire completion due to a combination of single occasion of service participants (n=104) and participants dropping out (n= 58).

Table 7.6 below reports DHI change by total diagnosis. Treatment created a positively skewed distribution of discharge DHI scores (skewness = 0.95) towards clinically normal values of less than 21/100. Analysis of the paired DHI results for all participants combined (n= 134), showed the DHI improved significantly with treatment, reducing from a clinically abnormal 38.1/100 (SD 22.1) by a mean difference of 13.5/100 (95% CI -9.9 to -17.1) to below the clinical normal cut off of 26/100.

Analysis of the dropout cohort of 162 participants demonstrated three non-random factors: planned discharges after a single occasion of service accounting for 104 (64%) of the DHI discharge dropouts, dropout of people with dizziness attending treatment from the Study 3 cohort, and a younger age of the dropout cohort. The SPSS missing data analysis found the dropout cohort to be significantly younger than the total cohort with a mean age of dropout participants of 51.2 years (SD 17.24); younger by a mean of 4.3 years (95% CI from 2.3 to 6.2).

Table 7.6 also lists the data showing the change in DHI by diagnosis when using imputed DHI scores to account for the drop out in discharge data. Considered by the whole cohort, treatment significantly reduced imputed DHI scores by 13.6/100 (95% CI 10.5 to 16.7) from a clinically abnormal initial assessment mean of 41.2/100 (SE 1.41). Neither paired nor imputed DHI scores differed significantly by gender or age decade, at initial assessment or on discharge.

Table 7.6Change in Dizziness Handicap Inventory by total diagnoses – Pairedpre assessment vs. post treatment Dizziness Handicap Inventory, and Total cohortpre assessment vs. Imputed post treatment Dizziness Handicap Inventory

diagnosis	n	DHI Paired pre (SD)	DHI Paired D/C (SD)	mean difference (95% CI)	р
BPPV	29	43.2 (22.22)	25.7 (24.26)	17.5 (11.6, 23.5)	< 0.001
UVH	68	37.4 (20.91)	22.9 (18.80)	14.5 (9.3,19.7)	< 0.001
VM	24	33.7 (20.87)	25.5 (22.30)	8.17 (-0.15, 16.5)	0.054
CD	31	41.3 (22.70)	29.3 (27.71)	12.0 (3.2, 20.8)	0.009
Anxiety	46	40.2 (22.29)	26.2 (24.86)	14.0 (7.2, 20.9)	< 0.001
diagnosis	n	DHI Imputed pre (SE)	DHI Imputed D/C (SE)	mean difference (95% Cl)	р
BPPV	62	44.9 (3.13)	28.8 (3.19)	16.1 (10.4, 21.8)	< 0.001
UVH	146	40.2 (1.98)	26.6 (2.18)	13.6 (8.6, 18.7)	< 0.001
VM	67	45.1 (2.91)	29.2 (2.56)	16.0 (10.2, 21.7)	< 0.001
CD	70	44.5 (2.84)	30.1 (3.14)	14.4 (7.18, 21.6)	< 0.001
Anxiety	98	46.4 (2.50)	29.7 (2.34)	16.8 (11.4, 22.1)	< 0.001

BPPV Benign Paroxysmal Positional Vertigo, CD Cervicogenic Dizziness, CI confidence interval, D/C discharge, DHI Dizziness Handicap Inventory, DHI Pre initial assessment DHI, DHI Post pooled mean of 5 imputed DHI discharge values, SD standard deviation, SE standard error of mean, UVH Unilateral Vestibular Hypofunction, VM Vestibular Migraine. Note SPSS only generates standard errors of the mean for pooled imputed analyses

#### 7.5.2 Activities-specific Balance Confidence Scale (ABC)

A total of 283 people completed pre-assessment Activities-specific Balance Confidence Scale questionnaires, the scores following a normal distribution with a mean score of 72.3/100 (SD 21.7) (18 missing). On discharge, 165 people completed the ABC with the distribution changing to a negatively skewed distribution (skewness = -1.31), trending towards scores of 100/100 with a mean score of 80.5/100 (SD 19.4). The dropout rate amounted to 136 cases (48.1%). Analysis of paired and of imputed ABC by total diagnosis is presented in Table 7.7 below. In the paired data analysis, the total cohort improved significantly by 7.8/100 (SD 17.3) (95% CI 5.1 to 10.6) and by diagnosis, benign paroxysmal positional vertigo, unilateral vestibular hypofunction, cervicogenic dizziness and anxiety all improved significantly with vestibular rehabilitation. Only unilateral vestibular hypofunction and cervicogenic dizziness exceeded the clinically normal cut off of 80/100. Vestibular migraine improved non-significantly but was above the clinically normal ABC cut off already at initial assessment. Total cohort imputed data improved significantly by 6.1/100 (SE1.26) (95% CI 3.6 to 8.7) with the imputed data for all diagnoses except vestibular migraine improving significantly with treatment. No imputed discharge ABC scores reached the normal cut off of 80/100. Neither the paired nor imputed ABC scores at initial assessment or discharge differed by gender or age groups.

Table 7.7Change in Activities-specific Balance Confidence Scale by totaldiagnoses- paired and imputed paired data pre- and post-treatment

diagnosis	n	ABC pre mean (SD)	ABC post mean (SD)	mean difference (95% CI)	р
BPPV	36	70.3 (22.58)	79.2 (18.23)	8.9 (3.0, 14.8)	0.004
UVH	85	73.6 (19.18)	80.7 (17.59)	7.1 (3.5, 10.8)	< 0.001
VM	27	80.4 (18.25)	85 (16.36)	4.6 (-1.3, 10.5)	0.123
CD	38	74.6 (19.78)	81.56 (17.75)	7.0 (1.5, 12.4)	0.014
Anxiety	48	69.7 (23.32)	78.5 (19.56)	8.9 (3.3, 14.5)	0.003
diagnosis	n	ABC imputed pre mean (SE)	ABC imputed post mean (SE)	mean difference (95% CI)	р
BPPV Imp	62	70.6 (2.67)	77.6 (2.82)	7.0 (1.0, 13.0)	0.025
UVH Imp	146	71.3 (1.75)	77.4 (1.74)	6.1 (2.8, 9.4)	< 0.001
VM Imp	67	73.8 (2.55)	79.0 (2.72)	5.2 (-0.3, 10.7)	0.064
CD Imp	70	72.2 (2.51)	77.6 (2.36)	5.4 (1.2, 9.6)	0.012
Anxiety Imp	98	68.4 (2.29)	76.4 (2.24)	8.0 (2.9,13.2)	0.004

ABC Activities-specific Balance Confidence scale, BPPV benign paroxysmal positional vertigo, CD cervicogenic dizziness, Imp pooled imputed pre assessment and post discharge ABC results, SD standard deviation, SE standard error of mean, UVH unilateral vestibular hypofunction, VM vestibular migraine, Note SPSS generates standard errors of the mean for pooled imputed analyses

#### 7.5.3 Physical performance tests

The following section reports the results of the physical performance tests including the Functional Gait Assessment and modified Clinical Test of Sensory Interaction in Balance versus the report of falls and those clinical tests specific to making a diagnosis and monitoring treatment effect including head position testing and dynamic visual acuity.

## a Functional Gait Assessment (FGA)

For Studies 3 and 4 combined, FGA means on initial assessment and on discharge for the reported diagnoses of BPPV, unilateral vestibular hypofunction, vestibular migraine, cervicogenic dizziness and anxiety, all scored normally above the clinical cut off of > 22/30 (see Table 7.8 below). Paired testing of the combined cohort completing the FGA on initial assessment and discharge (n=172) showed no difference between pre-treatment FGA (mean of 27.2/30 (SD 4.4)) and post-treatment FGA (mean of 27.4/30 (SD 5.8)). No dropout analysis was conducted for the FGA due to the lack of significant changes pre-assessment and post treatment and clinical normality. The initial assessment and discharge FGA did not differ significantly by gender, but the initial assessment

Table 7.8	Change in Functional Gait Assessment by total diagnoses - paired pre-
	and post-treatment

diagnosis	n	pre-assessment FGA mean (SD)	post treatment FGA mean (SD)	mean difference (95% CI)	р
BPPV	39	25.5 (5.07)	26.7 (5.56)	1.2 (0.7, 0.9)	0.209
UVH	74	26.5 (4.36)	27.5 (4.54)	1.1 (0.1, 2.2)	0.062
VM	40	28.3 (4.00)	27.1 (7.36)	-1.2 (1.0, -3.4)	0.268
CD	38	27.7 (3.90)	27.1 (7.28)	-0.7 (1.7, -3.1)	0.564
Anxiety	59	27.0 (4.44)	27.6 (5.18)	0.6 (-0.7, 1.8)	0.347

BPPV benign paroxysmal positional vertigo, CD cervicogenic dizziness, CI confidence interval, FGA functional gait assessment, SD standard deviation, UVH unilateral vestibular hypofunction, VM vestibular migraine

Functional Gait Assessment differed by age decade with the 80 years+ group scoring significantly lower than all other younger decades: Analysis of variance (ANOVA) Bonferroni corrected p< 0.001 with mean differences ranging progressively from - 5.2/30 (95% CI -1.5 to -8.8) compared with the seventh decade to 9.0/30 (95% CI - 4.5 to -13.5) with the second decade.

#### b Dynamic Visual Acuity

Dynamic visual acuity indicates the state of compensation in people with vestibular hypofunction and measures treatment effect in people with vestibular hypofunction and potentially with cervicogenic dizziness. Two hundred and ninety-three participants (97.3%) completed an initial assessment Dynamic Visual Acuity, with 125 scoring abnormal grade three results. Treatment reduced these grade three results down to 24 abnormal; a clinically and statistically significant result (Wilcoxon Signed-Ranks Test n= 293, Z= 10.05, p < 0.001).

c Modified Clinical Test of Sensory Interaction in Balance (mCTSIB) and report of falls

The mCTSIB was conducted with 260 participants while 298 participants answered the question about a history of falls. Chi Square analysis of these two categorical variables showed a significant relationship (Pearson Chi-Square = 5.86, p = 0.015) with 30 participants failing the mCTSIB and reporting a history of falls. The relative risk ratio of both failing the mCTSIB and reporting falls was 1.58 (95% CI 1.10 to 2.26). Nineteen of these 30 participants were diagnosed with bilateral vestibular hypofunction; in this cohort an uncommon diagnosis but a known factor for increased falls risk (Herdman, Blatt, Schubert, et al., 2000).

#### 7.5.4 Results by diagnosis.

In order to provide an indication of clinical effectiveness for common diagnoses experienced by people with dizziness attending the physiotherapy-led vestibular rehabilitation service, outcomes for the main reported diagnoses benign paroxysmal positional vertigo, unilateral vestibular hypofunction, vestibular migraine, cervicogenic dizziness and anxiety plus several associations between the disorders were investigated. Table 7.9 below outlines the age and occasions of service by primary diagnosis and total diagnoses categories. Further in-depth reporting for each diagnosis then follows.

Diagnosis	Primary mean age (SD)	OOS median (range)	Total mean age (SD)	OOS median (range)
BPPV	62.9 (13.67)	3 (1-17)	62.9 (13.56)	3 (1-17)
UVH	60.7 (16.73)	3 (1-11)	59.5 (16.59)	3 (1-17)
VM	38.9 (12.68)	2 (1-6)	42.3 (13.69)	2 (1-10)
CD	53.2 (12.67)	1 (1-7)	55.9 (15.08)	3 (1-14)
Anxiety	-	-	52.6 (16.89)	3 (1-17)

 Table 7.9
 Primary and Total Diagnosis age and Occasions of Service

BPPV benign paroxysmal positional vertigo, CD cervicogenic dizziness, FGA functional gait assessment, SD standard deviation, UVH unilateral vestibular hypofunction, VM vestibular migraine

#### a Benign Positional Paroxysmal Vertigo (BPPV)

In the doctoral programme of research, of the 62 people diagnosed with BPPV, one was bilateral, 31 left-sided and 30 right-sided. There were no differences by gender in mean age of people with BPPV. People with BPPV had a mean age of 62.9 years (SD 13.6) and were significantly older than those without BPPV by 9.4 years (95% CI 4.7 to 14.1). The distribution of occasions of service for people with BPPV was positively skewed (skewness= 2.1) with a median of 3.0 OOS. Eleven people with BPPV had a single occasion of service (17.7%), with eight of these not completing a discharge questionnaire.

Sixty-two people were diagnosed with primary BPPV; 61 had positive head position tests on initial assessment with one being detected on a subsequent review. Of the 50 paired results for people with BPPV, 48 had negative tests on discharge; an important clinical and statistically significant result (Wilcoxon Signed-Ranks Test n= 50, Z= -6.93, p < 0.001).

#### b Unilateral Vestibular Hypofunction

For the total diagnoses of unilateral vestibular hypofunction, 81 people had left unilateral vestibular hypofunction and 65 right (Binomial Test indicating no side bias n=144, p=0.211). Males with unilateral vestibular hypofunction were significantly older than females by 8.9 years (95% CI 3.5 to 14.3 years) with unilateral vestibular hypofunction (male age 67.7 years (SD 14.24), female age 58.8 years (SD 17.59)). People with unilateral vestibular hypofunction were significantly older than those without by 7.9 years (95% CI 4.1 to 11.7). The distribution of occasions of service for people with unilateral vestibular hypofunction was positively skewed (skewness= 2.1) with a median of 3.0 occasions of service.

The primary rehabilitation outcome measure for unilateral vestibular hypofunction, Dynamic Visual Acuity (DVA), determines the state of hypofunction compensation. Eighty-three people had abnormal, uncompensated Grade 3 DVA on initial assessment, with 29 people not recording a DVA on discharge. Of the 54 people completing a discharge DVA, 47 improved to normal grades. This was an important clinical and statistically significant result (Wilcoxon Signed-Ranks Test n= 83, Z= -6.18, p < 0.001).

c Vestibular Migraine

Primary diagnoses of vestibular migraine comprised 45 people including 37 females and eight males, while 67 had a diagnosis of vestibular migraine in the total diagnosis cohort including 54 females and 13 males. The mean age of people with vestibular migraines did not differ by gender for either the primary or total diagnosis cohort. People with a diagnosis of vestibular migraine were younger than those people without by 16.9 years (95% CI 13.0 to 20.8) and younger than the overall study mean age by 13.2 years (95% CI 9.8 to 16.5). The large proportion of planned single occasions of service in the total diagnosis vestibular migraine cohort at 27/67 (40%) contributed to the large number of discharge questionnaire dropouts (43/67 or 64%) for people with vestibular migraine. Vestibular migraine was strongly associated with the comorbidity of anxiety in this study (Chi-Square measure of association = 25.83, p < 0.001); the relative risk ratio for having anxiety with vestibular migraine in this study being 2.31 (95% CI 1.71, 3.12).

#### d Cervicogenic Dizziness

Twenty-five people were diagnosed with a primary diagnosis of cervicogenic dizziness (8.3 % of primary diagnoses), comprising 18 females and seven males. Seventy people were diagnosed with cervicogenic dizziness as part of their total

diagnosis (23.26 % of total diagnoses) with 49 females and 21 males. The mean age of people with cervicogenic dizziness did not differ from those people without cervicogenic dizziness.

As a potential outcome measure for the management of cervicogenic dizziness, dynamic visual acuity improved significantly in both the cervicogenic dizziness primary diagnosis cohort (Wilcoxon Signed Ranks Test Z = -2.828, p = 0.005) and its total diagnosis cohort (Wilcoxon Signed Ranks Test Z = -4.243, p < 0.001).

#### e Anxiety

Anxiety did not register as a primary diagnosis, but 98 people were recorded with a secondary diagnosis of anxiety in the total diagnosis cohort (32.6% proportion of total diagnoses); 67 females and 31 males. This prevalence was determined on the basis of reports included in referrals plus those made by participants. The relative risk ratio for females with dizziness having anxiety was 1.24 (95% CI 0.87 to 1.78) compared to males at 0.8 (95% CI 0.56 to 1.15). The mean age of 52.6 years (SD 16.9) for people with dizziness and anxiety did not differ by gender but was significantly younger than those who did not have anxiety by 4.2 years (95% CI 0.1, 8.3). Occasions of service for people with anxiety was not significantly different to that of the total cohort (Mann Whitney U Test Z= -1.901 p= 0.057), being dominated by the mode of a single OOS (24.5%). The relative risk ratio for people having anxiety and multiple occasions of service was 1.83 (95% CI 0.37 to 0.81).

Dizziness Handicap Inventory (DHI) pre-assessment scores using paired data for people with dizziness plus anxiety were significantly higher than those people with dizziness and no anxiety by 7.9/100 (95% CI 5.6 to 10.2). With treatment, people with dizziness and anxiety using paired DHI data reported a mean improvement of 14.0/100 (95% CI 7.1 to 20.9) down to 26.2/100 (SD 24.9). By discharge, people with dizziness plus anxiety did not differ significantly in their DHI scores to those with dizziness only; whether using paired or imputed data.

Activities-specific Balance Confidence scale scores did not differ significantly on initial assessment between people with and without anxiety. Those having dizziness and anxiety scored a mean Activities-specific Balance Confidence (ABC) scale score of 68.5/100; just above the increased falls risk clinical cut off of 67/100. By discharge, those with anxiety had improved up to a mean ABC score of 78.5; still below the clinically abnormal cut off of 80/100. In contrast people with dizziness improved up to a mean ABC score of 80.5/100; although not significantly different from that of people with dizziness and anxiety. The Functional Gait Assessment on initial assessment and on discharge for people with or without anxiety scored similarly and well above the normal cut off.

# 7.6 Discussion

Statistically similar demographics between Studies 2, 3, and 4, the reliability of diagnosis and referral for physiotherapy found in Study 3, and the same management processes used for people with dizziness between the three studies justified the inclusion of the Study 2 and 3 results in with that of Study 4 for pooled analysis. Demographics showed statistically similar mean ages and gender proportions between the three groups of study participants. Reliability in diagnosis and referral for physiotherapy was found to be similar based on the magnitude of percent agreement and Kappa statistic and confirmed with prevalence and bias indices analysis. This was despite lower than predicted sample size for Study 3 and wide confidence intervals for the resultant Kappa statistics. There were no differences in the initial assessment and treatment protocols between the three studies apart from outcome measures collected.

Three main areas of outcome are apparent from the analysis of Study 4 clinical and service results. Firstly, for the hypothesis that the physiotherapy-led vestibular rehabilitation service is one of high value care, Study 4 presents evidence of service effectiveness overall as well as down to the level of common diagnoses and continues to show safety for the model of care. Notable evidence of service effectiveness included:

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- the reduction in wait time between the years 2013 and 2017 by 297 days (80% reduction) for the two wait categories combined,
- an efficient two occasion of service median dominated by 104 (35%) participants having one occasion of service,
- a duration of treatment of one day for 25% of the participants,
- high participant satisfaction for the service with a median score of 10/10 cm using a visual analogue scale, and
- safety of the model demonstrated through no complaints, adverse events or misdiagnoses recorded by hospital safety registries for any of the three clinical studies.

Secondly, Study 4 shows notable evidence of clinical effectiveness as seen in the statistical improvement in patient-reported and physical measures including:

- the Dizziness Handicap Inventory for the whole cohort improving from a clinically abnormal mean of 38/100 to 24/100, below the cut off for normal scores
- the resolution of the common diagnosis of benign paroxysmal positional vertigo in 48 out of 50 paired participants,
- the improvement in the common diagnosis of unilateral vestibular hypofunction with the Dynamic Visual Acuity normalising in 76 of 83 cases
- and the improvement in cervicogenic dizziness with the Dynamic Visual Acuity normalising in 18 of 22 cases

In addition, as an important point of evidence for clinical effectiveness, the analysis of falls risk for the study's whole cohort of people with dizziness showed significant improvement within the sub-optimal level of the Activities-specific Balance Confidence (ABC) scale with treatment. At the time of initial assessment, the Study 4 cohort scored a mean of 72/100 on the ABC patient-reported measure, significantly below the clinically normal cut off of 80/100 (Myers et al., 1998)(mean difference 7.7/100 (95%CI 5.2, 10.3)), and significantly above the 67/100 increased falls risk cut-off (Lajoie & Gallagher, 2004) (mean difference 5.3/100 (5% CI 2.7, 7.8). In the

aged population the ABC was developed for (Myers et al., 1998), a score of 72/100 indicates reduced community participation. The same score in a younger population such as that of the Study 4 cohort underlines the loss of community function of Study 4 adults with sub-acute to chronic dizziness. With treatment and on discharge, participants reported the ABC at significantly improved levels to an imputed mean of 78/100 and just below the normal cut off of 80/100.

Another falls risk assessment, a cross-sectional assessment of falls association at initial assessment, compared dizziness-related falls history from the interview with the recording of falls responses to the physical measure of the modified Clinical Test of Sensory Interaction in Balance in the examination. This comparison showed 12% of participants both had a fall response to their modified Clinical Test of Sensory Interaction in Balance test and reported falls prior to initial assessment, a significant association (Pearson Chi-Square= 5.86, p= 0.015) with a risk ratio of 1.64. Thus, patient report at the time of initial assessment indicates concern with mobility on the basis of either reduced ability to do activities in the community or a history of falls. Treatment increased confidence expressed by the ABC to normal levels by discharge.

Claims of clinical effectiveness using repeated measures from an observation study with no controls cannot equal claims of causality from a study using repeated measures and controls. This needs to be considered when viewing the above results.

The third major outcome of Study 4 was the patient profile produced by the demographics and diagnostic proportions. Like many reports of case series of people with dizziness treated in specialty clinics (see Study 1 systematic review), the mean age of the participants approximated 55 years and there was a significantly greater proportion of women than men with a ratio of 63:37. Primary diagnostic proportions led with the common diagnoses of unilateral vestibular hypofunction (36%), and then benign paroxysmal positional vertigo (20%), vestibular migraine (15%), and cervicogenic dizziness (8%). Many people with dizziness had more than

one diagnosis with a notable secondary diagnosis, anxiety, occurring in 33% of participants.

Figure 7.2 below compares the diagnostic proportions of the physiotherapy reports in the Study 2 systematic review with those of the Study 4. The diagnostic proportions of Study 4 differed significantly with those of both the systematic review's ENT/Neurotology cohort (n= 17877, Chi-Squared Pearson statistic 474.7, p < 0.001) and physiotherapy cohort (n= 803, Chi-Squared Pearson statistic 101.2, p < 0.001). These differences are seen notably in the changes in the ratios of Meniere's disease to vestibular migraine and in the other diagnoses category to unilateral vestibular hypofunction. The change in these ratios is clinically meaningful, most likely reflecting changes in diagnostic practice over time with the adoption of refined diagnostic criteria plus the use of diagnostic technological advances such as videooculography to enable more complete assessments of the vestibular system.



