New Zealand Primary School Teachers' Knowledge of Hearing Impairment and Deafness

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Abstract

Aims: This study investigated New Zealand mainstream primary school teachers' knowledge of hearing impairment and deafness and its influence on children's learning in the classroom. In addition, the study aimed to identify teachers' learning needs about hearing impairment and their current sources of information.

Methods: An online survey was developed using the Qualtrics platform of survey software (2017). The development of the survey was based on a questionnaire used in research by Lass et al. (1985). A 10-minute online survey was anonymously completed by 146 New Zealand mainstream primary school teachers.

Results: The survey results suggest that teachers' knowledge of hearing impairment aetiology, audiology (e.g. what it covers), solutions (e.g. amplification options) and communication (supports) was variable. Higher levels of knowledge were found across the broad area of audiology and solutions. Awareness of Otitis Media was high, however there was a lack of awareness of diseases and illnesses that can cause hearing impairment and deafness. Teachers were aware of some communication strategies that are unhelpful for a hearing impaired person. Information and education on learning support strategies for hearing impaired children with amplification devices (hearing aids and/or implants) was identified as a skill area that teachers would like input on.

Conclusions: Teachers reported that they want knowledge of specific learning support strategies for hearing impaired and deaf children in their classrooms. Teachers would benefit from education on appropriate techniques and strategies for adapting their teaching for a hearing impaired child specific to their classroom environment and teaching style (e.g. ILE with collaborative teaching and/or students as teachers). Audiologists can provide such support. The New Zealand Deaf Education Centres (DECs) are due to implement teacher

education modules this year. It is hoped that information gained from this study will be useful to the DEC teacher training programme and that further studies investigate teacher education delivered by audiologists and the professional support network in schools.

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Definitions

The term “hearing impairment” appears throughout this thesis rather than hearing loss. Hearing impairment is consistent with the terminology used in the World Health Organization’s International Classification of Functioning, Disability and Health (ICF).

List of Abbreviations

ANSD	Auditory Neuropathy Spectrum Disorder
AoDC	Advisor on Deaf Children
APD	Auditory Processing Disorder
ASHA	American Speech-Language and Hearing Association
BAHA	Bone Anchored Hearing Aid
CHI	Conductive Hearing Impairment
CI	Cochlear Implant
dB HL	Decibel Hearing Level
DHB	District Health Board
ENT	Ear Nose Throat (specialist)
FM	Frequency Modulation
HA	Hearing Aid
HAs	Hearing Aids
HAT	Hearing Assistive Technology
HI	Hearing Impairment
IHCs	Inner Hair Cells
ILE	Innovative Learning Environment
KDEC	Kelston Deaf Education Centre
NZ	New Zealand

NZAS	New Zealand Audiological Society
OHCs	Outer Hair Cells
OM	Otitis Media
OME	Otitis Media with Effusion
RM	Remote-Microphone
RTD	Resource Teacher of the Deaf
SD	Standard Deviation
SHI	Sensory Hearing Impairment
SIN	Speech in Noise
SNR	Signal-to-Noise Ratio
UNHSEIP	Universal Newborn Hearing Screening Early Intervention Programme
US	United States
VADEC	Van Asch Deaf Education Centre

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1. Introduction

Hearing impaired and deaf children are not "simply hearing children who cannot hear"

(Marschark, Spencer, Adams, & Sapere, 2011, p. 4).

1.1 Introduction

Teachers play a critical role in the education of children with hearing impairment. The quote above from Marschark et al. (2011) encapsulates both the underlying assumption that educators can make about children who wear amplification devices (such as hearing aids or implants) and the challenges involved in providing the support to maximise learning and development for deaf and hearing impaired students in the classroom. Understanding teachers' knowledge of hearing, hearing impairment and deafness is the focus of this thesis. Children with hearing impairment have specific needs in the classroom that require teacher support to ensure their education success.

To gain an understanding of what primary school teachers might need to know about hearing impairment this thesis will firstly review the human auditory system and its functions, what happens when it is damaged, aetiologies of hearing impairment and current management options for hearing impaired children. To understand the context of primary school teachers' knowledge of the learning needs of a hearing impaired child this thesis will also consider the impact of the classroom environment and the effect of hearing on learning for children. A teacher who understands hearing impairment and associated learning needs for a hearing impaired child is better positioned to ensure a child has successful educational outcomes (Marschark et al., 2011).

1.2 Hearing Impairment

1.2.1 Overview

Hearing impairment is the most common congenital anomaly (Flexer & Maddell, 2014). Congenital hearing impairment is also the most frequent cause of childhood deafness with the majority (60%) of cases attributed to a genetic aetiology (Dupont, 2011). More than five percent of the world's population has disabling hearing impairment, including 32 million children (World Health Organization, 2017). The World Health Organization (2017) defines disabling hearing impairment for children as a hearing threshold of greater than 30 dB HL in the better ear as measured by puretone audiometry. For adults, it is a hearing impairment of greater than 40 dB HL in the better ear (World Health Organization, 2017). Hearing impairment in New Zealand is based on the Goodman (1965) classification where hearing is classified as normal, slight, mild, moderate, moderate-severe, severe or profound (Goodman, 1965). Individuals with profound hearing impairment have little or no residual hearing for speech (Katz, Medwetsky, Burkard, & Hood, 2009). The main difficulty experienced by people with hearing impairment is hearing speech or loud sounds (World Health Organization, 2017).

Hearing impairment involves a reduction in the amount and or quality of sound signals reaching the human cortex. Amplification devices such as hearing aids and implants provide a means for sound to reach the brain thereby stimulating and growing auditory neural connections. All of which are needed for development of spoken language and reading (Boons, Brokx, Dhooge, et al., 2012; Gordon, Papsin, & Harrison, 2003). The secondary effects of untreated or poorly diagnosed childhood hearing impairment can adversely affect development of speech, language, academic, emotional and psycho-social abilities (Maddell, 2014; World Health Organization, 2010). Amplification devices enhance the sound signal

that reaches the brain resulting in the development of critical auditory-neural pathways for young children (Flexer & Maddell, 2014).

In countries where there is no universal hearing screening programmes for babies, it is common for a child's diagnosis of hearing impairment to be delayed. Often children with a mild or unilateral hearing impairment are not diagnosed until age six or older (World Health Organization, 2017). Children diagnosed with hearing impairment who receive early intervention within the first few months of life have performed considerably better on school-related measures such as vocabulary development, articulation and social development (World Health Organization, 2010). Teachers are an integral part of a hearing impaired child's education success.

In New Zealand classroom teachers are included in a child's support team together with the Deaf Education Centre (DEC) professionals (P. Peryman, personal communication, March 13, 2017). Teachers can implement learning support strategies within their classroom teaching specific to the learning needs of a hearing impaired child (De Raeve, 2015; Marschark et al., 2011).

The implementation of the Universal Newborn Hearing Screening and Early Intervention Programme (UNHSEIP) in New Zealand, means that babies are now screened at birth for hearing impairment (National Screening Unit, 2017). The UNHSEIP is a national initiative led by the Ministries of Health and Education and administered in hospitals across New Zealand. The aims of the UNHSEIP are to identify new-born babies with hearing impairment and provide early intervention to improve language and learning outcomes (National Screening Unit, 2017). The goals of the UNHSEIP are to screen babies for hearing impairment by one month of age, complete audiology assessment by three months of age and

begin early intervention services (i.e. medical and audiological services, early intervention education services) by six months of age (National Screening Unit, 2017).

The introduction of the UNHSEIP in New Zealand has seen childhood hearing impairment and deafness identified and treated early (Ministry of Health, 2016). Estimates of New Zealand data in 2011 suggested that approximately 80-120 babies from the UNHSEIP would be diagnosed with moderate or severe hearing impairment that necessitated early intervention services (National Screening Unit, 2011). It follows that there is a new population of children in primary education who have improved literacy outcomes because of the identification of their hearing impairment very soon after birth (Maddell, 2014; Spencer & Oleson, 2008). Early identification of hearing impairment gives children the opportunity to receive amplification (e.g. hearing devices or implants) early (i.e., within the first two years of life) and therefore benefit from the early period of neural development which in turn allows a reasonably normal maturation of auditory pathways in the brain (May-Mederake, 2012).

Data from the first seven years of the universal newborn hearing screening programme in the National Health Service (NHS) in the United Kingdom shows the rate of permanent childhood hearing impairment (PCHI) is 1.19 (95% 1.16-1.22) per 1000 babies (≥40 dB HL better ear average (BEA) 0.5, 1, 2 and 4 kHz) (Tharpe & Seewald, 2016). Current New Zealand data on babies screened through the UNHSEIP is more difficult to obtain. As stated previously estimates of New Zealand data in 2011 suggested that approximately 80-120 babies from the UNHSEIP would be diagnosed with moderate or severe hearing impairment that require early intervention services (National Screening Unit, 2011). Accuracy of newborn hearing screening data is dependent on several factors including coverage (number of babies screened versus number of babies born), test sensitivity and families who follow up with a diagnostic audiology assessment (Tharpe & Seewald, 2016).

The UNHSEIP was fully implemented across all District Health Boards (DHBs) in New Zealand by 2010 (National Screening Unit, 2011). Many children who have been referred for audiological diagnosis of hearing impairment via the UNHSEIP early in life and have a confirmed hearing impairment are starting school with a formal audiological diagnosis and using amplification such as hearing aids or implantable devices to access speech (Spencer & Oleson, 2008).

It is important that teachers and parents understand hearing impairment and the amplification devices and/or system a child uses to hear speech in the classroom (Knoors & Marschark, 2012). Young children need support within the classroom environment to ensure their amplification devices are functioning and for troubleshooting if they are not working (Antia, 2015). Hearing impaired children also need teachers to utilise specific communication support strategies to augment their listening environment (Mahshie, 2005; Marschark et al., 2011; Starr, 2017). It is important that teachers understand the communication support a hearing impaired child needs in the classroom (Marschark et al., 2011). There is currently limited literature around primary school teachers' knowledge of hearing impairment and the impact of hearing impairment on children's classroom learning (Davis, Shepard, Stelmachowicz, & Gorga, 1981; Eriks-Brophy & Whittingham, 2013; Lass et al., 1985; Lass et al., 1990; Marlatt, 2001; Martin, Bernstein, Daly, & Cody, 1988).

1.2.2 Prevalence of Hearing impairment

The World Health Organisation (WHO) reported that there were 360 million people with disabling hearing impairment worldwide. This represents approximately 5% of the world's population and includes 32 million children (World Health Organization, 2017). Hearing impairment is a common problem. Between 10 and 16% of an adult population will report difficulty hearing (Kochkin, 1997; Wilson et al., 1999).

1.2.3 New Zealand Hearing Impairment Data

Hearing impairment was known to affect approximately 9% of the New Zealand population (880,350) in 2013 (MacPherson, 2014; The National Foundation for the Deaf Inc, 2017). The prevalence of hearing impairment increases with ageing. Most people have at least a mild hearing impairment in old age (e.g. 90+ years old). Hearing impairment is more prevalent in females than males (Deloitte Access Economics Pty Ltd, 2017). Official statistics for the number of deaf or hearing impaired children in New Zealand is not available. In addition, New Zealand specific data on prevalence of hearing impairment relies on a high level of self-report measures. Worldwide hearing impairment data is also sparse. Largely due to the logistics of collecting accurate data which typically requires a soundproof booth (Stevens et al., 2013). The Global Burden of Disease project estimated global prevalence of hearing impairment in 2008 among children aged 5 to 14 years with hearing levels ≥ 35 dB HL was 1.4% (Stevens et al., 2013). Hearing level was defined as the better ear hearing threshold in decibels averaged over four frequencies (0.5, 1, 2 and 4 kHz (dB HL). Childhood hearing impairment is less common than adult onset hearing impairment which was a leading cause of disability. Childhood hearing impairment has more serious implications around language acquisition which can then impact on speech perception, educational and economic disadvantage and social isolation (Stevens et al., 2013). The Stevens et al. (2013) Global Burden of Disease Project which is based on high income western countries is considered more representative of prevalence in New Zealand as discussed in Listen Hear! (Deloitte Access Economics Pty Ltd, 2017)

The limitations of New Zealand hearing impairment prevalence data make it difficult to clarify differences across demographic factors such as ethnicity and occupation. Digby (2016) reported several unconfirmed sources suggesting differences in prevalence of hearing impairment between Maori and New Zealand European children under 18 years of age. The

average age of diagnosis of hearing impairment based on referrals from UNHSEIP in New Zealand is now four months of age (Digby, 2017). Equally a lack of prevalence data impacts on the ability of agencies such as Ministry of Education (MoE) and Ministry of Health (MoH) to plan for appropriate levels of resourcing support for early intervention and education. School age children with hearing impairment in New Zealand are funded by MoE for support and MoH for equipment (Ministry of Education, 2016; Ministry of Health, 2017). Professional support services include Advisers on Deaf Children (AoDCs) and Resource Teachers of the Deaf (RTD). AoDC's provide support for communication and language development for children from birth to year 3 at school. AoDCs work collaboratively with the DECs, Cochlear Implant programmes (Northern Cochlear Implant programme and Southern Cochlear Implant programme) and Deaf Aotearoa New Zealand. RTDs are specialist teachers. They work with other specialists to assist teachers adapt their teaching to accommodate the learning needs of a hearing impaired child. RTD's work through the DECs.

The next section provides background knowledge of the anatomy and physiology of the ear. This is an important area of knowledge for teachers as it forms a foundation for understanding hearing, hearing impairment and how amplification devices work to overcome hearing damage and enable a user to hear speech.

1.3 Anatomy and Physiology of the Ear

The human ear comprises three parts. The outer, middle and inner ear. There are two parts to the inner ear which are the vestibular sytem for balance and the cochlea for hearing (Møller, 2013). The human cochlea (inner ear) is almost fully developed at birth. However, the central auditory pathways (beyond the cochlea) to the brain take over a decade to fully mature. The plasticity and learning aspects of auditory brain development continue through life. For children with hearing impairment, the long-term impact of early impairment on auditory brain development is an additional factor for consideration. Early intervention for

congenitally deaf infants who are provided with cochlear implants takes advantage of early auditory brain development (Tharpe & Seewald, 2016).

The following aspects of anatomy and physiology of the ear are valuable core knowledge for teachers. Knowing the type of hearing impairment and structure of the ear affected aids understanding of appropriate amplification options for a child, and their long-term hearing prognosis. Children with hearing impairment have varying needs for teacher communication strategies in the classroom depending on type of hearing impairment and amplification device and or accessories used (or not).

1.3.1 Outer Ear and Middle Ear

The outer ear consists of the pinna and external auditory canal (EAC). The pinna and external ear canal of the outer ear gather and modify acoustic sound from the environment to transfer it to the middle ear where it is then conveyed via the tympanic membrane (eardrum) and ossicle bones (malleus, incus, stapes bones) to the cochlea fluids of the inner ear (Pickles, 2012). The bumps and grooves of the pinna (also termed the auricle in Figure 1) collect and direct sound into the middle ear (Yost, 2007). The middle ear is made up of the tympanic membrane and the ossicles. The eustachian tube connects to the middle ear cavity and equalises the middle ear pressure with atomspheric pressure (Møller, 2013). The outer and middle ear protect the inner ear from excessive environmental changes (Yost, 2007). The outer, middle and inner ear are shown in Figure 1.

1.3.2 Inner Ear

The sensory organ of hearing is contained within the cochlea which is where the outer hair cells (OHCs) and inner hair cells (IHCs) are located (Møller, 2013). In the cochlea sound becomes electrical energy and is transmitted by the hair cells along the acoustic nerve to the central auditory nervous system for processing (Musiek & Baran, 2007; Pickles, 2012). The

OHCs amplify soft sounds while the IHCs convert mechanical vibrations from the cochlea into an electrical signal to travel along the 8th cranial nerve (auditory nerve) to the auditory cortex (Musiek & Baran, 2007; Pickles, 2012). Sound can also be transmitted to the cochlea via bone conduction (Møller, 2013). Figure 1 shows the main structures of the ear (outer, middle and inner ear).

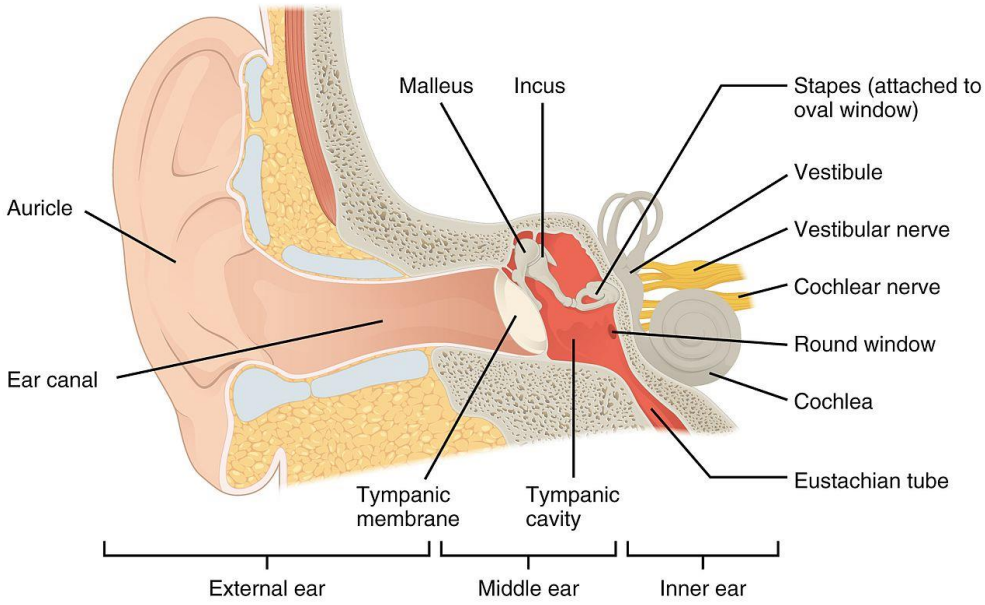

Figure 1. Main structures of the ear.

