Communicating with Masks and Assistive Listening Devices during the COVID-19 Pandemic

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Abstract

Since the appearance of COVID-19 in 2019, wearing face masks has been mandatory and normalised as a public health measure. Despite the benefit of minimising viral transmission, face masks impact our speech understanding capabilities, particularly in noisy situations. Those with hearing loss rely more heavily than others on seeing facial cues and lip movements to understand speech, and by wearing face masks these visual cues are inaccessible (Mheidly et al., 2020). This study aimed to describe the experiences of adults who use assistive listening devices in understanding speech while communicating with people wearing face masks. Semi-structured interviews were conducted with adult listeners with varying degrees of hearing loss, who use assistive listening devices (hearing aid(s) or cochlear implant(s)). The audio-recordings of each interview were transcribed for review and analysis. The interview data was qualitatively analysed using a reflexive thematic analysis approach (Braun & Clarke, 2006, 2022) to determine common themes related to communication experiences while wearing face masks for people using assistive listening technology. Four distinct themes were generated, each related to the overarching finding that assistive listening device users’ had individual and varying experiences communicating with others wearing mask. Themes were (1) Masks as a Barrier to Communication; (2) Experiences and Opinions of Mask Types; (3) Impact on Daily Life; (4) The Attitudes and Cooperation of Others. Overall it is evident that face masks interfere with communication and daily living, most notably for individuals who reported a more severe hearing loss. The findings of this study suggest that promotion of public awareness and understanding of hearing loss and effective communication for this population is necessary.
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Chapter 1. Introduction

Humans connect and interact with each other through face-to-face communication, which plays an integral role in our everyday life (Hartley, 2002). Communication can occur through many methods and systems, the most prominent being speech and language (Adler et al., 2012). For most, speech is understood using audio-visual integration to make sense of the visual lip movements and the speech sounds perceived (Driver, 1996). Even for listeners with good hearing, lip-reading is used to assist speech perception, particularly in difficult listening environments (Driver, 1996). In background noise, visualising the facial movement of the speaker can improve the speech reception threshold (SRT) by 3-5dB (Magee et al., 2020; Rahne et al., 2021). It is important to consider that for individuals with a hearing loss, many environments are considered degraded listening conditions, whether caused by external noise, hearing loss, or both, and that lip reading is more heavily relied on than it is for individuals with normal hearing levels (Moradi et al., 2017).

Living with the emergence of COVID-19 in our communities has seen face-mask wearing being widely enforced in public places to reduce transmission of the virus, sometimes in conjunction with additional protection barriers such as plexiglass shields (Nienke & Vroegop, 2021; Poon & Jenstad, 2022; Tonelli & Warick, 2022). This widespread use of face masks has meant that the lower portion of people’s faces have been covered in most situations outside of people’s homes. This, alongside the distorting effect masks have on the sound of speech produced, has created an additional challenge to our everyday listening environments, which often already includes challenges such as background noise, unfamiliar accents, and competing speech (Peelle, 2018).
Current estimates suggest that approximately 1.6 billion people live with hearing loss around the world (Tonelli & Warick, 2022). Even for the proportion of these individuals who use assistive listening devices, understanding speech in difficult conditions can remain challenging to varying degrees, depending on the configuration of the hearing loss, level of cognitive function, and fit of the device (Lesica, 2018; Mourão et al., 2020). In line with this, evidence has shown that the proportion of individuals experiencing difficulty communicating with face-masks increases with the severity of the hearing loss (Poon & Jenstad, 2022).

This thesis explores the use of face-masks and their impact on interpersonal communication for users of assistive listening devices. This chapter focusses on the purpose of face-masks in combatting COVID-19, and the factors involved in their interference with communication, specifically for individuals with hearing loss.

**COVID-19**

Since its outbreak at the beginning of 2020, COVID-19 has had widespread impacts on communities in approximately 200 countries, in terms of daily living, lives lost, and economic and social repercussions (Ciotti et al., 2020; Yuki et al., 2020). The virus is highly-transmissible and persistently evolving to evade herd immunity, even with the introduction of vaccines in the final quarter of 2020 (Liao et al., 2021). COVID-19 is caused by the virus SARS-Cov-2, which is an abbreviation for Severe Acute Respiratory Syndrome Coronavirus 2 (Ciotti et al., 2020; Yuki et al., 2020). General symptoms include headaches, brain fog, weakness, vomiting, fever, a dry cough or shortness of breath (Ciotti et al., 2020; Yuki et al., 2020). Respiratory symptoms can range from mild to severe, with some severe cases leading to acute respiratory distress syndrome (ARDS),
pneumonia, organ failure, and death (Tuli et al., 2021). Additionally, Covid-19 affects the cardiovascular system in some individuals, leading to complications such as myocarditis, acute myocardial infarction, heart failure and dysrhythmias, which can be life threatening in some cases (Ciotti et al., 2020).

Unfortunately, severe symptoms causing serious health complications and mortality are not rare, and many lives have been lost to this pandemic. According to WHO, of the 533,816,957 confirmed cases reported up to the 14th June 2022, there had been 6,309,633 deaths (World Health Organisation, 2022). Studies looking into the epidemiology of the virus have found that both the incidence and mortality is much higher in the elderly population than it is in younger adults and children (Yuki et al., 2020). As a result, major public health measures to minimise the spread of the virus have been taken globally to minimise the effects on communities and the loss of lives. In New Zealand (NZ), the government’s response to COVID-19 was strong and initiated early to minimise the spread of the virus. Despite this, the virus eventually reached the country and as of the 15th June 2022 there have been 1,248,298 cases and 1,295 deaths reported in NZ (World Health Organisation, 2022). Globally, countries have adopted various strategies to minimise transmission of the virus, such as encouraging hand hygiene, social distancing, mask-wearing, border closures, and lockdowns which have continued over months in some countries. Evidence indicates that initiating these lockdowns early significantly helped to avoid a dramatic increase in case numbers (Huang et al., 2021). Additionally, a vaccine against the virus became available within a year of the pandemic being announced, and according to WHO, 11,864,214,773 vaccine doses had been administered as of 14 June 2022 (World Health Organisation, 2022).
Face Masks

Air-borne virus carrying particles are the main means of COVID-19 transmission between individuals even in the absence of symptoms, therefore it is widely thought that face coverings are a critical and effective tool in minimising its spread (Brooks et al., 2020; Desai & Aronoff, 2020; Liao et al., 2021). Enforcement of face mask wearing is a public health strategy that has been adopted in the majority of countries around the world, generally in any public locations outside of one’s household (Liao et al., 2021; Nienke & Vroegop, 2021; Poon & Jenstad, 2022; Tonelli & Warick, 2022; Toscano & Toscano, 2021). This strategy works by blocking or filtering droplets, which can be ejected several metres by an infected individual coughing or sneezing (Liao et al., 2021).

Initially, the World Health Organisation (WHO) argued that there was not sufficient evidence to imply that healthy people would benefit from wearing face masks (Liao et al., 2021). However, considerable evidence has since indicated that face masks can effectively protect individuals from contracting the virus, by interrupting viral transmission routes (Davies et al., 2013; Leung et al., 2020). A study by Abboah-Offei et al. (2021) presented findings that if everybody adopts the use of a face mask in public spaces, this provides a double barrier against COVID-19 transmission. Considering this, WHO advised governments to encourage the use of masks in public environments where it was difficult to physically distance from one another (Liao et al., 2021; World Health Organisation, 2021). Healthy individuals were advised to wear a face mask for protection, as a likely route of viral transmission is by individuals in public spaces who are infected and contagious, yet asymptomatic (Feng et al., 2020; World Health Organisation, 2021). In New Zealand, compulsory face mask wearing in many public and vocational spaces was implemented.
in the middle of 2020, the first year of the pandemic, and remained a requirement in most public spaces including on public transport, and in retail stores, public facilities, court, and healthcare service facilities, until mid-2022. Only now, over two years since the virus reached New Zealand, has the requirement of face-masks been lifted in most settings, other than health-care or age-care facilities.