# Figure 7.2 Mosaic plot of the systematic review physiotherapy cohort compared with the physiotherapy-led vestibular rehabilitation service cohort

BPPV benign paroxysmal positional vertigo, BVH bilateral vestibular hypofunction, CD cervicogenic dizziness, MD Meniere's Disease, Other diagnoses other than common vestibular, Physio physiotherapy diagnostic proportions from the systematic review, Psych psychological and psychiatric diagnoses, RBWH ENT Primary Dx RBWH Study 4 using ENT-derived participants, UVH unilateral vestibular hypofunction, VM vestibular migraine, Note the graph on the right is a combined mean of both groups

# 7.7 Conclusions and following chapter

Study 4 demonstrated a combination of service and clinical effectiveness, an improvement in falls risk, and the production of a meaningful diagnostic profile. These attributes of the physiotherapy-led vestibular rehabilitation service supported the hypothesis that the model of care is one of high value care.

The burden of dizziness in relation to quality of life and the cost consequences analysis of the model of care also needed to be considered and are discussed in the following chapter.

# Chapter 8 Study 4: Analyses of quality-of-life utility, burden of disease and cost consequences

Chapter 8 analyses the measures of quality-of-life utility and burden of disability in people with dizziness. These results contribute to a cost consequences analysis of the model of care.

## 8.1 Abstract

Using repeated measures of the Assessment of Quality of Life 8 Dimensions (AQOL8D) health-related quality-of-life questionnaire, Study 4 produced measures of utility to both investigate the burden of dizziness and undertake the cost consequences analysis. The burden of dizziness was further analysed through repeated measures of the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire. Analysis of AQOL8D utility scores, using imputations to account for discharge questionnaire dropout, produced a mean imputed baseline utility of 0.58 for the Study 4 cohort; representing at least a 30% reduction in reported quality of life compared with normal population means. Treatment generated a significant improvement in the mean utility for the whole cohort by 0.08 (95% CI 0.06, 0.10) (p < 0.001); a greater improvement than the 0.06 minimally important difference of the comparative Assessment of Quality of Life 4 Dimensions questionnaire, but still not an improvement to levels of the normal population.

Considering the burden of dizziness further, the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) measured both lost time from employment (absenteeism) and lost productivity while at work (presenteeism). In 2013, annualised lost wages per participant amounted to a potential AUD \$16380. By 2017, this loss had reduced to AUD \$4095 with intervention by the new physiotherapy-led model of care and subsequent reduced waits. Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) results indicated presenteeism scored at 30% lost productivity for workplaces annualised to 68 mandays per year per person with dizziness; the probable effect at the start of the
doctoral programme of research in 2012. Again, given the contribution to reduced waits by the physiotherapy-led model of care, this lost productivity potentially improved to 16 man-days by 2017.

Two options for the management of people with dizziness, a physiotherapy-led vestibular rehabilitation service and the traditional ENT medical model, were analysed for cost using decision tree analysis. This chapter presents the costings data in a cost consequences analysis table with the physiotherapy-led model clearly dominant by an AUD \$500/person with dizziness differential.

# 8.2 Introduction

People with dizziness are often referred by their primary health carers to ENT services for the management of suspected vestibular dysfunction (Heaton et al., 1999; Leong et al., 2008; Maarsingh et al., 2010; Nedzelski et al., 1986). In the Australian public setting, these services are usually located in major district hospitals. Standard medical treatment for the most common forms of vestibular dysfunction follows a course of initial assessment by an ENT consultant and then either treatment by ENT or referral on to a vestibular physiotherapist. No cost effectiveness analyses have been conducted into this practice.

The physiotherapy-led vestibular rehabilitation service model of care comprised a vestibular physiotherapist performing the primary contact, hospital practitioner role for people referred to ENT with dizziness. The referrals were sourced from the category two and three wait lists of a quaternary referral hospital ENT service; whereby category two represented a maximum 90 day wait and category three, a 365 day wait The majority of these people with dizziness were safely managed by physiotherapy through standard treatment protocols (Bhattacharyya et al., 2008; Herdman et al., 1995; Hillier & McDonnell, 2011; Hilton & Pinder, 2014), referred to other health professionals as required, and then discharged, without needing to see an ENT consultant (Kasbekar et al., 2014). On the basis of labour costs alone, this model represented a potential cost savings over the traditional ENT driven model of care, while achieving similar clinical outcomes for the treatment of dysfunction.

Investigations producing tangible measurements of the burden of dizziness on the person with dizziness and on the health system, permitted cost effectiveness investigations into the physiotherapy-led vestibular rehabilitation service; a key aspect of Study 4's investigations into high value care.

The research question for Study 4's analysis of burden of dizziness was:

 What is the burden of dizziness for people managed by the vestibular rehabilitation model of care?

It was hypothesised that the reduction in quality of life and the financial burden as a result of vestibular dysfunction was substantial for people with dizziness and comparable to that identified for people in other countries.

A cost effectiveness evaluation was needed to support the assertion that the physiotherapy-led vestibular rehabilitation service was an example of high value care. Normally a cost utility analysis would suit this need, but it was not possible to generate a cost effectiveness ratio for the comparison ENT service. Therefore, this study conducted a cost consequences analysis using decision tree modelling to compare the physiotherapy-led and ENT-led models of care costs. The research question posed by Study 4 for the cost effectiveness of the model of care was:

 What are the cost consequences of the physiotherapy-led vestibular rehabilitation model of care?

It was hypothesised that the physiotherapy-led vestibular rehabilitation service was cost effective when compared to traditional medically led services using a cost consequences analysis.

# 8.3 Methods

A cost effectiveness evaluation was needed to support the multi-facetted investigation into the physiotherapy-led vestibular rehabilitation service being an example of high value care. The study used a prospective, observational, repeated measures design, collecting information from a population of outpatients referred to the vestibular rehabilitation service.

## 8.3.1 Study design

Study 4 investigated the burden of dizziness using an observational, repeated measures design, with data derived from questionnaires administered before initial assessment and on discharge, and from clinical costings generated by the local health service.

# 8.3.2 Setting and Participants

The Study 4 population came from hospital and health service districts in southern Queensland, Australia and included people with dizziness referred to the ENT outpatients service of the Royal Brisbane and Women's Hospital (RBWH). This is a quaternary referral, capital city hospital in Queensland whose ENT department supports a number of health service districts in eastern and southern Queensland with both inpatient and outpatient services. The hospital's physiotherapy department also provides both inpatient and outpatient services, including a physiotherapy-led vestibular rehabilitation service accepting internal and external referrals from medical officers and audiologists for people with dizziness. Ethical approval was granted by the RBWH Human Research Ethics Committee and the Australian Catholic University (see Appendices 1, 2 and 3).

### 8.3.3 Procedures: Participant inclusion criteria

Participants in the Study 4 case series were managed by the physiotherapy-led vestibular rehabilitation service; their referrals being screened between November 2013 and December 2017 from the wait lists of the ENT department using the inclusion criteria of people over the age of 17 with signs, symptoms, or a diagnosis of vestibular dysfunction. Exclusion criteria comprised those people with dizziness who refused to be assessed by physiotherapy, those younger than 17 years of age, those people incapable of giving informed consent, or those people not from the ENT wait lists.

#### 8.3.4 Procedures: Participant screening, recruitment, and administration

Referrals of those people meeting the criteria were transferred across to the physiotherapy service and then offered an initial assessment by phone, followed by a mailed-out participant information and consent form included with their offer of appointment. Participants signed a consent form after reading the participant information form and having the project explained to them at the time of the initial assessment. Physiotherapy managed these people with dizziness with a full vestibular assessment (see Appendix 4 for the vestibular assessment form used), appropriate treatment following clinical guidelines, referral on to other health professionals as appropriate, and discharged with discharge letters going to both the hospital ENT Director and the referring medical officer.

#### 8.3.5 Outcome measures

Study 4 collected repeated measures of the Assessment of Quality of Life 8 Dimensions (AQOL8D) health-related quality of life questionnaire (Hawthorne & Osborne, 2005) and the Work Productivity and Activity Impairment: Specific Health Problem questionnaire (Reilly et al., 1993) to gain personal burden of dizziness data. The AQOL8D output included a utility measure of quality of life to indicate the burden of dizziness, with repeated questionnaires enabling a measure of treatment effect on quality-of-life utility. The Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) (WPAI:SHP(Dizziness))instrument described from the perspective of a person with dizziness, the disease burden resulting from dizziness using four outcomes: absenteeism, presenteeism, work productivity and activity impairment (Reilly et al., 1993). The foci in the analysis of the WPAI:SHP(Dizziness) data were to describe the cost burden to a person with dizziness in the form of lost wages (absenteeism) and the cost burden to the workplace of someone with dizziness (presenteeism). Combined with health department clinical costings, a cost consequences analysis then investigated the burden on the health system.

Costs in Australian dollars for each participant with dizziness were calculated and reported by the clinical costings department of the Queensland Health Metro North

hospital and health service district in February 2018. These costs included medical and non-medical costs collated into one figure. Costings considered those physiotherapy, audiology and ENT outpatient appointments occurring within a participant's admission and discharge dates, including labour costs for professional groups (medical, nursing, allied health) and associated staff, consumables and supplies, and overhead costs.

### 8.3.6 Analysis

The study prospectively collected service and clinical data on admission and on discharge. Data was entered into a secure database and analysed using SPSS® version 27. Both the AQOL8D and WPAI:SHP(Dizziness) questionnaires were collected as part of the participants' initial assessment and discharge, while the clinical costings used in the cost consequences analysis were calculated by the clinical costings department of the local hospital and health service on completion of data collection. Examination of AQOL8D data considered paired data down to the level of common diagnoses. Using SPSS, a missing data analysis was conducted followed by multiple imputations to account for dropout in discharge questionnaires. Change in utility was compared to the minimally important difference of the related AQOL8D (Hawthorne & Osborne, 2005).

### 8.3.7 Decision tree modelling

Decision tree modelling considered two models of care; that of the physiotherapy-led vestibular rehabilitation service model of care as described above and that of the traditional ENT driven model of care. These two models became the treatment options from the triage decision point for ENT referrals of people with dizziness. Details of each option follow:

 Option 1 Management by physiotherapy (option 1.1) with successful treatment to discharge. Unsuccessful treatment led either to discharge (option 1.2) or to a referral back for ENT review (option 1.3)  Option 2 Management initially with an ENT assessment (option 2.1) and then referral to Physiotherapy (option 2.2) or with treatment by ENT to discharge (option 2.3)

Figure 8.1 below illustrates the decision tree. The decision node at triage was conducted by a combination of experienced physiotherapy, ENT and audiology clinicians. Physiotherapy management when Option 1 was chosen, comprised an initial assessment, treatment, referral on, and discharge by the physiotherapist. If treatment was unsuccessful, either the person with dizziness was discharged with no further care (or self-discharged), or they were returned to the ENT wait list for subsequent ENT management. ENT management comprised initial assessment by ENT and then a decision of either Physiotherapy management with its successful or unsuccessful pathways as described above or continuing on to ENT treatment and discharge.

#### 8.4 Results: Assessment of Quality of Life 8 Dimensions utility

Mean costs and occasions of service are used in the decision tree (Figure 8.1). The depicted decision tree is that for combined diagnoses data and in it, the physiotherapy pathways used a mean occasions of service value of 3.0 (1 initial assessment + 2 reviews) and the ENT pathway an estimated occasions of service value of 3.0 (1 initial assessment + 2 reviews). Failure rate from Physiotherapy was modelled at 10% and ENT at 0%. Probabilities assigned at the Option 2 decision node of 0.9 to physiotherapy and 0.1 to ENT represent a conservative model in which as many referrals of people with dizziness are sent to physiotherapy as possible. This permits the basic intent of the model of care by allowing physiotherapy to assist ENT in the throughput of their wait lists through managing people with dizziness well within the physiotherapy service's scope of practice. The experience of the physiotherapy-led model of care was that ENT probability of seeing people with dizziness analysis presented in Table 8.3 below lists the decision tree costs by diagnosis for options 1 and 2 plus the mean utility gained.



Figure 8.1 Combined Data Vestibular Decision Tree

Ax assessment, DC discharge, ENT ear nose and throat OOS occasions of service, PT physiotherapy, Rx treatment, \$ Australian dollars

Table 8.1 below reports the mean AQOL8D utility values for paired data for 137 participants and after imputation analysis by SPSS, imputed paired data for 232 participants. The other ten quality of life components generated by the AQOL8D for the total cohort are listed in Appendix 7.

Assessment of Quality of Life 8 dimensions data comprised 227 initial assessment participants (five missing); 142 females and 85 males. The mean age of people with dizziness was 55.7 years (SD 17.1) and not significantly different to Study 4 cohort's mean age of 55.5 years (SD 17.23); with no significant age difference between females and males (mean difference 2.8 years (95% CI -7.4 to 1.7 years)). Considering the whole cohort, treatment generated a significant improvement in the mean utility by 0.08 (95% CI 0.06, 0.10) (p < 0.001). Using analysis of variance (ANOVA), the mean initial assessment values did not vary significantly over the

course of the study, and the mean discharge values behaved similarly. This indicates the utility gained by the people with dizziness was likely the same at the

Diagnosis Data	n	pre-treatment utility mean (SE)	post-treatment utility mean (SE)	mean change in utility (95% CI)	р
BPPV paired	31	0.63 (0.03)	0.73 (0.04)	0.10 (0.04, 0.15)	0.001
BPPV imputed	47	0.57 (0.02)	0.68 (0.02)	0.11 (0.06, 0.15)	< 0.001
UVH paired	69	0.66 (0.04)	0.73 (0.02)	0.07 (0.04, 0.10)	< 0.001
UVH imputed	105	0.61 (0.02)	0.69 (0.02)	0.08 (0.05, 0.11)	< 0.001
VM paired	21	0.58 (0.05)	0.65 (0.05)	0.07 (0.02, 0.12)	0.008
VM imputed	54	0.51 (0.03)	0.54 (0.03)	0.10 (0.05, 0.14)	< 0.001
CD paired	30	0.61 (0.03)	0.68 (0.04)	0.07 (0.02, 0.13)	0.013
CD imputed	55	0.55 (0.03)	0.64 (0.03)	0.09 (0.03, 0.15)	0.006
Anxiety paired	38	0.56 (0.03)	0.66 (0.04)	0.11 (0.05, 0.16)	< 0.001
Anxiety imputed	76	0.48 (0.02)	0.54 (0.02)	0.12 (0.08, 0.16)	< 0.001

Table 8.1Paired testing of paired and imputed Assessment of Quality of Life 8dimensions utilities by diagnosis

BPPV benign paroxysmal positional vertigo, CD cervicogenic dizziness, CI confidence interval, imputed pooled imputed pair means, paired original paired data, SE standard error of the mean UVH unilateral vestibular hypofunction, VM vestibular migraine. Note SPSS produces standard errors of the mean for imputed pooled data

beginning and end of the study period and a testament to the consistency of the service's outcomes.

Utilities are also used to calculate quality adjusted life years (QALYs) for use in a specific type of cost effectiveness analysis called a cost utility analyses. Using an average duration of treatment of 74.3 days (SD 106.6) and the mean imputed change in utility of 0.07, the mean imputed quality adjusted life years gained per person was 0.067.

**8.5** Results: Work Productivity and Activity Impairment: Specific health problem (Dizziness)

In Study 4, 123 participants completed the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire, with 10 questionnaires missing on initial assessment and 16 on discharge. This amounted to a questionnaire dropout rate of 39.7%, a considerable amount without explanation apart from possible questionnaire fatigue for those attending initial assessments. However, the patient profiles of the WPAI:SHP (Dizziness) completed cohort were representative of the larger Study 4 cohort on the basis of the mean age of 55.9 years (SD 17.8), female: male proportions ratio of 1.46:1 and equivalent proportions of the common diagnoses of benign paroxysmal positional vertigo, unilateral vestibular hypofunction and vestibular migraine. When examined separately, the 44 working adults (25 females (57%)) who completed the WPAI:SHP (Dizziness) had a mean age of 46.0 years (SD 12.30), significantly younger than the Study 4 cohort mean age by 9.5 years (95 % CI 7.5 to 11.4). The 79 non-working adults (48 females (61%)) who completed the WPAI:SHP (Dizziness) had a mean age of 9.5 years (95 % CI 7.5 to 11.4). The 79 non-working adults (48 females (61%)) who completed the WPAI:SHP (Dizziness) had a mean age of 61.4 years (SD18.0) and were significantly older than the Study 4 cohort mean age by 5.9 years (95% CI 4.0 to 7.9).

Table 8.2 below reports the results of the WPAI:SHP (Dizziness) by question. Question 1 grouped the participants into those working for pay versus those not working and then questions 2 to 5 only relate to people working. People reported that due to dizziness they had lost almost five hours of work in the last week (question 2) and that they were working at moderate levels less than optimal (presenteeism) due to dizziness (question 5). Repeated measures analysis revealed significant improvements in responses to question 6 for both working

and non-working people, indicating treatment reduced the degree both groups perceived dizziness was affecting activities other than work.

### **8.6** Results: Burden from a patient's perspective- lost wages

The Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire provided a tangible means of measuring burden through its measure of hours worked in the last week. Twenty-five working women and 19 working men completed the WPAI:SHP (Dizziness) on initial assessment.

<b>0</b> <i>i</i>								
Question	Working				Non-			
					working			
question	pre (SD)	DC (SD)	Z	р	pre (SD)	DC (SD)	Z	р
Q1 number of working vs non-working	44	30			79	77		
Q2 hours missed from work (SD)	4.9 (14.3)	0.5 (2.5)	-0.447	0.655				
Q3 hours missed due other reasons (SD)	3.1 (8.1)	4.5 (11.2)	-0.631	0.528				
Q4 hours worked (SD)	25.2 (13.0)	28.4 (15.3)	-0.178	0.859				
Q5 degree of presenteeism (SD)	3.0 (3.1)	1.5 (2.2)	-1.786	0.074				
Q6 degree other activities affected (SD)	3.0 (2.8)	1.8 (2.4)	-2.893	0.004	4.5 (2.9)	2.2 (2.4)	-3.134	0.002

# Table 8.2Work Productivity and Activity Impairment: Specific Health Problem<br/>(Dizziness) questionnaire responses

DC discharge question, pre pre-assessment question, SD standard deviation, Z Wilcoxon Signed Ranks statistic

#### 8.6.1 Results: Burden from working person's perspective- absenteeism

With an average age of 46 years (SD 12.3), according to statistics published by the Australian Bureau of Statistics (Trewin, 2006) that 92% of working men worked full time at 43.2 hours per week and 56.7% of working women worked full time at 39.3 hours per week, with the remaining 7.9% of working men working part time at 16.4 hours per week, and the remaining 42.3% working women working part time at 16.9 hours per week (Trewin, 2006), the Study 4 WPAI:SHP (Dizziness) cohort was expected to work an average of 33.6 hours per week.

From the initial assessment WPAI:SHP (Dizziness) results, average hours worked in the last week were 25.2 hours. This means that compared with the average worker, these 44 workers with dizziness lost 8.4 hours in the last week of work. If the average working wage was approximately Australian dollars (AUD) \$1544 per week (Australlian Bureau of Statistics, 2018) or AUD \$37.50 per hour, this amounted to approximately \$315 lost per working person with dizziness in the last week. Should this reduced work and dizziness experience continue to reduce their work hours at a constant rate for the entire period they were on the wait list, lost wages annualise at AUD \$16380 per year.

The physiotherapy-led vestibular rehabilitation service contributed to a reduction in the wait list times for people with dizziness/vertigo from the 2013 levels of 390.2 days (SD 243.54) to the 2017 levels of 93.0 days (SD 219.38). Again, assuming that the reduction in hours/wages was constant for the entire time on the wait list, (and this cannot be assured), on average the vestibular rehabilitation service may have contributed to a potential savings in lost wages of \$16380 - \$4185 = \$12195 per working person with dizziness accessing the service in 2017.

#### 8.6.2 Results: Burden from the workplace's perspective- presenteeism

The above section accounts for the effect of lost wages from the perspective of the person with dizziness. Presenteeism is a separate issue that needed consideration to appreciate the full effect of dizziness on the working environment or the employer. Using the WPAI:SHP (Dizziness) outcome of question 4 with a mean degree of 3/10 (SD 3.1/10) in the effect of dizziness on productivity, presenteeism due to dizziness in this cohort equated to a loss of 30% man-days in productivity. Assuming 225 working days per year (working days/year =  $365 \times 5/7 - 10$  public holidays - 20 annual leave days – 5 sick days), then applying the dizziness presenteeism effect, 68 man-days were lost in full productivity to the workplace per person with dizziness per year. This equated to 13.6 weeks or \$20998 in wages for sub-optimal work output using average weekly wages in 2017 (Australlian Bureau of Statistics, 2018). This was a reasonable expectation for people with dizziness experiencing long waits (mean of 390 days) at the beginning of the doctoral programme of research in 2013. Since the model of care contributed to a marked reduction of waits by 2017, the expected impact on presenteeism was that by 2017, workplaces experienced a reduced level of presenteeism down to 17 man-days / four weeks lost in full productivity or AUD \$5308 in wages for sub-optimal work output in the workplace.

# 8.6.3 Results of effect on other activities

Table 8.2 above presents the analysis of the WPAI:SHP (Dizziness) question 6 results, showing significant improvement in activities other than work in both working and non-working groups. This supports the finding of improvement in utility and therefore quality of life as outlined above in Section 8.4.

# 8.7 Results of cost consequences analysis

The cost consequences analysis table, Table 8.3 below, lists professional costs, costs by diagnosis, and a summary of burden of dizziness costs. Total clinical cost incurred by the 234 included people with dizziness for 746 occasions of service was AUD \$218,496. In the cost consequences analysis, the interquartile range (25% and 75%) of costs provides an indication of the spread of costs attributable to the hospital and health service's use of activity-based and absorption costings. The second section of the table shows the variation in costs based on diagnoses and mean occasions of service, while the third section demonstrates the financial burden of dizziness adjusted for the wait experienced.

### 8.8 Discussion

Since no previous measures of utility for dizziness have been reported, understanding the magnitude of the Study 4 imputed utility score at time of initial assessment of 0.58 (SD 0.21) requires comparison with reported Assessment of Quality of Life 8 Dimensions (AQOL8D) normal population scores and those of other chronic diseases.