OpenStax. (2016). *Anatomy and physiology.* Retrieved from https://cnx.org/contents/FPtK1zmh@8.108:s3XqfSLV@9/Sensory-Perception

1.4 Types of Hearing Impairment

Hearing disorders are broadly described as conductive, sensory and neural. Conductive hearing impairment (CHI) is more common in the paediatric population (Maddell, 2014). A CHI may be temporary depending on the cause. Whilst a sensory or neural hearing impairment is usually permanent (Stach & Ramachandran, 2014). A

combination of conductive and sensory is termed a mixed hearing impairment. A mixed hearing impairment is caused by problems in the conductive and sensory mechanism (Paul & Norbury, 2012). Additional types of hearing impairment relevant to children that will also be discussed are retrocochlear and auditory processing disorders. Retrocochlear disorders are rare in children. They result from lesions of the nervous system. Auditory processing disorders (APDs) result from functional lesions of the nervous system and can be attributable to a developmental disorder or delay (Stach & Ramachandran, 2014). Auditory Neuropathy Spectrum Disorder (ANSD) and APD are sub-types of neural hearing impairment and occur beyond the cochlea. With ANSD the transfer of neural information along the auditory pathway is disrupted (Stach & Ramachandran, 2014).

Conductive hearing impairment (CHI) occurs with a disruption of sound moving through the outer and middle ear structures. Sensory hearing impairment (SHI) typically results from sensory or nerve damage in the inner ear, the auditory nerve and /or the brainstem (Mahshie, 2005; Tharpe & Seewald, 2016). ANSD is a subcategory of SHL that is situated beyond the structure of the cochlea and involves neural and central hearing impairment of the auditory system (central auditory cortex and/or other parts of the brain used to process sound) (Mahshie, 2005; Tharpe & Seewald, 2016). ANSD is also linked to hyperbilirubinemia (Tharpe & Seewald, 2016). Primary school teachers are likely to encounter children with CHI, SHI and ANSD. It is valuable for teachers to understand the causes and characteristic of the different hearing impairments. This could be helpful for understanding appropriate support strategies for a hearing impaired child in a classroom.

1.4.1 Conductive Hearing impairment

Conductive hearing impairment (CHI) occurs when the sound travelling from the outer ear to the middle ear is disrupted (Paul & Norbury, 2012). This results in an interruption of the transfer of mechanical sound into the cochlea due to loss of impedance matching by the

middle ear. The inner ear is functioning normally (Hunter, 2016). A CHI is often treatable and temporary (Paul & Norbury, 2012). A CHI can be caused by an obstruction or blockage (e.g. cerumen) in the ear canal. The most common cause of conductive hearing impairment amongst children is otitis media with effusion (OME) where the middle ear becomes infected and or inflamed due to a build-up of fluid (Maddell, 2014). Hearing impairment can fluctuate between 0 and 40 dB during an infection (Paul & Norbury, 2012; Schlauch & Nelson, 2015). OME can be treated with medications such as corticosteroids or antibiotics (Deloitte Access Economics Pty Ltd, 2017). A bone anchored hearing aid (BAHA) may be an appropriate implant option for a child with a significant CHI and where a hearing aid cannot be used. For instance in situations of chronic middle ear disease or a congenital aural atresia (Declau, Cremers, & Heyning, 1999; Dimitriadis, Vlastarakos, & Nikolopoulos, 2011). A BAHA system is shown in Figure 2.

1.4.2 Sensory Hearing impairment

Sensory hearing impairment (SHI) results from damage to the inner ear or cochlea. This can result from causes such as injury, infection, ototoxicity, ageing or it may be congenital (Paul & Norbury, 2012). Loss of hearing sensitivity is the main characteristic of sensory hearing impairment which ranges from mild to profound in severity and is usually permanent (Stach & Ramachandran, 2014). A SHI refers to any defect that interferes with the conversion of vibrations in the cochlea to nerve signals (Dillon, 2012). Hearing sensitivity tested by air conduction and bone conduction are decreased on an audiogram for a person with SHI (Bess & Humes, 2008). A SHI is thought to be largely caused by impairment of the IHCs (meaning the auditory nerve cannot be activated) and/or OHCs which affect the natural amplification system, reducing the energy of the incoming travelling wave and affecting auditory perception within the cochlea for an individual (Dillon, 2012; Dimitriadis et al., 2011; Stach & Ramachandran, 2014). A SHI can be caused by viral or bacterial diseases,

ototoxicity (drugs), noise exposure (termed noise induced hearing impairment) or age (presbycusis) (Bess & Humes, 2008). Knowing a child has a sensory hearing impairment informs a teacher about their likely speech perception needs. For example, an awareness of the impact background noise may have on ability to perceive and understand speech (Boothroyd, 2004; Crandell & Smaldino, 2000).

A cochlear implant can provide a surgical solution for amplification whilst a hearing aid may be an appropriate non-surgical intervention for a sensory and/or neural hearing impairment (Paul & Norbury, 2012). There are many factors to consider for cochlear implant candidacy. Children with profound hearing impairment benefit from cochlear implantation for hearing speech. Children with cochlear implants have performed better on measures of speech perception, speech production and educational placement than children with hearing aids and average hearing thresholds of 90 dB HL (equivalent to a profound hearing impairment) (Archbold, Nikolopoulos, Lutman, & O'donoghue, 2002; Fitzpatrick, McCrae, & Schramm, 2006; Horga & Liker, 2006). One of the most important factors for consideration in cochlear implant candidacy is the presence of a healthy auditory nerve (Dillon, 2012).

A mixed hearing impairment results from an impairment within both the conductive (outer and middle ear), sensory and/or neural (cochlea and beyond) parts of the auditory system (Paul & Norbury, 2012).

1.4.3 Neural Hearing Disorders

Neural hearing impairment describes a hearing system that is working normally from the outer and middle ear up to and within the cochlea (or inner ear). There is a deficiency in the connection from the cochlea to the auditory nerve or disrupted transmission of sound along the auditory nerve. In conjunction with this when OHC function is normal and either IHC, their connection to the auditory nerve, or the auditory nerve is damaged the hearing

impairment is called ANSD (Amatuzzi et al., 2001). ANSD is also known as an auditory dys-synchrony disorder and describes a disorder of the auditory system in the brain. The cochlea is functioning normally but the transmission of neural information along the auditory pathway is disrupted (Kumar & Jayaram, 2011; Musiek & Baran, 2007). The site of lesion for ANSD occurs somewhere between the cochlea and the brainstem. ANSD can be caused by low birth weight, prematurity, viral disease, seizure, anoxia or hypoxia (Musiek, Gonzalez, & Baran, 2015). The otoferlin gene is also implicated in ANSD (Runge et al., 2013).

The most common characteristics of neural hearing disorders seen in children are difficulty extracting the sound signal of interest from background noise (e.g. speech) and difficulty localising a source of sound particularly in background noise. The subsequent behaviours observed in children are often misinterpreted as inattentiveness and distractability (Stach & Ramachandran, 2014).

Children who experience auditory processing disorders (APD) are likely to experience learning difficulties. A teacher with a child with APD in their classroom needs an understanding of the disorder and specific learning support strategies for the child (Abrams & Kraus, 2015). Auditory processing disorders can occur independent of a peripheral hearing impairment or because of an impaired cochlea sending inadequate signals to the brainstem (Chisolm, Willott, & Lister, 2003). APDs can originate in the brainstem, mid-brain or auditory cortex (Chisolm et al., 2003). Auditory processing involves the complex process of perceiving and encoding auditory signals as they move through the auditory system. Children with APD have normal hearing sensitivity but experience difficulty understanding complex sounds (including speech) especially in background noise (Allen, 2016; Musiek & Baran, 2007). A child with APD will likely have difficulty following oral instructions, learning from what they hear, achieving academically and developing good communication skills (Allen, 2016). Auditory processing is the ability to perceive, interpret and understand a sound, even

in poor listening conditions. This is how a child learns new sounds and comes to identify familiar sounds that develop into meaningful links between sounds heard and their increasing knowledge of sound (Allen, 2016). A child with an APD will have difficulty learning new information in a noisy classroom (Allen, 2016). Children with APD need help with developing their cognitive abilities by using metacognitive strategies that improve their hearing and learning (Allen, 2016). Children with APD benefit from amplification and the use of Remote Microphone (RM) systems in a classroom learning environment (Abrams & Kraus, 2015).

Other neural hearing disorders that affect children include neoplasm which usually occurs in the form of benign tumours. The most common form of neoplasm for children is associated with neurofibromatosis type 2 (NF2). Hydrocephalus, hypoxia and hyperbilirubinemia can also cause neural hearing disorders in children (Stach & Ramachandran, 2014).

Hydrocephalus usually results from enlarged ventricles and manifests with a neuromaturational delay of the auditory system. Hypoxia (oxygen deficiency) often results in diffuse disorders of auditory neural function and sometimes progressive SHI alongside the effects of neonatal respiratory distress. Hyperbilirubinemia is an excess of bilirubin in the blood and is associated with auditory neuropathy and other neural hearing disorders. The resulting hearing impairment can be a permanent sensory loss or transient auditory dysfunction (Stach & Ramachandran, 2014).

1.5 Aetiology of Hearing impairment

Causes of hearing impairment can be grouped into three categories: genetic which includes chromosomal abnormalities; non-genetic or environmental which includes maternal behaviour or lifestyle (e.g. alcohol, drugs, diet), contaminants, radiation and infection; and

unknown (Tharpe & Seewald, 2016). Although aetiology of hearing impairment may vary between countries, it is agreed that up to half of congenital or early-onset hearing impairment is due to genetic mutations (World Health Organization, 2010). Non-genetic causes of hearing impairment include infections during pregnancy (such as cytomegalovirus, rubella and toxoplasmosis); diseases (e.g. meningitis, measles, mumps and chronic otitis media); birth conditions (e.g. asphyxia, low weight and hyperbilirubinemia); and head injury (Digby, 2017; World Health Organization, 2010). Irrespective of cause, hearing impairment at birth or early in life that goes undiagnosed impacts on development of speech and language, education and the individual's social-emotional development (World Health Organization, 2010).

1.5.1 Causes of Hearing Impairment in Children

Hearing impairment in children can be due to genetic, environmental or unknown causes (Tharpe & Seewald, 2016). Causes of childhood hearing impairment include disease, trauma, and developmental conditions (Stach & Ramachandran, 2014). Sensory hearing impairment occurs in the cochlea and can be attributed to congenital inner ear abnormality, maternal infection (e.g. toxoplasmosis, cytomegalovirus) or acquired infections such as meningitis or measles (Stach & Ramachandran, 2014). If the sensory hearing impairment is severe enough it can sometimes be treated surgically with a cochlear implant (for amplification) or with amplification such as a hearing aid device (Paul & Norbury, 2012).

Otitis media with effusion (OME) is one of the most common diseases in infants and children with the highest prevalence in the first two years of life (Bluestone, 2004; Stach & Ramachandran, 2014). Otitis media is usually a result of eustachian tube dysfunction following an upper respiratory tract infection (Cohen, 2011; Stach & Ramachandran, 2014). The role of the eustachian tube (protecting and equalising the middle ear space) is impaired due to swelling of the nasopharynx (Stach & Ramachandran, 2014). Treatment for otitis

media (OM) can include medical or surgical intervention. The preferred treatment for recurrent OM is insertion of tympanostomy tubes commonly known as grommets (Fria, Cantekin, Eichler, Mandel, & Bluestone as cited in Cohen, 2011).

A child's hearing disorder impacts on their speech and language development in a variety of ways depending on the severity (degree), type (e.g. sensory, neural, conductive) and configuration (e.g. across frequencies) of the hearing impairment, stability of hearing impairment and when in the developmental process the hearing impairment occurred (Maddell, 2014; Paul & Norbury, 2012). Measles, mumps, rubella and meningitis are all associated with permanent childhood hearing impairment (PCHI). They are also diseases for which immunisation is available in the developed world (Tharpe & Seewald, 2016). Since 2006 immunisation coverage in New Zealand has increased. This is likely to be resulting in decreased rates of hearing impairment from diseases such as meningitis, measles, mumps and rubella (Digby, 2016).

1.5.2 Congenital Hearing Impairment

Congenital disorders typically result from structural deformities or anomalies and can cause CHI. Often the resulting CHI cannot be treated until the child's skull is fully grown. Children with a recurrent middle ear disorder (e.g. OME) that is combined with fluctuating hearing sensitivity are more likely to experience language and/or learning difficulties. This is likely due to the inconsistent auditory input received during the critical language development period (Stach & Ramachandran, 2014).

Maternal rubella (also known as German measles) was once the main aetiology for congenital childhood hearing impairment which ended in the rubella epidemic of the 1960's. During this time 30,000 - 40,000 children were born deaf. The rubella vaccine drastically

reduced the incidence of hearing impairment as a cause of congenital and early onset deafness to the two percent of cases it accounts for now (Marschark, 2007).

1.5.3 Syndromic hearing impairment

Hearing impairment that is part of a syndrome (e.g. Down syndrome) can be sensory,neural, conductive or mixed. Hearing impairment also co-occurs as one of several developmental abnormalities comprising a genetic syndrome (Tharpe & Seewald, 2016).

1.5.4 Non-syndromic (non-genetic) hearing impairment (NZ)

Non-syndromic causes of hearing impairment include: prematurity, in-utero infection (e.g. CMV, toxoplasmosis and rubella) and diseases (e.g. meningitis, mumps, measles) (Digby, 2016; Stach & Ramachandran, 2014).

1.5.6 Acquired hearing impairment

Noise induced hearing impairment (NIHL) also termed occupational noise, accounts for 16-37% of hearing impairment globally (The National Foundation for the Deaf Inc, 2017). Within New Zealand 25% of the workforce encounters “noise” at work. For example workers in manufacturing, construction and mining (Digby, 2016; The National Foundation for the Deaf Inc, 2017). Other causes of acquired hearing impairment include meningitis and OME. Bacterial meningitis is more likely to cause permanent hearing impairment than viral meningitis (Marschark, 2007). Middle ear infection or otitis media with effusion (OME) is common in childhood. Otitis media in which the middle ear becomes infected and/or inflamed is the most common cause of CHI among children. (Tharpe & Seewald, 2016; Yiengprugsawan, Hogan, & Strazdins, 2013). CHI associated with otitis media usually fluctuates with recurrent episodes (Paul & Norbury, 2012). An Australian six-year prospective longitudinal study by Yiengprugsawan et al. (2013) found a significant relationship between repeated ear infections in early childhood and hearing impairment in

later childhood (for example, ear infections at 4-5 years of age were predictors of hearing problems at 8-9 years of age in one study cohort). A fluctuating mild-moderate CHI frequently accompanies otitis media with a duration ranging from weeks to months (Deloitte Access Economics Pty Ltd, 2017; Williams & Jacobs, 2009). Bacterial meningitis is more likely to cause permanent hearing impairment than viral meningitis.

1.6 Management of Hearing impairment

The WHO established resources for preventing, detecting and managing ear and hearing disorders for an individual. The worldwide newborn hearing screening programmes provide effective early intervention for congenital and early onset hearing impairment (World Health Organization, 2010).

In New Zealand, congenital and early onset hearing impairment is managed with early intervention under the UNHSEIP. Early intervention includes initiation of appropriate medical and audiological services (which may include fitting of hearing aids or implants), and early intervention education services to give a child access to speech (National Screening Unit, 2011). The UNHSEIP was fully implemented across all District Health Boards (DHB's) over a three-year phase from 2009-2010 (Ministry of Health, 2016).

1.6.1 Medical Treatment

Medical surgery may be required to correct hearing impairment especially for a CHI. Most SHIs are permanent and medical treatment is therefore not appropriate (Musiek & Baran, 2007). Surgeries for a CHI include inserting a ventilation tube for OM, removing fixated bone due to otosclerosis, removing a foreign body or cholesteatoma, or repairing damaged ossicles (bones of the middle ear, see Figure 1) (Musiek & Baran, 2007).

1.6.1.2 Implantable Devices

A cochlear implant is an electronic medically-implanted device that helps to transmit sound signals to the brain (The National Foundation for the Deaf Inc, 2017). The cochlear implant provides an electrical sound signal to the auditory nerve via a series of electrodes implanted in the cochlea (Cochlear Ltd, 2017). For children with congenital hearing impairment who are candidates for implantation, cochlear implants are recommended to be implanted as early as possible to optimise acquisition of speech and language (Dillon, 2012). Children with a bilateral profound sensorineural hearing impairment meet some of the criteria for receiving cochlear implants (Gifford, 2014). Cochlear implants are more effective at conveying mid-and high-frequency sounds. A cochlear implant should be implanted by twelve months of age to maximise a child's development of speech perception and speech production (De Raeve, 2010; Nicholas & Geers, 2006). In New Zealand, the aim is for audiological and early intervention services to be initiated for children diagnosed with hearing impairment or deafness by the age of six months (National Screening Unit, 2011).

Bone-anchored implants (also known as Bone Anchored Hearing Aids or BAHAs) are suitable for children with bilateral conductive or mixed hearing impairment. They are often used for children with atresia (no ear canal) and other anatomical abnormalities of the outer and middle ear that mean a hearing aid will not be of benefit or is not possible (Christensen, 2014). For children with a profound unilateral hearing impairment a BAHA can improve their understanding of speech in background noise (Christensen, 2014). A BAHA is a partially implanted bone conduction hearing device. It is fixed to the skull through the skin behind the ear with a titanium fixture. Figure 2 shows the three main components to a BAHA: sound processor, abutment (which can be a magnetic or snap-on connection), and implant.