Impact on Communication

Despite their health advantage, masks have a negative effect on communication, as facial expressions and lip movements are not visible, and speech sounds are attenuated (Chodosh et al., 2020; Homans & Vroegop, 2021). Various studies have found that the use of masks decreased speech perception scores in background noise, even for normal hearing listeners (Bandaru et al., 2020; Toscano & Toscano, 2021). Unfortunately, the locations in which individuals are required to wear a face mask are those where many individuals are sharing a space. Incidentally, these are the noisier environments where it is already more difficult to segregate target speech from other external auditory signals, without the added challenge of face masks (Signoret & Rudner, 2019). Sensorineural hearing loss causes individuals to have less ability to detect spectral changes in noise, due to reduced frequency selectivity, and therefore these individuals rely more heavily on visual signals for speech perception in noise (Chen et al., 2012).

Facial Cues in Speech Recognition

Trecca et al. (2020) found that one of the main issues of communicating with face masks for people with hearing loss is the impossibility to read lips. Since childhood, our brains perceive continuous speech using the combination of both auditory and visual signals (Strenlkov et al., 2015;
Auditory signals in the form of facial cues assist listeners with understanding the speech sound being made by the shape of the mouth, as well as providing reference to the rate of speech which is assistive in separating words (Bosker et al., 2020; Bourguignon et al., 2020; Puviarasan & Palanivel, 2011). Wearing a face mask covers the nose, mouth and chin, blocking access to this audio-visual information (Atcherson et al., 2017; Bourguignon et al., 2020; Goldin et al., 2020; Poon & Jenstad, 2022). Although, movement of the eyebrows and head remain visible with face masks, and also contribute to the speech prosody and the pitch and amplitude of voice, the most important audio-visual cues are the movements of the mouth (Strelnikov et al., 2015). Additionally, face masks also interfere with some facial cues used in signed language, as the lower facial region is used in some gestures, and facial expressions portray additional information on phrase boundaries and prosody (Poon & Jenstad, 2022; Sandler, 2012).

Although speech processing can be supported through the auditory system solely, in conditions of degraded auditory signal, the accuracy of speech perception can be increased with the added auditory signal of lip movements (Strelnikov et al., 2015). In everyday conversation, listeners use observation of the speaker’s articulatory facial gestures to assist with decoding speech (Bourguignon et al., 2020). In noisy situations, lip-reading is particularly important to provide the listener with temporal cues and language elements, particularly spoken consonants (Rahne et al., 2021). When listening to continuous speech, the cerebral cortex receives visual information approximately 100-200ms prior to receiving the corresponding auditory information (Strelnikov et al., 2015). This temporal dynamic provides the listener with strong predictive cues for the corresponding auditory information (Strelnikov et al., 2015).
Suffice to say, visual signals are an integral part of our speech processing system and many people with normal hearing, vision, and social skills, are likely unaware of the degree to which visualising lip movement subconsciously aids their speech perception (Puviarasan & Palanivel, 2011). For people with hearing loss, reliance on lip-reading for speech perception is likely increased to varying extents depending on the degree and configuration of the hearing loss. It was shown in a study by Moradi et al., (2016) that older adults using hearing aids experience greater audio-visual benefit from associating visual cues with speech than individuals of the same age group with normal hearing.

Attenuation of Sound Through Face Masks

Ttrecca et al. (2020) recognised the second main issue identified by people communicating with masks, with hearing loss, was the noise reduction of the speech. Facemasks behave as a low-pass filter, attenuating frequencies above 2kHz by 3 to 4 dB SPL for general surgical masks, and up to 12dB for N95 masks, while allowing low frequencies to pass through (Chodosh et al., 2020; Goldin et al., 2020). Speaking through face masks does not affect some features of voice quality, such as temporal pattern and harmonic-to-noise ratio, it is the speech signal that is affected (Rahne et al., 2020). There are three common types of masks used for COVID-19 protection; cloth, surgical, and N95 masks, which each vary in fabric weave tightness and fit (Magee et al., 2020). As indicated, the material or type of face mask affects the level of attenuation, which ultimately results in speech quality degradation (Goldin et al., 2020; Peelle, 2018). Alongside the absence of facial cues, this makes the process of correctly identifying speech sounds increasingly difficult.
Sensorineural hearing loss reduces spectro-temporal resolution, resulting in further difficulty to segregate target speech from external auditory signals, which can be overwhelming in public places (Signoret & Rudner, 2019). In adverse listening conditions, hearing the frequencies containing important aspects of the clarity of speech becomes increasingly important for understanding it, even for listeners with normal hearing (Erber, 1975; Janse & Adank, 2012). Increased spectral energy in the higher frequencies contributes to the clarity of speech for listeners, as this carries rich information about fricative consonants (Miller et al., 2017; Nguyen et al., 2021; Poon & Jenstad, 2022; Sakayori et al., 2002; Van Engen et al., 2012). This means that the clarity of speech is diminished for individuals with hearing loss in the high frequencies, and this is exacerbated in adverse conditions, such as with background noise or listening to the voice of somebody with an unfamiliar accent (Erber, 1975; Janse & Adank, 2012).

This concept is evident in the counselling of hearing aid fitting, where audiologists commonly advise their clients that a hearing loss in the high frequencies, above 2kHz, will reduce the clarity of speech, and a hearing loss in the lower frequencies will affect speech volume. For listeners with hearing loss in the high frequencies, the addition of a face mask attenuates these high frequencies further, increasing the level of difficulty in understanding speech, technically exacerbating their hearing loss by 3dB to 12dB depending on the type of face mask (Goldin et al., 2020).

**Hearing Loss and Assistive Listening Devices**

High background noise, reverberation, and distance between the source of interest and listener are regarded as three main factors which create difficult listening conditions for individuals with
hearing loss (Wagener et al., 2018). Many people who have been diagnosed with a hearing loss will either adopt the use of hearing aids, or undergo surgery for a cochlear implant (CI), depending on various factors such as funding, lifestyle, and the hearing loss itself (Pereira-Jorge et al., 2018). The nature of hearing loss is a large factor as there are various causes, degrees and configurations, and progression rates of hearing loss, which are considered in the type of assistive listening device recommended for each individual (Kricos, 2006).