Using two reported AQOL8D population utility scores, 0.83 for a six country mean (Australia, Canada, Germany, Norway, UK, USA) (Richardson et al., 2015) and 0.86 for Australia alone (Richardson et al., 2012), results from Study 4 indicated people with dizziness reported at least a 30% reduction in their quality of life. The reported AQOL8D utilities for chronic conditions such as depression (0.45), arthritis (0.63), heart disease (0.68), asthma (0.69) and hearing loss (0.72) (Richardson et al., 2015) show similar loss of quality of life to that of dizziness.

Service costs by specialty	mean cost AUD (SD)	IQR (25%,75%) AUD	OOS
			n
physiotherapy review 30 minutes	\$208 (159)	\$146, \$214	446
physiotherapy new > 60 minutes	\$357 (174)	\$235, \$424	211
audiology	\$610 (474)	\$387, \$957	64
ENT review 15 minutes	\$301 (234)	\$193, \$422	18
ENT new 60 minutes	\$522 (373)	\$289, \$1110	7
Decision Tree costs by Primary Diagnosis	option 1 costs AUD (95% CI)	option 2 costs AUD (95% CI)	improvement in imputed utility
combined cohort	\$781 (\$719 to \$844)	\$1285 (\$1229 to \$1342)	0.08
benign paroxysmal positional vertigo	\$1010 (\$844 to \$1178)	\$1491 (\$1342 to \$2183)	0.11
unilateral vestibular hypofunction	\$802 (\$719 to 885)	\$1304 (\$1229 to \$1379)	0.08
vestibular migraine	\$552 (\$490 to \$579)	\$1049 (\$993 to \$1073)	0.10
cervicogenic dizziness	\$636 (\$490 to \$781)	\$1125 (\$993 to \$1255)	0.09
anxiety	\$906 (\$781 to \$1031)	\$1366 (\$1255 to \$1480)	0.12
Patient costs - Burden of Dizziness	2013	2017	
mean wait days (SD)	390.2 (243.54)	93.0 (219.38)	
wait adjusted lost wages AUD/person (95%CI)	\$17511 (\$15656 to \$20223)	\$4174 (\$959 to \$7412)	
wait adjusted presenteeism AUD/person (95% CI)	\$22271 (\$16336 to \$28209)	\$5308 (\$3539 to \$7078)	

#### Table 8.3 Study 4 Costs consequences analysis

AUD Australian dollar value at time of service or identified year, ENT ear nose and throat, IQR interquartile range, OOS occasions of service, option 1 physiotherapy model, option 2 traditional model, SD standard deviation, note: standard error for options 1 and 2 used OOS SD and n of primary diagnoses, standard error for burden measures used SD of measure and n for the year

Table 8.1 shows differences between paired and imputed cohort utility scores. Utility values for the total cohorts changed by:

- paired utility from 0.63 to 0.70 with a significant improvement of 0.06 (95% CI 0.04, 0.09)
- imputed paired utility from 0.58 to 0.66 with a significant improvement of 0.08 (95% CI 0.06, 0.10)

Improvement in imputed utility was still at least 20% less than the lowest reported normal population score of 0.83. The AQOL8D is known to have a strong suite of measures to assess the psychosocial aspect of quality of life (Richardson et al., 2015). Given at least 30% of participants had a secondary diagnosis of anxiety within the Study 4 cohort, it is possible that the initial assessment utility score, the discharge utility scores, or both may have been influenced by the AQOL8D questionnaire's propensity to identify psychosocial changes in health associated with anxiety.

Analysing common diagnoses, utility change with treatment in both the paired utility and imputed paired data exceeded the Assessment of Quality of Life 4 Dimensions minimally important difference (MID) of 0.06 and improved significantly according to paired sample t-testing.

In 2013 at the start of collection of Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) data, the mean wait list time was 390.2 days (SD 243.5) or close to a year. The resultant annualised weekly lost wages of AUD \$16380 per year found by this study may thus represent a realistic financial burden encountered by these people. Using a mid-exchange rate for 2013 of 0.95 AUD to 1.0 United States dollar (USD) (www.rba.gov.au and www.poundsterlinglive.com ), this annual amount for lost wages lies between confidence intervals for 2013 American estimates of annual burden for bilateral vestibular hypofunction (here expressed in AUD) of AUD \$13704 (95% CI \$0, \$51400) and for unilateral vestibular hypofunction of AUD \$3716 (95% CI \$0, \$50991) (Sun et al., 2014). Note that the values reported by Sun et al. (2014) were reported for American patients including both health practitioner access costs and lost wages. Note also there is no explanation for the dropout in WPAI:SHP (Dizziness) questionnaire completion apart from possible questionnaire

fatigue by those attending initial assessments. This may have introduced bias into the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) burden findings.

Assessing the results of Study 4's WPAI:SHP (Dizziness) questionnaire, three European studies reporting absenteeism from work due dizziness provide relevant but differing results. An English study examining dizziness and anxiety in an urban population of working age adults found that 23% of the 2064 survey respondents reported dizziness in the last month. Of these people, 41% of those who were working or who wished to work also reported dizziness caused occupational difficulties and 25% had difficulties carrying out their jobs satisfactorily (Yardley et al., 1998). In a Belgian study, 400 consecutive working people with dizziness attending an outpatient dizziness centre used the World Health Organisation Health Performance questionnaire to measure indirect costs to the workplace. This group found that the reports of work hours were unreliable and had concerns with the questionnaire's validity, however they stated that 51% of people reported any absenteeism and 12% of people reported that they were unable to work due to dizziness (van der Zaag-Loonen & van Leeuwen, 2015).

Comparing the impact on work of people with dizziness in the cities of London and Siena, researchers developed a work impact questionnaire and then assessed people with dizziness attending specialist outpatient dizziness clinics in the two cities (Bronstein et al., 2010). This study found 21% of people reported giving up their jobs, 27% changed their jobs and more than 50% reported presenteeism or reduced quality of work at levels of between 25% and 75% while working (Bronstein et al., 2010). Giving up of work has the potential to reduce wages in people with dizziness, adding to their burden from dizziness, while presenteeism of up to 75% must have a large impact on workplaces. Study 4 did not investigate whether people gave up work as a result of their dizziness but found comparable levels of presenteeism with its mean reported degree of 30% from the WPAI:SHP (Dizziness) data. Anecdotally, based on interview findings from the physiotherapy-led service, a large proportion of people with dizziness report dizziness/vertigo and resultant dysfunction at work for greater periods of time than reported by the WPAI:SHP (Dizziness) due to delays in their accessing a GP before a referral is made. This suggests the above lost wages calculation may be an under-estimate of wages lost by working people with dizziness.

The cost consequences analysis in Table 8.3 shows the vestibular rehabilitation service is cost saving to the health service. The potential large gains in quality of life of people with dizziness and in productivity to their workplaces are also apparent. A tangible measure of the gains in ENT consultant time spent on other, potentially more urgent cases in busy specialist outpatient services of public hospitals is apparent given the 301 cases of people with dizziness seen in Study 4 by the physiotherapy-led model versus the seven seen by ENT.

The cost consequences analysis makes three key findings. Firstly, the physiotherapy-led vestibular rehabilitation model of care, Option 1, is clearly dominant in terms of costs compared to the traditional ENT model of care, Option 2. Secondly, the burden of dizziness is substantial when considered from lost wages perspective and the physiotherapy-led model of care clearly reduces this burden through reduction of waits and resolution of the dizziness. Finally, this cost saving translates to employers of people with dizziness through reduced presenteeism costs.

### 8.9 Conclusions

The reduction in quality of life and the financial burden as a result of vestibular dysfunction was considerable for people with dizziness. The average imputed utility as a measure of quality of life scored 0.58, matched levels of other chronic conditions, and represented at least a 30% reduction in quality of life compared to population norms. The average improvement in utility with treatment exceeded the comparable Assessment of Quality of Life 4 Dimensions minimally important difference of 0.06 by whole cohort and by all common diagnoses, indicating the service provided good clinical effect from the perspective of people with dizziness.

Work Participation and Activity Impairment questionnaire reports of improvements in activities other than work after treatment for dizziness further supported this finding.

Absenteeism with lost wages potentially had a considerable impact on people with dizziness when faced with long waits. A major impact of the physiotherapy-led vestibular rehabilitation service has been its contribution to significantly reducing waits for people with dizziness when referred to ENT. This led to markedly reduced potential loss in annualised wages by over \$12000 per year. Similarly, by the service improving the level of presenteeism through the resolution of dizziness in most people, potential workplace losses measured either in man-days not at full productivity or in wages paid for sub-optimal work have also been reduced.

Viewing the burden of dizziness and vertigo from the opposite perspective, that of the health system, would traditionally require a cost utility analysis. Pragmatically, from the outset of implementation of the physiotherapy led vestibular rehabilitation model of care, the intent was to assist ENT with wait list throughput. Wait lists at the time of study commencement were a matter of clinical and political concern and there was an imperative to reduced them and the waits people were experiencing. It was therefore not practical to randomise assessment and treatment of people with dizziness between ENT and physiotherapy. Thus, in the study of the physiotherapyled vestibular rehabilitation service model of care, it was not possible to calculate the utility of the traditional model of care by ENT since the ENT Category two and three referrals were transferred across onto the vestibular physiotherapy pathway, and not treated by ENT. As a result, a cost consequences analysis provided decisionmakers with a comparative guide to costs of models and a summary of the outcomes of lost wages experienced by people with dizziness and presenteeism costs to employers. Answering the Study 4 research question regarding the cost consequences of the physiotherapy-led vestibular rehabilitation service, this analysis has shown the model to be dominantly cost effective, adding support for the model of care being identified as one of high value care.

Given the comparable patient profiles and the supportive improvements in the service and repeated clinical measures that Study 4 generated and combined with

the physiotherapy-dominant cost consequences analysis, the hypothesis that the physiotherapy-led vestibular rehabilitation service model of care is one of high value is supported. The traditional pathway of ENT-only primary contact and management of people with dizziness does not reflect optimal current practice for a busy ENT outpatient service when there is local vestibular physiotherapy capability and capacity to manage these people. This new physiotherapy-led model-of-care represents both good quality care for people with dizziness and good value for money for those hospitals where both ENT and physiotherapy services are provided.

# **Chapter 9 Discussion**

The overall aim of this programme of research was to evaluate a physiotherapy-led vestibular rehabilitation service for acceptability by people with dizziness, clinical effectiveness, and cost effectiveness and thus determine whether of the model represented high value care. Three preparatory studies were undertaken. Study 1 was a systematic review to describe the diagnostic populations of people with dizziness that this and other services manage. Study 2 was a pilot study to determine feasibility of the service. Study 3 was an interrater reliability trial between a vestibular physiotherapist and audiologist to assess comparability with other multidisciplinary studies and to establish concurrent accuracy of diagnoses. These three studies informed the development and methodology of the physiotherapy-led vestibular rehabilitation service model of care reported in Study 4. The current chapter discusses the four studies of the research programme in terms of their aims and the research questions posed for each study. Clinical implications of these findings are considered in terms of value for the person with dizziness and value to the health system. Practical advice is provided towards the setting up such a model of care at a greenfield site (one without an existing service). Strengths and limitations to the programme of research and its results will be outlined together with future directions for research and the model of care.

# **9.1** Summary of findings

This section will initially summarise the findings of the studies within this programme of research in context of relevant literature.

### 9.1.1 Study 1

In planning for the pilot study, a need was identified to have comparative proportions from the literature with which a pilot study's proportions could be compared. The resultant systematic review, Study 1 had the aims of determining the diagnostic proportions for people with dizziness from international literature, investigating whether these differ by the specialty making the diagnoses, and determining whether diagnostic proportions have changed over time.

The systematic review reported diagnostic categories including benign paroxysmal positional vertigo (BPPV), bilateral vestibular hypofunction, cardiac, cervicogenic dizziness, Meniere's disease, neurological, other diagnoses, psychogenic, unilateral vestibular hypofunction, and vestibular migraine. Diagnostic proportions differed by the diagnosing specialty, with the category of other diagnoses forming the largest category for the primary contact specialties of general practice and emergency departments, while BPPV formed the largest category of vestibular dysfunction for the specialist outpatient services of ENT, neurology and physiotherapy. Demographics, when reported by the 42 papers included in the review, showed a mean age of 55.8 years (SD 8.39) and a female to male ratio of 59:41 for the reported populations of people with dizziness.

Differences in diagnostic proportions were attributed to the level of primary contact for the specialty making the diagnosis, to specialist interests, and to the time a report was published. The systematic review argued that those specialties associated with primary care, general practitioners, and emergency departments, experienced a full spectrum of people with dizziness including those with vestibular, neurological, cardiac and respiratory dysfunction. Primary practitioners reported different diagnostic proportions to the specialist services (ENT, neurology, physiotherapy); with the latter receiving appropriately filtered referrals of people with dizziness from primary care practitioners. Conditions commonly associated with particular specialist areas were reported more often by these settings. Thus, Meniere's disease was reported more commonly by ENT clinics, with neurological conditions and vestibular migraine more commonly diagnosed by neurology clinics, and cardiac conditions more frequently seen in emergency departments.

Diagnostic proportions changed significantly over subsequent decades with the most notable being the reduction in Meniere's disease; replaced by the increasing diagnosis of vestibular migraine. The review concluded that since the 1950's, diagnostic criteria have been described and refined as publications have increased and as diagnostic technology has advanced. Collectively, this has aided diagnostic processes and resulted in changing diagnostic proportions for people with dizziness over time. The findings of the systematic review permitted comparison of the proportions from this programme of research with those of the international literature, reported below in the discussion of Study 4.

#### 9.1.2 Study 2

The Study 2 pilot demonstrated the feasibility of the physiotherapy-led vestibular rehabilitation model of care and supported refinements for further investigations into the model of care. Feasibility in Study 2 was determined by comparing patient profiles, service and clinical outcomes with the outcomes of contemporaneously reported multidisciplinary models of care.

Study 2 revealed comparable patient profiles and service outcomes to two contemporaneous multidisciplinary ENT-based models reported from the public health system of the United Kingdom (Lee et al., 2011; Leong et al., 2008). These two reports were the first in the UK to explore models that reduced the requirement for ENT clinicians to fully manage people with dizziness referred to ENT. Reporting the study patient profile as a combination of demographics and diagnostic proportions, the Study 2 pilot found a significantly female-dominated gender ratio of 66:34 female to male similar to the UK findings with similarly female dominated ratios of 63:37 (Leong et al., 2008) and 72:28 (Lee et al., 2011). Additionally, the mean age of the pilot study participants (55.2 years SD 17.57) compared closely to that reported by Lee et al. (2011) of 54 years (SD 16) years. Considering diagnostic proportions, Study 2's primary diagnostic proportions of the four common diagnoses of BPPV, unilateral vestibular hypofunction, vestibular migraine and cervicogenic dizziness of 22%, 27%, 7% and 4% respectively, compared closely with the proportions of 18%, 29%, 7% and 8% (cervicogenic dizziness as part of an Other diagnosis category) of the Lee et al. (2011) model (statistically equivalent proportions Chi Squared = 2.852, p= 0.415) and 28% BPPV and 30% unilateral vestibular hypofunction (no other diagnoses reported) of the (Leong et al., 2008) model. Thus, BPPV and unilateral vestibular hypofunction were major diagnoses for all three

cohorts with proportions that did not differ statistically (Chi Squared = 1.739, p= 0.419).

The reporting of service outcomes for Study 2 represents a cross sectional view of the physiotherapy-led vestibular rehabilitation service for early 2013. Participant waits in Study 2 averaged 382.6 days (SD 246.3); exceeding the wait criteria of both ENT category two (90 days) and three (365 days) wait lists. In comparison, the waits reported at the beginning of the UK comparative models of care were significantly shorter at 24 weeks (168 days, one sample t statistic= 7.13, p < 0.001) (Leong et al., 2008) and 21 weeks (147 days) (Lee et al., 2011). Occasions of service in Study 2 were skewed positively (skewness = 1.7) with 46% of pilot study occasions of service being single occasions; mainly due to planned clinical discharges. Single occasions of service contributed markedly to the dropout of completed discharge outcome measures with 19 of the 31 single occasions of service not having discharge questionnaire data. Duration of treatment was similarly positively skewed (skewness= 3.7) towards a mode of one day, due to the large number of single occasions of service. Occasions of service, duration of treatment, and participant dropout from repeated measures were not reported for the two contemporaneous UK services. Referrals to ENT for assessment by the Study 2 physiotherapy-led vestibular rehabilitation service amounted to six cases (9%), compared with the much larger proportions of 81% by Leong et al. (2008) and 26% by Lee et al. (2011). The significance of the small number of referrals back to ENT in Study 2 is that the physiotherapy-led model enabled a genuine reduction in time spent by ENT in the management of these people with dizziness. At the same time, considering the patient safety, all three reported services stressed the importance of following red flag assessment criteria in the screening/initial assessment process, having access to ENT consultants to discuss cases, and as a direct measure of safety, all three reported that no adverse outcomes were recorded.

The Study 2 pilot investigated repeated measures of patient report (Dizziness Handicap Inventory (DHI) and Activities-specific Balance Confidence (ABC) scale) and physical measures (Dynamic Gait Index), considered falls risk, and determined

the success of treatment for the more common diagnoses to gain an *a priori* understanding of clinical effectiveness; thus, contributing to the feasibility assessment. Analysed at the whole cohort level, the initial assessment DHI mean of 35/100 and the ABC mean of 78/100 were both abnormal scores based on their clinical cut-offs of > 26/100 and < 80/100, respectively. These improved significantly with treatment to clinically normal scores of 11/100 for the DHI and 88/100 for the ABC. The Dynamic Gait Index scored clinically normal on initial assessment with a mean of 22/24. Falls risk analysis using the increased falls risk cut offs of the ABC (less than 67/100), Dynamic Gait Index (less than 19/24) and modified Clinical Test of Sensory Interaction in Balance (feet together standing on foam, fall with eyes closed in less than 30 seconds), revealed the Study 2 participants had normal levels of falls risk at initial assessment.

Analysis at the diagnostic level for the common diagnoses of BPPV and unilateral vestibular hypofunction using the outcomes of the head position tests for BPPV and the Dynamic Visual Acuity for unilateral vestibular hypofunction, showed Study 2 treatment led to complete resolution (100%) of these conditions. This compared well with those of Leong et al. (2008) who reported 50% resolution of people diagnosed and treated for BPPV by the pre-ENT clinic audiologists, with the other 50% being referred on to ENT or self-discharging. Lee et al. (2011) did not report specific resolution rates, apart from stating that 74% of their participants received vestibular rehabilitation and that 182 of 194 participants (94%) were discharged.

The small sample of Short Form 12 quality of life questionnaires collected in Study 2 and processed using the Short Form 6 Dimensions algorithm produced the useful quality of life measure of utility. Utility scores are useful academically in measuring the effect of dizziness on quality of life, clinically for expressing the change in quality of life with treatment though repeated measures, and economically for expressing effectiveness in cost effectiveness analyses by combining with cost and time to produce quality adjusted life years. Treatment led to an improvement of 0.05 in the utility score, exceeding the reported minimally important difference in the Short Form 6 Dimensions (SF-6D) utility of 0.041 (Walters & Brazier, 2005). Comparison of

Study 2 utility baseline score of 0.61 (SD 0.1) with the normal population utility of 0.8 (Richardson et al., 2015) indicates a 24% reduction in quality of life. Comparing Study 2 utility to those reported for the SF-6D algorithm for other chronic conditions, shows similar levels including depression 0.6 (SD 0.11) (Mihalopoulos et al., 2014), schizophrenia 0.67 (SD 0.13) (McCrone et al., 2009), hepatitis C liver disease 0.67 (SD 0.16)(Dan et al., 2008), rheumatoid arthritis 0.63 (SD 0.24) (Marra et al., 2004), and low back pain 0.66 (SD 0.14) / osteoarthritis 0.52 (SD 0.11) / chronic obstructive pulmonary disease 0.57 (SD 0.11) and irritable bowel syndrome 0.67 (SD 0.15) (Brazier et al., 2004). No previous measures of SF-6D utility for dizziness were reported in the literature.

Analysis of Study 2 outcomes enabled refinements to the subsequent main study, Study 4. Alterations in methodology included changing from the Dynamic Gait Index to the Functional Gait Assessment and changing the Short Form-12 health-related quality of life questionnaire to the Assessment of Quality of Life 8 Dimensions questionnaire. Visual analogue scales were added to measure participant satisfaction in the wait experienced before initial assessment and the satisfaction with the physiotherapy-led vestibular rehabilitation service on discharge. To explore patient burden due to dizziness, the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire was added as a repeated patient reported measure. Finally, given the improvement in utility found in the pilot, a cost consequences analysis was conducted using clinical costings incurred for the treatment of people with dizziness provided by the local hospital and health service district costings department and the Assessment of Quality of Life 8 Dimensions utility.

Summing up, the Study 2 patient profile in terms of demographics and diagnostic proportions matched those of other reported multidisciplinary services, while finding an *a priori* indication of service and clinical effectiveness for the physiotherapy-led vestibular rehabilitation service. Collectively, these factors showed the model of care to be feasible and worthy of further investigation. To enable an in-depth inquiry of this service that could determine whether this service represents one of high value

care and that could make confident conclusions about its effectiveness down the level of common diagnoses, examining a larger case series was indicated. In preparation for this investigation into the model of care, one further study was undertaken and is summarised next: an interrater reliability trial between a vestibular audiologist and vestibular physiotherapist assessing the concurrency of diagnoses and referrals to vestibular rehabilitation.

#### 9.1.3 Study 3

Study 3 demonstrated interrater reliability between a vestibular physiotherapist and a vestibular audiologist in their diagnoses and referrals for management, after conducting initial assessments of ENT category two and three wait list people with dizziness. This trial was necessary for several reasons. Firstly, audiologists in the local health care system often screened and made referrals for physiotherapy management of people with dizziness. There was a need to determine whether this screening and referral rates matched those done by physiotherapy; in which case, the data for the programme of research could be reliably compared with other multidisciplinary clinic reports using audiologists for screening. Secondly, this was an opportunity to demonstrate the accuracy of diagnoses made by the physiotherapist through concurrent initial assessment and confirming the validity of subsequent treatment. Finally, data collected from the reliability trial if found to be based on similar diagnoses and referrals rates, was valid for inclusion in the main study of the programme of research.