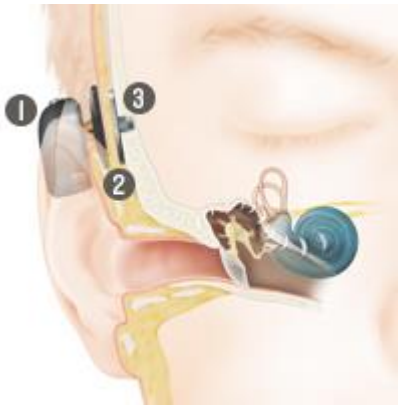

Figure 2. Cochlear BAHA Attract system and its components.

Note: 1 is the sound processor, 2 is the magnetic connection or abutment, 3 is the implant

Cochlear Ltd. (2017). Baha® Attract System. Retrieved from http://www.cochlear.com/wps/wcm/connect/au/home/discover/baha-bone-conduction-implants/baha-attract-system

Children with bilateral conductive or mixed hearing impairment can often use a BAHA (Christensen, 2014).

1.6.2 Non-medical Treatment

Hearing impairment that is not effectively treated medically may be improved with the use of amplification such as: hearing aids, bone-anchored hearing aids, cochlear implants or brainstem implants. Assistive devices can also be used to help with hearing impairment and sound processing alongside hearing aids or on their own (The National Foundation for the Deaf Inc, 2017).

1.6.2.1 Hearing Devices

Hearing and assistive devices referred to in the research survey were hearing aid, BAHA, cochlear implant and RM. These are devices commonly used for children with hearing impairment. A brief definition follows.

Two broad categories of hearing aids are Behind-the-Ear (BTE) and In-the-Ear (ITE). BTE aids fit behind the ear and are coupled to the ear via a tube from the aid to the ear with a

custom ear mould or dome placed in the ear canal. ITE aids fit in the ear canal and are typically custom made to fit an individual's ear (Groth & Christensen, 2015). A wireless RM system works with an individual's hearing aid. The RM picks up the speech signal and transmits it wirelessly to a receiver connected to either a loudspeaker (e.g. soundfield system) or personal hearing aid. The signal contains minimal reverberation or noise allowing a direct speech signal to be processed by the hearing aid. In a classroom environment this means the teachers voice is clear for the hearing aid user (Scollie, 2015). In a classroom the teacher will usually wear the RM. A personal RM (also known as FM – frequency modulation) only system can be used for children with normal hearing thresholds and auditory learning difficulties. For example APDs, attention deficits or mild CHI (Smaldino, Kreisman, John, & Lindsay, 2015).

Bone-Anchored Hearing Aids (BAHAs) are surgically implanted aids. BAHAs bypass the external and middle ear to stimulate the cochlea directly through bone conduction. The components of a BAHA are the titanium implant, external abutment and the sound processor. See Figure 2. Sound is picked up by the microphone on the sound processor and transmitted to the implant. BAHA devices are suitable for individuals with unilateral deafness, congenital ear malformations and chronic external and/or middle ear disorders.

Cochlear implants CIs) are suitable for individuals with moderate to profound sensory hearing impairment (Zwolan, 2015). CIs are surgically implanted and use a speech processor that is worn externally.

1.6.2.1 Hearing Aids

Hearing aids are amplification devices that amplify sound for people with hearing impairment. The primary purpose of hearing aids is to enable the user to understand speech without causing discomfort. For a young child a hearing aid will enable them to hear

language and develop speech (Bess & Humes, 2008). For children's cognitive development, hearing aids provide an important connection between sounds and events in their environment (Marschark, 2007). Children learn about cause and effect (e.g. falling crockery breaks and makes a noise), the nature of things (e.g. sound of an air conditioner is a mechanical sound), and the nature of communication (Marschark, 2007). The latter, for example, when a parent speaks and may be pointing to a toy, develops a connection between objects and forms a behavioural interaction between parent and child (Marschark, 2007).

For a child born with hearing impairment, fitting hearing aids early is important for them to acquire age-appropriate speech and language. Hearing aids should be provided as part of early intervention by six months of age (Dillon, 2012; National Screening Unit, 2011).

Hearing aids differ in their ability to amplify hearing depending on type of hearing impairment. The auditory impairment experienced by a person with a sensorineural hearing impairment means they need a signal-to-noise ratio greater than normal, to communicate effectively even with sound amplified by a hearing aid. This means that for individuals experiencing sensorineural hearing impairment control of background noise which confounds signal acquisition, and relies on the signal processing of any device-related amplification, is important (Dillon, 2012). Amplification from a hearing aid for a conductive hearing impairment can restore hearing close to normal range (Dillon, 2012). A CHI typically results from sound signals not being conducted normally to the inner ear. A hearing device can help overcome the conductive component. As this type of loss does not tend to involve survival of outer or inner hair cells of the inner ear, there tends to be a lack of distortion in the signal that can be associated with SHI. Therefore, a straightforward and appropriate amplification strategy that overcomes the conductive component can be effective (Dillon, 2012).

1.6.2.2 Remote Microphone (RM) Systems

RM technology is an effective solution to augment access to communication in difficult listening environments most often a classroom (e.g. background noise, high reverberation, large distance between speaker and listener) alongside hearing aids and implants (Wolfe, Lewis, & Eiten, 2016). A RM system consists of a microphone that is usually worn clipped onto the speaker's (e.g. teacher) clothing so that it is near their mouth (e.g. within 15-20 cm). The RM is coupled to a transmitter delivering the speech signal wirelessly to the listener's hearing technology (e.g. hearing aids or implants) receiver. A RM may also be hand-held or placed on a table in front of the speaker/s. For example on a child's desk during group work at school. Miniature ear-level RM receivers are appropriate for children of all ages both in and out of school (Wolfe et al., 2016). Hearing assistance technology such as a RM system supports children with hearing impairment and children with normal hearing and auditory processing needs in poor acoustic environments (such as a classroom with high reverberation). They transmit a clear speech signal with improved SNR to the child's ears (Allen, 2016; Wolfe et al., 2016). For a child with a bilateral hearing impairment significant enough to impact educational outcomes an RM system can achieve the greatest increase in speech perception and greatest decrease in listening effort in a classroom.

1.7 Effect of Hearing on Learning

The main impact of hearing impairment is on communication ability. Children with untreated hearing impairment often experience a delay in spoken language development (World Health Organization, 2017).

Auditory function for children continues to mature and develop up to approximately 12 years of age (Paul, 2007). New-born babies have the capability to distinguish most acoustic contrasts of speech used across the languages of the world. Infants lose the

sensitivity to non-native contrasts by the end of their first year of life (Kuhl & Kuhl, 1993). The auditory system maps speech sounds and reorganises to support the perception of speech sounds for the native language the child is exposed to (Paul, 2007). Auditory information has an important role in speech development in addition to interacting with visual information. The interaction between auditory and visual information provides the integration of sensory information (Paul, 2007).

Auditory learning is an important part of language and literacy development for children. For auditory learning to occur sound must first reach the brain (Maddell, 2014). For children with hearing impairment it is important that the adults (e.g. parents, teachers) around them understand the importance of auditory learning on their language acquisition and literacy development and actively work towards building those skills (Maddell, 2014). Otitis media in childhood can negatively influence cognitive and educational outcomes for children (Williams & Jacobs, 2009). The cognitive skills affected by hearing impairment are most likely to be auditory processing, attention, behaviour and speech and language (Williams & Jacobs, 2009). Williams and Jacobs (2009) suggested that incidents of hearing impairment in infancy could change perceptual capabilities (relating to speech perception) that in turn affect language-learning abilities for children.

A component of a child's learning at school comes from incidental learning with peers. Low levels of peer interactions in curricular and co-curricular activities appears to contribute to slower academic progress (Marschark, 2007). In the classroom, differences observed between hearing children and those with hearing impairment can be attributable to hearing impairment rather than spoken language skill (Marschark, 2007). All children need active participation in classroom discussions for learning (e.g. asking and answering questions). Language stimulation in all modes (i.e. verbal, visual) is important for children's

language development from an early age (Marschark, 2007) . Language acquisition requires regular input and feedback across a child's first 2-3 years of life (Marschark, 2007) .

Learning written language and school discourse can be challenging for hearing impaired children. At school children need to learn the formal instructional discourse of teachers (e.g. narrative and expository) which differs to the dialogue of a conversational discourse (Mahshie, 2005).

A hearing impaired child with amplification may be able to hear better than without amplification but this alone does not provide them with the ability to listen (Flexer, 1999). Teaching listening skills to children will make them proficient listeners. For this to occur they need opportunities to learn the meaning of sounds they are hearing. Thus an integration of spoken language and listening skills will facilitate the acquisition of auditory skills (Flexer, 1999). Auditory comprehension is the outcome of auditory skill development. Starting with the ability to detect a speech sound, then discriminate between sounds, then identification of sounds, suprasegmental (or prosody) speech and finally comprehension (Flexer, 1999). Early intervention with hearing aids, cochlear implants, or other devices appropriate for an individual child's hearing impairment, give young children the opportunity for neuroplasticity changes associated with sound access to facilitate central auditory system development (Maddell, 2014).

The introduction of UNHSEIP in New Zealand for new-born infants means that hearing impairment can be identified within the first few months of life. Amplification in the form of implants or hearing aid devices is now provided for children by 12 months of age (Paul & Norbury, 2012).

1.7.1 Learning

Children with congenital or acquired hearing impairment have different listening needs to adults. Children are often receiving their first amplification devices during the critical period for development of speech and language skills (birth to two years of age). It is widely understood that children with hearing impairment need more speech audibility than adults or children with normal hearing. In order to optimise acquisition of speech and language children with hearing impairment need more gain, a higher SNR and a wider audible bandwidth of speech (Bagatto & Scollie, 2016). Hearing impairment can affect language acquisition and speech articulation. One study found that children with mild to severe hearing impairment demonstrated persistent errors in producing consonant fricatives and affricates (e.g. /f/, /th/, and /ch/, /j/) in their speech (Elfenbein, Hardin-Jones, & Davis, 1994).

1.7.2 Classroom Acoustics

International research has shown that speech perception decreases steeply for hearing impaired listeners in a room where reverberation time is greater than 0.4 seconds (Crandell, C. C., Gold, M.J. & Siebein, G.W. as cited in Wilson, 2002). Reverberation time refers to the time it takes for a steady state sound to decrease 60 dB from its peak amplitude (Smaldino & Flexer, 2014). In terms of speech, a reverberant room means that speech is reflected off hard surfaces such as walls and floors delaying the time for components of speech to reach a listener's ear. The reflected speech can mask less intense sounds of the speech spectrum for direct speech resulting in an overall decrease in speech recognition for the listener. The suggested guidelines for SNRs for people with hearing impairment is for greater than +15 dB for accurate speech recognition (Smaldino & Flexer, 2014). Following an analysis of literature Crandell and Smaldino (2000) recommended that classroom reverberation levels should not exceed 0.4-0.6 seconds to minimise the adverse effect on speech perception for children with SNHL and normal hearing sensitivity. Recommendations for primary school

children with language or hearing impairments is for school classroom noise levels to be 10 dBA lower and RTs 0.2s lower than that recommended for typically developing children (MacKenzie & Airey, 1999). Hearing impaired listeners require a higher SNR than normal hearing listeners so that they can understand the same proportion of words in a speech signal (Plomp, 1978). Children in turn are inefficient listeners and need a higher SNR than adults because their brains are neurologically immature and they do not yet have the experience to predict speech from context (Boothroyd, 2004; Smaldino & Flexer, 2014; Wilson, 2002). Children who have not heard key words, phrases or concepts due to a poor listening environment have difficulty keeping up with the classroom teaching, are at risk of academic under-achievement and can develop behaviour problems in the classroom (Wilson, 2002). An estimated 15-20% of New Zealand primary school children are considered in the 'at risk' group which includes children with temporary hearing impairment due to otitis media, a permanent hearing impairment, learning disability, speech impairment and for young children and those with English as a second language (Wilson, 2002).

The New Zealand Audiological Society (NZAS) supports recommendations for a 0.4-0.6 reverberation time in the single octave frequency bands 125 Hz to 5 kHz in a classroom environment alongside acoustic absorption materials appropriate to the teaching practice in each classroom space (New Zealand Audiological Society, 2015). NZAS also recommends that learning environments for children with learning problems and English as a second language should have reverberation times at the lower end of the recommended range (New Zealand Audiological Society, 2015).

Classroom acoustics impact the ability of children to hear speech (Crandell & Smaldino, 2000). Reverberation time in a classroom increases with acoustically hard floors and ceilings. A reverberation time of more than 0.4 seconds in a room means that speech perception for hearing impaired listeners is drastically reduced (Wilson, 2002). Hearing impaired listeners

need a higher signal-to-noise-ratio (SNR) than listeners with normal hearing to perceive speech. Children, in turn, need access to sound in their environment for incidental language learning and a higher SNR than adult listeners (Dillon, Ching, & Golding, 2014). This is because their brain is still developing and they do not yet have the language experience for predicting speech from context. Children are inefficient listeners who need optimal listening conditions to hear and understand in their environment. It is estimated that in New Zealand 15-20% of children are considered to be at risk of low academic achievement, developing behaviour problems and having difficulty keeping up with peers in classroom learning (Wilson, 2002).

Siebein, Gold, Siebein, and Ermann (2000) identified ten ways to improve classroom acoustics (for American classrooms designed in the 1980's and 1990's). This included selection of an air-conditioning system with low background noise levels (e.g. below 30-35 Noise Criteria (NC), where higher NC levels meant higher background noise in a room). Rooms with central air conditioning systems and duct lengths sufficient to attenuate sound resulted in the lowest NC levels. Air conditioning systems needed noise control devices to maintain appropriately low NC levels. Other key strategies to improve classroom acoustics and the impact on students included limiting the ceiling height (to approx. 9-12 feet), provision of sound absorbing surfaces (where the sound absorbing materials match the floor area) and carpet. Recommended teaching strategies included an alternative teaching style to the traditional lecture-style where the objective is to decrease distance between the students and teacher. This can reduce the voice drop of the teacher from 6-9 dB from the front of the room to the back in a traditional classroom where children are seated in rows and teachers use a lecture-style from the front of the classroom; to a less than 4 dB decrease in sound level to the students using alternative teaching strategies (e.g. the teacher walking through aisles, students seated in a circle or sitting on a carpeted floor for story time).

Classroom amplification can reduce the impact of deficits of hearing, listening and attention for a child in the classroom regardless of hearing aetiology (ASHA, 2005; Crandell & Smaldino, 2000). Effective listening skills needs to be overtly taught to children so that they can receive and process a meaningful speech signal. Focussing on phonological awareness skills will also improve literacy outcomes (Williams & Jacobs, 2009).

1.7.3 Development

Hearing impaired 18 year olds in the United States (US) have median reading levels comparable to that of nine-year old hearing children (Traxler, 2000). In a study by Easterbrooks and Beal-Alvarez (2012) literacy outcomes of hearing impaired students were considered in the context of the average American. Hearing impaired children encounter difficulty at fourth-grade (approximately nine years old) reading level. Eighth-grade (approximately 12 years old) reading level is typical among American adults. They recommend future research examine the predictors of fourth-grade literacy success (Easterbrooks & Beal-Alvarez, 2012) .

In general, grammar of hearing impaired children is similar in features but delayed compared to normal hearing children during language acquisition. Research (Ruder, 2004) suggests that children with hearing impairment rely more on semantic and conceptual cues than grammar of language. For example, hearing impaired children can mark a plural /s/ (‘boys’, ‘girls’, ‘actresses’) but are liable to omit the third person singular /s/ (‘she climbs’, ‘he runs’, ‘it rains’).

Literacy continues to be a challenging area of development for children with hearing impairment. Literacy outcomes are vastly improved for children with early implantation of cochlear implants (Geers, Tobey, Moog, & Brenner, 2008). The early focus for a child with a cochlear implant is on improving listening skills and responses to new sounds alongside early

speech and language goals that are fostered in a meaningful social context. Speech and language therapy is an important support during the language acquisition stage of the child's life (Paul & Norbury, 2012). Exposure to print in early pre-literacy language development is a known factor that contributes to literacy development for children with hearing impairment (Paul & Norbury, 2012). Kretschmer and Kretschmer (2000) report that pre-reading skills can sometimes be overlooked when the focus is on amplification and developing oral language skills. They found that when children with hearing impairment are exposed to print-rich and engaging environments at home and school they display emergent literacy that is comparable in form and content to their normal hearing peers (Kretschmer & Kretschmer, 2000).

1.7.4 Psycho-Social

There is evidence that learning about mental states requires rich conversational experience with others. Studies cited in Paul & Norbury (2012) emphasise early exposure to language and communication in meaningful social contexts is of greater importance than hearing impairment alone for children to develop socially appropriate use of language.

Social-cognition of a learner incorporates Theory of Mind (ToM) and facilitates a child's academic learning (Morgan, 2015). A child who is delayed in understanding the reasons for other people's behaviour and has less social awareness than their peers will experience a learning disadvantage in the classroom (Morgan, 2015). Some researchers consider ToM development to be controlled by language acquisition. Although it is still unknown what developmental factors contribute to delayed development of ToM for deaf children (Morgan, 2015). Social-cognition assists children to understand pragmatics such as rhetorical questions as well as the ability to reflect on the emotional impact their behaviour may have on another person. ToM can be important for a child to understand the discussion around abstract concepts in a classroom situation (Morgan, 2015). Amplification devices (e.g. hearing aids or implants) work well for allowing a child to have increased access to spoken

language for face-to-face communication. A hearing impaired child wearing an amplification device will still have difficulty hearing and understanding multiple conversations around them in a noisy classroom (Akhtar, 2005). Hearing impaired children need to understand social situations they are involved in with other children. This allows them to understand mental states driving the actions of others (e.g. if a peer is upset or calls out in the classroom they will look over and make sense of the reason for the peer's reaction) (Akhtar, 2005). Children typically develop social-cognition from a combination of incidental learning through overheard and direct conversations, actively participating in language rich social situations and language development. Teachers need an awareness of social-cognitive development and how it links to academic success for hearing impaired children. As a group, deaf children are at risk of missing social-cognitive milestones (Akhtar, 2005).