When intact, the auditory system has the ability to hear soft to intense sounds over an incredibly wide range of frequencies (Banerjee, 2017). This dynamic range is reduced with a sensorineural loss, meaning average conversational speech no longer falls into the middle of the range as it does with an intact auditory system, and soft sounds are barely audible (Banerjee, 2017). Both hearing aids and cochlear implants perform sound processing to allow for improvement of the user’s hearing sensitivity, however they do not restore a person’s hearing entirely (Lesica, 2018; Shekar & Hansen, 2021). Hearing loss profoundly distorts neural activity in the inner ear, and the specific patterns of activity across these neurons over time (Lesica, 2018; Young, 2008). Although assistive listening devices function to replicate parts of the inner ear’s abilities, they do not restore some important aspects of these neural patterns within the central auditory system (Lesica, 2018; Pereira-Jorge et al., 2018). This weakening of the signal between the ear and the brain affects the temporal processing abilities of the auditory system, which plays an important role in speech perception in noise (Lesica, 2018; Gourévitch et al., 2014; Peelle & Wingfield, 2016). Studies on rehabilitation with a CI and hearing aids, collectively referred to as auditory rehabilitation, have shown that functioning of the central auditory system can be at least partially recovered (Giraud et al., 2001; Pereira-Jorge et al., 2018). Magnetic Resonance Imaging (MRI) and Positron Emission
Tomography (PET) use has shown this partial recovery of auditory cortex activity, through the use of assistive listening devices (Giraud et al., 2001; Lazard et al., 2013; Lee et al., 2003; Pereira-Jorge et al., 2018). However, this neuroplasticity and the level of restoration is variable between individuals, particularly in the adult brain, and may not be fully recoverable (Lee et al., 2003).

Current hearing aids effectively replace the function of the outer hair cells which no longer function with a sensorineural hearing loss, by amplifying and compressing sound (Hoppe & Hesse, 2017; Lesica, 2018). This is achieved through multichannel wide dynamic range compression, a sound processing feature of hearing aids designed to aid with speech intelligibility (Lesica, 2018; Shekar & Hansen, 2021). The aim of this is to apply different amounts of gain to soft, moderate and intense sounds, essentially squeezing environmental sounds into the reduced dynamic range of the listener, amplifying the necessary frequencies specific to their hearing loss (Banerjee, 2017; Lane, 2012; Lesica, 2018). Soft consonant sounds are amplified independently of vowel sounds, which are more intense, in an effort to increase audibility and therefore speech intelligibility (Banerjee, 2017). However, unfortunately this mechanism of amplification is not sufficient to restore speech perception abilities in noisy environments, as this only partially compensates for impaired function of hair cells, so this remains a widely reported difficulty for both hearing aid and cochlear implant users (Lesica, 2018; Mourão et al., 2020; Rahne et al., 2020). Lesica (2018) reported on this, stating that a common complaint of individuals with hearing loss is, “I can hear you, but I can’t understand you” (Kochkin, 2000; Lane, 2012). For hearing aid users, despite the potential for the central auditory system to recover to some extent, there remains little evidence that the peripheral auditory system, specifically the auditory nerve and cochlea, will evolve following use of the device (Pereira-Jorge et al., 2018).
There are various other features in hearing aids which aim to increase speech intelligibility, such as directional and omnidirectional microphones designed to register where speech is coming from and pick up on this sound (Dillon, 2012; Voss et al., 2022; Wagener et al., 2018). Voss et al., (2022) reported that directional microphones are the only hearing aid feature with evidence showing that it significantly increases speech understanding for users. The study also outlined the importance of individuals with hearing loss receiving a signal-to-noise ratios (SNR) of 10dB higher than individuals with normal hearing, in order to achieve speech understanding of the same level (Voss et al., 2022). Although most directional microphones provide an improvement in SNR of about 4 to 5dB, this is not sufficient to the 10dB increase required for a user with moderate hearing loss, and 20dB required for those with a severe to profound hearing loss (Wagener et al., 2018). Wagener et al., (2018) also purported to the idea that hearing aids mechanisms such as directional microphones may be ideal for listening while stationary, yet diminish sound quality when walking. Additional features are available in higher technology hearing aids to assist with speech perception in noisy environments, with noise reduction systems aiming to further improve the listening comfort for users by improving the SNR (Wong et al., 2018). This is achieved by reducing the gain in frequency regions dominated by noise, through algorithms in the hearing aid, which results in an increased SNR (Brons et al., 2013; Kim et al., 2020). However, studies on the efficacy of these features in real life situations have shown that although there is some modest improvement, this is variable between individuals and real-life situations, and they do not provide users with the same listening abilities as those with normal hearing levels (Cox et al., 2014; Lesica, 2018; Magnusson et al., 2013; Wong et al., 2018; Wu et al., 2019).
Cochlear implants (CIs) are surgically implanted, and regarded as the most successful neural prosthesis invented in terms of hearing function restoration (Wilson & Dorman, 2008). Sound is picked up by a microphone similarly to a hearing aid, however rather than amplifying the sound, the acoustic signals are converted to electrical impulses and transmitted directly to the acoustic nerve, stimulating it in response to sound (Chung, 2020; Gaylor et al., 2013; Raman et al., 2015). This means the sound signal completely bypasses the damaged hair cells of the inner ear, directly stimulating the auditory nerve with currents delivered through the electrodes of the implant positioned along the length of the cochlea (Gaylor et al., 2013; Wilson & Dorman, 2008).

CIs restore communication abilities in quiet situations for individuals with severe to profound hearing loss, yet in noisy situations communication can remain difficult (Mourão et al., 2020). Voss et al., (2022) reported that individuals with a severe to profound hearing loss require a SNR increase of up to 20dB, compared to normal-hearing individuals to achieve the same level of speech intelligibility. Employing an array of electrodes which stimulate different portions of the cochlea, the CI aims to mimic the frequency resolution normally employed when processing speech (Healy & Bacon, 2006). Modern CIs have around twenty stimulating electrodes, however the effective number of independent information channels presented through the implant is around four to seven (Moberly et al., 2016). This is due to regions of neural stimulation overlapping, due to the spread of excitation from adjacent electrodes, and as a result the speech heard by a CI user is spectrally degraded and shifted (Moberly et al., 2016).

Another limitation which can lead to degraded sound quality, is that the electrode array cannot cover the entire apex due to surgical insertion constraints, resulting in spectral mismatch between
the electrode locations and the acoustic input (Guérit et al., 2014; Moberly et al., 2016; Svirsky et al., 2015). To limit the consequences of this, CIs are programmed specifically to the needs of the user in order to allow them to hear sounds from the CI electrode array as clearly as possible (Gaylor et al., 2013). Despite this, CI users generally show lower speech recognition performance compared to individuals with normal hearing, largely due to the degraded speech signals (Friesen et al., 2001; Harris et al., 2016; Wilson & Dorman, 2008). With rehabilitation strategies and consistent use of the assistive listening device, many can make sense of the degraded speech signal despite this and have great success in improving their listening abilities (Harris et al., 2016).

To further overcome spectral degradation and improve CI user’s speech perception abilities in noisy environments, directional microphones are used, much like hearing aids. The use of this technology has been shown to improve the speech reception threshold for users in noisy environments (Hamacher et al., 1997; Sivonen et al., 2020). As discussed, the neural pathways of the central auditory system play a role in a CI user’s ability to understand speech, particularly in a noisy environment. In adults with post-lingual hearing loss there are various factors to this, a large factor being the duration of profound deafness prior to receiving a CI (Blamey et al., 1996, 2013; Lazard et al., 2014; Lee et al., 2003).

Technology is continuously evolving, with a main point of focus on improvement of sound quality. Hearing aid user satisfaction is highly correlated with satisfaction with the quality of sound: users desire rich, natural, and clear sound (Abrams & Kihm, 2015; Dawes et al., 2014). Although technology levels and individual factors play a large role in the efficacy of assistive listening devices, the complexity of the intact auditory system is not replicable by technology at this stage,
therefore understanding speech in noise remains a difficult task for those with a hearing loss (Hamacher et al., 1997; Hochberg et al., 1992; Lesica, 2018). Considering this, with reduced speech level in noise due to sound attenuation and visual cues removed wearing face masks, in combination with reverberation in a noisy environment, speech can be rendered close to unintelligible for individuals with hearing loss (Goldin et al., 2020; Rahne et al., 2020).