Assessment, diagnosis, and subsequent referral patterns of the two clinicians were compared using both the Kappa statistic and percentage agreement. Establishing positive interrater reliability indicated validity in comparisons between the doctoral programme of research and reports from audiology-led models of care (for example Leong et al., 2008). Furthermore, the demonstrated common referral process permitted the inclusion of data from Study 3 into the Study 4 analysis.

Overall, Kappa statistic results for diagnoses and referrals made showed substantial to almost perfect levels of agreement with low levels of prevalence and bias effect.

The statistic of percentage agreement for all diagnoses was greater than 85% apart from unilateral vestibular hypofunction, and similarly for referrals to audiology, ENT, GP and physiotherapy, was greater than 85%.

Considering the Kappa statistic for diagnoses, there was perfect agreement in the diagnosis of BPPV, and substantial level of agreement for the other considered diagnoses of unilateral vestibular hypofunction, vestibular migraine and cervicogenic dizziness, without prevalence or bias effects on the Kappa outcome. This outcome was tempered by the wide 95% confidence intervals arising from lower than planned subject numbers. These wide confidence intervals did not exclude the already clinically low, Kappa test score of 0.4, except for the important category of referral to vestibular rehabilitation. Reduced level of agreement in diagnoses for this filtered population of people with dizziness was clinically acceptable, since there was a high likelihood of people with dizziness being appropriately referred for vestibular rehabilitation. Analysis of referrals by the audiologist and by the physiotherapist to vestibular physiotherapy exhibited interrater reliability through an almost perfect agreement Kappa statistic of 0.89 (Cl 95% 0.68 to 1.0, excluding the Kappa test statistic of 0.4) without notable prevalence or bias effects, and confirmed by the high percent agreement of 95.5%.

With interrater reliability established between a vestibular audiologist and a vestibular physiotherapist, comparison with reports by other multidisciplinary clinics employing both audiologists and/or physiotherapists was supported and enabled the inclusion of Study 3 data in the combined analysis undertaken in Study 4. Furthermore, this concurrent assessment of diagnoses between the physiotherapist and another health professional leading to appropriate treatment, added to the evidence of clinical effectiveness for the physiotherapy-led model of care.

### 9.1.4 Study 4

In order to achieve the goal of demonstrating the physiotherapy-led vestibular rehabilitation service as one of high value care, Study 4, investigated the effects of the service on clinical, service, consumer engagement and cost outcomes. This study was a comprehensive, prospective collection of data including patient profile data of demographics and diagnoses, repeated measures of patient-reported and physical outcomes, repeated measures of consumer engagement and burden of disease, and cost and utility outcomes necessary to conduct a cost consequences analysis. Furthermore, the study compared the diagnostic proportions generated by the model of care with those reported by the Study 1 systematic review. Where possible, Study 4 outcomes were compared with those reported in the literature to enable an informed understanding of the clinical implications of the model of care outcomes.

The main study demonstrated service and clinical effectiveness down to the level of common diagnoses of vestibular dysfunction. It established the magnitude of burden of dizziness expressed by measures of quality of life, the costs of absenteeism or lost wages to working people with dizziness, and the costs of presenteeism or suboptimal productivity to businesses employing people experiencing dizziness. Finally Study 4 presented a cost consequences analysis demonstrating the dominance of the physiotherapy-led vestibular rehabilitation service over the traditional ENT model.

#### a Patient profile- demographics and diagnostic proportions

Patient profile analysis of the Study 4 cohort showed similarities in demographics and diagnostic proportions with the literature. The female: male ratio of 63:37, was comparable to the 59:41 ratio of the Study 1 systematic review, and the same as a subsequent report involving physiotherapy management of people with dizziness (Burrows et al., 2017). The mean age of 55.5 years (SD 17.23) did not differ to the Study 1 systematic review age of 55.8 years (SD 8.39) but was significantly younger than the 62 years reported by Burrows et al. (2017) (one sample t = -6.59, p< 0.001).

Comparison of Study 4 diagnostic proportions with the ENT and physiotherapy cohorts from the systematic review of Study 1 revealed significant differences between the three cohorts, evidenced in the change in ratios of Meniere's disease to vestibular migraine and other diagnoses to unilateral vestibular hypofunction. The clinical implications of these diagnostic differences are that they most likely reflect the combined use of the most up to date diagnostic criteria for vestibular migraine and Meniere's disease and the use of recent diagnostic technology. Study 1's review demonstrated the ratio of vestibular migraine to Meniere's disease diagnoses increased over time from the 1950's to present, with Study 4's ratio of 5.6:1 ratio continuing this trend; probably reflecting the continued clinical development in, and clinical knowledge of vestibular migraine diagnostic criteria over time. Furthermore, Study 4 methodology included the use of video-head impulse testing (vHIT) for all participants since 2014. Since only a video-head impulse testing can routinely assess vertical semicircular canal dysfunction at the bedside (MacDougall et al., 2013), cases of vertical canal vestibular hypofunction in Study 4 were recorded as unilateral vestibular hypofunction, whereas without the video-head impulse testing, the diagnosis might have been recorded in the other diagnosis category.

Supporting this, ENT services in the past routinely employed calorics testing (Lee et al., 2011) thus detecting only lateral canal dysfunction (Bell et al., 2015) for recording as unilateral vestibular hypofunction and missing vertical canal hypofunction in conditions such as isolated vertical canal unilateral vestibular hypofunction (Halmagyi et al., 2010) and presbyvestibulopathy (Agrawal et al., 2019). Anecdotally, based on the experience with the use of video head impulse test in Study 4, the occurrence of isolated vertical canal dysfunction is common.

A relevant multidisciplinary vestibular service-related article published after the systematic review data acquisition reported diagnostic proportions of BPPV 24%, unilateral vestibular hypofunction 11%, vestibular migraine 24%, cervicogenic dizziness 0.5% and Meniere's disease 2.4% (Burrows et al., 2017), which differ significantly from those of Study 4 (Chi-Square statistic 26.9, p< 0.001). The model of care for this UK vestibular rehabilitation service comprised referral triage by an audiologist followed by assessment and treatment by an independent prescribing vestibular physiotherapist with the aim of managing all people referred with dizziness and balance disorders to the associated ENT service (Burrows et al., 2017). A comparison of the two studies showed similar BPPV and Meniere's disease proportions with notable differences in the unilateral vestibular hypofunction, Other

diagnoses and cervicogenic dizziness proportions. The routine use of videooculography by the physiotherapy-led vestibular rehabilitation service may explain the greater proportion of unilateral vestibular hypofunction and lower Other diagnoses in Study 4 proportions, whilst the initial chronicity of the Study 4 participants in the first three years may have led to the increased proportion of cervicogenic dizziness in Study 4.

#### b Service effectiveness

Study 4 considered the collection and analysis of the service outcomes of wait list time, occasions of service, duration of treatment, adverse events, and participant satisfaction. An assessment of change in wait time over the duration of the study demonstrated an important effect of implementing the service since the Study 2 pilot. The time on a wait list for people with dizziness reduced significantly by 297.2 days (95% CI 200.2, 394.2) in 2013, down to a mean of 93 days (95% CI 18.74, 167.2) in 2017. Considering the burden of dizziness, this 42-week reduction in wait is obviously important to the person on the wait list. From a service perspective, the effect of removing long wait referrals by either seeing screened people with dizziness or by cold calling to ask if they still need the service, reduces the resultant waits for other people needing ENT. A 42-week reduction compares well with the UK services reported reductions in waits of between six weeks for people with the full range of vestibular dysfunction (Kasbekar et al., 2014; Lee et al., 2011) and 21 weeks for people diagnosed with BPPV only (Leong et al., 2008). The physiotherapy-led service, in seeing these people with dizziness experiencing long waits over the first three years, contributed to a significant wait reduction, supporting its service effectiveness.

A notable feature of this physiotherapy-led service was the large number of single occasions of service (n=104, 35%) that positively skewed the distribution of occasions of service (skewness= 2.0). This is a feature of reports by other multidisciplinary models with 51% single occasions of service being reported by Kasbekar et al. (2014) and 35% by Burrows et al. (2017). In Study 4, these single occasions of service largely arose from the combined clinical outcomes of the

management of vestibular migraine, the probable successful use of a single canalith repositioning manoeuvre in the management of BPPV with the participant subsequently not attending their review appointment, and the identification of resolved and non-vestibular causes for dizziness.

Examining occasions of service data down to the level of diagnosis, BPPV had an elevated median occasions of service of 3.0. The literature shows for many people the resolution of BPPV in the short term (as it often recurs in the long term) is achieved with one canalith repositioning manoeuvre (Aron et al., 2015; Balatsouras et al., 2012; Balatsouras et al., 2014; Hilton & Pinder, 2014; Hughes et al., 2015) usually followed by a re-testing occasion, thus making two occasions of service. The most likely contributing factor to the higher occasions of service found for people with BPPV in Study 4 was the presence of comorbid diagnoses. Forty-four percent of people with BPPV were diagnosed with unilateral vestibular hypofunction as well; thus, many people required vestibular rehabilitation as well as canalith repositioning manoeuvres.

Of the other common diagnoses, treatment of unilateral vestibular hypofunction with a median of three occasions of service and a duration of treatment of 47.5 days (6.8 weeks) performed clinically as expected. Recent studies of the effects of similar vestibular rehabilitation to that used in Study 4 reported five weeks of therapy (5 occasions of service) for people post unilateral vestibular deafferentation surgery (Millar et al., 2020) and five weeks (10 occasions of service) in people over the age of 65 years with vestibular dysfunction dominated by unilateral vestibular hypofunction and BPPV (Verdecchia et al., 2018). Both teams measured significant improvements in the Dizziness Handicap Inventory similar to the improvement in imputed Dizziness Handicap Inventory of 20/100 of Study 4. Clinical guidelines for the vestibular rehabilitation of peripheral vestibular hypofunction (Hall et al., 2016) noted an average of 6.7 weeks of supervised weekly sessions was reported from 61 prospective studies using expert opinion extrapolated from the evidence, while 20 retrospective studies representing actual clinical practice reported a mean duration of 10 weeks. The guidelines continued on to advise in addition to a daily home exercise

programme, two to three weeks of weekly supervised vestibular rehabilitation for people with acute or subacute vestibular hypofunction increasing to four to six weeks of weekly supervised exercise for people with chronic vestibular hypofunction (Hall et al., 2016). Thus, Study 4's treatment of people with unilateral vestibular hypofunction compared well with the literature.

People with vestibular migraine had a median of two occasions of service, explained by a combination of the physiotherapy-led service's practice of referring people with vestibular migraine back to their GP for medication management after a single occasion of service, plus a frequent comorbidity with unilateral vestibular hypofunction and/or anxiety. Considering the whole cohort, the median duration of treatment of just over a month followed the pattern of occasions of service. This reflected not only the single day duration frequency (n= 75 single day duration) but also the service's clinical management of conditions such as BPPV and cervicogenic dizziness with people diagnosed with these conditions typically seen once a week to resolution, while people with unilateral vestibular hypofunction were seen once every two weeks. It should be noted that the treatment intensity of practice for unilateral vestibular hypofunction was not as intense as that described the literature but still achieved excellent resolution within comparable durations of treatment (Hall et al., 2016; Millar et al., 2020; Verdecchia et al., 2018). Thus, the service performed as expected with both occasions of service and duration of treatment.

No adverse events were recorded on either of the hospital's safety reporting systems, Prime® or Riskman®, and no reports of misdiagnoses or complaints were reported during the programme of research. This was consistent with reports of multidisciplinary models of varying levels of clinical independence (Burrows et al., 2017; Kasbekar et al., 2014; Leong et al., 2008) and with notable reviews into vestibular rehabilitation (Hall et al., 2016; McDonnell & Hillier, 2015).

Referrals back to ENT at 5% match or undercut the low number of interventions by ENT reported for recent models: 3% (Burrows et al., 2017) and 22% (Kasbekar et al., 2014). In contrast, referrals back to referring general practioners for medical management of conditions such as migraine (vestibular or not), postural hypotension, neurological dysfunction and medications management were seen as part of the vestibular rehabilitation service's routine care.

Visual analogue scale reports of satisfaction for time on the wait list scored highly with a negatively skewed distribution and median of 9.3 cm/10 cm and scoring consistently throughout Study 4 (Kruskall-Wallis Test=13.6 p= 0.138). Similarly, for service satisfaction, the visual analogue scale (VAS) reports scored highly with a median of 10 cm/10 cm and scored consistently throughout Study 4 (Kruskall-Wallis Test= 3.44 and p= 0.904). These high levels matched reports of satisfaction for reported multidisciplinary models (Burrows et al., 2017; Kasbekar et al., 2014). A randomly controlled trial investigating the effects of vestibular rehabilitation on people hospitalised with vertigo used repeated VAS to measure self-reported anxiety (Teggi et al., 2009). They found a significant improvement in self-reported anxiety in the rehabilitated group, although the small size of the group (n= 20) and the general nature of a VAS for assessing anxiety warrants caution in drawing conclusions. Perhaps the consistently high approval measured by Study 4 VAS represents relief from a combination of factors including being assessed, being listened to and being treated.

Overall, these service outcomes demonstrate that the physiotherapy-led service managed people with dizziness safely, efficiently and with a patient-centred focus.

#### c Outcome measure data dropout

Before considering the clinical effect as indicated by the change in repeated measures of the Dizziness Handicap Inventory (DHI), Activities-specific Balance Confidence (ABC) scale, Assessment of Quality of Life 8 Dimensions (AQOL8D), head position testing and the Dynamic Visual Acuity, consideration of discharge data completion needs to be made.

Dropout of data required a definition and since the DHI was used in all three studies, dropout was defined as a failure by a participant to record a discharge DHI (n = 162). From this proportion, participants were removed due to their diagnoses being

identified as other or having completed the discharge questionnaire but not the initial assessment questionnaire. Thus 147 participants (49.3%) were identified as having dropped out from a total of 277 DHI participants. The mean age of participants dropping out was significantly younger by 8.7 years (95% CI 6 to 11.4 years, p < 0.001) than the mean Study 4 age. Accounting for this dropout of data, multiple imputations were performed of DHI, ABC, and AQOL8D data performed by SPSS® version 27 incorporating age, wait, length of stay, and individually, DHI, ABC, and AQOL8D as factors. The SPSS imputation algorithm's default calculation protocol was used, producing five imputations with pooled means and a standard error of the mean. Changes in the clinical outcomes are discussed in more detail.

#### d Dizziness Handicap Inventory findings

No differences were found between Study 4's initial assessment Dizziness Handicap Inventory (DHI) scores for people with BPPV, vestibular migraine and cervicogenic dizziness, and their respective scores reported by a brief literature review (see Figure 4.1 in methods Chapter 4). Initial assessment unilateral vestibular hypofunction scores of Study 4 were significantly lower than the review's mean score of 50.5/100 by a mean difference of 9.4/100 (95% CI 6.7 to 12.2), probably due to the review's inclusion of literature scores for acute vestibular hypofunction in comparison to the sub-acute to chronic nature of unilateral vestibular hypofunction in people with dizziness managed in Study 4.

Using either paired or imputed paired DHI data showed the clinical effectiveness of the service from the person's perspective. Paired DHI testing by the whole cohort and by diagnosis showed significant clinical improvements for the whole cohort and for all reported diagnoses except vestibular migraine. The use of imputed paired DHI values showed all common diagnoses improved significantly.

Study 4 data showed a significant, moderately strong, inverse Pearson correlation coefficient of -0.679 (p= 0.01) between the pre assessment DHI and Activities-specific Balance Confidence (ABC) scale questionnaires and a correlation of -0.615 (p = 0.01) for discharge questionnaires. These results compare well with the

reported correlation of -0.635 using Spearman rank correlation between the DHI and ABC (Whitney et al., 1999). Furthermore, the literature reports that higher scores of the DHI correlate with increased odds of anxiety and/or depression (Maarsingh et al., 2011), with mental health surveys including the Hospital Anxiety and Depression Scale (Formeister et al., 2020), and with diagnoses of functional and psychiatric disorders with or without structural causes of dizziness (Graham et al., 2021). This usefulness as a measure of disability due to dizziness and potentially an indicator of concomitant mental health, supports the use of the DHI in the programme of research, in future research and in ongoing service use.

#### e Measures reporting falls risk

The assessment of falls risk in Study 4 used repeated measures of the Activitiesspecific Balance Confidence scale questionnaire, initial assessment interview reports of falling, and physical measures including the modified Clinical Test of Interaction in Balance at time of initial assessment and repeated measures of the Functional Gait Assessment. Analysis of these measures showed that Study 4 participants, considered either as a whole cohort or down to the level of common diagnoses, were not at increased risk of falling. People with dizziness scored the Activity-specific Balance Confidence scale at the time of initial assessment at levels significantly less than the physical activity abnormal cut-off of 80/100 (Myers et al., 1998) (with the exception of those with vestibular migraine), but at levels significantly greater than the increased falls risk cut off of 67/100 (Lajoie & Gallagher, 2004). Treatment led to significant improvements in the ABC for all but those with vestibular migraine.

Functional Gait Assessment scores at initial assessment all scored well above the clinically normal 22/30 cut-off level (Wrisley & Kumar, 2010), matching the ABC findings of non-elevated falls risk. In contrast to the ABC and Functional Gait Assessment initial assessment results for the whole cohort, a significant association was found in a small group of people who reported falling before the initial assessment and were 1.64 times more likely to have a fall reaction during modified Clinical Test of Sensory Interaction in Balance testing. Many of these people were diagnosed with bilateral vestibular hypofunction; a condition with a known increased

falls risk (Brown et al., 2001; Herdman, Blatt, Schubert, et al., 2000; Herdman et al., 2015; Ward et al., 2013). Thus, in the Study 4 cohort, most people with dizziness had concerns about their balance and resultant function in the community but were not at increased risk of falling.

#### f Diagnostic specific outcomes

Assessment of the clinical effectiveness of vestibular rehabilitation provided by Study 4 needed to consider the accuracy of diagnoses and changes in symptoms and signs of people with dizziness with treatment.

Concurrent analysis of diagnostic accuracy was undertaken for the doctoral programme of research in Study 3, the interrater reliability trial of diagnoses and referral practice between a vestibular audiologist and a vestibular physiotherapist. Kappa statistic and percentage agreement results found high levels of diagnostic agreement for the common forms of vestibular dysfunction. Future interrater reliability trials of diagnosis considering agreement between two groups of physiotherapists or groups of physiotherapists and ENT surgeons represents a future avenue for this model of care to take for ongoing validation of its performance.

There was clear evidence that the vestibular rehabilitation provided by Study 4 was effective in managing the signs and symptoms of people with dizziness for the main diagnoses of BPPV and unilateral vestibular hypofunction through resolution of their key outcome measures. Since both of these diagnoses are recurrent in nature, the resolution evidence presented by Study 4 represents their successful short-term management. For BPPV, short-term resolution amounted to cessation of the head position test symptom of vertigo plus the sign of nystagmus, while for unilateral vestibular hypofunction, resolution as compensation was indicated by the change in abnormal, grade three, Dynamic Visual Acuity scores to normal Dynamic Visual Acuity scores of grades one or two. This effectiveness in management of both diagnostic groups was supported further with strong, significant improvements in repeated measures of the patient-reported Dizziness Handicap Inventory and the Activity-specific Balance Confidence scale. Combined, the treatment results

reflected the evidence of benefit shown by Cochrane reviews into BPPV and unilateral vestibular hypofunction treatment (Hilton & Pinder, 2014; McDonnell & Hillier, 2015).

Success in the treatment of vestibular migraine was not able to be established outright by Study 4. Due to the large proportion of single occasions of service for people with vestibular migraine, the repeated measures of the Dizziness Handicap Inventory and Activities-specific Balance Confidence scale had a 64% dropout and could not measure change accurately for this diagnosis. Benefit to ongoing vestibular rehabilitation for people with vestibular migraine has not been established in the literature (Alghadir & Anwer, 2018; Sugaya et al., 2017), however those individuals with comorbid BPPV or unilateral vestibular hypofunction as contributing factors in vestibular migraine, would benefit from standard vestibular rehabilitation. The main benefits provided by the service in the management of people with vestibular migraine were in the initial assessment and discussion of the potential diagnosis of vestibular migraine, the subsequent education in its management, and the referral back to the person's general practitioner for consideration of pharmacological management; all done in one occasion of service. Validation of the diagnosis and assessment of success in treatment would have required close followup of participants' subsequent successful combined use of medication prescribed by their general practitioner, identification of migraine triggers and amelioration of risk factors. This follow-up was neither possible nor planned for the doctoral programme of research but represents a future study topic for this cohort.

Cervicogenic dizziness does not have a gold standard test nor a formal physical outcome measure to measure effect of treatment (Jung et al., 2017; Reiley et al., 2017). Dynamic Visual Acuity (DVA) may be shown to be one in the future with further controlled research. Interestingly, the uncontrolled Study 4 results demonstrated significant improvements in DVA data for both the cervicogenic dizziness primary and total diagnosis cohorts.

Control of eye fixation uses three known reflexes: the vestibular ocular reflex acting through head movement, the optokinetic reflex responding to movement of the
viewed target, and the cervical ocular reflex acting through movement of the neck on the head (Kelders et al., 2003). The Dynamic Visual Acuity test assesses the visual ocular reflex by passively moving the head at a 2 Hz sinusoidal frequency (Lee et al., 1997) while seated and viewing a fixed target. The cervical ocular reflex is known to operate at lower frequencies (< 0.2 Hz) (Bronstein & Hood, 1986) than the vestibular ocular reflex in the DVA test (2 Hz). Expressed as a gain or ratio of peak eye velocity to peak neck velocity, the cervical ocular reflex gain has been shown to increase with age (Kelders et al., 2003), with the decreased gain of a reduced vestibular ocular reflex (Bronstein & Hood, 1986), and with unilateral cervical restriction (Zamyslowska-Szmytke et al., 2019).

The first two of these conditions were not present in the people with cervicogenic dizziness from Study 4 since the mean age of approximately 55 years did not differ from the overall study mean age and the people were assessed as vestibular normals as part of the diagnosis of exclusion. If, as the Study 4 results suggest, the DVA test distinguishes people with otherwise normal vestibular systems from those with cervical dysfunction due to loss of range of motion and / or cervical pain, other cervical afferent inputs including the cervical ocular reflex, pain, and changed proprioceptive input to the central nervous system may be at play. Future randomised controlled studies are required to compare the DVA gains with those of cervico-ocular and vestibular ocular reflex gains conducted in darkened testing environments using video nystagmography with subjects with normal and abnormal vestibular systems, and with cervical dysfunction. This will help to determine whether a hidden variable has confounded the results of Study 4 and to outline the formal relationship between the DVA test and people with cervicogenic dizziness.