Porter, Sladen, Ampah, Rothpletz, and Bess (2013) found that children with minimal hearing impairment (defined as a diagnosed mild hearing impairment) whose diagnosis of hearing impairment was delayed had associated psychoeducational difficulties and low maternal education. The children in the Porter et al. (2013) longitudinal study were born after implementation of new-born hearing screening. Despite this some children in the study were diagnosed with hearing impairment as late as ages three to five years old. The researchers found that children with mild hearing impairment may have greater difficulties with selective attention in contrast to children with normal hearing. Selective attention can have a negative impact on classroom learning and psychoeducational outcomes (Porter et al., 2013).

1.7.5 Education

Academic achievement of deaf and hearing impaired students appears to be related more to what happens in the classroom than the composition of classroom interaction and teacher instruction (Cawthon, 2015). Learning encompasses social contexts and cognitive functions. The school classroom gives the social context in which cognitive processes

develop meaning for children. A child's cognitive learning process is limited by accessibility to a number of factors including language, social interaction, teaching skills of teachers and characteristics of the students such as prior knowledge, memory and executive function (Cawthon, 2015). Spencer and Marschark (2010) reported a study by Hadjikakou, Petridou, and Stylianou (2005) found that pre-teaching hearing impaired secondary school students in small groups and one-on-one for materials to be covered in general teaching in the mainstream classroom allowed most students to understand and follow the general teaching curriculum. It should be noted that 29% of students reported they could not participate in the classroom lessons. Students in the Hadjikakou et al. (2005) study report that mainstream teachers did not modify lessons whilst teachers reported their level of adaptation varies (Hadjikakou et al., 2005). In the study by Hadjikakou et al. (2005), both hearing impaired children and teachers made suggestions for adapting the teaching curriculum to meet the educational needs of the children. Adaptations included fewer lessons, modification of mainstream classroom delivery (e.g., clear, slow, natural speech), less homework, provision of written material and modification of language used in text books and tests.

This information has been gained from studies in Cyprus and the US and across primary and secondary school children. Teaching pedagogies may vary and / or not be relevant to New Zealand. It is therefore important to acquire an understanding of the context for primary school teachers supporting children with hearing impairment in New Zealand classrooms.

During the time children are developing literacy children with hearing impairment need explicit instruction for vocabulary development (Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008). Children with normal hearing acquire a proportion of new vocabulary through incidental learning (Nagy, McClure, & Mir, 1997; Saffran, Newport, Aslin, Tunick, & Barrueco, 1997). Hearing impaired children need teachers to support them

meeting the challenges of learning new vocabulary and developing alphabet knowledge and phonological awareness skills (Easterbrooks et al., 2008). It is well documented that early phonological awareness skills are strong predictors of early reading and spelling abilities (e.g. rhyming and syllable segmentation of words) (Lonigan, Burgess, & Anthony, 2000; Maclean, Bryant, & Bradley, 1987).

1.7.6 In Educational Settings

Spencer and Marschark (2010) considered teaching and learning of hearing impaired children to significantly impact on their academic achievement. Accordingly, they report that teachers of hearing impaired children need to have an awareness of ways in which hearing impaired children differ from hearing children in the classroom and the ability to adapt their teaching for the hearing impaired children. An example of this is providing teacher instruction in a mainstream classroom with hearing children with separate classroom space for hearing impaired children. Teachers working with hearing impaired children need to understand the cognitive and language abilities underlying their learning and use teaching methods and materials tailored to the individual (Detterman & Thompson, 1997). In the literature review by Spencer and Marschark (2010) several factors impacting the ability for hearing impaired children to access the curriculum were highlighted. These include the fact that hearing impaired children are starting school with less knowledge of the world and less developed academic knowledge than their hearing peers. They have cognitive differences attributable to their experience of the world either without hearing or with reduced hearing and the type of experience they gain through interactions with others including teachers. Also, teacher factors in what is taught, where it is taught and how it is taught (Spencer & Marschark, 2010).

Students who wear cochlear implants and display age-appropriate speech and language abilities still need adjustments and communication strategies in a classroom

environment where there is a listening and spoken language focus (Starr, 2017). The wearable components of hearing devices continue to get smaller and more discreet with time and advances in technology. This also means that it is more difficult for teachers to recognise children who use CI's at times resulting in misunderstanding of a child's classroom behaviour. A child's listening difficulty may be misinterpreted as a behaviour or attention issue (Starr, 2017). Classrooms are a constant source of student and background noise which impacts on learning for deaf and hearing impaired children. Starr (2017) suggested eight key strategies for students and teachers to focus on that improve the classroom listening environment for children with implants and hearing devices.

Research on deaf and hearing impaired children has shown they display delays and deficits in all aspects of Theory of Mind. This refers to the development of the ability to infer thoughts, beliefs, and intentions of others and understand or predict how others act. The two main components of Theory of Mind are cognitive and affective incorporating interpersonal and intrapersonal constructs (Moeller, Ertmer, & Stoel-Gammon, 2016). Deaf and hearing impaired children tend to exhibit cognitive interpersonal Theory of Mind delays which has been attributed to their decreased experience of communication interactions (Moeller et al., 2016). This is the ability of a child to infer from a discourse or text such as "Winnie the Pooh", about the motivations and feelings of the characters using interpersonal Theory of Mind skills (Moeller et al., 2016).

It is important that teachers understand social cognitive milestones and can identify when hearing impaired children may be showing delays. Such delays may impact a child's ability to develop healthy peer relationships as well as their ability to understand abstract concepts and pragmatics in a classroom context (Akhtar, 2005; Morgan, 2015). An informed teacher will more easily be able to initiate appropriate teaching support (e.g. teacher aid or

separate pre-teaching sessions) for the child early on in their school year and their school education, thereby optimising a child's educational outcomes (Hadjikakou et al., 2005).

1.8 Teachers Knowledge of Hearing Impairment

1.8.1 From an Individual Perspective (Psycho-social)

Hearing impaired students typically enter and leave mainstream education with less content knowledge than their hearing peers despite having skilled teachers and sign language interpreters (Marschark et al., 2011). Hearing impaired and deaf children benefit socially from attending schools where there are other children with hearing impairment in a classroom with two or more co-teachers and one of the teachers specialises in teaching deaf and hearing impaired children (Marschark et al., 2011). An inclusive learning environment ensures the students with hearing impairment also interact with both hearing and hearing impaired peers and modifications to the presentation of the curriculum accommodate their needs for learning. From a teaching perspective, this requires an investment of resources and teaming and leadership between teachers (Marschark et al., 2011) .

The hearing impaired and deaf population is heterogeneous in language and communication needs and abilities. The language and communication approaches will change and need modifying over time for any one child (De Raeve, 2015). The communication approach or strategy for a child will change depending on the setting and context (Wheeler, Archbold, Hardie, & Watson, 2009). Deaf and hearing impaired children who have received early intervention (i.e., amplification devices such as hearing aids or implants) often have absent or delayed language, cognitive and social skills. These skills (which encompass joint attention, working memory, executive function, ToM and pragmatics) in combination enable a child to capture the classroom information and assimilate it into their learning (Beer, Kronenberger, & Pisoni, 2011; Boons, Brokx, Frijns, et al., 2012). De Raeve (2015)

suggested teachers use the following communication techniques with hearing impaired children in the classroom:

- face the student and stay close (e.g. within 1-1.5m);
- ensure students are seated at the front of the room and slightly to the side to allow clear view of speaker and some of the students;
- speak clearly with a pause after questions to allow for processing time;
- give clear indications of topic and alert student to change of topic;
- gain student's attention for giving any instructions;
- stand in one place (rather than wander);
- avoid speaking while writing on a whiteboard (face is not visible);
- keep beards and moustaches trimmed and hair, hands and pencils away from mouth when speaking;
- enhance communication with gesture, facial expression, body language when appropriate;
- rephrase a message if student has not understood;
- for group work ensure student is seated opposite teacher, all participant faces are visible and one speaker at a time, repeat back other student comments;
- position self on the device side of the student if they wear a device in one ear only;
- use an RM or induction loop hearing system in classroom if available;
- use a note-taker or interpreter.

Teachers need an understanding of a hearing impaired child's cognitive ability so they can make recommendations for learning support and can provide appropriate classroom teaching for the child (Easterbrooks, 2008). Knowledge of the cognitive function and abilities

of children in the classroom can assist teachers to use suitable strategies for an individual (Marschark & Green, 2000).

1.8.2 From a Learning Perspective

Higher academic achievement of hearing impaired students is more likely when teachers are specialists in their subject and when they are knowledgeable about specific learning needs of students with hearing impairment (Spencer & Marschark, 2010). Teaching strategies that focus on visual modelling and visual presentation of information have potential especially for the teaching of mathematics and science concepts. Embedding writing with science related teaching has a positive effect on developing concepts and literacy skills (Spencer & Marschark, 2010). Siebein et al. (2000) outline recommendations for classroom seating configurations that optimise children's ability to hear the teacher. For example, utilising a floor plan shape of a "Y", conference arrangement or small groups for student desks. These specific seating arrangements reduce the student-teacher distance that leads to a decrease in sound level in a traditional row and aisle seating set up. The ideal class size is 25-30 students. The use of a RM amplification system between the student and teacher or a classroom sound amplification system to amplify the teachers voice for all students acts to improve the classroom signal to noise ratio (SNR) (Siebein et al., 2000). Whilst amplification devices such as hearing aids and implants enable hearing impaired students to follow spoken instruction in a classroom, visual supports are still needed to augment the teacher communication and spoken instructions (Marschark, Lang, & Albertini, 2002). Teacher visual supports include using a whiteboard or projector screen when providing instructions to students (Marschark et al., 2002). Children in a learning environment need to receive 90-100% of the useful language information by the sounds of speech. This is because their speech processing skills and ability to use context are still maturing and developing which impacts on their ability to simultaneously maintain pace with the speaker and understand the

meaning of what's being said (Boothroyd, 2012). Boothroyd (2012) identified three main factors that impair good speech perception for a child in a classroom. They are distance, noise and reverberation. Distance refers to distance the listener is from the speaker and how far the speech signal travels. In a classroom, the 6-dB rule applies up to a critical distance thereafter the level of sound is determined by reflected sound and remains constant regardless of increasing distance. The 6-dB rule refers to: as speech from the person talking travels further, for every doubling of distance between speaker and listener 6 dB of amplitude is lost. For example, a listener 3m away could perceive speech at approximately 56 dB SPL whilst a listener 6m away would perceive the same speech at 50 dB SPL. In a classroom, the quality of the speech signal heard is weaker due to wall and ceiling reflection (Smaldino, 2011). Classrooms tend to be noisy. To ensure the speech signal from the speaker is not masked by classroom noise the intensity of speech needs to be at least 15 dB above the noise (Boothroyd, 2012). In a classroom where the teacher's speech is only 5 dB above the background noise level, it is likely only 50% of the speech will be perceived by the child listener. Children require 90-100% audibility to understand speech in a learning environment. Noise can be an additional distracting factor. Individual children vary in their ability to ignore distractions and focus attention on a speaker. Hearing impaired children may need a speech-to-noise ratio that is greater than 15 dB (i.e. the speech signal is 15 dB louder than the background noise) (Taub, Kanis, & Kramer, 2003). Finally, classroom reverberation, the continuance of sound in a room due to many repeated reflections off room surfaces, decreases the strength of the speech signal for the listener. Reverberation is measured by the time taken for the sound level to reduce by 60 dB after the sound stops. A reverberation time of close to 1 second significantly impacts on sound quality due to late reflection of the sound (Boothroyd, 2012). Primary school and kindergarten classrooms are often noisy with high reverberation (De Raeve, 2015). Classroom environments with poor acoustics have greater

negative effects on learning ability, concentration and listening skills for hearing impaired children than hearing children. A child with hearing impairment will experience more decrease in speech perception than a child with normal hearing levels in poor acoustic classroom environments.

An important aspect of a teacher's role is monitoring and actively managing classroom noise levels. Understanding the contributing factors and the negative effects of noise on children's learning will enable a teacher to implement appropriate teaching strategies and manage the classroom environment. A hearing impaired child will benefit from individualised communication strategies and a classroom setup that minimises the impact of noise on their learning (Boothroyd, 2012; Marschark et al., 2002; Siebein et al., 2000; Taub et al., 2003).

Classroom acoustics can be improved in a manner to aid learning for hearing impaired children using some of the following suggestions by National Deaf Children Society (2001): encourage a quiet working atmosphere with the children, make classroom children aware of noises a hearing device amplifies such as doors banging, chairs scraping, talking, shouting and items being dropped; ensure hearing impaired children are positioned in quieter areas of the classroom (away from open windows, noisy equipment); actively reduce external background noise by closing windows and doors; wall displays and carpet on the floor will decrease reverberation; have a "quiet" work area available in the classroom; use acoustic ceiling tiles; modify chairs/desks with soft materials on legs to decrease noise output; use classroom amplification systems.

Research by Cawthon (2001) found that mainstream classroom teachers focussed less communication toward deaf children compared to hearing children. Teachers tended to ask deaf children 'yes' or 'no' questions instead of open-ended questions. Mainstream teacher's

tendency to be less familiar with hearing impaired children and assistive listening devices can be a limitation to a child's classroom learning (Knoors & Marschark, 2012).

1.8.3 From a Support Perspective

For young children who wear hearing aids or have implants the most important issue is that the devices are always in place and functioning correctly. It is important that parents and teachers have the knowledge and understanding to troubleshoot any problems that arise (Antia, 2015). Suggestions from Antia (2015) for troubleshooting knowledge include being able to check devices are working daily (e.g., by using the Ling 6-Sound Test with a child), being aware of the device's flashing lights that indicate functioning, have spare parts/batteries available, have contact details for audiologist or support personnel for a child's device/s.

Students with hearing impairment need communication support irrespective of language modalities (e.g. sign language, spoken language) they use to ensure equal access to information presented in a classroom environment (Marschark et al., 2011). Regular visits to the classroom or school of a hearing impaired student by a teacher of the deaf is inadequate for the education they are entitled to. Classroom teachers need to have the skillset for assisting a hearing impaired student on a day-to-day basis (Marschark et al., 2011). Visual cues and resources support hearing impaired children in the classroom. Visual materials provide additional context for developing understanding and knowledge of a topic (De Raeve, 2015).

Lip reading ability in children is a skill that develops over time and varies enormously between individuals (Tye-Murray, Hale, Spehar, Myerson, & Sommers, 2014). Hearing impaired children acquire lip reading skills during the primary years. Tye-Murray et al. (2014) found that children with hearing impairment out performed children with normal hearing on four lip-reading measures across the 7 to 14-year age range. They also found that

lip-reading ability improved with age for both groups of children. Lip reading requires more cognitive effort for children than adults (Lyxell & Holmberg, 2000; Pisoni & Cleary, 2003). Predictors of successful lip-reading ability in children are age, hearing status plus visuo-spatial working memory (Feld & Sommers, 2009; Lyxell, Andersson, Borg, & Ohlsson, 2003; Tye-Murray et al., 2014). The presence of a hearing impairment heightens an amplification user's dependence on visual speech information, especially when listening conditions are poor (Tye-Murray et al., 2014). From a teaching perspective, understanding that lip reading is a developing skill for a child will contribute to ensuring that age appropriate learning strategies are used in a child's classroom (Tye-Murray et al., 2014).

For a child with APD, the classroom teacher is critical to the success of an amplification device and RM system. A child with APD has optimal hearing ability within two metres of the teacher unless using an RM system with hearing aids. Other classroom teaching strategies specific to children with APD include speaking with clear speech, speaking at a reduced rate and with slightly higher intensity and provision of visual and written communication support (Abrams & Kraus, 2015). Additionally, the teacher needs to clarify understanding of instructions with the child. An audiologist can advise and assist classroom teachers about APD including an explanation of the child's difficulties, appropriate management strategies and how to manage the amplification system (Abrams & Kraus, 2015).

Research suggests that teachers are only slightly more likely to obtain information on a child's hearing impairment from sources other than an audiologist. This was research undertaken in US schools where it is known that audiologists send reports to teachers (Blair, EuDaly, & Benson, 1999). Common information sources for teachers included audiological evaluation report, speech language pathologist and parents. Despite the information sources, teacher knowledge of a child's hearing impairment was still low (Blair et al., 1999).

Teachers of children with hearing impairment need to have the knowledge and skills to work with parents and families; understand the effects of hearing impairment and aetiologies of hearing impairment; and understand the socio-emotional and psychological factors that impact on education success for children with hearing impairment (Easterbrooks, 2008).

1.8.4 Previous Research

Research shows that specially trained teachers and para-professionals for hearing impaired children are critical to supporting their development. The aim of the teaching profession is to support all children to reach their potential (Spencer & Marschark, 2010).

1.9 Classroom Environments

1.9.1 Mainstream Classrooms

Children with disabilities were integrated into mainstream education over thirty years ago (Marschark et al., 2011). Hearing impaired children face academic challenges across the curriculum (Spencer & Marschark, 2010). One consideration for New Zealand children may be the learning environment. In New Zealand, the Ministry of Education are implementing ‘innovative learning environments’ (ILE) (also termed ‘modern learning environments’) for classrooms to encompass flexible learning spaces and collaborative teaching. Many schools are currently transitioning from a traditional cellular classroom to an ILE set up whilst others now have ILE classrooms. In principle ILE’s provide good acoustics, lighting, technology, heating and air quality as well as supporting a teaching practice that promotes technology, collaborative work groups and problem solving (Ministry of Education, 2017b).