**Cognitive Processing and Listening Effort in Adverse Conditions**

In order to understand degraded speech and identify sounds, additional cognitive processing is required compared to the requirements of a quiet listening environment (Mheidly et al., 2020; Peelle, 2018; Pichora-Fuller et al., 2016). Although assistive listening devices improve hearing, they do not restore the user’s hearing to normal levels (Rahne et al., 2020). Therefore, assistive listening device users require increased listening effort, particularly in challenging listening environments, to understand speech (Lesica, 2018; Rahne et al., 2020; Signoret & Rudner, 2019). In order to understand the challenges faced by listeners with hearing loss, it is critical to understand the concept of cognitive demand, and the idea that reduced speech levels result in increased stress on cognitive resources (Peelle, 2018; Rahne et al., 2020).

Individuals with a healthy auditory system require little or no cognitive processing contribution when listening to speech in environments which are very quiet (Lesica, 2018). However, understanding speech in background noise requires the engagement of cognitive processes, as the incoming neural activity patterns become distorted and are different from those stored in the brain (Lesica, 2018; Peelle, 2018). The effect of this is more significant for individuals with hearing loss, and although this can be compensated for with high cognitive function, low cognitive function can
increase the difficulty of speech understanding (Lesica, 2018). The use of assistive listening devices does not necessarily decrease the involvement of cognitive processing, in some cases it can heighten the requirement of cognitive processing as the technology can cause distortion of incoming speech (Lesica, 2018). For those who experience difficulty with cognitive functions, these distortions can be distracting and difficult to ignore, interfering with their speech perception abilities, however those with high cognitive function may have the ability to ignore this sound distortion (Lesica, 2018). Listening or cognitive demand refers to the challenges associated with each particular listening situation (Peelle, 2018). Understanding acoustically degraded speech requires increased listening effort, a term used to describe the energy or resources utilised in order to meet the required cognitive demand in varied listening situations (Peelle, 2018; Pichora-Fuller et al., 2016; Rahne et al., 2020). Furthermore, as the listener is focussed on interpreting this acoustically degraded signal, remembering the perceived sentences can be more difficult, particularly in the older population (Akeroyd, 2008; Heinrich et al., 2008; Murphy et al., 2000; Pichora-Fuller et al., 1995; Surprenant, 1999).

Additional cognitive demand is required in everyday conversations when involving background noise, or even foreign accents, as these factors can add to the challenge of depicting the acoustic speech signal, not to mention the heightened risk of incorrectly identifying words (Peelle, 2018). With the fear of misinterpreting what has been said, listeners can feel stressed and anxious about communicating with others (Lane, 2012; Pichora-Fuller, 2016). Cognitive function has been shown to significantly decline with auditory status in many cases, and whether this is a causal or age-related decline, this factor can increase the difficulty of speech comprehension (Naramura et al., 1999; Peelle, 2018). In appreciating and understanding the contribution of cognitive
functioning in processing degraded speech, we can better understand the differences in the efficacy of assistive listening devices for users with varying types of hearing loss, in terms of the entire auditory system and the cognitive functioning beyond it (Lesica, 2018; Peelle, 2018).

Returning to the concept of communication with face-masks specifically, the cognitive demand and listening effort required to understand speech with the aspect of visual cues removed is further increased (Moradi et al., 2017). Audio-visual presentation of speech results in reduced cognitive demand required to process the speech signal, an advantage which is taken away by the use of face masks covering the lower portion of the face (Moradi et al., 2017). Given that degraded speech is already more difficult to remember, the absence of visual cues in assisting with speech understanding when listening to somebody wearing a face mask exacerbates this. For some, increased listening demand can result in increased stress, depending on the demands of the situation and the listener’s belief in their capacity to meet those demands (Pichora-Fuller, 2016). When stress comes into play in adverse listening conditions, such as communicating with a person wearing a facemask in background noise, auditory and cognitive functioning can be inhibited (Pichora-Fuller, 2016).

**Communication and Quality of Life**

Communication is the means by which the social lives of people are created, as it allows us to connect with one another. Furthermore, individuals rely on their capacity to hear for the sharing of ideas, experiencing their surroundings, relating to others, and assessing danger (Wallhagen 2009). It is also well understood that our psychological wellbeing is significantly impacted by our relationships at home, work and all other contexts (Hartley, 2002). Therefore, it is not surprising
that there are links between hearing loss and decline in quality of life or mental health, as disruption in interpersonal communication can lead to social withdrawal through declining self-confidence (Dawes et al., 2014; Lane, 2012; Lesica, 2018; Park, 2020). Social isolation, low self-esteem, anxiety and increased difficulty or confidence to participate in conversation amidst challenging listening scenarios are all common experiences for people with hearing loss, even with the use of assistive listening devices (Cacciatore et al., 1999; Ciorba et al., 2012; Dawes et al., 2015; Lane, 2012; Naramura et al., 1999). Additionally, stigma around hearing loss can affect help-seeking behaviours of those living with it, and can additionally make it difficult for them to interact with groups they were once part of, leading to isolation and loneliness (Barker et al., 2017; Hogan et al., 2013; Southall et al., 2010; Wallhagen, 2009). Movement of the lower half of the face is a key aspect of interpersonal communication, as it aids our recognition of emotions, helping the listener to better understand the feeling behind the speech (Mheidly et al., 2020). With the use of face masks, this emotional recognition is removed, and along with struggling to recognise speech, this can cause listeners to feel isolated and ostracized (Mheidly et al., 2020). Studies looking into the effects of hearing loss have found that it commonly causes reduced emotional and social interactions, and reduced communicative relationships which can lead to an overall decrease in quality of life (Ciorba et al., 2012).

This chapter has discussed background research regarding communication, face masks, and various other specific topics relevant to communication for individuals with hearing loss who use assistive listening devices. The aim of this chapter was to introduce relevant literature for the background of this research topic. The following chapter provides a critical review of literature reporting findings related to how face masks affect speech and communication. The remainder of
the thesis consists of chapter 3, which provides detail of the methods of this research study, and chapter 4, which presents the study’s results. Chapter 5 includes consideration of these results in contrast to existing literature and suggestions for future related research, current study limitations and concluding remarks.
Chapter 2. Literature Review

This chapter explores literature relating to the challenges of communicating with face masks, focussing on international findings. The studies included had a variety of aims focussed on sound attenuation through face masks, communication issues due to face masks, and how this has affected individuals with hearing loss.