The uncontrolled but statistically strong improvements in the patient-reported repeated measures of the DHI and the ABC scale supported the clinical improvement shown by repeated physical tests of DVA. Combined, these outcome measures established the success in treatment of cervicogenic dizziness by the model of care.

Anxiety was not a primary diagnosis identified across the research studies. However, despite not being formally identified and treated, anxiety occurred frequently as a

secondary diagnosis, through it being included in the person's referrals or reported by participant. The thirty-three percent proportion of people with dizziness recorded as having anxiety in this manner in Study 4 was representative of recent literature reports specifically screening for anxiety in people with dizziness.

Prevalence rates for anxiety have been reported for cohorts of people with dizziness varying between 11 and 40% (Kurre et al., 2012). Examples of studies investigating dizziness and anxiety include a survey of working aged people with dizziness which found 46% of people also reported anxiety and or avoidant behaviour (Yardley et al., 1998), an epidemiological study in which 28.3% of people with dizziness had at least one anxiety disorder (Wiltink et al., 2009), prospective studies using the Hospital Anxiety and Depression Scale cut off of greater than 10 reported a range of probable anxiety proportions from 18% (Kurre et al., 2012), 32% (Piker et al., 2015) and 33.9% (Monzani et al., 2001), and a prospective observational study of people with dizziness at a tertiary dizziness centre reported 28.9% of people with anxiety/phobic disorder (Lahmann et al., 2015).

In Study 4, the initial assessment results showed a significantly higher imputed mean Dizziness Handicap Inventory (DHI) score in people with dizziness and anxiety than in those with dizziness only, by 7.8/100 (95% CI 2.0 to 13.7). Treatment saw a reduction in this DHI difference to 3.2/100 (95% CI 2.0 to 8.3) with the discharge DHI of people with anxiety not differing significantly to that of people without anxiety. However, people with dizziness and anxiety averaged 30/100 in their DHI on discharge, so were still clinically abnormal. Confirmation of a positive treatment effect on anxiety for this model of care would need future concurrent collection of a validated screening tool for anxiety such as the Generalised Anxiety Disorder-7 scale (Jordan et al., 2017; Lowe et al., 2008; Spitzer et al., 2006).

In summary, Study 4 investigations indicated the service was effective from clinical, service and consumer engagement perspectives.

9.1.5 Burden of Dizziness: Assessment of Quality of Life 8 Dimensions and Work Productivity and Activity Impairment - Specific Health Problem (Dizziness) questionnaires

The mean imputed Assessment of Quality of Life 8 Dimensions (AQOL8D) utility score of 0.58 in people with dizziness at the time of initial assessment represents approximately a 30% reduction in quality of life compared to a six-country normal population AQOL8D mean of 0.83 (Richardson et al., 2015). Further, the mean initial assessment utility score is lower than those of many chronic diseases using the AQOL8D as reported by Richardson et al. (2015). This considerable reduction in quality of life due to dizziness improved with treatment by approximately eight percent, so members of this cohort often did not return to full quality of life after treatment. One explanatory factor for this may be the high proportion of comorbid anxiety found in the group.

People with dizziness who completed the Work Productivity and Activity Impairment -Specific Health Problem (Dizziness) were statistically representative of the Study 4 cohort. Analysis of the questionnaire data found 44 people were working and 79 were not, with working groups of both genders much younger than those not working. Both groups reported significant improvement in the effect of dizziness on their regular activities outside of work. Importantly, working people with dizziness worked a mean of 8.4 hours less than an average Australian worker, amounting to AUD \$315 lost per person with dizziness in the week before completing the questionnaire and annualized, amounted to AUD \$16380 per year in 2013. This annualized figure fitted between estimates of costs for accessing health care plus lost wages for American patients with bilateral vestibular hypofunction and unilateral vestibular hypofunction (Sun et al., 2014).

With this annualization comes the assumptions that the effect of dizziness lasts for extended periods of time, that there were long waits in excess of one year at this time, that dizziness actually leads to a reduction in work, and that the WPAI:SHP (Dizziness) sample of 44 working people with dizziness represented the working population of people with dizziness. The first assumption was based on the

established longevity of dizziness experienced with people with unilateral vestibular hypofunction (Kammerlind et al., 2011; Kammerlind, Ledin, et al., 2005) where up to half of people with unilateral vestibular hypofunction reported experiencing dizziness or vertigo with head movement for between three and six years after onset of the condition. The assumption also follows numerous other reports of studies into people with dizziness including where mean dizziness longevity was at least 18 months (Nazareth et al., 1999), between 31 and 56 months (Bronstein et al., 2010), up to five years (Kroenke et al., 1992) and greater than five years (Yardley et al., 2012; Yardley et al., 1998), and applies the logic that unresolved or uncompensated vestibular dysfunction will continue to lead to episodes of dizziness until resolution. The next assumption of year-long waits is supported by the Study 4 service analysis, where the mean wait in 2013 for people with dizziness was reported at 390 days (95% CI 330, 450). The assumption that dizziness leads to lost work has been supported by studies into the effect of dizziness on work (Bronstein et al., 2010; van der Zaag-Loonen & van Leeuwen, 2015; Yardley et al., 1998). Finally, from a demographic perspective, the WPAI:SHP (Dizziness) cohort was a representative sample of the Study 4 cohort with an expected female greater than male ratio of 25:19 and with a mean age of 46.0 years (SD 12.3); 9.5 years (95% CI 7.5 to 11.4) younger than the whole cohort age as expected of the working population.

Absenteeism from work and presenteeism at work has been researched in people with dizziness. Three studies reported the percentage of people reporting having stopped work or not being able to work at 12% (van der Zaag-Loonen & van Leeuwen, 2015) and 21% (Bronstein et al., 2010; Yardley et al., 1998), with one study also reporting 11.2 days off work in the last six months for people with chronic dizziness in London (or approximately 0.5 day a week if time off is assumed to be constant over six months)(Bronstein et al., 2010). Another study considered days lost in the last three months in 13 countries (five African, seven European, one Asian), so possibly incorporating heterogenous data (Benecke et al., 2013). In this study, the mean days lost in the last three months prior to the first diagnostic visit for dizziness ranged from 8.7 days (~ 0.75 day a week) to 26.7 days (~2.5 days a week).

Thus, hours lost in these studies ranged from four hours to 20 hours a week, effectively bracketing the 8.4 hours per week of the Study 4 findings.

Presenteeism has been reported to be between 25 and 75% reduction in work efficiency for 50% of participants considered by a study into people with dizziness in London and Sienna (Bronstein et al., 2010), while 41% of working people with dizziness reported occupational difficulties and 26% difficulty in working satisfactorily (Yardley et al., 1998). This range brackets the 30% reduction in work efficiency found by the Study 4 WPAI:SHP (Dizziness) questionnaire.

### 9.1.6 Cost consequence analysis

The cost consequence analysis displayed the differences in costs between two decision tree modelled options for the management of people with dizziness. The physiotherapy option was dominant, being as effective but cheaper than the ENT option. Considering lost wages and presenteeism imposts on workplaces, Study 4 showed the burden of dizziness to be substantial. The physiotherapy-led model of care reduced this burden through reduction of waits and resolution of the dizziness.

## 9.2 Clinical implications

Ultimately, the studies in this programme of research demonstrate that a physiotherapy-led vestibular rehabilitation model of care represents high value care from both the perspectives of the person with dizziness and the health service. These studies support the premise that independently practicing, appropriately trained physiotherapists can safely screen ENT category two and three wait lists for people with dizziness, appropriately triage, and then manage these often-complex presentations successfully. For this model to be successful, physiotherapists also need to be part of a multi-disciplinary team, with local access to audiology for specific investigations and to ENT and Neurology consultants for review of complex vestibular, otolaryngologic and neurological presentations. This physiotherapy-led model, embedded within a multidisciplinary team provides a safe, productive, and efficient continuum of care for people with dizziness.

The immediate implications of the studies in this programme of research are as follows. Study 1, the pilot study, found the physiotherapy-led model of care was feasible and safe using whole cohort data, meaning a main study was needed to investigate the model of care further. This needed the informed use of outcome measures to determine effectiveness down to the level of common diagnoses and to determine whether the model was one of high value care. Study 2 established the diagnostic proportions expected by medical specialties through a systematic review and showed these have changed over time. This meant the main study patient profiles comprising demographics and diagnostic proportions could be meaningfully compared with literature-based patient profiles. Study 3 established interrater reliability between a vestibular audiologist and a vestibular physiotherapist in the accuracy of diagnoses and the referrals for vestibular rehabilitation. This permitted comparison with published audiology-led models of care and inclusion of Study 3 data in the overall Study 4 analysis. Furthermore, the high accuracy of diagnoses implied correct subsequent treatment provision by the physiotherapy-led service. The pooled analysis of data from Studies 2, 3, and 4 demonstrated the physiotherapy-led vestibular rehabilitation service to be safe, plus it was service, clinically and cost effective down to the diagnostic level for the four common diagnoses of BPPV, unilateral vestibular hypofunction, vestibular migraine and cervicogenic dizziness. These are the main implications for a prospective clinician wishing to establish their own service.

Research into the burden of dizziness by Study 4 adds to the literature with its finding of marked 30% reduction in quality of life due to dizziness using utility as a measure and an incomplete return to population norms of quality of life with treatment. Further insight has been gained into the impact on people with dizziness in terms of absenteeism and presenteeism and the effect of implementing a physiotherapy-led vestibular rehabilitation service on these aspects of patient burden. This provides more evidence for clinicians to present during their arguments to start a greenfield service. The potential to reduce waits and therefore to reduce the potentially lost wages associated with absenteeism due to dizziness, plus to reduce the impact of presenteeism on employers adds significantly to the argument. Finally, the Study 4

cost consequences analysis shows a physiotherapy-led service when available, will assist an ENT outpatient service in the management of people with dizziness through reduction in demand for ENT time, through reduction in costs and by increasing outpatient throughput.

Indirect clinical implications of establishing the physiotherapy-led model of care in a greenfield site include the potential to add expertise to the assessment of people with dizziness with a loosely formed but effective multidisciplinary team, and to add to the hospital's training capability for the management of people with dizziness. The uptake of vestibular physiotherapy has the potential to add to the output of both regional and major centre hospitals. In the regional setting where there may be a sparsity of either generalist or specialist medical staff to manage people with dizziness, vestibular physiotherapists can contribute to the acute diagnostic process of people with dizziness on wards and in emergency settings, as well as in their local, ongoing management. Treating people locally has obvious advantages over travelling to city hospitals for management. In major referral centres which have an ENT service, given the traditional referral of people with dizziness to ENT, vestibular physiotherapy has the potential to be considered a valuable component of the ENT team. The presence of vestibular physiotherapy in a hospital setting also encourages and enables the internal referral of people with dizziness for management from a wide range of specialties including infectious diseases, emergency, neurology, neurosurgery, and general medicine.

### 9.3 Setting up a new service

Key lessons gained from the set-up of the physiotherapy-led vestibular rehabilitation service may be of benefit for future greenfield site projects. These include the adoption of a formal project management process such as the Logical Framework Approach, and the use of a change management approach throughout the life of the project such as Kotter's eight steps of change model.

An effective project framework aids in planning the hierarchy of project outcomes; this research programme recommending the use of the Logical Framework Approach (Dearden, 2005) (see Fig 9.1 below). Each step in the approach informs the next, building a coherent and inclusive plan to follow, with regular reviews encouraged of the Logframe matrix and Monitoring and Evaluation Framework. Examples of activities within the Logframe matrix hierarchy of goals are shown in Figure 9.1.

The use of change management processes is valuable in project management to prevent project failure. A description of the use of the principles of Kotter's eight steps of change (Kotter & Rathgeber, 2006) follows. These steps include developing a sense of urgency, building a guiding team, create a vision, communicating the vision, empower action through breaking down barriers and encouragement, generating and celebrating short term wins, maintaining pressure for change, and instituting the change in business as usual (Kotter, 1995).

Analysis of literature evidence in combination with an audit of ENT wait lists was used to develop a simple consistent vision for stakeholders - a physiotherapy-led vestibular screening and rehabilitation service is safe, and clinically, service and cost effective.

- Establishing local demand using an audit of specialist outpatient lists,
- Recording service and clinical outcomes in a database,
- Developing an effective multidisciplinary team including audiology, ENT and physiotherapy.
- Making grant applications to fund clinical backfill
- Analysing wait lists, literature review, stakeholder needs
- Creating a Stakeholder Analysis framework- considering the following

Stakeholders Impact I name project	y Influence on project	Stake	Contributions	Barriers	Engage strategies
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 Problem Tree to Solution Tree- identifying the main problem's causes and effects and then change the problems into a solutions



Creating a Logframe matrix- solution tree causes become project activities and

main problem the project outcome, using horizontal and vertical logic

Hierarchy	Summary	Indicators	Verification	Assumptions/Risks
Goal				
Project				
Outcomes				
Outputs				
Activities				

Monitoring and evaluation framework populated by each Logframe line

outcome indicator definition baseline target data frequency responsible reporting
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Figure 9.1 Logical Framework Approach processes

At the time in the state of Queensland, Australia, there was both political and health service will to address specialist wait lists with large numbers of long waits using underutilised allied health professionals (Young et al., 2015). A pilot study of the model of care based on the vision was proposed to the allied health alternative models of care project, creating a sense of urgency (Queensland Health, 2013b). To gain support with the change to a new model of care, the project created a supportive, visionary team including physiotherapy and audiology department, medical and executive champions. Communicating the vision for buy-in used a multimedia approach with face-to-face meetings internally and externally to the hospital, email, and presentations at conferences. Results based on pilot study outcomes broke down barriers using inservice opportunities, using the training of physiotherapists and audiologists and using face-to-face meetings with key stakeholders such as ENT and neurology consultants, and departmental and executive champions. Once implemented, the model's short-term wins (the pilot study outcomes) were reported and celebrated. Maintenance of a consistent effort over the five years of the research programme employed the use of the simple message, presentations of the model of care whenever given the opportunity, and adoption of an ongoing training effort for physiotherapists rotating in for a year's practice in the service. These strategies ensured sustainability of the model of care and continually removed barriers. Finally, instituting the vestibular service through ensuring newcomers to the service were fully aware of the model's effectiveness and had training in its function, plus continuing the relationships within the clinical team of physiotherapists, audiologists, ENT surgeons and neurologists led to embedding the vestibular service culture into hospital processes.

Within this structure of a Logframe approach facilitated using Kotter's eight steps of change, three notable learnings informed the model of care.

 First, the ultimate goal of any project should be sustainability. In the case of the physiotherapy-led vestibular rehabilitation model of care, this was facilitated using clinical data to justify the service and by ensuring departmental processes enabled succession planning for practitioners through education and clinical rotation. Data analysis demonstrated the service's effectiveness, not only in clinical outcomes, but also in service outcomes including the reduction in the demand on ENT specialist input, and the reduction in waits for people with dizziness. Once operating, the service needed to be resistant to staffing pressures exerted by a sole operator model. To counter this risk, the vestibular rehabilitation service generated up to five one day lists to be seen by five trained clinicians.

Secondly, from the onset, the practitioner needs to consider barriers to change, which may be numerous. A qualitative study into perceived barriers, supports and incentives to the sustainable implementation of extended scope physiotherapy in Australia, reported the top five themes raised by relevant expert clinicians in a tertiary hospital included formal training, quality of practice, definition of extended practice, legislative changes, and recruitment (Morris et al., 2014). The theme of formal training was complex, drawing from the in-house training experiences of physiotherapists in the National Health Service of the UK (Morris et al., 2014). In the case of the current practice of vestibular rehabilitation as advanced practice physiotherapy, these concerns are likely to focus on the level of training since medication prescription and legislative change are not involved. Hence concerns will most likely come from the medical hierarchy due to differences in training and practice between the professions (Durrell, 1996) and from financial constraints raised by the allied health directorate.

Physiotherapists need to use the evidence from the literature showing the value of advanced practice physiotherapy (for example Desmeules et al., 2012), to demonstrate their clinical knowledge of vestibular rehabilitation area, and to demonstrate knowledge of patient list audit analysis to present the case for change. They also should be able to demonstrate their practice credentials whether it be evidence of training or by availing themselves for opportunities for medical supervision or credentialling. Value adding through the provision of opportunities for training and research may further help with these barriers. Funding clinical backfill through research grants is usually a primary way to get

a service operating but this does not create a sustainable service. Expanding into a recurrently funded service needs guidance by the departmental director and may include a business case for change. Ultimately, Kotter's guiding team (Kotter, 1995) of the departmental director and medical champions projecting the vision are key participants in the reduction of barriers.

 Finally, consider accelerants to the process. In the case of the physiotherapyled vestibular rehabilitation service, this was in the state government's political will for change; for allied health practitioners to practice at full or advanced scope to help with the demand on busy specialist outpatients services like ENT (Queensland Health, 2014; Young et al., 2015).

A proposal for a new service that incorporates these three considerations together with not only clinical benefit for people with dizziness, but also service effectiveness, client satisfaction, cost effectiveness, and opportunities for training and research, makes it a comprehensively persuasive one.

### **9.4** Impact of the physiotherapy-led vestibular rehabilitation service

When given the opportunity to roll out the model of care across Queensland, the learnings gained in Studies1 to 4 were demonstrated and then applied successfully. The pilot study findings enabled application for the Vestibular Collaborative project funded by Allied Health Professions Office Queensland and conducted between 2015 and 2017. This fitted into the political and medical need and willingness to expand allied health scope of practice, in this case audiology and physiotherapy, to assist traditionally medically-orientated models of care existing in public hospitals at the time (Queensland Health, 2014). As a result, six major hospitals across the state currently have recurrently funded, locally adjusted models of physiotherapy-led vestibular rehabilitation assisting their ENT or neurology outpatient services. More hospital services are pending. Recurrent funding was achieved through the collection of service and clinical data and the use of the analysed results to demonstrate effectiveness in managing outpatients with dizziness. Continuing to gather data and enter it into a state-wide allied health database has enabled these

six services to produce combined reports of outcomes as evidenced in Figure 9.1 below. In 2017, the Vestibular Collaborative project successfully transitioned into the Queensland Vestibular Network; a formal, multi-disciplinary network aiming to promote networking, education, clinical support and research for both audiologists and physiotherapists with interests in vestibular rehabilitation in the state's public and private health care sectors.

By 2021, the physiotherapy-led vestibular rehabilitation service at the Royal Brisbane and Women's Hospital had grown into a recurrently funded, one full time equivalent service comprising five physiotherapists accepting primary contact referrals from ENT, GP, and neurology and secondary contact referrals from all hospital medical departments. Each physiotherapist serviced a one-day list, seeing two new people with dizziness requiring 75-minute assessments and seven 30-minute reviews. This number of clinicians with advanced skills in vestibular physiotherapy at any one time ensures capacity to meet the demand for vestibular physiotherapy from both inpatients and outpatients in this large quaternary referral hospital. Having five trained physiotherapists practicing at once also ensures sustainability of the service from a human resources perspective, permits in-reach for consultation and treatment to the hospital acute wards, and importantly, provides ongoing, work-based supervision of newly trained physiotherapists by advanced practice clinicians.

Allied Health Specialst Clinics Project

# Vestibular Specialist Clinics Combined Report

1st April 2016 – 31st March 2019 for 6 clinics







### Patient status on SOPD waitlist following discharge Remained/Reinstated on SOPD waitlist



Apr 16 - Oct 16 - Apr 17 - Oct 17 - Apr 18 - Oct 18 Sep 16 Mar 17 Sep 17 Mar 18 Sep 18 Mar 19



Clinician requested Patient requested Consultant initiated

#### Of the 838 clinic attendees:

- · 24% were referred to other medical professional/s.
- 10% had further investigations initiated.
- · 2% had an earlier medical review facilitated.



# Figure 9.2 Vestibular Specialist Clinics Combined Report August 2018

In-house training of *ab initio* clinicians included education by the vestibular service team - the doctoral candidate and experienced colleagues - through a formal process of didactic workshops, clinical observation opportunities, and supervised clinical practice - to advance clinical competence in vestibular rehabilitation. External training included the attendance and contribution to scientific meetings of the Neuro Otological Society of Australia, attendance and contribution to vestibular rehabilitation competency training courses offered locally, nationally, and internationally, and involvement in local in-service and training programmes such as for emergency departments. Benefits of this training process include independence from need for external training of new vestibular physiotherapists, the clinical education benefit to the trainers and the ongoing benefits of networking. However, no formal qualifications or external recognition result from this training process, nor is there any measure of competency as is suggested would be valued for extended scope physiotherapy training (Morris et al., 2014).

### 9.5 Limitations

Limitations of this doctoral programme of research are acknowledged and include:

**Loss to follow-up** - Telephone follow-up by a research assistant was conducted in 2016 for all patients with missing data from Studies 2 and 4 (greater than 50 participants were followed up in this effort). Telephone follow-up was discontinued after 2016 due to poor yield of completed data. Included in the phone contacts was assistance with completing the questionnaires when questions arose, plus encouragement to send in completed questionnaires using mailed out stamped envelopes.

Study 4 dropout from patient-reported outcomes of Dizziness Handicap Inventory, Activities-specific Balance Confidence scale, and Assessment of Quality of Life 8 Dimensions necessitated the use of multiple imputations to investigate the effect of lost data. This was in line with the normal critical appraisal of cohort studies considering the follow up of participants and whether lost data biased results and has been accounted for in the analysis (Clinical Appraisal Skills Programme, 2020; Joanna Briggs Institute, 2020). Where appropriate, paired vs. paired imputed statistics have been presented to enable an appreciation of the effect of the imputation process. Despite the loss of data, the imputed and paired data produced similar results for these variables, indicating the loss of data may not have changed the outcome behaviour with treatment. Analysis in Study 4 considered subgroup diagnoses, countering the effect of confounding variables due to different behaviour by the common diagnoses.

The missing data as stated above largely arose from many clinically and research appropriate single occasions of service with a much smaller portion due to genuine dropout. This occurred throughout Studies 2 and 4 and may be an inherent limitation to the study of this subacute to chronic population of people with dizziness. Factors affecting drop out might include amongst others, a combination of clinical success with interventions and conditions self-resolving over time. Benign paroxysmal positional vertigo and unilateral vestibular hypofunction, which form more than 50 percent of the population when combined (based on Study 4 clinical findings and reports in other contexts), are notable conditions that both can resolve quickly with initial assessment and treatment (people with BPPV in Study 4 had 18 percent single occasions of service) and can self-resolve over time; thus, potentially contributing to this drop out behaviour.