1.9.2 Innovative Learning Environment Classrooms

A literature review by a New Zealand researcher (Wilson, 2015) reported there is inconsistent evidence for open learning spaces in classrooms having a positive impact on

student academic achievement. There is a paucity of data available on the effectiveness of modern learning environments (MLEs) in the literature (Wilson, 2015). Wilson (2015) described difficulty obtaining data from schools in New Zealand and Australia specifically on the difference MLEs made to academic achievement of students. Alongside MLE classroom use in schools is a change in approach to teaching practice in open spaces. The emphasis is on active student involvement in learning that promotes collaboration and inquiry. A common concern with MLEs is excessive noise levels and distractions for students (Wilson, 2015).

1.9.3 Traditional Teaching Classrooms

Children with hearing impairment who use cochlear implants in a traditional classroom have the following needs for consideration when learning: preferential seating, use of personal and sound-field remote microphone (RM) systems, and presentation of salient learning material in written form with regular checks by the teacher for comprehension (Wilkins & Ertmer, 2002). Children with hearing impairment have difficulty integrating into a predominantly oral language learning environment even with good speech and language skills (Spencer & Marschark, 2010). Spencer and Marschark (2010) conclude that further research is needed to establish method and outcomes in the training of classroom teachers and special education teachers who will be working with hearing impaired students in traditional mainstream classrooms.

1.9.4 Impact of Noise on Learning

Noise has a detrimental effect on children's learning. Specifically, for auditory tasks of speech perception and listening comprehension. Reading, writing and short-term memory are also affected by noise (Klatte, Bergström, & Lachmann, 2013). Attention to classroom acoustics can improve learning for children by reducing the level of noise within a classroom. Reverberation times and potential classroom noise can be decreased with sound absorption measures such as acoustic ceiling tiles, wall coverings and carpets (Dockrell & Shield, 2006).

1.9.5 Interaction between Noise and Hearing Impairment on Learning

The Siebein et al. (2000) study recommended utilising RMs and other sound amplification systems when needed for individual children. Also design of special purpose rooms with special purpose acoustics (with the aim of achieving acceptable noise reduction in spaces such as gymnasiums), collaboration between audiologists, teachers and acoustical consultants with expertise in classroom planning and design and establishing a national technical research effort to explore issues of classroom acoustics relating to speech perception and learning for all children.

1.10 Literature Review

There have been several research studies on knowledge of hearing impairment and deafness (Lass, Carlin, et al., 1986a, 1986b; Lass, Carlin, Woodford, Campanelli-Humphreys, Judy, Hushion-Stemple, & Wilson, 1986; Lass, Woodford, Lundeen, Lundeen, & Everly-Myers, 1987). However most have focussed on a range of population groups that does not include teachers. Few studies have investigated teacher knowledge of hearing impairment and deafness (Lass et al., 1985; Lass et al., 1990; Martin et al., 1988). Several observational studies have investigated teaching professional's knowledge of hearing impairment related to classroom teaching. Of relevance to this thesis are three US studies examining school health educators, classroom teachers and special educators' knowledge of hearing impairment. The studies were conducted at a time when there were increasing numbers of children with hearing impairment attending mainstream schools rather than special education schools in the US.

The study by Lass et al. (1985) provided information on classroom teachers' and special educators' knowledge of and exposure to hearing impairment. At a time when hearing impaired children were integrating into mainstream education schools the authors recognised that classroom teachers and special educators in mainstream schools were responsible for

educating these children. They considered the teachers to be a critical link for the later success of their hearing impaired students in society. The level of knowledge held by the educators and their exposure to hearing impairment would likely influence the academic progress and educational outcomes of hearing impaired students. The potential impact of knowledge or lack of knowledge relating to hearing impairment possessed by the educators with hearing impaired children in their classrooms needed to be assessed. The questionnaire design and teacher study group made it an appropriate study to review for this thesis project.

The study used subjective 'true / false' measures from a 25-item questionnaire. The questionnaire was completed via return mail. The purpose of the questionnaire was to determine classroom teachers' (N = 98) and special educators' (N = 77) knowledge of and exposure to hearing impairment. The participation rate for the teacher group was 49% and the special educators group was 39%. The questions covered aspects of hearing impairment that included prevalence, aetiology, hearing aids; testing, prevention and treatment of hearing impairment; receptive and expressive communication skills; and characteristics of hearing impaired individuals.

Results showed 'some' deficiency in academic exposure to hearing impairment for special educators and 'severe' deficiency for classroom teachers. Overall results from the study found a need for more information on hearing impairment and more experience with hearing impairment in academic training programmes in education, special education and continuing education programmes for classroom teachers and special educators.

There was no description of the participants which may have been because the demographic information was not collected in the questionnaire. This could be considered a weakness of the study as it is difficult to identify sample bias. The non-treatment cross-sectional survey design gave a truthfulness rating of four using Cox (2005) level of evidence

scale (1-6) where 1 is the highest and most trustworthy level and 6 is the lowest and least trustworthy. This means the validity of the research is less trustworthy which indicates a low rating for the risk of sample bias. The outcome measures were not stipulated but percent correct was used in the appendix. The authors reported the standards for scoring were sourced from literature cited within the published article.

Strengths of the study were reporting of participant recruitment and dropouts. Limitations include the low participation rate (i.e. less than 50%) for each group. This may be a weakness of the study design (mailout questionnaire) at the time. Participants could self-select out of or into the study, although the participants were randomly selected for the questionnaire mailout which may be considered a strength of the study.

The understanding that over-exposure to noise resulting in an increased prevalence of high frequency hearing impairment amongst school aged children led to the later study by Lass et al. (1990). This evaluated the knowledge of the health educators that deliver educational programmes for students on hearing and good hearing health practices through the school health education curriculum. The participants answered 27 questions in a format of 'yes/no', multi-answer, 'true / false' and 'fill in the blank'. The knowledge areas under investigation were: exposure to noise and knowledge of hearing and hearing impairment. This study did not stipulate outcome measures but questions were summarised in the appendix under target knowledge areas with percent correct scores. The authors did not state how participants were recruited. This could be considered a weakness of the study as dropouts are not known and it is difficult to calculate a participation rate. It is noted that participants came from six states across America. Results indicated 'some' deficiencies in surveyed health educators' knowledge of the normal hearing mechanism and hearing impairment, including the impact of over-exposure to noise on hearing. The findings of the second study match the outcome rating of 'some deficiencies of knowledge' as the first study

does for special educators. The questionnaire and questions were slightly different for both studies with a focus on noise exposure in the second study. The non-treatment cross-sectional survey design gave a truthfulness rating of four using Cox (2005) level of evidence scale (1-6). This means the validity of the research is less trustworthy which indicates a low rating for the risk of sample bias. The outcome measures used were percent correct and descriptive summaries of the questionnaire reported in a summary of major findings. The overall outcome indicates a need for more information on hearing, hearing impairment, and hearing health practices in preservice and continuing education programmes for health educators. Recommendations for programme content were: the normal auditory system, types of hearing impairment, causes of hearing impairment, noise and its effect on hearing, the indicators of noise-induced hearing impairment, and recommendations for preventing noise-induced hearing impairment.

Martin et al. (1988) observed that a significant proportion of mainstream classroom teachers had no training in special education, yet they were responsible for the education of hearing impaired children within their classrooms. With a lack of educational programmes focused on hearing impaired children the researchers set out to examine teacher knowledge and attitudes relating to hearing impaired children. Ten specific research questions were investigated (Martin et al., 1988). The study sample size was N = 184 teachers with three dropouts who did not fit the criteria for the study. Participation rate was therefore 98%. Participants were regular teachers enrolled in graduate level communications courses from five states in the east of America. Participants taught school in elementary grades (kindergarten to grade 5), junior and senior high school level (grade 6 to 12) with a few teaching preschool and high school to adult students. Several outcome measures were used. A one-way frequency distribution Analysis of Variance (ANOVA) was used to calculate knowledge and attitude differences between the two participant groups (regular and special

education teachers). Pearson Product-Moment correlations were used to assess relationships. The Coefficient Alpha test was used to determine internal reliability of respondents' questionnaires. The authors noted that not all participants answered all questions (Martin et al., 1988). Participants answered 57% of questions in the knowledge section (hearing and related considerations) correctly (M=9.77) with the coefficient alpha = .53 suggesting low overall internal reliability for that part of the questionnaire and indicating inconsistency or randomness of responses. This means conclusions about teachers' knowledge from the questionnaire is uncertain. The magnitude of correlation between knowledge and experience variables was small with two exceptions that were statistically significant (Martin et al., 1988).

The non-treatment cross-sectional survey design gave a truthfulness rating of four using Cox (2005) level of evidence scale (1-6) together with a (+) rating for interpretation of rating. This indicated a low risk of bias in the sample as identified weaknesses or omissions of information would be unlikely to change conclusions of the study.

A Pearson product-moment correlation coefficient found a positive correlation between variables of teacher experience and general attitude toward mainstreaming hard-of-hearing students for 'regular classroom teachers and special education teachers' ($r = .13$, $n = 167$, $p = < .05$); and for 'other training on teaching the hearing impaired' ($r = .18$, $n = 165$, $p = < .05$). The general attitude of the sample group toward mainstreaming hard-of-hearing students used a rating scale from 1 to 5 (1 = strongly negative and 5 = strongly positive). Averaged across all 28 questionnaire items this showed the general attitude was slightly positive ($M = 3.54$, $SD = .48$). Clinically this shows the majority of the sample group thought that teacher training programmes did not adequately prepare regular classroom teachers to educate hard-of-hearing students in mainstream settings (Martin et al., 1988).

The correlation between knowledge of hearing impairment and overall attitude toward mainstreaming hard-of-hearing students into regular classrooms was ($r = .21$, $p = <.05$). Types of information participants believed most beneficial for teachers with hard-of-hearing students in their classes were rated using a 1 to 5 scale (1 = least important; 5 = most important). All nine items were important with a range of $M = 4.49$, $SD = .62$ (most important) to $M = 3.87$, $SD = .98$ (least important). The two least important items were 'trends in treatment and medical management of hearing impairment' and 'hearing aids and their use'. Most important were 'educational methods of teaching the hard-of-hearing' and 'types and characteristics of hearing impairment'.

Participants indicated that audiologists provided or would have provided the most helpful support. Audiologists were rated twice as high as teacher aides who were considered the second most helpful supportive service. Other support services in descending order of helpfulness were: teacher of the deaf, speech language pathologist, special education teacher and psychologist. Speech and hearing reports provided the following most helpful functions: explaining the extent of a hearing impairment and increasing teachers' understanding of their hearing impaired students. Main outcomes of the study are as follows: general attitude toward mainstreaming was positive with the majority of participants indicating a preference to teach hearing impaired students when considerable training was available alongside appropriate support personnel. Participants are interested in helping hearing impaired students despite most having no professional training in this area. It follows that participants' level of knowledge about hearing disorders was low. Participants acknowledged that knowledge of this subject is important and should be mandatory. The importance of the subject of hearing aids was not considered important to participants. The authors note this could reflect lack of information and orientation to hearing aids for teachers in their education and training. Lastly, the authors recommend a goal for classroom teachers to be knowledgeable about

hearing impairments and related educational implications for their students. The authors aim for the information from their research to provide direction and content for future development of quality programmes to educate teachers of hearing impaired children in mainstream education.

The work of Lass et al. (1985)., Lass et al., (1990) and Martin et al., (1988) provides background information on level of knowledge of classroom teachers, special educators and health educators at a time when increasing numbers of deaf and hearing impaired children were attending mainstream schools for their education. These studies were also conducted long before any newborn hearing screening programmes were introduced in the US or New Zealand. UNHSEIP was fully implemented across New Zealand DHBs by 2010 (National Screening Unit, 2011). The purpose of the current research is to gain information on the current New Zealand context and establish the current knowledge level of primary school teachers in New Zealand of hearing impairment and deafness in relation to their classroom teaching. The knowledge base under investigation also included experience and familiarity with children's personal amplification devices and accessories used by the teachers. Mainstream education has been the norm for nearly all children with disability for many years now. Most deaf or hearing impaired children in New Zealand attend mainstream schools. There are two deaf education centres (DEC) in New Zealand. The DECs provide deaf education services across New Zealand, supporting over 2000 deaf and hearing impaired children within mainstream education classrooms and special needs classroom environments.

1.11 Study Rationale

Newborn hearing screening now occurs in many countries (e.g., Australia, NZ, Canada, USA, United Kingdom, Brazil, China, Germany) for children at birth (World Health Organization, 2010). Hearing impairment is therefore identified and treated with early intervention in children at neonatal age (less than four weeks of age). Thus, there is a new

population of children whose hearing impairment has been identified at birth and treated whilst they are a neonate. Children with hearing impairment start school with amplification and a reduced impact of the secondary effects of hearing impairment such as developmental and communication impairments (Maddell, 2014). Primary school teachers have children in the classroom who wear hearing aids or implants with accompanying accessories (e.g., RM system) to give them access to speech. This has an impact on the teaching practice of teachers and the access to learning via the curriculum for the child.

1.12 Aims and Research Questions

The aim of this project was to establish New Zealand primary school teachers' knowledge of hearing impairment and deafness, and its influence on children's learning in the classroom. In addition, the study aimed to also identify teachers' learning needs about hearing impairment and their current sources of information.

The four research questions are:

1. What is the knowledge of New Zealand mainstream primary school teachers about hearing impairment and deafness?
2. What is the knowledge of New Zealand mainstream primary school teachers in relation to how they adapt their classroom teaching for hearing impaired and deaf students?
3. Where do New Zealand mainstream primary school teachers acquire their knowledge of hearing impairment and deafness?
4. What information / education about hearing loss and deafness do New Zealand mainstream primary school teachers want or need?

2. Method

2.1 Ethics

This project was approved by the University of Canterbury Educational Research Human Ethics Committee on Thursday 1st June 2017 (Ref: ERHEC-LR 2017/07). See Appendix A.

2.2 Participants

The target group for this research project were current New Zealand primary school teachers in mainstream schools. Participants were recruited via an email sent to primary school principals and then to all primary schools within New Zealand. Participants completed an online survey via the Qualtrics website. Participants were offered incentives of entering a draw for one of twenty $NZD20 fuel vouchers at the end of the survey. Recruitment took place over a five-week period with the aim to continue recruiting until 100 participants were reached or until the time constraints inherent in Master's thesis prevented further data collection. In total 221 participants were recruited over five weeks. A total of 146 participants fully completed the online survey. Seventy-five surveys were only partially completed and the results from these were excluded from the data analysis.

2.3 Survey

A survey was developed based on a questionnaire used in research by Lass et al. (1985). The questions were designed to ascertain school teachers' and special educators' knowledge of hearing impairment and exposure to hearing impairment in public schools across the state of West Virginia (Lass et al., 1985). The 25-item questionnaire was used as a baseline to create the 46-question online survey for this thesis. Questions on knowledge of audiology were derived from adaptations of Lass et al. (1985).

The survey included questions related to knowledge of audiology, aetiology of hearing impairment, hearing solutions; and communication with a hearing impaired person,

amplification devices participants have had experience with; and sources of knowledge and information participants would like about hearing impairment. Sample questions from the research survey are:

- *Some diseases and illnesses are known to cause hearing impairment. Tick the diseases or illnesses listed below that you think can cause (permanent or temporary) hearing impairment.* 9 options provided. See Table 4.
- *Where have you gained your knowledge of hearing impairment for children in your classroom?* 7 options provided. See Table 7.
- *What hearing devices and accessories have you had experience with and used to modify your teaching for hearing impaired children?* 5 multi-answer options. See Table 5.
- *How many children in your classroom are hearing impaired?* See Table 2.
- *How many of the hearing impaired children in your classroom wear hearing aids to hear speech?* See Table 2.

See Appendix B for list of full survey questions.

The study design used a survey format and was created using the Qualtrics platform of survey software (2017). A survey was a suitable choice because the research questions were obtaining information from participants rather than a measure of their performance (Portney & Watkins, 2009). A pilot of the survey was completed on eight people who were working as teachers or in education at the time. Following the pilot and feedback from respondents' amendments were made to the survey questions and design. For example, an introduction for each section: *'the next set of questions will be about'* and for the Likert-type questions an instruction was added: *'For the following questions please indicate the degree to*

which you agree or disagree with the accuracy of the statements.' Also, definitions were added for the terms *'hearing impairment'* and *'deaf'* (see Appendix B).

2.4 Measures

The survey used multiple choice questions, a five-point Likert-type scale and demographic questions. Some multi-response questions included an option for "other" giving participants an opportunity to provide a text response that the researcher may not have considered. Statistical analysis was completed using SPSS to establish median scores following testing for skewness of data with multiple-choice and Likert-type questions. Multi-answer and text response questions are reported in a sentence summary format. For the purposes of analysis, the survey questions were categorised into four knowledge areas relating to hearing impairment and deafness. These were: aetiology, audiology, solutions and communication (research question one and two). An additional standalone grouping was information and/or education that participants would like in the future (research question 4). Demographic questions were grouped into 'participant demographic' and 'school demographic'. These categories were used for displaying the results in the next section. In the online survey, the term "amplification" was explained to include CI, BAHA, hearing aids and RM systems. The online survey requested that participants not use Google to search for information whilst completing the survey.

Data analysis for the survey questions has been completed using percentages of the total number of respondents. A random number generator was used in Excel to draw the winners of the vouchers. Participant winners were contacted by email and the vouchers were mailed to them. A total of 58 participants provided their email addresses to receive a final summary of the study. This will be emailed to them upon completion of the full thesis.

The survey consisted of nine sections. These were demographics, knowledge of audiology, educational courses attended, source of knowledge of audiology, information useful to teaching practice, knowledge of aetiology of hearing impairment, knowledge of hearing impairment and knowledge of hearing solutions and communication strategies. See appendix B for survey questions. Questions were answered using a Likert-type scale, multi answer, multi choice options and text responses.

The survey link was sent out via email with a link to the survey using the Qualtrics platform online to New Zealand principals from the New Zealand Principals' Federation and then to New Zealand primary schools. Consent and study information was embedded at the beginning of the survey. No responses were received directly following the email to the New Zealand Principals' Federation. Responses were received immediately following email to New Zealand primary schools. The time frame for survey completion encompassed a five-week period.