Homans and Vroegop (2021) conducted a research study which aimed to investigate the effects face-masks and shields have on understanding speech for adults with hearing loss. Their results showed significantly lower speech perception scores with the use of a face mask, in both noisy and quiet environments (Homans & Vroegop, 2021). The results of this study can be considered reliable and relevant to this research, as they used a relatively large sample group of 42 participants and also investigated adults using hearing aids or cochlear implants. The method of the study appeared well planned and carried out. This involved participants completing a Speech Tracking Test in a sound-attenuated booth, under different conditions, with and without a surgical mask. They concluded that the impact the surgical mask had on speech perception was correlated with the auditory performance each participant had with their assistive listening device. This was based on evidence that the difference in speech perception with the surgical mask in use compared to without it was most significant for those with the worst auditory performance. Additionally, the study found that the surgical face mask attenuated sound most significantly in the frequencies above 2kHz, up to 5dB. These findings are considered useful in the background research to the current study, and what communication experiences we might expect assistive listening device users to have had with masks, in terms of their auditory performance.
Goldin et al. (2020) conducted a similar study, however used a variety of face masks types to compare the difference in sound attenuation for each. The study was conducted using white noise output through a head and torso simulator wearing each of the mask types, with a microphone set two metres away measuring this output acoustic signal. The main finding of this study was that each face mask is serving as a low-pass filter, reiterating that the frequencies above 2kHz are the most effected. They found that the surgical mask attenuated this sound between 3-4dB, and that N95 face masks resulted in around 12dB attenuation of the higher frequencies. This study was conducted with the aim of quantifying the potential challenge to a listener’s comprehension with no mask, a simple (surgical) mask, and two varieties of N95 masks. Although the study did not use human participants, nor did it aim to address the potential challenges specifically for individual’s using assistive listening devices or their experiences, it did aim to gain useful and relevant information to the larger topic of communication with face-masks, and the findings are interesting to consider in terms of what this study’s participants may have experienced communicating with people wearing these different mask types.

A study by Bandaru et al., (2020) aimed to summarise the effects of face shields and N95 masks on speech perception thresholds for healthcare workers with normal hearing. This study recruited twenty healthcare workers, ensuring that they had normal hearing levels with pure-tone audiometry, before assessing each of their speech perception thresholds with and without the COVID-19 protective wear, and again with a face shield and N95 mask. Using this COVID-19 protective wear, they recorded a 12.4dB mean increase in threshold, therefore concluding that the equipment significantly impairs speech perception. The study was conducted under reliable and consistent audiological conditions for each participant, and the required sample size was calculated
Based on the result of a pilot study on five volunteers. These study conditions combined with the use of independent t-tests to analyse the results of the study, indicate that the results of the study are reliable and provide relevant information to the research aims of the current study. However, the study is based on individuals with normal hearing, and investigates speech perception effects of a combination of both an N95 mask and a face shield, therefore the research aims are different to those of this study. Despite there being sufficient evidence to say that face masks attenuate sound in the frequency range affecting speech understanding, many of these studies have been based on participants with normal hearing levels. Therefore, although these findings are relevant to this study, the evidence has not taken into account the additional complexities hearing loss has on the auditory system and the additional challenges faced for users of assistive listening devices.

The findings have also been supported by various other studies, who also used speech testing to find out the impact face masks have on speech perception, mostly based on participants with normal hearing levels (Magee et al., 2020; Nguyen et al., 2020; Rahne et al., 2020; Toscano & Toscano, 2020). However, a study by Magee et al. (2020) found that there was no significant difference in the accuracy of speech recognition between the three main mask types included in the study. Rahne et al. (2020) also showed that face masks mainly reduce the sound pressure level at frequencies above 2kHz, and the resulting signal is similar to that registered by an individual with a slight high-frequency hearing loss, defined as hearing levels between 16-25dB HL between 2 – 8kHz. To further emphasise the sound attenuation of face masks, a study by Bandaru et al. (2020) reported that speech discrimination scores for listeners with normal hearing levels were around 7 per cent worse with the use of an N95 face mask and face shield combined. Toscano & Toscano (2020) demonstrated that speech recognition while wearing masks is affected to varying
degrees based on the speaker and background noise level, and this impact is significant for the speech perception of listeners with hearing loss.

Brown et al. (2021) highlighted the differences in the methods of other studies on the intelligibility of speech with face masks, compared to their study method. They used five different face mask conditions, and three different background noise levels to address the concept that varying levels of visual information are helpful for speech perception depending on the background noise level. The researchers argued that most studies on this topic had used either a single face mask type, a single signal-to-noise ratio, or only speech in quiet, whereas their method assessed more variable environments in terms of noise and face mask type. They found similar results to Goldin et al. (2020), however they found less significant attenuation levels of 5.2dB with KN95 face masks, and 2.0dB with surgical face masks (Brown et al., 2021).

A small number of studies have been conducted outside New Zealand on the impacts face mask use has had for people with hearing loss using assistive listening devices, and how face masks have affected their interpersonal communication experiences. A survey of 641 people with hearing loss, conducted by Tonelli & Warick (2022), found that 76% of those with moderate hearing loss and 95% of those with profound hearing loss reported difficulty in understanding people wearing face masks. Poon and Jenstad (2022) recently published a study addressing this, focussing on the effects face masks have had for adults understanding speech with hearing loss, using a cross-sectional study on 656 participants. They reported that over 80% of their respondents reported having difficulty in understanding people wearing a face mask, and over 60% reported difficulty understanding someone behind a plexiglass barrier. Participants noted that their assistive listening
devices were not always sufficient to facilitate communication when talking to people wearing face-masks. They also noted that communication in these situations caused some participants frustration and stress, particularly when they experienced inflexibility from people to accommodate their listening needs. Overall, the study used reliable research methods on a large sample size to find evidence that face masks have created communication difficulties for many adults with hearing loss, largely due to the sound attenuation and removal of visual cues, and this has resulted in negative emotional reactions for some (Poon & Jenstad, 2022).

A similar study by Trecca et al. (2020) was conducted on 59 participants in Italy with hearing loss ranging from mild to profound, and these results found that for 44.1% of subjects, the main concern with face masks was the attenuation of sound, and for 55.9% it was being unable to read lips. They addressed the fact that these results were preliminary, yet shed light on the ways face masks have affected people with hearing loss during the pandemic. Another study by Saunders et al. (2021) looked into the experiences of interactions with face masks and how this has impacted communication, particularly for those with hearing loss. The 460 participants were recruited through snowball sampling, through which they intentionally recruited more people with hearing loss. The participants took an online survey comprised of open and closed questions, and reported that for the majority face masks had impacted their hearing, understanding, connection, and engagement with speakers in a negative way (Saunders et al., 2021). It was also found that those with hearing loss were more significantly impacted than others, and that communicating with face masks was more fatiguing, and increased stress, anxiety, frustration, and embarrassment.
Overall, the findings from the studies discussed indicate that mask-wearing has caused increased communication difficulties by obscuring lip movements and attenuating speech sounds (Poon & Jenstad, 2022; Tonelli & Warick, 2022; Trecca et al., 2020). For individuals with hearing loss who are using assistive listening devices, the affected facial cues and speech clarity are relied on more heavily for speech understanding (Chodosh et al., 2020; Mckee et al., 2020; Saunders et al., 2021). Although the news media has provided ample anecdotal evidence on the topic of face-mask wearing, there is limited research-based evidence involving the individual experiences of users of assistive listening devices communicating with face-masks, specifically using qualitative analysis and based locally on New Zealanders. The data analysis techniques utilised in the majority of the studies discussed were of quantitative nature, and few detailed explicit experiences of users of assistive listening devices communicating with face masks. None of the reviewed research studies have utilised qualitative interviews with participants to gain insight into the personal experiences of this community. This research aims to capture the experiences of these individuals and identify any themes, based on the following research question:

1. What are the communication experiences of individuals with hearing loss who use an assistive listening device during the COVID-19 mask-wearing experience?
Chapter 3. Methods

Overview

This chapter describes the research methods of this study, including the participants involved, data gathering, and analysis. Data was gathered through semi-structured interviews, and analysed to produce themes using reflexive analysis (Braun & Clarke, 2006). This is a form of qualitative analysis where themes from the dataset and relationships between these themes are produced, considering how these relate to the wider context of the research (Braun & Clarke, 2022). Due to the nature of this data analysis method, it is inevitable that the research will be influenced by the researcher’s assumptions, and therefore relies on the researcher remaining reflexive when conducting the analysis to produce a coherent story about the dataset (Braun & Clarke, 2022).