Less common diagnoses- The low case numbers of less common diagnoses in these research studies was supported by the prevalence rates described in the systematic review. Low numbers of cases with diagnoses such as bilateral vestibular hypofunction, Meniere's' disease, persistent postural perceptual dizziness, superior canal dehiscence and autoimmune disease meant statistical analysis was not appropriate nor possible. The synthesized proportions of these diagnoses outlined in the systematic review Chapter 3 supports the findings that the common diagnoses of vestibular dysfunction in these research studies were benign paroxysmal positional vertigo, unilateral vestibular hypofunction, vestibular migraine, and cervicogenic dizziness.

**Sample size for burden of dizziness questionnaires-** The working participant dependency component of the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire was impacted by the number of responses

from participants who were of working age (n= 44 working participants). This limited the ability to report findings about lost wages. The confidence intervals produced (see cost consequences analysis Table 8.1) indicated a reasonable level of confidence in the overall costs by diagnosis and more importantly, produced consistent differences between the options of physiotherapy-led and ENT-led models. However, due to the age range of people recruited for the research studies, the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) did not produce meaningful data relevant for people with dizziness who were no longer or not able to work. Future studies investigating the burden of dizziness need to explore other tools to investigate the impact on work productivity and activities outside of work.

Lack of control groups- This programme of research used a prospective, observational study design for each of the four studies conducted. Randomised, controlled designs such as wait list controls or ENT service management would ideally have allowed an understanding of confounding factors such as maturation and natural recovery in the case of wait list design and for testing procedure bias with ENT management control. A greater claim to clinical and service effectiveness with access to control data would have been permitted. Further, ENT control would have enabled the collection of ENT generated utility and therefore permitted a cost utility analysis as well as the cost consequences analysis. However, the desired health service deliverable when the service commenced was for the service to have an immediate effect on wait list times and on wait list throughput. This through reducing the number of people with dizziness waiting for ENT review by appropriate screening and management by a physiotherapy-led service. The clinical costings undertaken as part of this programme of research support this health service deliverable.

**Risk of bias-** Epidemiological bias or non-causal associations between exposures and outcomes are assumed to be present to some degree in observational studies and represent a challenge to the validity of any causal inferences made. Effective study design helps to eliminate bias depending on the type (Choi & Pak, 2005; Lipsitch et al., 2010). For example, in the methodology of all studies reported by this thesis, a full assessment process for all study participants with dizziness, plus assistance provided in the completion of questionnaires, aimed to eliminate mismeasurement or information bias. Acceptance of all Category Two and Three ENT referrals of people with signs, symptoms, or a diagnosis of vestibular dysfunction for inclusion in the study prevented participant selection bias,

Confounding bias occurs in the analysis of results (Choi & Pak, 2005) and to some degree has been accounted for through use of statistical technique to investigate the pre and post measurements of outcomes by, for example, diagnoses or by gender. As examples, this thesis considered confounding bias through its reporting of the demographic bias towards females in all clinical studies of people with dizziness. In the service analysis, the thesis acknowledges the increase in occasions due to the study design requiring review to confirm resolution of diagnosed conditions. In the analysis of effect of dizziness on productivity, the sample of participants in Study 4 who completed the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) questionnaire were statistically compared to the total cohort of Study 4 in terms of gender, age and diagnostic proportions and found to be representative. Conclusions drawn from the analysis of the Work Productivity and Activity Impairment: Specific Health Problem (Dizzinest) were deemed applicable to the whole Study 4 cohort.

Examples of confounding bias in this study not explored in detail perhaps include the high proportion of people with both vestibular dysfunction and concomitant hearing dysfunction and or anxiety. Accounting for either co-occurring diagnosis during statistical analysis may have had serious impact on cohort numbers (Choi & Pak, 2005).

As such, this PhD analysis of the new physiotherapist-led model of care using observational pre and post intervention treatment data sets the scene for further studies using randomised controlled trials testing for example, agreement in diagnoses between clinicians (for example between ENT and Physiotherapists), testing of treatment and service outcomes efficacy, analysing consumer outcomes and a full cost utility analysis with comparison of ENT and physiotherapy service costs and quality of life gained.

Conflict of interest risk- Conflict of interest is an inherent aspect of research into one's own model of care (Nicolini & Wendler, 2020). Classic conflicts include the potential for monetary gain, which did not exist in this PhD programme conducted in the public sector by an already fully employed clinician and his team members, and the conflict of clinician investigators being the treating clinician, which did exist. In the planning phase, all studies gained ethical approval from the relevant human research ethics committees. In the clinical phase, one additional level of review might have been to have an independent clinician witness all consenting processes at the time of initial assessment, but this was not practical in Studies 2 and 4. However, it was conducted in Study 3. The PhD researcher initially screened, assessed, and treated people with dizziness alone but once the hospital service was established recurrently, additional physiotherapy staff were trained for the service and engaged the studies' participants clinically. This reduced the likelihood of biased outcomes particularly in Studies 3 and 4. There were a wide number of outcome measures used by this research collected both by the researcher, the other service staff and by the clinical costings department in the case of the clinical costings for burden analysis. No apparent bias was found except for more young people dropping out of follow up. This might reflect bias by the participants against one researcher if that was the clinician they saw or might reflect a dissatisfaction with the service in general.

On reflection, the Study 2 pilot study, was the only study with a serious risk of conflict of interest and that only due to the investigating clinician being the treating clinician as well.

### 9.6 Strengths

Notable strengths included a number of firsts for the project:

- First study of the management of people with dizziness to compare the costs of a physiotherapy-led service to the traditional ENT-led model using a cost consequences analysis.
- First study to use the Assessment of Quality of Life 8 Dimensions and in particular Assessment of Quality of Life 8 Dimensions utility, to assess the effect of treatment on people with dizziness.
- First study to investigate the independent practice of physiotherapy in managing people with dizziness from ENT wait lists.
- First study of a physiotherapy-led vestibular rehabilitation model of care in Australia
- Study 4 contributed to the understanding of tangible measures of burden of dizziness in terms of lost wages (absenteeism) and effects on workplaces (presenteeism).
- Study 4 collected sufficient cases to enable statistical analysis of clinical and service outcomes of commonly occurring diagnoses.
- Study 4 identified and accounted for the loss of discharge questionnaire data using multiple imputations for key clinical outcomes, in line with expectations of critical appraisal practices. Given the high proportion of single occasions of

service encountered by this study and other reported services indicates a norm for this population of people with dizziness, the transparent management of data loss using multiple imputations represents a high standard in outcome analysis.

The impact of the doctoral programme of research ultimately contributed to a statewide roll out of the model of care at regional hospitals and to the creation of the Queensland Vestibular Network. This multi-disciplinary clinical network continues to support clinicians in service development, clinical training and mentoring, and ongoing professional development plus it promotes research into vestibular rehabilitation and advocates for the professions involved.

## **9.7** Future directions

Further studies indicated from this doctoral programme of research include:

- A cost utility analysis with a full comparison of two models of care (ENT and physiotherapy) either from a multi-centre trial or using a randomised assignment for wait listed people with dizziness to ENT or physiotherapy, and thus using a large data set of cases for costs and quality of life outcomes. The current doctoral programme of research was not able to collect the quality-oflife outcomes for the ENT model of care, hence the cost consequences analysis reported. Cost utility analyses consider outcomes in terms of cost effectiveness ratios which enable direct comparison with other models of care and human conditions.
- Further analysis of tangible measures of the burden of dizziness by increasing the sample size of repeated measures of the Work Productivity and Activity Impairment: Specific Health Problem (Dizziness) plus the use of another tool to measure change in burden in non-working people with dizziness.

- A study using a formal, repeated, patient-reported screening measure for anxiety, investigating the management of people with dizziness plus anxiety in Australia. Such a study might include repeated measures of the Generalised Anxiety Disorder- 7 (GAD-7) as a screening measure for associated anxiety.
- A multi-centre trial of vestibular rehabilitation in Queensland Health hospitals to gain case numbers sufficient to permit the confident analysis of the less common diagnoses such as bilateral vestibular hypofunction, Meniere's Disease, superior canal dehiscence, persistent postural perceptual dizziness and autoimmune disease.
- Future concurrent diagnosis interrater reliability trials between vestibular physiotherapy and ENT and/or neurology consultants could potentially add to the confidence in the vestibular physiotherapeutic management of people with dizziness referred from specialist outpatient wait lists.

Ultimately, for widespread acceptance in at least the Australian and British medical systems, a published body of evidence investigating and supporting the physiotherapy-led vestibular rehabilitation model of care is necessary. Allied health professionals such as physiotherapists are routinely viewed in these health systems as first contact practitioners or have avenues of development to gain first contact practitioner status. The recent growth in awareness of the efficacy of physiotherapy in managing suitable screened people with dizziness has the potential to push this patient-acceptable, and service, clinical and cost-effective model of care into wider service in these countries.

### 9.8 Conclusions

Dizziness and vertigo are symptoms representing a notable health issue for both the people with dizziness and the system they access for its resolution. The doctoral

programme of research investigated a physiotherapy-led vestibular rehabilitation service which aims to resolve such symptoms and showed that accessing the right clinician in the right time and place through this service safely and effectively managed the dizziness and potentially reduced the burden of dizziness and vertigo for all. Multi-disciplinary vestibular screening and rehabilitation services including key service provision by advanced scope physiotherapy practitioners, and flexibly drawing upon a team of health practitioners including audiologists, ENT surgeons, general practitioner's, neurologists and psychologists, represent important value to community-based people with vestibular disorders and associated burden of dizziness.

Exploration of the physiotherapy-led vestibular rehabilitation service model of care through a series of prospective observational studies collecting service, safety, clinical, cost, reliability and consumer engagement outcomes provided clear evidence of the high value care represented by this model. Notable achievements of the service included the reduction of wait times to within wait category criteria and effective management of vestibular dysfunction for common diagnoses including improved quality of life, reduced burden of dizziness, and superior cost effectiveness. The service was notable for its quick throughput of patients, rapid restoration of function through safe, clinical and cost-effective interventions, and resultant encouragement of primary health through normal movement. The physiotherapy-led model of care has shown a translation of these results into other services in Queensland managing comparable populations of ENT people referred with dizziness or vertigo. Obvious improvements in outcomes with no adverse effects and economical demands on ENT time for review of red flag cases should make this model of care attractive to ENT outpatient departments.

### Appendices

### Appendix 1 Study 2 Pilot Study ethics



Metro North

Hospital and Health Service

#### Royal Brisbane & Women's Hospital Human Research Ethics Committee

Enquiries to: Telephone: Facisimile: File Ref; Email: Ann-Marce Gordon A/Coordinator 07 3646 5490 07 3646 5849 HREC/15/QRBW/141 RBWH-Ethics@health.gld.gov.au

Mr Ian Parker RBWH GARU Physiotherapy Rosemount Hospital Cartwright Street Windsor Q 4030

Dear Mr Parker,

#### Re: Ref Nº: HREC/15/QRBW/141: RBWH Vestibular Service Model of Care Trial

Thank you for submitting the above research project for single ethical review. This project was received by the Royal Brisbane & Women's Hospital Human Research Ethics Committee (RBWH HREC) (EC00172) on 31 March 2015 and was considered by a sub-Committee of the HREC.

I am pleased to advise that the sub-Committee approved of this low risk project. This approval was ratified by the RBWH Human Research Ethics Committee at its 11 May 2015 meeting.

The opt-out consent process was considered justified in accordance with National Statement 2.3.6 and is approved.

For information on submitting a Public Health Act (PHA) application, please visit the Health and Medical Research website at: <u>http://www.health.qld.gov.au/ohmr/html/regu/aces\_conf\_hth\_info.asp</u>

The nominated participating site for this project is:

· Royal Brisbane & Women's Hospital, Qld

This letter constitutes ethical approval only. This project cannot proceed until separate research governance authorisation has been obtained from the CEO or Delegate of the Royal Brisbane & Women's Hospital under whose auspices the research will be conducted.

The approved documents include:

Royal Brisbane & Women's Hospital Level 7 Block 7 Butterfield Street, Herston Qid 4029 Australia Telephone +61 7 3646 5490 Facsimile +61 7 3646 5849 www.health.gld.gov.au/bwh/research/hrec.asp Royal Brishane & Women's Hospital HREC Ref No: IIREC/15/ORBW/141

Document	Version	Date
Covering Letter		30 May 2015
Low or Negligible Risk Research Application (Submission Code: AU/10/98FD111)	1.0 (2011)	29 March 2015
Protocol	5	30 March 2015
Participant Information Letter & Op-Out Consent Form	4	16 March 2015

2

Approval of this project from the RBWH HREC is valid from 27.04.2015 to 27.04.2018 subject to the following conditions being met:

- The Coordinating Principal Investigator will immediately report anything that might warrant . review of ethical approval of the project.
- The Coordinating Principal Investigator will notify the RBWH HREC of any event that . requires a modification to the protocol or other project documents and submit any required amendments in accordance with the instructions provided by the HREC. These instructions can be found at http://www.health.qld.gov.au/rbwh/research/hrec.asp.
- The Coordinating Principal Investigator will submit any necessary reports related to the ٠ safety of research participants in accordance with the RBWH HREC policy and procedures. These instructions can be found at http://www.health.qld.gov.au/rbwh/research/hrec.asp.
- In accordance with Section 3.3.22 (b) of the National Statement the Coordinating Principal . Investigator will report to the RBWH HREC annually in the specified format, the first report being due on 27.04.2016 and a final report is to be submitted on completion of the study. These instructions can be found at http://www.health.qld.gov.au/ohmr/html/regu/reporting\_templates.asp.
- The Coordinating Principal Investigator will notify the RBWH HREC if the project is . discontinued before the expected completion date, with reasons provided.
- The Coordinating Principal Investigator will notify the RBWH HREC of any plan to extend the duration of the project past the approval period listed above and will submit any associated required documentation. Instructions for obtaining an extension of approval can be found at http://www.health.qld.gov.au/rbwh/research/hrec.asp.
- The Coordinating Principal Investigator will notify the RBWH HREC of his or her inability to continue as Coordinating Principal Investigator including the name of and contact information for a replacement.
- A copy of this ethical approval letter together with completed Site Specific Assessment (SSA) and any other requirements must be submitted by the Coordinating Principal Investigator to the Research Governance Office at the Royal Brisbane & Women's Hospital

12.05 2015

Royal Brisbane & Women's Hospital HREC Ref No: HREC/15/QRBW/141 3

12.05.2015

in a timely manner to enable the institution to authorise the commencement of the project at its site.

Should you have any queries about the RBWH HREC's consideration of your project
please contact the HREC Coordinator on 07 3646 5490. The RBWH HREC's Terms of
Reference, Standard Operating Procedures, membership and standard forms are available
from <a href="http://www.health.qld.gov.au/rbwh/research/hrec.asp">http://www.health.qld.gov.au/rbwh/research/hrec.asp</a>.

The RBWH HREC wishes you every success in your research.

Yours sincerely,



Chairperson RBWH Human Research Ethics Committee Metro North Hospital and Health Service 12.05.2015

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007). The processes used by this HREC to review research proposals have been certified by the National Health and Medical Research Council.





to: Professor Laweie Powell Director of Research MNHHS-RHWH CACR 87 3646 2352

Royal Brisbane and Women's Hospital Metro North Hospital and Health Service

Mr Ian Parker **RBWH GARU Physiotherapy Rosemount Hospital Cartwright Street** Windsor Q 4030

Dear Mr Parker,

#### Re: Ref Nº: HREC/15/QRBW/141: RBWH Vestibular Service Model of Care Trial

Thank you for submitting your research protocol approved by Royal Brisbane & Women's Hospital Human Research Ethics Committee (RBWH HREC) (EC00172) on the 27 April 2015. I am pleased to inform you that authorisation has been granted for this study to be conducted at the MNHHS-Royal Brisbane and Women's Hospital. Your trial meets the principles and practices set out in the Australian Code for the Responsible Conduct of Research (2007 Universities Australia, updated 2014) and the ICH Harmonised Tripartite Good Clinical Practice (GCP) Guidelines.

The following documents approved by above mentioned HREC are specifically accepted for the MNHHS-RBWH site:

Document	Version	Date
Covering Letter		7 July 2015
Low or Negligible Risk Research Application (Submission Code: AU/10/98FD111)	1.0 (2011)	29 March 2015
Low or Negligible Risk SSA Research Application (Submission Code: AU/11/B16F110)	1.0 (2011)	10 June 2015
Protocol	5	30 March 2015
Participant Information Letter & Op-Out Consent Form	4	16 March 2015

When submitting electronically an HREC approved amendment to the RGO please email to <u>RBWH-RGO@health.gld.gov.au</u> and provide the description and the rationale for it and attach the related documents that have been approved. This will assist in the governance review to see if any further documentation is required for our MNHHS-RBWH site.

When the study commences please complete the Commencement form and send it to the HREC office with a copy to the Research Governance office. If you have any questions relating to this authorisation please contact the Research Governance Officer on 3646 8579.

I wish you continued success with your research.

Yours sincerely

Professor Lawfie Powell AC MD PhD Director of Research, MNHHS-RBWH, Centre for the Advancement of Clinical Research 11/15 ć.

Royal Brisbane and women's r	inspiral - we don't smoke neve i	infinite		
Office Royal Brisbane and Women's Hospital Butterfield Street Herston	Postal Post Office Herston 4029	Phone (07) 3646 8111	Fax (07) 3646 4240	

External review thesis 7/2/21

### Appendix 2 Study 3 Interrater Reliability Trial ethics



Metro North Hospital and Health Service

#### Royal Brisbane & Women's Hospital Human Research Ethics Committee

Enquiries to: Telephone: Facisimile: File Ref: Email:

Ann-Marce Gordon A/Coordinator 07 3646 5490 07 3646 5849 HREC/15/QRBW/142 RBWH-Ethics@health.qld.gov.au

Mr Ian Parker RBWH GARU Physiotherapy Rosemount Hospital Cartwright Street Windsor Q 4030

Dear Mr Parker,

#### Re: Ref Nº: HREC/15/QRBW/142: RBWH and Logan Hospital Vestibular Assessment Reliability Trial

Thank you for submitting the above research project for single ethical review. This project was received by the Royal Brisbane & Women's Hospital Human Research Ethics Committee (RBWH HREC) (EC00172) on 31 March 2015 and was considered by a sub-Committee of the HREC.

I am pleased to advise that the sub-Committee has approved of this low risk project. This approval will be noted by the RBWH Human Research Ethics Committee at its 11 May 2015 meeting.

The nominated participating site for this project is:

- · Royal Brisbane & Women's Hospital, Qld
- Logan Hospital, Qld

This letter constitutes ethical approval only. This project cannot proceed at any site until separate research governance authorisation has been obtained from the CEO or Delegate of the institution under whose auspices the research will be conducted at that site.

The approved documents include:

Royal Brisbane & Women's Hospital Level 7 Block 7 Butterfield Street, Herston Qld 4029 Australia Telephone +61 7 3646 5490 Facsimile +61 7 3646 5849 www.health.qld.gov.au/rbwh/research/hrec.asp Royal Brisbane & Women's Hospital HREC Ref No: HREC/15/QRBW/142

Document	Version	Date
Covering Letter		30 March 2015
Low or Negligible Risk Research Application (Submission Code: AU/10/A8FD110)	1.0 (2011)	29 March 2015
Protocol	3	30 March 2015
Participant Information Sheet & Consent Form	2	30 March 2015
Data Sheet	1	27 March 2015

2

Approval of this project from the RBWH HREC is valid from 29.04.2015 to 29.04.2018 subject to the following conditions being met:

- The Coordinating Principal Investigator will immediately report anything that might warrant review of ethical approval of the project.
- The Coordinating Principal Investigator will notify the RBWH HREC of any event that
  requires a modification to the protocol or other project documents and submit any
  required amendments in accordance with the instructions provided by the HREC. These
  instructions can be found at <u>http://www.health.qld.gov.au/rbwh/research/hrec.asp.</u>
- The Coordinating Principal Investigator will submit any necessary reports related to the safety of research participants in accordance with the RBWH HREC policy and procedures. These instructions can be found at http://www.health.qld.gov.au/rbwh/research/hrec.asp.
- In accordance with Section 3.3.22 (b) of the National Statement the Coordinating Principal Investigator will report to the RBWH HREC annually in the specified format, the first report being due on 29.04.2016 and a final report is to be submitted on completion of the study. These instructions can be found at <a href="http://www.health.qld.gov.au/ohmr/html/regu/reporting\_templates.asp">http://www.health.qld.gov.au/ohmr/html/regu/reporting\_templates.asp</a>.
- The Coordinating Principal Investigator will notify the RBWH HREC if the project is discontinued before the expected completion date, with reasons provided.
- The Coordinating Principal Investigator will notify the RBWH HREC of any plan to extend the duration of the project past the approval period listed above and will submit any associated required documentation. Instructions for obtaining an extension of approval can be found at <u>http://www.health.qld.gov.au/rbwh/research/hrec.asp</u>.
- The Coordinating Principal Investigator will notify the RBWH HREC of his or her inability to continue as Coordinating Principal Investigator including the name of and contact information for a replacement.

Royal Brisbane & Women's Hospital HREC Bef No: HREC/15/QRBW/142 3

- 29.04.2015
- A copy of this ethical approval letter together with completed Site Specific Assessment (SSA) and any other requirements must be submitted by all site Principal Investigators to the Research Governance Office at each participating institution in a timely manner to enable the institution to authorise the commencement of the project at its site/s.
- Should you have any queries about the RBWH HREC's consideration of your project
  please contact the HREC Coordinator on 07 3646 5490. The RBWH HREC's Terms of
  Reference, Standard Operating Procedures, membership and standard forms are available
  from <a href="http://www.health.qld.gov.au/rbwh/research/hrec.asp">http://www.health.qld.gov.au/rbwh/research/hrec.asp</a>.

The RBWH HREC wishes you every success in your research.

Yours sincerely,



Chairperson RBWH Human Research Ethics Committee Metro North Hospital and Health Service 29.04.2015

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007). The processes used by this HREC to review research proposals have been certified by the National Health and Medical Research Council.