3. Results

3.1 Data Analysis

Survey data was analysed using IBM SPSS statistics 24 and Excel 2016. A total of 221 participants took part in the survey which was delivered via email with a website link to the Qualtrics Survey. There were 75 incomplete survey responses which were discarded by the researcher prior to data analysis. A total of 146 fully completed surveys were analysed. Responses to 45 survey questions were analysed to answer the four research questions.

There was non-normal distribution of results with some survey questions (e.g. Likert-type questions). Therefore, non-parametric statistical analysis was used with median and range.

Note: For some survey questions, the number of responses (*n*) exceeded the total number of participants because the questions allowed for multiple responses. For some questions, more than one answer was correct and acceptable.

3.2 Survey Demographics

<u>Teacher Demographic:</u>

The participants in the current survey were 89% (*n* = 130) female and 11% (*n* = 16) male. The survey sample group constitutes 2% of the target population in New Zealand. The total number of full time equivalent primary school teachers in New Zealand is approximately 8,400 (Ministry of Education, 2017c). Of this total 1,160.5 (13%) are male and 7,241.4 (86%) are female (Ministry of Education, 2017c).

Participants were evenly spread across the nine primary school year groups they were teaching from new entrant up to Year 8 with 10-12% teaching each year group (*n* = 37 - 43). Most participants were teaching across two year groups. Nearly all the survey participants identified as female (89%, *n* = 130) and the majority were aged between 40 and 59 years

(64%, *n* = 92). Most participants (75%, *n* = 110) had more than ten years of teaching experience and a similar number (79%, *n* = 116) reported they held an additional qualification/s to their teaching qualification (e.g. bachelor's degree, master's degree or diploma). A small number of participants (19%, *n* = 26) had a hearing impairment themselves, the duration of which ranged from 2 - 50 years. Only 6% (*n* = 14) of participants reported they do not know anyone with hearing impairment.

Most participants (91%, *n* = 141) responded that they have taught between one and four hearing impaired students over their teaching careers. For the participants who had taught hearing impairment children, the number of hearing impaired children taught over their career ranged from 1 - 54 children (*M* = 6.07, **SD** 8.13). A small proportion (9%, *n* = 12) of participants had not taught a hearing impaired student at all.

School Demographic:

Approximately half (49%, *n* = 72) of participants had one hearing impaired child at their school, whilst 8% (n = 12) reported zero children with hearing impairment at their school. Table 1 shows the type of school participants were teaching at when they completed the survey. Most participants (85%, *n* = 139) were teaching at a Primary Year 1-8 school. More than half (55%, *n* = 83) of participants were teaching in a traditional classroom whilst 26% (*n* = 40) were teaching in a innovative or flexible learning space. Some participants (19%, *n* = 23) were teaching in an environment that included a combination of traditional and flexible learning spaces or were transitioning from traditional to flexible or included play, mixed media, special needs or a combination of single cell classrooms with opening doors.

Table 1: *Type of School Participants Were Teaching At.*

	School Type								
	Primary							Technology Centre	Other
No. Participants	Y 1-8	Y 1-8 Integrated	Y 1-8 Te Kura-Kaupapa	Y1-8 Montessori	Y 1-8 Rural	Y 1-2 Rural Two teacher	Y 1-8 Sole teacher		
N	124	2	1	1	13	1	1	1	2
%	85	1	< 1	< 1	9	< 1	< 1	< 1	1

The average number of children in a classroom was relatively low (*M* = 26, ***SD*** 14.43) with a minimum number of 2 and maximum of 90 students. Less than half (48%) of participants reported they had a child in their classroom who was hearing impaired. The number of hearing impaired or deaf children in participant classrooms is summarised in Table 2 below.

Table 2: *Number of Hearing Impaired and Deaf Children With and Without Amplification in Participant Classrooms*

No. children in classroom	*0*		*1*		*2*		*3*		*4 or more*		*Participants*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*N*	*%*
Hearing-impaired	76	52	46	32	17	12	6	4	1	< 1	146	100
Hearing-impaired wearing hearing aids	33	47	26	37	11	16	0	0	0	0	70	100
Deaf	131	90	13	9	2	1	0	0	0	0	146	100
Deaf wearing implants	5	33	9	60	1	7	0	0	0	0	15	100

Note. the use of the term 'deaf' in this context does not refer to the deaf community.

Classroom teaching and learning approaches or styles are illustrated in Table 3. Most participants reported using a combination of approaches. 'Other' responses included self-directed learning, cooperative learning groups, parents or students as teachers and using a digital platform. Also having a teacher aid, special needs teacher or specialist teacher assisting, flipped learning, play-based, gaming for learning and project based learning.

Table 3*: Participant Classroom Teaching and Learning Styles*

		Classroom teaching and learning style			
		Peer learning	Traditional instruction from teacher	Collaborative teaching with > 1 teacher in classroom	Other
Participants	*(n)*	108	111	63	33
	(%)	34	35	20	10

Research question one asks what **is the knowledge of New Zealand mainstream primary school teachers in relation to classroom teaching?** This question was addressed under the following areas: knowledge of aetiology of hearing impairment, knowledge of audiology, knowledge of solutions and knowledge of communicating with deaf and hearing impaired people.

Knowledge of aetiology

Four questions related to aetiology of hearing impairment. Results suggest that participants understood aetiology in terms of acquired damage to hearing relating to the impact of factors such as noise exposure (M = 4.1 '*agree'*) where the range is 1 – 5 (1 = strongly disagree and 5 = strongly agree). In contrast participants demonstrated poor knowledge of the effect of medication on hearing (M = 3.0 '*neither agree nor disagree'*) with a range of 1 – 5 (1 = strongly disagree and 5 = strongly agree). More than half of participants

(57%, *n* = 83) selected the correct approximate number of New Zealanders with hearing impairment.

Participants demonstrated a lower level of understanding of disease and illness as a cause of hearing impairment. Only 5% (*n* = 7) of participants identified all nine diseases and illnesses (in the survey question) that can cause hearing impairment (see Table 4). There was no correlation between the seven participants who selected all nine diseases and illnesses and age or teaching experience. Of the nine diseases and illnesses to consider there were a majority four that were most frequently recognised for their link with permanent or temporary hearing impairment by the participants. They were '*otitis media with effusion'* (OME) also known as ear infection or glue ear (80%, *n* = 117), '*rubella (maternal) contracted during pregnancy'* (67%, *n = 98*), '*meningitis*' (62%, *n = 91*) and '*measles contracted in childhood'* (42%, *n = 62*). The most frequently selected condition was OME. Illnesses such as hypoxia and hydrocephalus were selected with less frequency suggesting a lack of awareness and/or knowledge of these illnesses and their subsequent side effects.

Table 4: *Participant Responses for Recognising Diseases and Illnesses That are Known to Cause Hearing Impairment*

Diseases / illnesses known to cause hearing impairment	*No. participant responses*	
	n	*%*
Otitis Media with effusion (ear infection or glue ear)	117	80
Rubella (maternal) contracted during pregnancy	98	67
Meningitis contracted in childhood	91	62
Measles contracted in childhood	62	42
Mumps contracted in childhood	45	31
Toxoplasmosis contracted during pregnancy	34	23
Hydrocephalus	29	20
Cytomegalovirus (CMV) contracted during pregnancy	23	16
Hypoxia	14	10

Note. Participants provided multiple responses
Note. All nine diseases / illnesses are known to cause hearing-impairment

Knowledge of audiology

The study found that participants had a good understanding of the broad field of audiology. Most people responded that an ENT '*is the medical doctor who specialises in treating ear disease'* (71%, *n* = 108), and an audiologist '*is the non-medical professional who specifically studies hearing and tests people's hearing'* (82%, *n* = 120). Again, most participants (75%, *n* = 110) responded '*audiologist*' when asked who to go to '*If you needed to purchase a hearing aid'*. For knowledge about '*the ability to test babies / infants hearing'* the responses were non-normally distributed, with skewness of 0.97 (SE = 0.20) and kurtosis of 2.27 (SE = 0.40) toward disagreement (*Mdn* = 2) with the statement and range = 1 to 5. Disagreement was the correct response. This indicated that 87% (*n* = 127) of participants know that babies and infants can have their hearing tested.

Knowledge of solutions

Participants had a good understanding of the power source of a hearing aid, where 99% (*n* = 144) of the multi-choice responses were for '*battery*' as the power source; and the cost of hearing aids in comparison to glasses: For the statement *'hearing aids usually cost much more than glasses'* the Likert-type scale was non-normally distributed (*Mdn* = 4), with skewness of -0.60 (SE = 0.20) and kurtosis of 0.66 (SE = 0.40) toward agreement (range = 1 to 5). For the statement *'a hearing aid brings hearing to within normal range just as glasses bring vision back to normal'* the response was normally distributed at '*neither agree nor disagree*' (*Mdn* = 3) on the five-point Likert-type scale where 1 = strongly disagree and 5 = strongly agree (range = 1 to 4). This indicates that participants are unsure about the level of hearing that wearing an amplification device adds for a hearing impaired person.

Table 5 shows a range of amplification devices participants have experience with from children in their classroom. It is noted that one of the '*none'* responses included a sound

field amplification system. The number of participant responses for hearing aids and RM systems is similar. This is likely because most children with hearing aids will be using an RM system alongside their hearing aids in the classroom. Those teachers will be familiar with their role from the perspective of wearing the remote microphone that transmits their speech signal to the child's hearing aids.

Table 5: *Hearing Devices and Accessories Participants Have Had Experience With in the Classroom*

What hearing devices and accessories have you had experience with and used to modify your teaching for hearing impaired children?	*No. participant responses*	
	n	%
Hearing Aids	95	65
Cochlear Implants	34	23
Bone Anchored Hearing Aids (BAHA)	10	7
FM systems (or Remote Microphones)	96	66
None	21	14

Note. Participants provided multiple responses

Knowledge of communication with hearing impaired and deaf people

Table 6 shows participant responses in relation to communicating with a hearing impaired person. On the five-point Likert-type scale where 1 = strongly disagree and 5 = strongly agree, participants understanding of '*lip-reading*' ability (by a hearing impaired person) was skewed towards *'agreement'* (*Mdn* = 4 *'agree'*) with the statement "*In lipreading we learn to "see each sound" and can understand complicated passages even at a great distance from the speaker*". Participants response to the statement "*speaking very loudly to a hearing impaired person makes it easier for him/her to understand*" (by a communication partner) was skewed toward '*disagreement*' (*Mdn* = 2 '*disagree'*) on the five-point Likert-type scale.

Table 6: *Non-Normal Distribution of Responses Relating to Participant Knowledge for Communicating with Hearing Impaired People*

Likert-type statement	N	Minimum	Maximum	Median	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Speaking very loudly to a hearing-impaired person makes it easier for him/her to understand	146	1.00	4.00	2.00	2.29	0.77	0.44	0.20	-0.01	0.40
In lipreading we learn to "see each sound" and can understand complicated passages even at a great distance from the speaker	146	1.00	5.00	4.00	3.81	0.88	-0.59	0.20	0.66	0.40

Note. 1 = strongly disagree and 5 = strongly agree

Participants reported "*a feeling of isolation"* to be the '*worst consequence of hearing impairment*' (42%, *n* = 62) and the '*worst consequence of deafness*' (47%, *n* = 69) in their opinion from a choice of seven statements. See appendix B.

Participants' understanding of the link between hearing impairment and speech production was skewed toward '*agree*' *(Mdn* = 4) on the five-point (1-5) Likert-type scale, where 4 = 'Agree' with the statement: *'A hearing impaired person may have difficulty with making certain speech sounds when talking*'; and normally distributed for the statement: '*A hearing impaired person finds vowels (e.g. "ah", "ee", "oh") easier to hear than consonants (e.g. "s", "sh", "f")'* with the median response '*neither agree nor disagree' (Mdn* = 3.0). In summary, these responses were correct (73%) and unsure (54%) respectively. Nearly all participants (96%) correctly recognised sign language as a non-verbal communication system for deaf or hearing impaired people.

Teachers source of knowledge of hearing impairment and deafness

The number of participants who had attended a course with information on hearing impairment over their teaching career was low (40%, *n* = 58). Most of the participants (70%, *n*=30) who attended courses did not recall the course titles. Course titles reported included

courses run by Kelston Deaf Education and Van Asch School for the Deaf, and courses specific to hearing impairment such as New Zealand Sign Language (NZSL). Of the participants who attended courses, the most frequent course duration was one-day (43%, *n* = 23) and three hours (17%, *n* = 9).

Two questions asked participants to identify the source of their knowledge about hearing impairment for children in their classroom. Participant responses are summarised in Figure 1. A total of nine participants selected 'other' and provided a variety of text responses. 'Other' responses related to people (e.g., Resource Teachers for Learning and Behaviour, Special Education Needs Co-ordinators, Audiologist, Doctor), online, on the job, personal experiences, and professional development courses. The most commonly reported sources for participant knowledge of hearing impairment for children in their classroom was gained primarily from parents (32%, *n = 46)*, the children with hearing impairment (25%, *n = 37*), Resource Teacher of the Deaf (RTD) (23%, *n = 34*), Adviser on Deaf Children (AoDC) (21%, *n = 31*), and paraprofessionals (21%, *n = 30*).

Table 7: *Participant Sources of Knowledge of Hearing Impairment for Children in Their Classroom*

Where have you gained your knowledge on hearing impairment for children in your classroom?	*No. participant responses*	
	n	%
Parents of children with hearing impairment or deafness	46	32
Children with hearing impairment or deafness	37	25
Resource Teacher of the Deaf (RTD)	34	23
Adviser on Deaf Children (AoDC)	31	21
Paraprofessionals (e.g. Teacher Aid, ASSIST, Educational Support Worker, Resource Teacher for Learning and Behaviour (RTLB)).	30	21
Teacher Colleagues	25	17
Other	9	6

Note. Participants provided multiple responses

Note. Participants (*N* = 146)

Participants were asked what information and education they would find beneficial about hearing impairment and deafness from six multi-response options. Information about learning support strategies for children with hearing aids to assist with teaching practice (86%, *n* = 125) and information about learning support strategies for children with implants to assist with teaching practice (66%, *n* = 96) were the most frequent responses. 'Other' responses included "*audiologist"* and "*doctor".*

Table 8: *Education and Information Participants Would Like That Will Assist Their Teaching Practice.*

If you have a child with hearing impairment in your class what education or information about hearing impairment or hearing disorders would assist your teaching practice?	*No. participant responses*	
	n	%
Information about the hearing system	54	37
Information about how hearing aids work	53	36
Information about how implants work	45	31
Information about learning support strategies for children with hearing aids	125	86
Information about learning support strategies for children with implants	96	66
Other (please explain)	19	13

Note . Participants provided multiple responses

4. Discussion

This study set out to establish New Zealand primary school teachers' knowledge of hearing impairment and deafness, and its influence on children's learning in the classroom. In addition, the study aimed to identify teachers' perceived learning needs for providing support to students with hearing impairment and their current sources for accessing information about hearing impairment. Overall the levels of teacher knowledge demonstrated in the current study appear higher than those reported by Lass et al. (1985) in some knowledge areas and of a similar level in others. Participant knowledge of hearing disorders was found to be limited in the research study by Martin et al. (1988). It must be noted that the Lass et al. (1985) study was a 25-item questionnaire and the current study was a 45-item survey. Also, Lass et al. (1985) surveyed teachers and special educators whilst this study surveyed primary school teachers only.

From the teacher demographic information, it can be concluded that very few participants did not know anyone with hearing impairment or alternatively most teachers have encountered hearing impairment in their personal or teaching lives. This included children they have taught or people within their lives (e.g., friends, family, acquaintances). These results are consistent with previous research which reported that 90% of classroom teachers had known a hearing impaired person (Lass et al., 1985).

From the school demographic, it is evident that nearly half the teachers in the survey sample taught at a school with at least one hearing impaired child and over half taught in a traditional classroom environment. Some participants were teaching across a combination of traditional and flexible learning spaces. Participant teaching style in the classroom was wide ranging and often included more than one style. This included 'self-directed learning', 'cooperative learning groups', 'parents or students as teachers' and 'using a digital platform',

as well as having a teacher aid, special needs teacher or specialist teacher assisting and using ‘flipped learning’, ‘play based’, ‘gaming for learning’ and ‘project based learning’ styles. These results would infer that there is a need for teachers in schools to be informed and educated on strategies for enabling hearing impaired children to access the curriculum in a range of classroom settings that incorporate a variety of teaching styles. Strategies suggested in the literature include a “Y” floor plan, conference set up or small group setup of desks (Siebein et al., 2000). Such strategies contribute to improving the high SNR for the child student that characterises a traditional row and aisle seating arrangement. Further teaching support strategies provided to New Zealand primary school teachers would need to include traditional classrooms, ILEs and a combination of the two as well as play, mixed media, special needs or a combination of single cell classrooms with opening doors. As these are the teaching environments the study participants are working in. Teaching strategies suggested in the literature could be incorporated with the range of classroom environments and styles reported by participants (De Raeve, 2015; Starr, 2017). Teachers with a knowledge of a hearing impaired child’s cognitive abilities can tailor teaching strategies to the individual (Marschark & Green, 2000). Children who wear cochlear implants in a traditional classroom environment need specific teaching strategies to ensure their learning needs are met (Wilkins & Ertmer, 2002)

Aetiology of hearing impairment

Results suggest that participants understand aetiology in broad terms such as acquired damage to hearing relating to the impact of factors such as noise exposure or OME (disease or illness). In contrast participants demonstrated poor knowledge of the effect of medication on hearing where hearing impairment can be the side-effect of medication. Participants demonstrated a lower level of understanding of disease and illness as a cause of hearing impairment (including in-utero and childhood illnesses). The four diseases and illnesses most

frequently recognised for their link with permanent or temporary hearing impairment by the participants were OME, maternal rubella, meningitis and childhood measles. The most frequently selected condition was OME. This is likely due to the prevalence of OME amongst primary school-aged children. OME is one of the most common childhood diseases (Bluestone, 2004; Stach & Ramachandran, 2014). Illnesses such as hypoxia and hydrocephalus were selected with less frequency suggesting a lack of awareness and/or knowledge of what these illnesses are and their subsequent side effects. Otitis media and meningitis are known to be the most infectious causes of preventable childhood hearing impairment in the developing world (Kaspar, Kei, Driscoll, Swanepoel, & Goulios, 2016). One participant emailed the researcher with an anecdotal report from teaching in New Zealand in the 1980's when she was a Resource Teacher of Literacy. The school the participant was based at had *"a whole class of "deaf" children with their own teacher"*. She also reported that her "*friend was a full-time Teacher of the Deaf and Hearing Impaired who went around all the other schools… teaching 1:1".* For the participant, the story illustrates *"the positive impact of the Rubella vaccinations in later years and how inclusive schools are today".* Over half of participants (67%) recognised maternal rubella as a cause of hearing impairment. Congenital rubella where the mother is infected with rubella whilst pregnant was the most common reported cause of childhood sensorineural hearing impairment (16-22% of babies) from the 1970's to 1980's in Europe (Tharpe & Seewald, 2016).