Ethics

This study was approved via the University of Canterbury Te Whare Wānanga o Waitaha Human Research Ethics Committee on the 24th of May 2022 (see Appendix A).

Participants

This project involved 9 individuals over the age of 18 who used assistive listening technology (hearing aid(s), cochlear implant(s)), or both. This group was selected to provide a variety of individual experiences, and a range of perspectives on communication with assistive listening devices while wearing face masks. The participants were recruited from around Christchurch via advertisement at local community clubs and a local hearing clinic. Those interested were asked to make contact via the researcher’s email address to receive full study information and consent forms (see Appendix B) before confirming participation in the interview. All individuals who responded
with interest proceeded to complete an interview within two weeks of their response to the advertisement.

**Procedure**

Semi-structured interviews were conducted individually with each of the nine participants, in-person in a quiet environment where their experiences of communicating during the COVID-19 and their experiences with face mask use could be discussed. Each interview lasted between 25 to 60 minutes and was audio recorded with participant consent to support the creation of an interview transcript. Those who requested to review their transcript were sent a copy within two weeks of the interview, though none requested to make any edits or additions to their final transcript. The interview questions were open-ended, probing into participants’ use of their assistive listening devices, their view of their hearing loss and the impact it has on their communication with and without masks, and their quality of life, experiences, and perspectives on communicating with people wearing each mask type throughout the COVID-19 pandemic. These were structured using theory triangulation and data source triangulation to develop a comprehensive understanding of the gathered data (Carter et al., 2014). Rating scales were used in some interview questions, to help participants describe how they felt about their communication and understanding of speech with and without face masks. Depending on the participant’s responses, in the nature of semi-structured interviewing, some aspects of the interview were discussed in more detail with further questioning and discussion initiated by the researcher. Some funding provided by the University of Canterbury meant that a small koha of $20 in the form of a supermarket voucher was given to each participant at their interview to acknowledge their participation.
Data Analysis

With the qualitative data gathered in the form of interview transcripts, a reflexive thematic analysis approach was used to analyse the data for themes addressing the research question (Braun & Clarke, 2022). The six-step approach was followed to achieve this; data familiarisation, coding, theme generation, theme development and reviewal, theme refinement, and write-up (Braun & Clarke 2006, 2022). These six phases are as follows.

1. Data familiarisation: involved reading each participant’s interview transcript at least twice to become familiar with experiences discussed in each.

2. Coding: included systematically working through each interview, creating codes in a table. These codes were colour-coded to identify which participant had used each code, and the codes were sectioned under draft sub-theme ideas.

3. Theme generation: studying the table of codes created in the previous step, grouping these into draft themes and subthemes. This involved shifting codes around the table, using a table of contents to allow for efficient navigation of the table full of data extracts. By grouping the relevant codes together, due to common features, overarching ideas and themes were produced.

4. Themes development and review: through titling them on a separate document, and creating subthemes under each of these themes to ensure that each code was covered. This ensured that the data was being analysed in its entirety, and that themes were representative of the participant’s responses and experiences, without missing any information which could be relevant within a theme.
5. Theme refinement: this involved identifying four main themes produced, with clear subthemes under each to capture the essence of each participant’s views and the overall experiences of participants.

6. Themes written up: creation of a narrative of the data collected through the interview process.

The over-arching and sub-themes, and supporting participant quotes to address the research question are provided below. Every effort was made to ensure that these quotations or any data presented does not include the identity or support identification of any participants, as agreed on with participants and the ethics approval for this study.
Chapter 4. Results

Participant Demographics

As shown in Table 1, the sample group was heterogenous due to the recruitment technique and the aim of the study. Through interviewing a variety of adults from Christchurch, in terms of age, hearing levels, and assistive listening device use, the findings are unbiased towards one demographic. Aside from these differences, there were an even number of Cochlear Implant and Hearing Aid users, for comparison of their unique experiences. The small sample size means the differences between the individuals, particularly in their hearing levels and needs, are more apparent, yet the findings are not necessarily representative of the entire community of adults who use assistive listening devices in New Zealand.

Table 1. Participant Demographics

<table>
<thead>
<tr>
<th>Participant Demographics</th>
<th>Percentage (number)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Devices Used</strong></td>
<td></td>
</tr>
<tr>
<td>Hearing Aid (bilateral)</td>
<td>44.4% (n=4)</td>
</tr>
<tr>
<td>Cochlear Implant (bilateral)</td>
<td>22.2% (n=2)</td>
</tr>
<tr>
<td>Cochlear Implant (unilateral)</td>
<td>22.2% (n=2)</td>
</tr>
<tr>
<td>Cochlear Implant and Hearing Aid</td>
<td>11.1% (n=1)</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>20-35</td>
<td>22.2% (n=2)</td>
</tr>
<tr>
<td>36-50</td>
<td>11.1% (n=1)</td>
</tr>
<tr>
<td>51-65</td>
<td>0% (n=0)</td>
</tr>
<tr>
<td>66-80</td>
<td>44.4% (n=4)</td>
</tr>
<tr>
<td>81-95</td>
<td>22.2% (n=2)</td>
</tr>
<tr>
<td><strong>Age Fitted with first Assistive Listening Device</strong></td>
<td></td>
</tr>
<tr>
<td>Under 10</td>
<td>33.3% (n=3)</td>
</tr>
<tr>
<td>Decade</td>
<td>Percentage</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>50’s</td>
<td>22.2%</td>
</tr>
<tr>
<td>60’s</td>
<td>22.2%</td>
</tr>
<tr>
<td>70’s</td>
<td>11.1%</td>
</tr>
<tr>
<td>80’s</td>
<td>11.1%</td>
</tr>
</tbody>
</table>

**Themes Summary**

Participants presented with some highly similar experiences, and some largely difference experiences. These could not be related to the age of the user, the type of assistive listening device, or the length of time they had used the device for. The difference could, however, be related to the self-reported hearing level of the assistive listening device user, as increased communication difficulty was reported in correlation with more severe hearing losses reported. For some users, their overall feeling was that their experiences of communication with masks were not dissimilar to individuals with normal hearing levels, and other than the physical nuisance of the face masks, their experiences of communication were largely neutral. These types of overall experiences were summarised by statements such as, “I’d be hard put to say the masks made any difference” when asked about how they found understanding speech in noise. For others, when asked about their experiences of communicating with face-masks, the response was “Terrible. It’s one of the worst things since I’ve, you know, had to have assistance and help, and the implant and all the rest, it’s actually wearing the face mask”. The variety of responses from this small sample group led to the general summary, that user’s of assistive listening devices had individual experiences communicating with masks, largely correlated with the degree of their hearing loss. However, highlighting the details of these experiences, four distinct themes have been generated in relation to this overarching finding (1) Masks as a Barrier to Communication; (2) Experiences and
Opinions of Mask Types; (3) Impact on Daily Life; (4) The Attitudes and Cooperation of Others, as shown in Figure 1.