#### 07 October 2015

Ms Sonia Hancock Research Governance Manager Centres for Health Research Princess Alexandra Hospital Metro South Health Tel: 07 3443 8046 email. sonia.hancock@health.gld.gov.au

Dear Ms. Sonia Hancock,

Re: Addition of the reliability phase of Study 3 to the Research Collaboration Agreement dated 1<sup>st</sup> of June 2015 for the Project entitled "A comparison of clinical and cost effectiveness between the Physiotherapist-led Royal Brisbane and Women's Hospital Vestibular Screening and Rehabilitation Service and the Audiologist-led Logan-Mater Hospitals Vestibular Dysfunction Screening Service"

I am writing with regard to the above mentioned Project where Prof. Nancy Low Choy is the principal supervisor of ACU PhD candidate lan Parker.

Following the execution of the Research Collaboration Agreement entered into between Metro South Hospital and Health Services via the Logan Hospital and ACU dated 1<sup>st</sup> of June 2015, approval has been obtained to undertake an <u>inter-tester reliability study</u> as a subcomponent of the main Phase 3 Study being undertaken by Ian Parker. The project is titled: RBWH and Logan Hospital Vestibular Assessment Reliability Trial

- The reliability study has been approved under HREC Number: HREC/15/QRBW/142
- The main Phase 3 study and protocol is approved undertaken under HREC Number: HREC/14/QRBW/86.

The addition of a reliability study will determine the level of agreement in the assessments undertaken by the Physiotherapist, (leading the model of care at RBWH) and the Audiologist (leading the Logan-Mater Service). The same protocol is being used in the initial assessment approved under the main study (HREC / 14 QRBW/86). The reliability study was added to the Phase 3 study following a recommendation by the confirmation committee who reviewed the PhD Program being undertaken by Mr Ian Parker.

If you could please arrange for this letter to be signed and return a scanned copy of this letter to me to acknowledge the addition that would be greatly appreciated.

Please contract Dr. Lihong Kong on 02 9739 2105 or via email Lihong.kong@acu.edu.au if you need any further information.

Yours sincerely,



(Name and signature) Metro South Hospital and Health Service via The Logan Hospital ABN 86 834 068 616 (Name and signature)

Australian Catholic University Limited ABN 15 050 192 660

### Metro South Health



Enquiries to: Phone: Fax: Our Ref: E-mail

s to: Centres For Health Research Research Governance (07) 3443 8050 (07) 3443 8050 HREC/15/QRBW/142 - SSA/15/QPAH/592 PAH-Research@health.gid.gov.au

Mr lan Parker RBWH Physiotherapy Department Royal Brisbane & Women's Hospital Herston QLD 4029

#### SSA AUTHORISATION LOGAN HOSPITAL METRO SOUTH HOSPITAL AND HEALTH SERVICE

#### HREC Reference number: HREC/15/QRBW/142

SSA reference number: SSA/15/QPAH/592

Project title: RBW and Logan Hospital Vestibular Assessment Reliability Trial

#### Dear lan,

Thank you for submitting your application for authorisation of this project. On the recommendation of the Human Research Ethics Committee (HREC), I am pleased to inform you that approval is granted for your project to proceed at the Logan Hospital.

This approval is subject to researcher(s) compliance throughout the duration of the research with certain requirements as outlined in the National Statement on Ethical Conduct in Human Research 2007 and Australian Code for the Responsible Conduct of Research.

#### The duration of this study approval is up until expiration of the reviewing HREC's approval.

The following conditions apply to this research proposal. These are additional to those conditions imposed by the approving HREC.

- SAEs: Where serious adverse events (SAEs) are encountered, during the course of the study which may have ethical implications. Research Governance Office must be notified as soon as possible. <u>http://www.health.gld.gov.au/pahospital/research/adverse\_events.asp</u>
- 2. Proposed amendments to the research protocol or conduct of the research which may affect the ongoing ethical acceptability of the project and/or the site acceptability of the project are to be submitted firstly to the HREC for review and then to the research governance office after a HREC decision is made. A copy of the HREC approval/rejection letter must be submitted to the RGO.
- Lapsed Approval: If the study has not commenced within twelve months approval will lapse requiring resubmission of the study to the approving HREC.

Office	Postal	Phone	Fax	
Centres for Health Research	37 Kent Street	61 7 3443 8050	61 7 3443 8003	
Princess Alexandra Hospital	Woolloongabba Qld 4102			
Metro South Hospital and Health				
Service				

- 4. Annual Reviews: All studies are required by the NHMRC to be reviewed annually and reported to the relevant HREC within the 12 month reviewing period. The MS HREC Annual Report template is accessed through the MS HREC website http://www.health.qld.gov.au/pahospital/research/monitoring.asp
- 5. Ongoing duty of care must be followed regarding confidentiality of public information and patient privacy, when research involves the recruitment of Metro South Hospital and Health Service (MSHHS) patients. You are required to comply at all times the Australian and Queensland Laws including the Health Services Act, the Privacy Act, Public Health Act (2005) and other relevant legislation, ethics obligations and guidelines which are applicable to the MSHHS including any requirement in respect of the maintenance, preservation or destruction of patient records.

We wish you every success in undertaking this research.

Yours sincerely,



Prof Ken Ho, Chair, Centres for Health Research METRO SOUTH HEALTH

12,10,2015

Office Centres for Health Research Princess Alexandra Hospital Metro South Hospital and Health Service	Postal 37, Kent Street Woolloongabba Qld 4102	Phone 61 7 3443 8050	Fax 61 7 3443 8003	
6.VitesearchiGovernancelCorrespondencei2018/651	600115-602baue-15-592 Governance Approv	al Latter doc		Page 2 of 2



### MHS & MMRI Human Research Governance - SSA Authorisation

27 July 2015

Mr Ian Parker Physiotherapy Department Royal Brisbane and Women's Hospital Level 2, Ned Hanlon Building Herston, QLD 4029

Dear Mr Parker

Re: Mater Research Governance Reference Number: RG-14-279 HREC Reference Number: HREC/14/QRBW/86 Project Title: A comparison of clinical and cost effectiveness between the Physiotherapist-led Royal Brisbane and Women's Hospital Vestibular Screening and Rehabilitation Service and the Audiologist-led Logan-Mater Hospitals Vestibular Dysfunction Screening Service

Thank you for submitting an application for authorisation of this project. I am pleased to inform you that authorisation has been granted for this study to take place at the following site(s):

### Mater Hospital Brisbane, Mater Health Services, South Brisbane

Documents reviewed and Authorised by Mater Research Governance are as per HREC Approval Letter dated 28 March 2014 and include:

- Protocol; Version 2 dated 10 February 2014
- Participant Information Sheet and Consent Form; Version 4 dated 26 March 2014

The following conditions apply to this research proposal. These are additional to those conditions imposed by the Human Research Ethics Committee that granted ethical approval.

- The Research Governance Officer must be informed of any problems that arise during the course of the study which may affect conduct of the study at the site.
- Proposed amendments to the research protocol or conduct of the research which may affect the ethical acceptability of the project, and which are submitted to the HREC for review, are copied to the research governance officer;

U	
неаа оптсе	Dignity
Level 3 Aubigny Place, Raymond Terrace, South Brisbane, Qld, 4101	Care
Telephone +61 7 3163 2555 Fax +61 7 3163 2550 ABN 28 109 834 719	Commitment
research.mater.org.au www.facebook.com/materqld	Quality

Mercy

 Proposed amendments to the research protocol or conduct of the research which only affects the ongoing site acceptability of the project, are to be submitted to the research governance officer;

4. Proposed amendments to the research protocol or conduct of the research which may affect both the ongoing ethical acceptability of the project and the site acceptability of the project are to be submitted to the research governance officer after a HREC decision is made.

We wish you every success in undertaking this research.

Yours sincerely

Dominique Rossouw Research Governance Officer Mater Research Office Room 270, Lvl 2, Aubigny Place Raymond Terrace South Brisbane Qld 4101 Email address: research.governance@mmri.mater.org.au

Head office Level 3 Aubigny Place, Raymond Terrace, South Brisbane, Qld, 4101 Telephone +61 7 3163 2555 Fax +61 7 3163 2550 ABN 28 109 834 719 research.mater.org.au www.facebook.com/materqld Mercy Dignity Care Commitment Quality

° Matei Research

### Appendix 3 Study 4 Ethics documents

Enqu Phor Fax: Our E-m



Royal Brisbane and Women's Hospital Metro North Hospital and Health Service

### Office of the Human Research Ethics Committees



iries to:	Ann-Marce Gordon
	A/Coordinator
ve:	07 3646 6132
	07 3646 5849
Ref:	HREC/13/QRBW/92
hit	RBWH-Ethics@health.gld.gov.au

Mr Ian Parker Physiotherapy Department Level 2, Ned Hanlon Building Royal Brisbane & Women's Hospital Herston Q 4029

Dear Mr Parker,

#### Re: Ref N<sup>9</sup>: HREC/13/QRBW/92: The Prevalence, Profile and Efficacy of conservative management for Royal Brisbane and Women's Hospital Ear Nose and Throat Category 2 and 3 wait list patients with vestibular dysfunction

Thank you for submitting the above research project for single ethical review. This project was considered by the Royal Brisbane & Women's Hospital Human Research Ethics Committee (RBWH HREC) (EC00172) at its meeting held on 15 April, 2013.

I am pleased to advise that the RBWH Human Research Ethics Committee has granted ethical approval of this research project.

The nominated participating site for this project is:

· Royal Brisbane & Women's Hospital, Qld

This letter constitutes ethical approval only. This project cannot proceed until separate research governance authorisation has been obtained from the CEO or Delegate of the Royal Brisbane & Women's Hospital under whose auspices the research will be conducted.

The approved documents include:

Document	Version	Date
Covering Letter		22 March 2013
Application: NEAF (Submission Code: AU/1/C6C1115)	2.0 (2008)	22 March 2013

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007). The processes used by this HREC to review multi-centre research proposals have been certified by the National Health and Medical Research Council.

Office	Postal	Phone	Fax
Butterfield Street Herston Q 4029	Post Office Herston Queensland 4029 Australia	07 3646 5490 ISD + 61 7 3646 5490	07 3646 5849
Royal Brishane & Women's Hospital HREC2 Ref No: HREC/13/QRBW/92

28.06.2013

Document	Version	Date
NEAF Signature Page		1
RBWH Research Advisory Committee Grant Approval Letter		12 November 2012
Activities-Specific Balance Confidence (ABC) Scale	1	22 March 2013
Dizziness Handicap Inventory		22 March 2013
Screening Test for Hearing Problems (STHP)	1	22 March 2013
RBWH Physiotherapy Vestibular Assessment		
Vestibular Rehabilitation Wait Time Satisfaction Survey	1	22 March 2013
Vestibular Rehabilitation Service Satisfaction Survey	1	22 March 2013
Curriculum Vitae of Ian Gerard Parker		
Curriculum Vitae of Deborah A Mackenzie		1
Curriculum Vitae of Nancy Louise Low Choy		
Curriculum Vitae of David Andrew Good		
Response to Request for Further Information		27 May 2013
SF-12 Health Survey		1
Response to Request for Further Information		25 June 2013
Protocol	1	17 June 2013
Response to Request for Further Information		26 June 2013
Participant Information Sheet	3	26 June 2013
Participant Consent Form	3	26 June 2013
Participant Withdrawal of Consent Form	3	26 June 2013

Approval of this project from the RBWH HREC is valid from 28.06.2013 to 28.06.2016 subject to the following conditions being met:

- · The Coordinating Principal Investigator will immediately report anything that might warrant review of ethical approval of the project.
- The Coordinating Principal Investigator will notify the RBWH HREC of any event that . requires a modification to the protocol or other project documents and submit any required amendments in accordance with the instructions provided by the HREC. These instructions can be found at http://www.health.qld.gov.au/rbwh/research/hrec.asp.
- The Coordinating Principal Investigator will submit any necessary reports related to the ٠ safety of research participants in accordance with the RBWH HREC policy and procedures. These instructions can be found at http://www.health.qld.gov.au/rbwh/research/hrec.asp.
- · In accordance with Section 3.3.22 (b) of the National Statement the Coordinating Principal Investigator will report to the RBWH HREC annually in the specified format, the first report being due on 28.06.2014 and a final report is to be submitted on completion of the study. These instructions can be found at

http://www.health.qld.gov.au/ohmr/html/regu/reporting\_templates.asp.

Royal Brisbane & Women's Hospital HREC3 Ref No: HREC/13/QRBW/92

- The Coordinating Principal Investigator will notify the RBWH HREC if the project is discontinued before the expected completion date, with reasons provided.
- The Coordinating Principal Investigator will notify the RBWH HREC of any plan to extend the duration of the project past the approval period listed above and will submit any associated required documentation. Instructions for obtaining an extension of approval can be found at <a href="http://www.health.qld.gov.au/rbwh/research/hrec.asp">http://www.health.qld.gov.au/rbwh/research/hrec.asp</a>.
- The Coordinating Principal Investigator will notify the RBWH HREC of his or her inability to continue as Coordinating Principal Investigator including the name of and contact information for a replacement.
- A copy of this ethical approval letter together with completed Site Specific Assessment (SSA) and any other requirements must be submitted by the Coordinating Principal Investigator to the Research Governance Office at the Royal Brisbane & Women's Hospital in a timely manner to enable the institution to authorise the commencement of the project at its site.
- Should you have any queries about the RBWH HREC's consideration of your project
  please contact the HREC Coordinator on 07 3646 5490. The RBWH HREC's Terms of
  Reference, Standard Operating Procedures, membership and standard forms are available
  from <a href="http://www.health.qld.gov.au/rbwh/research/hrec.asp">http://www.health.qld.gov.au/rbwh/research/hrec.asp</a>.

The RBWH HREC wishes you every success in your research.

#### Yours sincerely,

Dr Conor Brophy Chairperson RBWH Human Research Ethics Committee Metro North Hospital and Health Service 28.06.2013

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007). The processes used by this HREC to review research proposals have been certified by the National Health and Medical Research Council.







Royal Brisbane and Women's Hospital Metro North Hospital and Health Service

> Enquiries to: Prof Keshwar Baboolal A/Executive Director, RBWH Phone: 07 3646 1585 Fax: 07 3646 4481 Ref

Mr Ian Parker RBWH Physiotherapy Department Level 2 Ned Hanlon Building, RBWH Herston, QLD 4029

Dear Mr Parker

Re: HREC/13/QRBW/92 The Prevalence, Profile and Efficacy of conservative management for Royal Brisbane and Women's Hospital Ear Nose and Throat Category 2 and 3 wait list patients with vestibular dysfunction

Thank you for submitting an application for authorisation of the above research project. I am pleased to inform you that authorisation has been granted for this study to be conducted at the Royal Brisbane and Women's Hospital.

In addition to the conditions of approval imposed by the Human Research Ethics Committee, when submitting an amendment to the HREC, please also submit (electronically) to the RGO a copy of the covering letter for the amendment as well as a description and the rationale for it. This is to allow the RGO to determine whether or not there are research governance implications connected with the amendment. Amendments may include changes to the protocol, budget, information sheets, consent forms, clinical trial agreements and any other researchrelated documentation. The RGO will then advise you whether or not further documentation is required.

When the study commences, please complete the Commencement Form and send it to the HREC office with a copy to the Research Governance Office.

If you have any questions relating to this authorisation please contact the Research Governance Officer on 3646 8579.

I wish you every success with your research.

Thank you for conducting this important research.

Yours sincerely Professor Kesh Baboolal A/Executive Director 22. I/O/CS

c.c. , RBWH

Royal Brisbane and Women's Hospital - we don't smoke here anymore

 Office
 Postal
 Phone

 Royal Brisbane and Women's Hospital
 Post Office
 (07) 3646 8111

 Butterfield Street
 Herston 4029
 Herston

Fax (07) 3646 4240

# Appendix 4 Vestibular Assessment Form

Wayal Brisbane & Women's Hospital       URN:         PHYSIOTHERAPY VESTIBULAR ASSESSMENT       Image: Given Names: Address:         Date of Birth:       Sex:       M         Current main problem:	
Reyal Brisbane & Women's Hospital       Family Name:         PHYSIOTHERAPY       Given Names:         Address:       Date of Birth:       Sex:       M       F         Referred by:	
PHYSIOTHERAPY VESTIBULAR ASSESSMENT       Given Names: Address: Date of Binh:         Sex:       M         Referred by:	
Address:       Date of Birth:       Sex:       M       F         Referred by:	
Date of Birth:       Sex:       M       F         Referred by:	
Referred by:	
Current main problem: Symptoms of dizziness: Vestibular – spinning, merry-go-round, drunkenness, tilling, motion sickness, on a ship, intermittent Non Vestibular – light headed, floating, swimming, body dissociation, giddy, faintness, constant, off-ba spinning inside the head, rocking, swaying or wobbling not apparent to others, floor moving Visual – complex visual stimuli such as shopping centres, shop displays, computer work, other visual t History of initial symptoms (description; duration and triggers): Date of onset:/  Gradual versusSudden  Behaviour of current symptoms: Constant versusIntermittent Frequency / number of attacks: One – severe and prolonged – irreversible peripheral/central lesion? Frequency / number of attacks: Anny – BPPV Falls history:	
Symptoms of dizziness: Vestibular – spinning, merry-go-round, drunkenness, tilting, motion sickness, on a ship, intermittent Non Vestibular – light headed, floating, swimming, body dissociation, giddy, faintness, constant, off-ba spinning inside the head, rocking, swaying or wobbling not apparent to others, floor moving Visual – complex visual stimuli such as shopping centres, shop displays, computer work, other visual 1 History of initial symptoms (description; duration and triggers): Date of onset:// Gradual versusSudden Behaviour of current symptoms:Constant versusIntermittent Frequency / number of attacks:Onesevere and prolonged – irreversible peripheral/central lesion?Few – MD, transient VBI, MigraineMany – BPPV =	
• Non Vestibular – light header, including, swinning, body dissociation, globy insociation, globy insoci	
<ul> <li>Visual – complex visual stimuli such as shopping centres, shop displays, computer work, other visual in the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shop displays, computer work, other visual is the shopping centres, shopping centres,</li></ul>	lance,
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History of initial symptoms (description; duration and triggers): Date of onset:/ Gradual versus Sudden Behaviour of current symptoms: Constant versus Intermittent Frequency / number of attacks: One - severe and prolonged - irreversible peripheral/central lesion? Few - MD, transient VBI, Migraine Many - BPPV Falls history:	
History of initial symptoms (description; duration and triggers): Date of onset:/ Gradual versusSudden  Behaviour of current symptoms:Constant versusIntermittent  Frequency / number of attacks:One - severe and prolonged - irreversible peripheral/central lesion?Few - MD, transient VBI, MigraineMany - BPPV Falls history:	
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Date of onset: //   Gradual versusSudden   Behaviour of current symptoms:   Constant versusIntermittent   Frequency / number of attacks:   One - severe and prolonged - irreversible peripheral/central lesion?   Few - MD, transient VBI, Migraine   Many - BPPV   Falls history:	
Behaviour of current symptoms: Constant versus Intermittent  Frequency / number of attacks: One - severe and prolonged - irreversible peripheral/central lesion? Few - MD, transient VBI, Migraine Many - BPPV  Falls history:	
Behaviour of current symptoms:   Constant   versus   Intermittent      Frequency / number of attacks:   One - severe and prolonged - irreversible peripheral/central lesion?   Few - MD, transient VBI, Migraine   Many - BPPV   Falls history:	
Behaviour of current symptoms: Constant versus Intermittent Frequency / number of attacks: One – severe and prolonged – irreversible peripheral/central lesion? Few – MD, transient VBI, Migraine Many – BPPV Falls history:	
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Frequency / number of attacks: One – severe and prolonged – irreversible peripheral/central lesion? Few – MD, transient VBI, Migraine Many – BPPV Falls history:	
Frequency / number of attacks: One – severe and prolonged – irreversible peripheral/central lesion? Few – MD, transient VBI, Migraine Many – BPPV Falls history:	
Frequency / number of attacks: One – severe and prolonged – irreversible peripheral/central lesion? Few – MD, transient VBI, Migraine Many – BPPV Falls history:	
One – severe and prolonged – irreversible peripheral/central lesion?     Few – MD, transient VBI, Migraine     Many – BPPV  Falls history:	
☐ Few – MD, transient VBI, Migraine ☐ Many – BPPV Falls history:	
☐ Many – BPPV Falls history:	
Falls history:	
Falls history:	
Falls history:	

- 9 AMIC				(	Affi>	k patient iden	tification la	bel here)	)		
		URN									
Queensland Royal Brisbane & Women's Hospital											
PHYSIOTHERAPY		Givor		no.							
VESTIBULAR ASSESSMEN	т	Giver	Indi	105.							
	621	Addro	ess:					11111			
		Date	of Bir	th:			Sex:	<b>M</b>	F		1
Dizziness Triggers Table											
Activity			S	everity	_			Dur	ation		
Rolling in bed (L/R)		lot at a		Some		Severely					
Bending over (L/R)		ot at a		Some		Severely					
Looking over your shoulder (L/R)		ot at a		Some		Severely					
Sitting up from lying		ot at a		Some		Severely					
Standing up		ot at a		Some		Severely					
Sitting down		lot at a		Some		Severely					
Lying down		lot at a		Some		Severely					
Walking in a dark room		lot at a	ull [	Some		Severely					
Walking on uneven surfaces		ot at a	ul [	Some		Severely					
Walking on uneven surfaces at night	🗌 N	ot at a	ul [	Some		Severely					
Sitting in a car on a bumpy road		ot at a	ul 🗌	Some		Severely					
Walking on a busy street		lot at a	ul [	Some		Severely					
Walking up / down stairs		lot at a		Some		Severely					
Turning when standing		lot at a	ul [	Some		Severely					
Turning your head while walking		lot at a		Some		Severely					
Riding in elevator		lot at a	u [	Some		Severely					
Riding escalator		lot at a	ul [	Some		Severely					
Loud noises		lot at a		Some		Severely					
Tunnels, bridges	🗌 N	lot at a	ul [	Some		Severely					
Cough, sneeze, strain, laughing, blowing up balloons		lot at a	ill [	Some		Severely					
Movement of objects in the environment		lot at a	ul E	Some		Severely					
Moving your eyes while your head is still		lot at a	ill [	Some		Severely					
Wide-open spaces		lot at a	III [	Some		Severely					
Supermarkets / busy shopping areas		lot at a	ul 🗌	Some		Severely					
Menstrual periods		lot at a	ul [	Some		Severely					
Headaches		lot at a	ul [	Some		Severely					
Migraines and / or symptoms of migraines		lot at a	il E	Some		Severely					
Neck pain or movement of head on neck		lot at a	u [	Some		Severely					
Hypersensitive to own motion		lot at a	u [	Some		Severely					
NB: Duration: Seconds – BPPV; Minut Hours – Meniere's disease: Days	es to ho – vestib	ours – n oular ne	nigrair uritis.	ne, TIA; vertebro-	basil	lar territory inf	arction: mid	araine			
Associated symptoms / Other sensations	that	accor	npar	v spec	ific	problem					
		Yes	No						Ye	s	No
Migraine symptoms		Π	Π	Liaht-h	ead	edness				1	
Flashes of light		Ē		Faintne	ess					i	
Pins and needles / numbness	-	Ē		Spinnir	na ir	the head				1	П
Difficulty talking	-	Ē		Anxiety	1					it	Π
Difficulty swallowing	-	<b>H</b>		Fear of	pul	blic spaces				i t	
Difficulty controlling arms / legs				Crosse	d er	ves or lazv e	ves?			i	
Double vision				Motion	sicl	kness	,			<u>i</u>	
Drop attacks				Sweati	na				Г	1	
Weakness		H		Nause						i	
Wobbly or jumping vision when walking or in a ca	ır			Vomitir	ng					j	