Slightly more than half the participants correctly estimated the number of New Zealanders with hearing impairment. There are approximately 380,000 people (9% of the population) with hearing impairment in New Zealand (MacPherson, 2014). This contrasts with respondents in the Lass et al. (1985) study of which 79% of did not know the incidence of hearing impairment in the US. This indicates a higher awareness of hearing impairment prevalence than previous research findings (Lass et al., 1985).

Knowledge of audiology

Overall the study found that participants had a good understanding of the broad field of audiology. Most participants could identify the medical and hearing specialty of ENT and an audiologist respectively. In previous research two thirds (63%) of the classroom teachers did not know *'the medical doctor that specialises in treating ear disease is called an … Ear Nose and Throat specialist (otologist, otolarnyngologist or otorhinolaryngologist)'(*Lass et al., 1985*)*.

Participant knowledge about the ability for babies and infants to have their hearing tested was also high. At the time of the Lass et al. (1985) study universal screening of babies and infants at birth was not in place, although it was still possible to test a baby or infant's hearing with an audiologist. UNHSEIP has been in place in New Zealand since 2010 (Ministry of Health, 2016).

Knowledge of solutions

Nearly all participants knew that a battery provides the power source for a hearing aid and that the cost of hearing aids is much more than glasses. The latter knowledge level is considerably greater than in previous research where over one-third (36%) of classroom teachers did not know that hearing aids usually cost more than glasses (Lass et al., 1985). Participants were unsure about the level of hearing that amplification adds to a hearing impaired person. The level of amplification a device gives to a hearing impaired person depends on the type and severity of an individual's hearing impairment. An amplification device can give near normal hearing levels to a person with a CHI because the OHCs and IHCs of the inner ear are intact. In contrast a person with a sensory hearing impairment requires a SNR greater than normal to hear speech even with sound amplified by a hearing aid (Dillon, 2012). It follows that a hearing impaired child with a SHI or mixed hearing

impairment with a sensory component using amplification will have an ongoing need for the classroom teacher to employ teaching strategies suggested in the literature to improve the listening environment (Siebein et al., 2000; Starr, 2017; Wilkins & Ertmer, 2002)

Knowledge of communication with hearing impaired and deaf people

Survey participants correctly understood that speaking loudly to a hearing impaired person was not a helpful strategy in assisting the individual to hear speech. In contrast participants incorrectly considered that a hearing impaired person could lip-read and understand "*complicated passages even at a great distance from the speaker*". This finding is consistent with previous research where more than 40% of classroom teachers also incorrectly believed the above statement to be true (Lass et al., 1985). Research in the literature found that children with hearing impairment out performed children with normal hearing at lip-reading (Tye-Murray et al., 2014). It is questionable whether the children in the Tye-Murray et al. (2014) study would be lip-reading 'complicated passages' which the statement in this research survey refers to. Also, the research survey statement was intended to apply to the general population across all age ranges.

Participants understood that '*A hearing impaired person may have difficulty with making certain speech sounds when talking'*; and results were normally distributed for the statement: '*A hearing impaired person finds vowels (e.g. "ah", "ee", "oh") easier to hear than consonants (e.g. "s", "sh", "f")'* with the mean responses indicating that participants are unsure about the impact of hearing-loss on the ability to hear vowels versus consonants. In summary, these responses were correct and unsure respectively. Nearly all participants recognised sign language as a non-verbal communication system for deaf or hearing impaired people. This finding is consistent with previous research (Lass et al., 1985).

Participants reported "*a feeling of isolation"* to be the '*worst consequence of hearing impairment*' and the '*worst consequence of deafness*' in their opinion from a choice of seven statements. This finding was consistent with that of Lass et al. (1985). In the absence of literature on teachers' perception of worst consequences of hearing impairment or deafness it may be concluded from this study and Lass et al. (1985) that teachers are aware of the risk of a deaf or hearing impaired student feeling isolated. A factor such as feeling isolated may have a negative effect on the ability of a hearing impaired child to engage in incidental learning with peers which stimulates language acquisition and language development (Marschark, 2007). Evidence in the literature supports hearing impaired children attending schools where there are other hearing impaired peers in the classroom and two or more co-teachers with one a specialist teacher of deaf and hearing impaired children (Marschark et al., 2011). From a teaching perspective an investment of resourcing and teaming between teachers is necessary to ensure hearing impaired children are learning in an inclusive environment (Marschark et al., 2011).

Source of knowledge

The number of teachers who had attended a course that included information about hearing impairment was similar to previous research (Lass et al., 1985). This outcome together with the relatively low duration time of courses that were attended (most commonly one day and next most common of three hours duration) suggests that New Zealand teachers would benefit from some form of training to provide information about hearing aids, implantable hearing devices and classroom communication strategies for children with hearing impairment and their use of amplification devices to hear speech. Lass et al. (1985) concluded that teacher and special educator training programmes needed to include more information on hearing impairment and exposure to hearing impairment.

For the participants who had attended a course with hearing impairment related information, many of the courses attended were run by the New Zealand Deaf Education centres, either Van Asch Deaf Centre or Kelston Deaf Education Centre. Courses attended also included New Zealand Sign Language (NZSL).

Participants reported the most common resources for an individual child's hearing impairment information were *'parents of children with hearing impairment'* and *'children with hearing impairment'* themselves. An audiologist was a source for only one participant. From the results it appears that teachers are reliant on the official adviser / assist network to gain necessary information on a child's specific hearing needs. Primarily the parents and in some cases the child are the most reliable source. This may be due to time constraints and workload pressures on teachers. A future study will need to further investigate the reason for using parents and the child first rather than professionals and official networks, as well as accessibility and availability of formal professional support services from the MoE. In previous research the most common source of information for teachers was an audiological report, a speech language pathologist and parents (Blair et al., 1999). A child's hearing impairment configuration (i.e. type and severity) is specific to the individual and varies widely within the paediatric population. This is a good reason for teachers to consult with the child, their parents and the audiologist on an individual basis. The success of this approach for the child will depend on both the teacher and the parents. For instance, whether both are pro-active, the parents are strong advocates for their child and how confident the child is to approach the teachers in the classroom environment. In Ching and Dillon (2013) parents of children who received early intervention expressed the need for information to be specific to the needs of the individual child. A VADEC audiologist reported the formal source of information for mainstream primary school teachers in New Zealand is from the adviser / assist network through MoE (P. Peryman, personal communication, March 13, 2017).

Secondary sources of information include the Resource Teachers of the Deaf (RTD) who work with a child in their mainstream school, a child's parents, an audiological report, public awareness campaigns (e.g., the National Foundation for the Deaf (NFD)), and the internet (e.g., MoE website). P. Peryman (personal communication, March 13, 2017) also reports there are currently new online resources being developed by the two New Zealand Deaf Education Centres (VADEC, KDEC) aimed at supporting mainstream teachers with deaf or hearing impaired children in their classroom.

Information and education teachers would like

The information and education about hearing impairment or hearing disorders requested by most participants that would be of greatest assistance with teaching practice was overwhelmingly 'information about learning support strategies' for 'children with hearing aids' and 'children with implants'. This is consistent with the research findings of Martin et al., (1988). Participants in the Martin et al., (1988) study considered that teacher training programmes did not adequately prepare teachers to educate hearing impaired students in a mainstream classroom. Participants ranked the two most important types of information of benefit to teachers with hearing impaired students in their classroom as being educational techniques for teaching hearing impaired children, and types and characteristics of hearing impairment (Martin et al., 1988). Spencer and Marschark (2010) recognise that teachers of hearing impaired children need to have an awareness of and accommodate ways in which hearing impaired children differ from their hearing peers in the classroom to ensure their academic achievement is not compromised by the skill level of the teacher. Teachers working with hearing impaired children need an understanding of individual cognitive and language abilities underlying their learning and teaching approaches (Detterman & Thompson, 1997).

The first research question explored participants' knowledge of hearing impairment and deafness with broad categories of aetiology, audiology (*e.g. what it covers)*, solutions

(e.g. *amplification options)* and communication *(supports)*. Awareness of OME was high whilst there was a considerable lack of awareness of diseases and illnesses that can cause hearing impairment and deafness (e.g. hypoxia, hydrocephalus, toxoplasmosis, CMV). Awareness of medications as a cause of hearing impairment was also low. These two aspects of aetiology could be a target area for a future education programme. Knowledge of aetiology may improve awareness of risk factors for hearing impairment, some of which are relevant in a classroom environment in terms of noise or noticing behaviour changes (e.g. attention changes may be related to onset of OME). Participants demonstrated good knowledge of the professionals who work in the field of audiology and awareness of prevalence of hearing impairment, and the ability to test hearing from birth.

Knowledge of solutions showed a presence of awareness and experience with amplification devices in the classroom. Most participants were uncertain how a device changes hearing for a hearing impaired person. Participants had good awareness of the risk of feeling isolated as a consequence of hearing impairment. Teacher knowledge of amplification devices, hearing impairment type and severity and communication strategies is important for knowing appropriate communication and learning strategies to implement for an individual child with hearing impairment in a specific classroom environment (e.g. ILE versus traditional). It is equally important that teachers have the skills to ensure inclusive learning for a hearing impaired child whilst having an awareness of their cognitive learning ability in relation to peers. This may decrease the risk of hearing impaired children feeling isolated in their education environment.

The second research question considered the knowledge of New Zealand mainstream primary school teachers in relation to classroom teaching. Participants had a good awareness of the limitations of lip-reading for a hearing impaired person and were aware that hearing impairment may impact on ability to produce speech. Also they are aware that speaking at

increased volume is not an appropriate communication strategy to use. Teachers will benefit from information on appropriate techniques and strategies for adapting their teaching for a hearing impaired child specific to their classroom environment and teaching style (e.g. ILE with collaborative teaching and/or students as teachers).

The third research question examined where New Zealand mainstream primary school teachers acquire their knowledge of hearing impairment and deafness. The primary source for an individual child's hearing impairment was the parents and the child themselves. Relying on parents and the hearing impaired child as the main source of information adds unfair pressure and responsibility upon the family to ensure a child's teacher is well informed of their needs for optimal educational outcomes. Audiologists were not a primary source of information for an individual with hearing impairment. The formal channels in New Zealand for teacher knowledge of a child's hearing impairment are the adviser / assist network of the DEC's (P. Peryman, personal communication, March 13, 2017). A low number of participants had attended courses that included information on hearing impairment. Courses were of short duration (e.g. one day or 3-hours) and included NZSL which may not be relevant to many hearing impaired children in a mainstream classroom environment.

The fourth research question asked New Zealand mainstream primary school teachers what information and/or education they would like about hearing impairment and deafness. Information and education on learning support strategies for children with amplification devices (hearing aids and/or implants) was identified as a skill area that needs more input. Future research is recommended that would be structured to provide a sample group of mainstream primary school teachers with hearing impaired children in their classroom a training package incorporating communication strategies suggested by De Raeve (2015). Education delivered by audiologists on the hearing system and how hearing aids and implants work is also recommended for inclusion in the intervention.

4.3 Clinical Implications

Teachers in the survey sample rely on parents and the children with hearing impairment in the first instance, then paraprofessionals for classroom teaching support strategies. Teachers do not appear to have a direct channel to a child's audiologist for providing information on hearing impairment and communication and listening strategies specific to the child. Children with hearing impairment would benefit from targeted teacher in-service training where there is a focus on specific learning support strategies for children with hearing aids and implants, and information on how to tailor teaching practice for a child's individual hearing needs. Children with hearing impairment have cognitive and language learning needs that differ from children with normal hearing (Detterman & Thompson, 1997; Spencer & Marschark, 2010).

Online training modules for mainstream classroom teachers are currently being developed by the New Zealand DECs. Some modules are expected to be available for teachers early in 2018. Topics include: the ear and hearing, hearing aids, daily hearing instrument checking, RM systems and cochlear implants (P. Peryman, personal communication, January 22, 2018). This is a much-needed resource. It will be interesting to monitor the impact of upskilled teachers on hearing impaired children in mainstream classrooms. Also of interest will be feedback from mainstream teachers taking part in the training modules in relation to adaptations they make to their classroom teaching practice. It would be interesting to complete the survey from this study with teachers taking part in the DEC training modules pre - and - post training to monitor any change in knowledge level.

The demographic information gathered in this survey provides useful information for planning of future research and possible intervention. An intervention can be tailored around teaching styles, classroom environment and class sizes specific to the New Zealand mainstream primary school environment.

4.4 Study Limitations

The study sample is potentially biased in terms of the profile of the participants who responded. The participants self-selected survey participation from an email they received. The sample bias may have been toward participants with an interest in the topic area, or who are strong advocates for their students or both. Potential study participants who opted out may have characteristics or variables that are not represented because they did not participate. The result would be inadequate sampling of a population. Overall the participant sample represented a range of variables including age, teaching experience and experience of teaching hearing impaired children. There appears to be an over-representation of females in the survey sample (89%), although this does fit with the New Zealand primary school teacher population which comprises 86% female and 13% male teachers (Ministry of Education, 2017c).

Participant data was not collected for geographic location in New Zealand or the decile rating of the school. A decile rating is a measure used by the Ministry of Education in New Zealand to assist with funding decisions for schools (Ministry of Education, 2017a).

There were 75 people who started the survey and did not complete it. Possible reasons may have been due to the survey timing out when they did not complete it in a single session or deciding part way through the survey they did not fit the criteria as they were not "classroom teaching" or taught across several year groups (e.g. a deputy principal or a 'special education needs coordinator' (SENCO). Some participants emailed the researcher advising of the latter reason for not completing the survey.

Limitations of using an online survey mean it is not possible to ask participants questions or gain more specific information for any question. The dropout rate may be higher than an interview scenario. There is no follow-up second survey. The latter point was intentional for this study.

Participants were asked about the number of students in their school with hearing impairment or deafness. There may have been children at their school with undiagnosed hearing impairment or with hearing impairment that was unknown to the participant. This was difficult to qualify in the survey.

This study has focused on children with hearing impairment only. Many children with hearing impairment also have co-existing conditions that impact on their learning. This group of hearing impaired children also need to be considered for any classroom teacher training strategies (Spencer & Marschark, 2010).

4.5 Survey Questions

Two survey questions were ambiguous in the way they were worded. There was no opportunity for participants to explain reasons for their answers to the questions: *A hearing impaired person may have difficulty with making certain speech sounds when talking'* and '*A hearing impaired person finds vowels (e.g. "ah", "ee", "oh") easier to hear than consonants (e.g. "s", "sh", "f")'*. For both these questions the answer depends on when the person with hearing impairment acquired their hearing impairment and severity and type of hearing impairment. For example, at birth (congenital) or after language development (acquired). A question that provides better information on participant understanding of a hearing impaired person's speech production and speech understanding would be: *"A hearing impaired person's speech may be characterised by speech-sound errors (imprecise articulation)"* and *"A hearing impaired person finds some people harder to hear than others (e.g. children, males or females)".*

Several multiple response survey questions had a text box following "other" for the participant to provide an explanation. Some questions with text responses were difficult to

analyse but did provide the researcher with insight into further response options. For example, use of ‘all of the above’ and the greater range of classroom teaching styles used.

4.6 Future Research

The survey results present several areas for further research into contents of an education and information programme, accessibility of audiologists and the effectiveness of formal professional support services for teachers and hearing impaired children. A focus group or pilot group at several New Zealand mainstream primary schools with pre - and - post - measures for delivery of an education and information programme with primary school teachers would be an interesting follow-up to this study. The education and information programme would focus on providing the requested learning support strategies for hearing impaired children using amplification in the classroom. It is equally important that course content for mainstream teachers is relevant to their teaching style, classroom environment and children. Recommendations for content of future education programmes for mainstream teachers include modules on learning support strategies and communication strategies appropriate to various teaching styles and classroom environments. Also, daily care of amplification devices with input from audiologists.

Future research may investigate how teachers access audiologists as a source of knowledge for an individual hearing impaired child. An audiologist has the expertise to provide information and recommendations for learning support strategies individualised for a hearing impaired child. It is important for the child that an audiologist is part of the team involved in their education.

Conducting a more in-depth investigation into teachers’ experiences and perceptions of supporting students with hearing impairment would provide valuable insights for improving education and support programmes for teachers. For example, through the use of

face-to-face interviews and focus groups. The results of such a study are likely to provide further insight into the challenges and opportunities presented by including students with hearing impairment in mainstream classroom environments. Such a study could also examine aspects of results of this study such as identifying the reasons that teachers use parents and the child first rather than professionals for a source of information of a child's hearing impairment. A component of this research could be the accessibility and timeliness of formal professional support services from the MoE.