**Figure 1. Themes and Sub-Themes Generated from Participant’s Interview Data**

### Themes

#### Theme 1: Masks as a Barrier to Communication
- Communicating was Okay
- Massive Barrier
- Lack of Visual Cues
- Localising the Speaker
- Difficult Listening Environments
- Sound Distortion
- Lack of Facial Expression

#### Theme 2: Experiences and Opinions of Mask Types
- Three Main Mask Types
- Face Shields
- Transparent Masks

#### Theme 3: Impact on Daily Life
- Altering Social Behaviour
- Access to Information
- Emotional Experiences
- Removal of Mask Mandate

#### Theme 4: The Attitudes and Cooperation of Others
- Awareness of Hearing Loss and Assistive Listening Devices
- Attitudes of Others
- Friends and Family
- Strategies to Accommodate Communication
- Explaining Hearing Needs
Theme 1: Masks as a Barrier to Communication

Communicating was Okay

For a minority of participants, communicating with face masks was not an issue, and they were “hard-put to say that masks made any difference” to understanding speech. One participant stated “I wasn’t conscious that people were asking me more, you know, what did.. would you repeat that? And I wasn’t doing it any more than usual, so I find it hard to blame the masks”. The experiences in communicating with masks had been overall positive for these participants, and they had found that “because the hearing aids are there… (masks didn’t) make any difference”. Additional to the benefit of the hearing aids, one participant mentioned that speaking on the telephone had also helped prepare people for communicating with masks, as talking to strangers with a mask is “very like the first time you talk to strangers on the telephone”, in terms of perceiving the speech of an unknown voice.

A Massive Barrier

For other participants, masks were a “massive barrier for communication”, and their experiences communicating with them were described as “terrible, utterly, utterly terrible”, and “horrendous”. Of the nine participants interviewed, five found communicating with masks remarkably difficult, and this included both cochlear implant and hearing aid users. These participants found that communicating with face masks involved increased concentration, and asking for increased repetitions of questions which would sometimes still be incomprehensible through the mask. For some this became an expectation, thinking “if they’ve got a mask on, perhaps my mind’s saying ‘you’re not going to understand’”. To express the extent to which the face masks act as a barrier to understanding speech, one participant stated “with masks, I’ve lost up to about 80% sometimes”.

For another participant, communicating with a face mask was impossible and they “wouldn’t sit with someone and try to understand them, they have to remove it or I can’t have that conversation”. They stated that it has been a barrier; “we’ve got a right to communication like everybody else. So yeah it has definitely been a barrier, definitely”.

Lack of Visual Cues

Participants who had experiences which lead them to consider masks as a barrier to communication, and having “had something taken from (them)”, are assistive listening device users who also rated themselves as heavily reliant on lip reading, as the speech they hear lacks clarity. One participant expressed the issue of not being able to see the mouth and hearing a different sound quality with the statement, “you’re looking at somebody and you don’t see their mouth, or their expressions, or it has a different quality of sound, and that’s absolutely terrible”. Although they found that both the removal of visual and sound attenuation are factors in masks being a barrier to communication, the lack of visual cues was regarded as the main difficulty. For one hearing aid user, in a quiet room with no face masks they expressed that they already had to work hard to understand speech, “and then all of a sudden we’re having that covered up, and expecting to understand what eyes and eyebrows are doing, doesn’t tell me anything, there’s nothing there.”. To provide context to the extent to which these individuals feel they rely on lip reading, two rated their reliance a 5-6/10 in quiet environments, and 9-10/10 in background noise, and one rated their reliance 10/10, stating “I have to see what I can hear, what I can see allows me to understand what people are saying – I can’t do one without the other… If you had a big barrier there…. I could hear your voice, but not what you’re saying, don’t know if you’re male or female”. A fourth participant stated that “probably three quarters of what I can benefit from is through being able to lip read as well…. (sometimes) you think, ‘how did I cope with that?’, and then I know
because somebody has spoken very clearly, and I’ll lip read rather than actually hearing them”. Although these participants who reported struggling with this were already aware that they are reliant on watching people’s mouths when they speak to facilitate speech perception, they found that communicating with facemasks throughout the pandemic has heightened their awareness of it. One participant recalled feeling surprised noticing this when communicating with a family member, stating, “I took my (family member) with me, and this was really interesting for me, it was the first time it happened… I can understand him normally, as soon as he put a mask on him I couldn’t understand him”. Another participant summarised this by saying that communicating with masks was a “daily reminder of, even though I hear really well… that I do rely heavily on lip-reading”.

Localising the Speaker

For some, localising where or who the speaker became more difficult when everybody wore masks, as again it was not possible to see the movement of the mouth. This was particularly difficult for those without directional hearing, as they have an assistive listening device on one side and have no hearing on the other. One participant explained, “I’d basically have to scan around the room for whoever was sort of nodding, or their mask was moving aggressively, so that’s a big thing because of not having directional hearing”. This was an experience commented on by a number of participants, including those who wore assistive listening devices on both ears. Another participant described their experiences with this through KN95 masks, stating, “you see less visual movement, you can’t see what’s going on. So if they’re wearing that I’m like, ‘are you talking to me? I’m not really sure’”.
Difficult Listening Environments

Conversations in background noise were regarded as the most difficult environments for communicating with masks, specifically supermarkets and restaurants. As mentioned, those who considered masks a significant barrier to communication were already aware of being reliant on lip-reading, and their reliance on this is increased in background noise. With face masks covering mouths, their ability to read lips to fill in gaps to understand speech was removed. This was discussed by a participant who mentioned, “when you add face masks to it, that’s pretty much impossible”. Another participant expressed the difficulty of understanding speech in noisy environments with masks, stating “you maybe pick up a few words in a sentence, and then you’re trying to piece it together, and it’s to the point where I’m not really following a conversation”. It was also pointed out that “when it’s real life… 80% of the time it’s going to be in noise, when you’re talking to people”, outlining how common this type of difficult listening environment was during the days of compulsory mask-wearing. A specific environment mentioned by multiple participants who considered masks as a barrier to communication was the supermarket. One participant outlined one of their experiences wearing masks in the supermarket, stating, “I just found it horrible… I couldn’t sort of locate who was talking, people who were talking around the supermarket, and then at the counter, because there was a lot of background noise, I was basically guessing” what they were saying. Multiple participants mentioned that they adopted this strategy of guessing what the checkout person was saying, behind a mask and protective screen. Another participant noted that they had “learnt after a while to just look at the screen” to find out when and how much to pay, as they could not understand speech at the checkout behind masks. Others referred to cafes and restaurants as “a nightmare” with masks, in terms of communicating with staff. To manage communicating with masks in restaurants, one participant stated “If I go to a
restaurant and the waitress is wearing a mask, I completely give up and basically use everyone else like a guide dog in a way… I just abdicate all responsibility”.

**Sound Distortion**

Distortion of sound through face masks was also regarded as a major factor in the increased difficulty of communicating with masks, as “the high frequencies get muffled by the mask”. The majority of participants reported that they had found speech more muffled through masks, whether or not they had difficulty understanding speech through masks. For participants who found communication okay with masks, the distortion of sound was considered to deficit speech perception more than the lack of visual cues. It was also mentioned that familiar voices were easier to understand through masks; “and that’s the same with lip reading… so if I recognise the voice… the better I know the person, the less likely I am to have to ask them to repeat themselves”. In line with this, the participants reported finding accents more difficult to understand, as well as quiet voices with masks.