Page 2 of 8

Royal Brisbane & Women's Hospital PHYSIOTHERAPY VESTIBULAR ASSESSMENT Past Medical History:	URN: Family Name: Given Names: Address: Date of Birth:	(Affix patient id	lentification la	bel here)	<u> </u>
General health / Surgical history (Cardiac/CVA/Epi	lepsy/Cancer/Diabet	es/Hypertension/N	/ligraine/Neck	Pain/Recent Infec	tions/TBI)
Ears – Red Flag Questions				Yes	No
Have you had infections of ears?					
Do you have difficulty with hearing? If yes:	🗌 Left	Right	Both		
Do you think your hearing loss onset was:	Sudden 🗌	Gradual			
Do you have noises in your ears? If yes:	Left	Right	Both		
During your dizziness / vertigo attacks do you notice: Changes in hearing / ringing in the ears / ears feel bloc	ked				
Do you hear your own body sounds? (e.g. heart beating	g, digestion)				
Do you have ringing in your ears (Tinnitus)? If yes: Steady / Pulsating / Sudden onset / Gradual onset / Hig	Left    Left	Right Right	Both		
Pain, fullness, popping, or pressure in the ear? If yes:	🗌 Left	Right	Both		
Pain, pins and needles / numbness, twitching or weakn	ess of your face?				
Changes in the LAST SIX MONTHS				Yes	No
Loss of strength					
Loss of energy					
Weight loss					
Memory loss					
Change in hand writing					
Pins and needles / numbness in arms or legs					
Muscle or joint aches					
Urinary incontinence					
Sleep problems					
Shortness of breath					
Trouble chewing, swallowing or speaking					
Inco-ordination					
Heart palpitations					
Anxiety – panic / phobia – anticipatory anxiety in advan avoidance of such situations due to phobic fear of cons accompanying dizziness	ce of situations as equences of dizzir	sociated with dia ness, panic sym	zziness, ptoms		
Generalised anxiety - excessive worry about routine life	e events				
Minor anxiety – anxiety causing minor interference in da	aily activities				

Page 3 of 8

. 366.		(Affix patient identifica	tion lab	oel here)	
		URN:			
Queensland	Royal Brisbane & Women's Hospital	Family Name:			
	PHYSIOTHERAPY	Given Names:			
VE	STIBULAR ASSESSMENT	Address:			
		Date of Birth	Sex.		
Medica How ma Can you •	ations any prescribed medications do you take? u name the medications? Vestibular Suppressants – antihistamines, anti Ototoxic medications – strepta / gentamicin	-cholinergics, diazepam (Valium)			
Heada	ches				
Age of c	onset:				
Number	per month:				
Pain inte	ensity: of vestibular symptoms:				
coronay				Yes	No
Migraine	e definition: Have you had 5 or more headaches	that:			
	Lasted at least 4 hours (up to 72 ho	urs)?			
	Were throbbing / pulsatile?				
	Were severe enough to interfere wit	h routine daily activities?			
	Were aggravated by routine physica	I activity?			
	Were accompanied by nausea and	vomiting, phonophobia and / or photopho	obia?		
	Symptoms were associated with ver	tigo?			
	Aura?				
	Food triggers?				
	Sleep irregularity?				
	Hormonal changes?				
	Treatment included dark room and I	ie down and medication?			
Minor an	nxiety – Anxiety causing minor interference in da	aily activities:			
Subjec 1.	tive Outcome Measures Activities-specific Balance Confidence (AE (<67 fallers and 50-80 reduced community participat	3C) Scale ion)			
2.	Dizziness Handicap Inventory (DHI) (>26 significant dizziness handicap – high emotional	score – psychological referral)			
3.	Screening Test for Hearing Problems (STI	HP)			

Page 4 of 8

- 100 F		(A	fix patient identification	label here	)	
		URN:				
Queensland Government Royal Brisbane & Women's Hos	pital	Family Name:				
PHYSIOTHERAPY	<b>7</b>	Given Names:				
VESTIBULAR ASSESS	MENT	Address:				
		Date of Birth:	Sex	Пм	ΓF	
VBI Test Cervical Spine Assessment		1				
Sustained Rotation/Extension						
Oculomotor Assessment						
	Fixation		No Fixation			
Spontaneous Nystagmus						
Gaze evoked Nystagmus						
Ocular Range of Motion						
Pursuit						
Saccades						
Skew Deviation						
VOR Testing						
VOR Suppression						
Head Impulse Test (+ve single catch up saccade following head thrust to lesion side)						
Head Shake Nystagmus (30° fwd tilt, eyes closed, passive rotation 20x- +ve if >3 beats of nystagmus on opening eyes)						
Fistula Testing						
Heneberts sign (Tragal pressure valsalva against pinched nostrils and closed glottis >10 secs)						
Tullio Phenomenon						
(Own sustained singing of E >10secs)						
Dynamic Visual Acuity						
Static Visual Acuity (using Snellen ch	art): Line of f	first error				
Dynamic Visual Acuity:	Line of f	irst error				
DVA Grade:						
Drop of 1 line = Grade 1 (Normal), Drop of 2 lin	nes = Grade 2 (N	Normal), Drop of 3 lines	or more = Grade 3 (Abnor	nal)		

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Royal Brisbane & Women's Hospital PHYSIOTHERAPY VESTIBULAR ASSESSMENT					(Affix patient identification label here) URN: Family Name: Given Names: Address:							
Desition Testin	-				Date of	Birth:	_		Sex:	ШМ	L F L	
Test	g			lide	Inte	neitv		Duration		Nve	taamus	-
Hall Pike Dix				eft		inaity	-+-	Duration		Nys	taginus	
Ear Down Test				.eft			-					
Ear Down Test			F	Right			-					
Hall Pike Dix			F	Right								
Static Balance	Assessr	nent	5	Shoes:								
Assessment Item			C	Date: / /	Dat	e: / /		Date: / / /		Date	e://	
Sitting												
Feet Apart	E(	0 C										
Feet Together	E0	0 C						5				
Stride Stance	Le Ri	eft Forward ight Forwa	d ard									
Foam Stand (feet tog	gether) E( E(	0 C										
Single Leg Stand	Le Ri	eft ight			5							
		In	itials									
Gait and Neuro	logical A	Assessr	nent									
Functional Gait	Assess	ment* /	Dynar	nic Gait Ir	idex (DGI s	Score of $\leq 19/3$	24 indi	cates increased fall	s risk)			
	Date: /	/D0	GI/24	FGA/30	Date: /	/ DGI	/24	4 FGA /30	Date: /	/ DGI	/24 FGA	/30
Condition	Normal (3)	Mild (2)	Moderate (1)	Severe (0)	Normal (3)	Mild (2)	Mode ate (1)	er Severe (0)	Normal (3)	Mild (2)	Moderate (1)	Severe (0)
Level Surface*												
Change in Speed*												
Horiz. Head turns*												
Vert. Head turns*												
Pivot Turns*												
Over Obstacle*								-			-	
Around Obstacle												
Steps*											_	
Deeleward- O-14t							-	-			-	ļ
Backwards Gait				-			-	-			-	
Eyes Closed Gait*												
Narrow Base Gait*											_	

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-340 F	(Affix patient identification label here)					
	URN:					
Queensland Government Royal Brisbane & Women's Hospital	Family Name:					
PHYSIOTHERAPY	Given Names:					
VESTIBULAR ASSESSMENT	Address:					
	Date of Birth:		Sex:	Пм	ΠF	
Timed 10 Metre Walk Test					_	_
With head turn						
Problem List						
Diagnosis						
Goals						
Treatment Plan						

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# Appendix 5 Study 3 Vestibular Reliability Trial Data Sheet

Interview Nominal Data	Yes	No
History suggests vestibular dysfunction		
History suggests cervical dizziness		
History suggests visual vertigo		
History suggests vestibular migraine		

Objective Assessment Nominal Data	Yes / Left	No / Right
Audiogram suggests vestibular dysfunction		
Cervical Spine Active Range of Motion Reduced		
Cervical Spine Active Range of Motion causes dizziness		
Spontaneous Nystagmus present		
Gaze evoked Nystagmus present		
Gaze evoked Nystagmus present Left Right		
Direction changing Nystagmus present		
Normal Pursuit		
Normal Saccades		
No Skew Deviation		
VOR Suppression Normal		
Head Impulse Test Normal		
Head Impulse Test Abnormal Left Right		
DVA Score Normal		

Head Position Testing Normal	
Head Position Testing Posterior Canalithiasis Left Right	
Head Position Testing indicates other BPPV	
Head Position Testing indicates positional nystagmus	

Interpretation of Results	Yes	No
Patient has BPPV		
Patient has Vestibular Hypofunction		
Patient has Vestibular Migraine		
Patient has Cervicogenic Dizziness		
Patient has Other Vestibular Dysfunction		
Patient has Central Dysfunction		
Patient has Psychological Dysfunction		
Patient needs referral for further investigations by Audiology		
Patient needs referral to Physiotherapy for treatment		
Patient needs referral to ENT		
Patient needs referral to Neurology		
Patient needs referral to Psychology		
Patient needs referral to GP		

# Appendix 6 Study 3 Interrater Reliability Trial Results

Variable	ariable Abnormalities Detected		% Agree	Kappa	Lower Cl	Upper CI	р
Interview	assessor 1	assessor 2					
Vestibular Dysfunction	19	18	95.5	0.83	0.51	1.15	<0.001
Cervicogenic Dizziness	6	4	90.9	0.74	0.42	1.07	0.001
Visual Vertigo	4	0	77.3	0.00			
Vestibular Migraine	5	5	90.9	0.74	0.40	1.08	0.001
Examination							
PTA Dysfunction	4	3	95.5	0.83	0.51	1.15	<0.001
Cervical Spine AROM	4	3	86.4	0.49	0.00	0.98	0.019
Cervicogenic Dizziness	4	1	77.3	-0.08	-0.21	0.05	0.629
Spontaneous Nystagmus	0	0	100	NA			
Gaze evoked Nystagmus	7	6	95.5	0.89	0.68	1.10	<0.001
GEN Left Right	7	7	95.5	0.91	0.75	1.08	<0.001
Direction Changing Nyst	0	0	100	NA			
Pursuit	1	2	95.5	0.65	0.01	1.28	0.001
Saccades	0	0	100	NA			
Skew Deviation	0	0	100	NA			
VOR Suppression	1	2	95.5	0.65	0.01	1.28	0.001
Head Impulse Norm	8	9	95.5	0.90	0.72	1.09	<0.001
Head Impulse Abn Side	7	8	95.5	0.91	0.74	1.08	<0.001
Dynamic Visual Acuity	14	14	100	1.00			<0.001
Head Position Test	3	4	95.5	0.87	0.61	1.12	<0.001
Posterior Canal BPPV	3	3	100	1.00			<0.001
BPPV Side	4	4	100	1.00			<0.001
Other BPPV	2	2	100	1.00			<0.001
Positional Nystagmus	0	0	100	1.00			<0.001
Interpretation							
BPPV	3	3	100	1.00			<0.001
Vestibular Hypofunction	12	13	77.3	0.54	0.18	0.89	0.011
Vestibular Migraine	3	2	95.5	0.78	0.36	1.20	<0.001
Cervicogenic Dizziness	7	4	86.4	0.65	0.30	0.99	0.001
Other Vest Dysfunction	1	2	95.5	0.65	0.01	1.28	0.001
Central	1	2	95.5	0.65	0.01	1.28	0.001
Psychological Dysfunction	4	4	90.9	0.69	0.30	1.09	0.001
Referral							
Audiology Investigations	5	2	86.4	0.51	0.06	0.96	0.006
Vestibular Physiotherapy	16	15	95.5	0.89	0.68	1.10	<0.001
ENT Referral	4	5	86.4	0.58	0.16	1.00	0.006
General Practitioner Referral	2	4	90.9	0.62	0.16	1.09	0.002

Vestibular dysfunction present, Cervicogenic Dizziness present, Visual Vertigo present, Vestibular Migraine present, PTA Dysfunction pure tone audiogram suggests vestibular dysfunction, Cervical Spine AROM cervical spine active range of motion reduced, Cervicogenic Dizziness Cervical spine active range of motion causes dizziness, Spontaneous Nystagmus present, Gaze evoked nystagmus gaze evoked nystagmus present, GEN Left Right gaze evoked nystagmus present Left Right, Direction Changing Nyst direction changing nystagmus present, Pursuit normal, Saccades normal, Skew Deviation not present, VOR Suppression normal, Head Impulse normal, Head Impulse Abn HIT abnormal side Left 1 Right 2, Dynamic Visual Acuity Score normal, Head Position test normal, Posterior Canal BPPV posterior canalithiasis benign paroxysmal positional vertigo present, BPPV Side Left 1 Right 2, Other BPPV Head position testing indicates other BPPV, Positional Nystagmus Head position testing indicates positional nystagmus, ENT Ear Nose and Throat, NA not applicable as Kappa not calculated due at least one variable being a constant, CI 95% confidence interval, p Bonferroni adjusted

Combined Cohort					
Dimension	n	Pre Rx (SE)	Post Rx (SE)	mean difference (95% CI)	р
Utility	234	0.58 (0.14)	0.66 (0.014)	0.08 (0.06, 0.10	< 0.01
Independent Living	234	0.77 (0.01)	0.80 (0.01)	0.04 (0.02, 0.06)	<0.001
Happiness	234	0.74 (0.01)	0.75 (0.01)	0.02 (-0.01, 0.04)	0.132
Mental Health	234	0.56 (0.01)	0.61 (0.01)	0.05 (0.02, 0.08)	0.008
Coping	234	0.71 (0.01)	0.76 (0.01)	0.06 (0.04, 0.08)	<0.001
Relationships	234	0.66 (0.01)	0.70 (0.01)	0.04 ().01, 0.06)	<0.001
Self-Worth	234	0.74 (0.01)	0.77 (0.01)	0.04 (0.0, 0.06)	0.049
Pain	234	0.64 (0.02)	0.68 (0.02)	0.04 (-0.02, 0.08)	0.156
Senses	234	0.73 (0.01)	0.76 (0.01)	0.03 (0.0, 0.05)	0.006
Super Dimensions					
Mental	234	0.31 (0.01)	0.38 (0.02)	0.07 (0.04, 0.10)	<0.001
Physical	234	0.53 (0.01)	0.59 (0.02)	0.06 (0.03, 0.09)	0.001

### Appendix 7 Study 4 Assessment of Quality of Life 8 Dimensions factors by diagnosis

#### Benign Parxoysmal Positional Vertigo

F USILIUITAI VEILIYU					
Dimension	n	Pre Rx (SE)	Post Rx (SE)	mean difference (95% CI)	р
Utility	46	0.57 (0.03)	0.68 (0.03)	0.11 (0.06, 0.15)	< 0.01
Independent Living	46	0.78 (0.03)	0.81 (0.02)	0.03 (-0.01, 0.06)	0.095
Happiness	46	0.72 (0.03)	0.77 (0.03)	0.05 (0.0, 0.10)	0.039
Mental Health	46	0.55 (0.02)	0.61 (0.03)	0.06 (0.02, 0.11)	0.012
Coping	46	0.71 (0.02)	0.79 (0.02)	0.09 (0.05, 0.13)	<0.001
Relationships	46	0.66 (0.02)	0.71 (0.02)	0.04 (0.01, 0.08)	0.008
Self-Worth	46	0.73 (0.03)	0.78 (0.03)	0.05 (0.01, 0.1)	0.029
Pain	46	0.66 (0.04)	0.72 (0.04)	0.06 (-0.02, 0.14)	0.15
Senses	46	0.72 (0.02)	0.76 (0.02)	0.04 (0.0, 0.09)	0.06
Super Dimensions					
Mental	46	0.31 (0.03)	0.40 (0.03)	0.09 (0.05, 0.14)	<0.001
Physical	46	0.54 (0.03)	0.61 (0.03)	0.07 (0.02, 0.12)	0.011

Dimension	n	Pre Rx (SE)	Post Rx (SE)	mean difference (95% CI)	р
Utility	80	0.61 (0.02)	0.69 (0.02)	0.08 (0.04, 0.11)	<0.01
Independent Living	80	0.77 (0.02)	0.81 (0.02)	0.04 (0.0, 0.08)	0.023
Happiness	80	0.76 (0.02)	0.78 (0.02)	0.02 (-0.01, 0.05)	0.181
Mental Health	80	0.59 (0.01)	0.64 (0.02)	0.05 (0.01, 0.08)	0.006
Coping	80	0.72 (0.02)	0.79 (0.02)	0.07 (0.04, 0.10)	<0.001
Relationships	80	0.67 (0.02)	0.70 (0.02)	0.03 (0.0, 0.07)	0.057
Self-Worth	80	0.78 (0.02)	0.80 (0.02)	0.03 (-0.01, 0.06)	0.109
Pain	80	0.67 (0.02)	0.72 (0.02)	0.05 (0.01, 0.09)	0.017
Senses	80	0.73 (0.02)	0.77 (0.02)	0.03 (0.0, 0.07)	0.052
Super Dimensions					
Mental	80	0.34 (0.02)	0.42 (0.02)	0.08 (0.04, 0.12)	<0.001
Physical	80	0.54 (0.02)	0.62 (0.02)	0.08 (0.04, 0.11)	<0.001

### Unilateral Vestibular Hypofunction

Vestibular Migraine					
Dimension	n	Pre Rx (SE)	Post Rx (SE)	mean difference (95% CI)	р
Utility	38	0.51 (0.04)	0.62 (0.04)	0.10 (0.03, 0.17)	0.007
Independent Living	38	0.75 (0.03)	0.80 (0.03)	0.05 (0.0, 0.10)	0.065
Happiness	38	0.70 (0.03)	0.71 (0.03)	0.02 (-0.08, 0.06)	0.642
Mental Health	38	0.53 (0.02)	0.59 (0.03)	0.06 (-0.13, 0.0)	0.08
Coping	38	0.67 (0.02)	0.72 (0.03)	0.05 (0.0, 0.10)	0.032
Relationships	38	0.63 (0.02)	0.67 (0.03)	0.04 (-0.02, 0.10)	0.147
Self-Worth	38	0.66 (0.03)	0.73 (0.04)	0.07 (0.01, 0.13)	0.023
Pain	38	0.56 (0.04)	0.60 (0.05)	0.04 (-0.06, 0.14)	0.419
Senses	38	0.72 (0.03)	0.75 (0.03)	0.03 (-0.02, 0.07)	0.235
Super Dimensions					
Mental	38	0.34 (0.03)	0.49 (0.04)	0.07 (0.02, 0.14)	0.014
Physical	38	0.49 (0.04)	0.55 (0.04)	0.07 (-0.01, 0.14)	0.08

Dimension	n	Pre Rx (SE)	Post Rx (SE)	mean difference (95% CI)	р
Utility	21	0.52 (0.05)	0.60 (0.05)	0.09 (0.0, 0.17)	0.047
Independent Living	21	0.76 (0.04)	0.80 (0.04)	0.03 (-0.02, 0.09	0.253
Happiness	21	0.70 (0.04)	0.71 (0.04)	0.01 (-0.05, 0.08)	0.661
Mental Health	21	0.52 (0.03)	0.56 (0.04)	0.04 (-0.03, 0.11)	0.198
Coping	21	0.70 (0.04)	0.74 (0.03)	0.04 (-0.02, 0.10)	0.224
Relationships	21	0.65 (0.03)	0.67 (0.04)	0.02 (-0.02, 0.08)	0.334
Self-Worth	21	0.73 (0.04)	0.75 (0.05)	0.05 (-0.09, 0.13)	0.701
Pain	21	0.54 (0.05)	0.56 (0.05)	0.02 (-0.05, 0.09)	0.564
Senses	21	0.68 (0.03)	0.71 (0.04)	0.03 (-0.03, 0.09)	0.288
Super Dimensions					
Mental	21	0.28 (0.04)	0.35 (0.04)	0.07 (0.0, 0.14)	0.061
Physical	21	0.46 (0.05)	0.53 (0.05)	0.07 (-0.04, 0.17)	0.182

Anxiety					
Dimension	n	Pre Rx (SE)	Post Rx (SE)	mean difference (95% CI)	р
Utility	76	0.48 (0.02)	0.60 (0.02)	0.12 (0.08, 0.16)	<0.001
Independent Living	76	0.72 (0.02)	0.77 (0.02)	0.05 (0.02, 0.08)	<0.001
Happiness	76	0.68 (0.02)	0.71 (0.02)	0.03 (0.0, 0.07)	0.093
Mental Health	76	0.51 (0.01)	0.58 (0.02)	0.07 (0.03, 0.12)	0.004
Coping	76	0.65 (0.02)	0.73 (0.02)	0.08 (0.03, 0.12)	0.003
Relationships	76	0.60 (0.02)	0.66 (0.02)	0.05 (0.02, 0.08)	0.001
Self-Worth	76	0.66 (0.02)	0.73 (0.02)	0.07 (0.03, 0.11)	0.017
Pain	76	0.55 (0.03)	0.63 (0.04)	0.09 (0.02, 0.16)	0.02
Senses	76	0.71 (0.02)	0.75 (0.02)	0.04 (0.0, 0.07)	0.021
Super Dimensions					
Mental	76	0.24 (0.02)	0.33 (0.02)	0.09 (0.05, 0.13)	<0.001
Physical	76	0.46 (0.02)	0.55 (0.03)	0.09 (0.04, 0.14)	<0.001

n cases, Pre Rx pre-treatment, Post Rx post treatment, SE standard error, CI confidence interval, p probability

Cervicogenic Dizziness

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