Research could also focus on the effectiveness of professional development programmes such as the packages currently under development by the DECs. This information will help describe steps that educators can take to help maximise the learning and development of students with hearing impairment in New Zealand mainstream classrooms.

5. Conclusion

In summary, this study highlights a need for the availability of more current information and education for New Zealand mainstream primary school teachers to assist them with providing effective teaching and learning strategies to hearing impaired and deaf children. The developed world has made enormous progress with implementing the UNHSEIP across many countries since the 2000's. It is now time to consider and focus on the next step for hearing impaired and deaf children to ensure they have equal and appropriate access to the school curriculum in whatever form that may be in their school learning environment. The same information gap was highlighted for teachers in the Lass et al. (1985) study over thirty years ago.

Teachers are using the resources that are easily accessible to them to obtain the knowledge and strategies they need specific to the children they have in their classrooms with hearing impairment and deafness. The resources they are currently using are the parents of the children, the children themselves and then the paraprofessionals of the education system who are linked into the needs of the hearing impaired children.

Participants predominantly requested information on learning support strategies for children with hearing aids and implants to assist with teaching practice in their classrooms. A consideration for supporting teachers with hearing impaired children in their classrooms in the future would be to initiate a regular training or education programme they could access easily from their school. Such a programme could be setup in the form of online modules with videos and live chat from hearing professionals such as audiologists and AoDC's. The Deaf Education Centres in New Zealand are currently working on such a resource which will hopefully ensure that New Zealand mainstream primary school teachers are becoming upskilled for teaching hearing impaired children. The modules being developed by the Deaf

Education Centres for mainstream teachers cover the following topic areas: the ear and hearing, hearing aids, daily hearing instrument checking, remote microphone systems, cochlear implants (P. Peryman, personal communication, January 22, 2018). These modules cover some of the knowledge areas identified in this research as areas for teacher upskilling. It is critical that knowledgable and skilled teachers support students with hearing impairment. It is hoped these individuals will provide the necessary support to ensure that students with hearing impairment learn and develop in a similar manner to their hearing peers.

6. References

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7. Appendices

Appendix A: Ethics Approval Letter

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

HUMAN ETHICS COMMITTEE

Secretary, Rebecca Robinson
Telephone: +64 03 369 4588, Extn 94588
Email: human-ethics@canterbury.ac.nz

Ref: 2017/07/ERHEC-LR

1 June 2017

Sue Coombe
Department of Communication Disorders
UNIVERSITY OF CANTERBURY

Dear Sue

Thank you for submitting your low risk application to the Educational Research Human Ethics Committee for your research proposal titled "New Zealand Teachers' Understanding of Hearing Loss".

I am pleased to advise that this application has been reviewed and I confirm support of the School's approval for this project.

With best wishes for your project.

Yours sincerely

pp R. Robinson

Dr Patrick Shepherd
Chair
Educational Research Human Ethics Committee

Appendix B: Qualtrics Survey

Start of Block: Survey

Thank you for your interest in participating in this survey. Firstly, there is study information and consent to complete, then you will be asked to respond to a series of questions about your knowledge of hearing loss.

New Zealand Teacher's Understanding of Hearing Loss: Study information

Tēnā koe, my name is Sue Coombe, I am a student at the University of Canterbury studying to become an Audiologist. This study is designed to develop an understanding of what New Zealand teachers know about hearing loss and its influence on students' learning.

The study involves completion of an online survey that includes questions about your – · understanding of hearing impairment · sources of information about hearing impairment · professional learning needs related to hearing impairment. The questionnaire will take approximately 10 minutes to complete.

All responses will remain anonymous and the information you provide will be stored in password protected computer files at the University of Canterbury. If you choose to enter the draw for a gift voucher your personal contact details will be stored separately to your questionnaire responses to maintain anonymity of your responses.

Your participation is voluntary and you have the right to withdraw any information you have provided after you have completed the survey. However, once analysis of raw data starts in July 2017, it will become increasingly difficult to remove the influence of your data on the results. If you would like to withdraw, please contact me as soon as possible after completing the survey.

The results of the project will form the basis for a Masters thesis which is a public document and will be available through the UC library. Results may also be presented at professional conference or published in an academic journal. However, you are assured of

complete confidentiality of data gathered in this study. Results will not identify any participants. Only the researcher and supervisor will have access to the raw data which will be destroyed after 5 years.

Please indicate your consent to participate by referring to the consent information provided on the first page of the online survey form.

The project is being carried out as a requirement for the Master of Audiology degree by Sue Coombe (sue.coombe@pg.canterbury.ac.nz) under the supervision of Dr Dean Sutherland (dean.sutherland@canterbury.ac.nz). We will be pleased to discuss any concerns you may have about participation in the project.

This project has been reviewed and approved by the Educational Research Human Ethics Committee at the University of Canterbury, and participants should address any complaints to The Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).
Thank you for participating.

New Zealand Teacher's Understanding of Hearing Loss Consent **Information for participants in this study.** *Please check the box to indicate your consent*

I have read the study information and agree to participate. I understand that: Participation is voluntary and I may withdraw without penalty. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain practically achievable. Any information or opinions I provide will be kept confidential to the researcher and her supervisor, Dr. Dean Sutherland and that any published or reported results will not identify the participants or their school. A thesis is a public document and will be available through the UC Library. All data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form and will be destroyed after five years. I can contact the researcher Sue Coombe (sue.coombe@pg.canterbury.ac.nz) or Dr. Dean Sutherland (dean.sutherland@canterbury.ac.nz) for further information. If I have any

complaints, I can contact the Chair of the University of Canterbury Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz)

Thank you for participating in this research project.

Are you?

- Female (1)
- Male (2)
- Other (3)
- Prefer not to say (4)

What is your age group?

- 20-29 years (1)
- 30-39 years (2)
- 40-49 years (3)
- 50-59 years (4)
- 60-69 years (5)
- 70 + (6)

Which year group do you currently teach? *(tick all the answers that apply)*

- New Entrant (1)
- Year 1 (2)
- Year 2 (3)
- Year 3 (4)
- Year 4 (5)
- Year 5 (6)
- Year 6 (7)
- Year 7 (8)
- Year 8 (9)

Do you teach at a mainstream classroom school?

- Yes (1)
- No (2)

Please describe the school you teach at *(e.g. Year 1-8, full primary, area school)*_____

Which classroom environment do you teach in?

- Flexible Learning Space (1)
- Traditional Classroom (2)
- Other (please explain) (3) _____

How many years have you been teaching?

- Less than 2 years (1)
- 3-5 years (2)
- 6-10 years (3)
- More than 10 years (4)

What other qualifications do you hold *(in addition to your teaching qualification)*?

_____

How many children are in your classroom this year? *(Drag slider to the right to indicate number of children)*

(	1	2	3	4	5	6	7	8	9	10
0	0	0	0	0	0	0	0	0	0	

Children (3)

This information clarifies terms used in further questions:

The term **"hearing impaired"** refers to people with partial hearing that ranges from mild to profound in severity.

The term **"deaf"** refers to people with no hearing. Without amplification (e.g. cochlear implant, bone-anchored hearing aid or hearing aids) people with profound hearing impairment cannot hear sounds at normal levels.

How many children in your classroom are hearing impaired?

- (1)
- (2)
- (3)
- (4)
- or more (5)

How many children in your classroom are deaf?

- (1)
- (2)
- (3)
- (4)
- or more (5)

The photos on the next screen help clarify the difference between a hearing aid, cochlear implant, bone-anchored-hearing-aid (BAHA) and remote microphone (RM) as they are worn by children and teachers. They are collectively known as hearing devices. This information relates to following questions

Hearing Aid

Cochlear Implant

Bone Anchored Hearing Aid (BAHA)

Remote Microphone on Teacher

Display This Question:

If How many children in your classroom are hearing impaired? != 0

How many of the hearing impaired children in your classroom wear hearing aids to hear speech?

- (1)
- (2)
- (3)
- (4)
- or more children (5)

Display This Question:

If How many children in your classroom are deaf? != 0

How many of the deaf children in your classroom wear a cochlear implant to hear speech?

- (1)
- (2)
- (3)
- (4)
- or more children (5)

How many (approximately) children in your school are hearing impaired?

	0	1	2	3	4	5	6	7	8	9	10
Number of hearing impaired children (1)											

How many (approximately) hearing impaired children have you taught over your teaching career?

	(	1	2	3	4	5	6	7	8	9	10
	0	0	0	0	0	0	0	0	0	0	
Number of hearing impaired children (1)											

Describe your classroom teaching and learning approaches / styles *(tick all that apply)*

- Peer learning (1)
- Traditional instruction from teacher (2)
- Collaborative teaching with more than 1 teacher in the classroom (3)
- Other (please explain) (4) _____

What hearing devices and accessories have you had experience with and used to modify your teaching for hearing impaired children?

- Hearing Aids (1)
- Cochlear Implants (2)
- Bone Anchored Hearing Aids (BAHA) (3)
- FM systems (or Remote Microphones) (4)
- Other (please explain) (5) _____

Many profoundly deaf individuals ***"talk with their hands"***. This is called:

- Sign Language (1)
- Finger Talking (2)
- Gesticulation (3)
- Gestures (4)
- Hand Signals (5)

The non-medical professional who specifically studies hearing and tests people's hearing is called a(n):

- Audiologist (1)
- Speech Language Therapist (2)
- Occupational Therapist (3)
- Psychologist (4)

The medical doctor who specialises in treating ear diseases is called a(n):

- Paediatrician (1)
- Audiologist (2)
- Ear Nose and Throat (ENT) Specialist (3)
- Optometrist (4)
- Regular Medical Doctor who specialises (5)

If you needed to purchase a hearing aid, you would go to a(n):

- Audiologist (1)
- Doctor (2)
- Doctor to give a recommendation (3)
- Ear Nose and Throat (ENT) Specialist (4)
- Neurologist (5)
- Optometrist (6)
- Opthalmologist (8)

The power source for a hearing aid is a:

- Battery (1)
- Solar Energy Cell (2)
- Transmitter (3)
- Amplifier (4)

The number of people in New Zealand today with some degree of hearing loss is approximately:

- 25,000 (1)
- 400,000 (3)
- 500,000 (4)
- 1,000,000 (2)

In your opinion, the worst consequence of **hearing impairment** is:

- A feeling of isolation (1)
- A feeling of insecurity (2)
- A loss of the primary warning systems (3)
- Loss of feeling that you are a part of a living, alive world (4)
- Loss of ability to talk freely with others (5)
- Loss of ability to hear others talk (6)
- Other (please explain) (7)

  _____

In your opinion, the worst consequence of **deafness** is:

- A feeling of isolation (1)
- A feeling of insecurity (2)
- A loss of the primary warning systems (3)
- Loss of feeling that you are a part of a living, alive world (4)
- Loss of ability to talk freely with others (5)
- Loss of ability to hear others talk (6)
- Other (please explain (7) _____

Do you have a hearing impairment?

- Yes (1)
- No (2)

Skip To: Q54 If Do you have a hearing impairment? = Yes

Skip To: Q34 If Do you have a hearing impairment? = No

How long have you had a hearing impairment?

(Drag slider to the right to indicate number of years)

(	1	2	3	4	5	6	7	8	9	10
0	0	0	0	0	0	0	0	0	0	

Number of years (1)

Do you know anyone with hearing impairment? *(please tick all that apply)*

- Mother (3)
- Father (4)
- Brother (5)
- Sister (6)
- Aunt (7)
- Uncle (8)
- Cousin (9)
- Friend (10)
- Grandmother (11)
- Grandfather (12)
- I don't know anyone with hearing impairment (13)
- Add comment (14) _____

Have you ever attended a course that included information about hearing impairment, deafness or hearing disorders?

Yes (1)

No (2)

Skip To: Q58 If Have you ever attended a course that included information about hearing impairment, deafness or h... = No

Skip To: Q56 If Have you ever attended a course that included information about hearing impairment, deafness or h... = Yes

What was the duration of the course/s?_____

What was the title of the course/s? *(if known)*_____

Where have you gained your knowledge on hearing impairment for children in your classroom?
(Tick all that apply)

- Parents of children with hearing impairment or deafness (1)
- Children with hearing impairment or deafness (2)
- Teacher Colleagues (5)
- Adviser on Deaf Children (AoDC) (3)
- Resource Teacher of the Deaf (RTD) (7)
- Paraprofessionals (e.g. Teacher Aid, ASSIST, Educational Support Worker, Resource Teacher for Learning and Behaviour (RTLB)). *(Please specify)*_____
- Other *(please explain)*_____

If you have a child with hearing impairment in your class, what education or information about hearing impairment or hearing disorders would assist your teaching practice? *(tick all that apply)*

- Information about the ear and hearing system (1)
- Information about how hearing aids work (2)
- Information about how implants work (3)
- Information about learning support strategies for children with hearing aids (4)
- Information about learning support strategies for children with implants (5)
- Other *(please explain)* (6) _____

End of Block: Survey

Start of Block: Likert

The next set of questions are related to knowledge of hearing impairment and causes of hearing impairment.

Some diseases and illnesses are known to cause hearing impairment. Tick the diseases or illnesses listed below that you think can cause (permanent or temporary) hearing impairment.

- (maternal) contracted during pregnancy (6)
- Meningitis contracted in childhood (3)
- Measles contracted in childhood (4)
- Mumps contracted in childhood (5)
- Otitis Media with effusion (ear infection or glue ear) (7)
- Hypoxia (8)
- Hydrocephalus (9)

For the following questions please indicate the degree to which you agree or disagree with the accuracy of the statements.

Most hearing losses can be medically treated

- Strongly Agree (1)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

Hearing aids usually cost much more than glasses

- Strongly Agree (2)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

In lipreading we learn to "see each sound" and can understand complicated passages even at a great distance from the speaker

- Strongly Agree (2)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

Exposure to loud noises can cause a person's ears to ring

- Strongly Agree (2)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

A drug by itself **cannot** cause permanent hearing loss (e.g. gentamicin (antibiotic), chemotherapy, aspirin)

- Strongly Agree (2)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

Infants/babies **cannot** have their hearing tested

- Strongly Agree (2)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

A hearing aid brings hearing to within normal range just as glasses bring vision back to normal

- Strongly Agree (2)
- Agree (3)

- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

A cochlear implant (surgically implanted to the inner ear) brings hearing to within normal range just as glasses bring vision back to normal

- Strongly Agree (2)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

Speaking very loudly to a hearing-impaired person makes it easier for him/her to understand

- Strongly Agree (2)
- Agree (3)
- Neither agree nor disagree (4)
- Disagree (5)
- Strongly Disagree (6)

A hearing-impaired person may have difficulty with making certain speech sounds when talking

---

- Strongly Agree (1)
- Agree (3)
- Neither agree nor disagree (2)
- Disagree (5)

- Strongly Disagree (6)

A hearing impaired person finds vowels (e.g,. "ah", "ee", "oh") easier to hear than consonants (e.g., "s", "sh", "f")

- Strongly Agree (1)
- Agree (3)
- Neither agree nor disagree (2)
- Disagree (5)
- Strongly Disagree (6)

End of Block: Likert

Start of Block: Completion

Thank you for your time spent completing this survey - it is much appreciated. Please tick the following boxes if you wish to go in the draw for a gift voucher and/or would like to receive a summary of the study results.

Your contact information will be kept separate from the survey you have completed.

- Yes, I would like to enter the draw for one of twenty $20 MTA gift vouchers. (1)
- Yes, I would like a summary of the study results sent to me (2)
- Neither (3)

Skip To: End of Survey If Thank you for your time spent completing this survey - it is much appreciated. Please tick the fo... = Neither

Please enter your name and email address for us to contact you

Name (1) _____

Email (2) _____

End of Block: Completion

Appendix C: Recruitment Email to Principals Association and Primary Schools

Re: Research: NZ Teachers' Understanding of Hearing impairment

Tēnā koe, my name is Sue Coombe, I am a student of Audiology at the University of Canterbury. I am conducting a study that aims to develop an understanding of what New Zealand teachers know about hearing impairment and the effect on students' learning.

I am looking for New Zealand primary school teachers to complete a short online questionnaire that includes questions about your:

· understanding of hearing impairment

· sources of information about hearing impairment

· professional learning needs related to hearing impairment

The questionnaire takes approximately 10 minutes to complete.

I would be grateful if you could take some time to complete the questionnaire and contribute to the study.

In recognition of your time you may go into the draw for one of twenty $20 gift vouchers.

Please click on the link below to take part in the study.

http://canterbury.qualtrics.com/jfe/form/SV_agTtfcc5z5C9J8V

Appendix D: Phonak Consent Email for Photo Use (in survey)

2/5/2018 Gmail - Permission for using photos from Phonak website

Gmail

Sue Coombe <smcoombe@gmail.com>

Permission for using photos from Phonak website
3 messages

Sue Coombe <smcoombe@gmail.com> Wed, Jun 14, 2017 at 12:01 PM
To: david.crowhen@phonak.com

Hi David,

Following our phone conversation this morning here is the link to the photos I was referring to.
I would like to ask permission to use the below pictures from the Phonak website in my Qualtrics online survey for teachers as part of my MAud thesis.

Roger Pass-around photo and the photo of two female teachers and 4 children from here:
https://www.phonak.com/nz/en/hearing-aids/accessories/roger-touchscreen-mic.html

If these photos are not available for use could you please suggest alternative photos I could use? I want a photo of a Roger pen accessory and another photo of a Roger mic in use between teacher and pupil if possible.

Thanks and kind regards

Sue

Sue Coombe
021 0237 5770

Crowhen, David <David.Crowhen@phonak.com> Wed, Jun 14, 2017 at 1:06 PM
To: Sue Coombe <smcoombe@gmail.com>

Hi Sue,

As I understand it, this is an image developed and owned by Phonak so you can use.

Kind regards

David Crowhen
BSc., MAud (Hons), Post Grad Dip Bus Admin, MNZAS

Brand Manager – Phonak NZ

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