**Lack of Facial Expression**

Both those who experienced masks as a barrier to communication, and those who had no issues communicating with them, expressed that “something’s lost when you’re talking to someone with a mask”. This was an experience independent of their hearing levels, as it was relevant to the deeper connection involved in the communication, as opposed to hearing the speech. One participant referred to this in their statement, “the one thing I’ve missed is reading people’s faces”. Another discussed experiences of not being able to read their emotions and the way in which speech was spoken, stating “you didn’t get as full an impression as you would have had they not
had a mask, you’d know if they were angry or if they were obviously happy or something, but you
didn’t get the same feel”. Another participant discussed similar experiences, stating “sometimes if
you’re asking a question, or you’re wanting an opinion or something, it’s the person’s expression
on their face that gives you an answer, rather than even talking…but you can’t see that under a
mask”.

Theme 2: Experiences and Opinions of Mask Types

For four of the nine participants, there was no difference noted between the three main mask types
(cloth, surgical, and KN95) in their communication experiences. Most of these were participants
who did not struggle to communicate with masks, other than one participant who noted that “a
hearing person would be able to pick that that sort of thing up more than me… I could most likely
say it would be muffled, but a lot of speech can be muffled to me”, indicating that it is difficult to
know whether it is due to the mask type. However, for other participants, there were various factors
which played a role in the different communication experiences they had with people wearing each
of these mask types, and the fact that they “muffled speech in some sort of way”.

Three Main Mask Types

A common opinion was that “the N95’s don’t really move when people speak”, and that because
they cover more of the face, it’s harder to interpret speech because less expression can be
visualised. Seeing throat muscles and jaw movement assists some participants to understand
speech, therefore having this area also covered made it harder to communicate. This was noted as
an issue for understanding speech and for localising the speaker, discussed by one participant with
the statement, “speech was muffled, but I did noticed if I needed to scan the room because I hadn’t
picked up who was speaking, the N95’s just weren’t moving at all”. For medical reasons, KN95 were reported as a preference for most, despite these issues raised on communicating with them. The sound was reported to be “so much clearer” through blue or white surgical masks compared to other masks for many participants. Opinions on cloth masks, often hand-made and varying in thickness, were generally positive for localising the speaker, but negative for sound distortion. Some reported that the “cloth mask probably muffled speech the most, in the sense because it was so tightly fitting across the face”. However, it was also mentioned that the cloth masks were a “favourite, in terms of being able to pick up who is speaking” as the masks moved with speech. Overall, the opinions of which masks were best for communicating were varied, yet the least challenging mask type was the surgical mask.

*Face Shields*

Face Shields have the benefit of allowing lip movements to be seen whilst providing viral protection, however one participant mentioned that they had opted not to use this because it hindered communication in sign language. They stated, “we had considered the face shield, but you can’t sign with that on because you can’t touch your face, so in that way it’s a barrier”. Aside from this, the visible screens were regarded as beneficial for seeing lip movements, however participants noted that they looked strange and were less effective in preventing the spread of the virus. One participant stated, “I’d much rather have someone wearing an effective mask, than people wearing 80% effective face shields. I did see people with face shields, but…it didn’t make too much of a difference for me, and they’re a wee bit weird”, despite this participant having difficulty understanding speech with masks. Another participant had similar views, stating “I
wouldn’t want to be walking around the town like that, or places publicly, but if you take it for something like when you’re talking to a doctor” then it is a positive option for communication.

*Transparent Masks*

When asked about the concept of transparent masks which would allow lip movements and facial expressions to remain visible, all participants were in favour of the idea if they could be functional in terms of preventing the spread of COVID-19. One participant commented on the feasibility of the material of this transparent mask, stating two issues, “one is that when you’re breathing air in there, it fogs up. If you could get like an anti-fog in there, that could work, until your lip touches it, well the lip pattern just disappears, you can’t follow it anymore”. Overall, participants felt that if this issue could be overcome and transparent masks were protective, they would be good in terms of speech understanding and bringing back deeper connections through facial expressions.

**Theme 3: Impact on Daily Life**

Overall participants’ opinions on how communicating with masks has impacted the participants’ quality of life was that it hadn’t, for varying reasons. For some, as described above, communication has been fine with masks and their only report on how the use of them has effected daily life has been that “masks are a nuisance” physically. For others, although their daily life has been impacted by having to communicate with masks, they have not allowed this to affect their quality of life. One participant attributed this to always having viewed their hearing and use of a cochlear implant in a positive way, stating, “I’ve always seen it as giving me a lot of opportunities.. like a gift… So to be reminded of the fact that I rely so heavily on lip-reading and stuff has never been sort of a negative thing for me”. This attitude was also raised in the statement “I just find them annoying in
the sense of being able to communicate with people, that side I find difficult, but na, no sort of difference in quality of life”. This positive outlook on not letting the communication difficulties affect their quality of life was shared by other participants too, with statements “I’m probably quite determined to not let things like that get the better of me”, and, “If I was younger I probably would, being older I think you sort of get a bit more, come on”. From a social perspective, however, one participant did feel that their quality of life was impacted as they stated, “it definitely decreases the quality of life, because you’re missing out on those conversations that, you don’t feel included”. Despite the overall positive views on the quality of their daily lives, participants did mention how their daily lives were affected by the need to communicate with people wearing face-masks. The difficulty in communication was a significant issue for some participants, and ultimately affected their daily life in a significant way. This was emphasised in statements such as, “I can’t think of anything positive, because I’ve had something taken from me, so no, nothing.”, in response to whether they could recall any positive communication experiences with masks.

**Altering Social Behaviour**

As an example of this, experiences of noticing altering their own behaviour to manage communicating with masks were discussed. A common experience was in noisy or difficult listening environments, to find themselves “a lot more eager to avoid people in those sorts of situations, just so then (they) don’t have to talk” to people. One participant discussed feeling less engaged with new people, stating, “If I’m with people that I don’t know then definitely, I’d be less engaged than usual”. A participant who experienced that masks were generally fine in terms of communicating, did note that the depth of their communication could be limited by masks. They stated, “it doesn’t stop our communicating. It might have stopped the depth of our
communicating”. Another noted that they withdraw more from conversations with masks, stating there are “lots of times that I do avoid things just in everyday life, if we’re out anywhere and somebody asks a question, I nearly always let (partner) answer, because I probably haven’t picked up the whole question”. Another participant noted that they didn’t avoid situations where they would need to communicate through masks, but they were aware that they may need to walk away if they can’t hear. They reported, “you’d always go, try, and if it didn’t work, you end up walking out rather than causing a big hassle”. For one participant, they were avoiding situations as a family to avoid catching COVID-19, however for them it was because of the difficulty of communicating through masks, as they mentioned, “for me it was about the masks, but for my family it was about COVID”. Another participant discussed how they had altered their social behaviour by explaining, “small talk I would just try and avoid at all costs, and then just the talk has to be basically a necessity”. Along with being more dismissive during some interactions with others, they noted a change in their behaviour to have the best chance at understanding speech through the masks. The explained that where they would normally prefer to be face to face with people in noisy situations to have the best chance at understanding speech, when masks were involved, they “would go side to side with my predominant implant, leaning into them in a way… instead of looking at them face to face… sometimes I’d even shut my eyes, and then just try and focus on what I could hear”.

For the majority, participants felt their social lives were not affected more than anybody else, as they felt that everybody’s social lives had been affected by the spread of COVID-19 and the risk of catching it. For some, this was again because communicating with masks was not seen as an issue. For others, this was because they had not let it affect their social life, “but it did make it harder”. Another reason that their social life was not affected, despite masks making
communication more difficult, was raised by one participant who said, “because most social situations people haven’t really had to wear masks, you know if you go to a party or if you go out for a meal, the people around you aren’t wearing masks.

Access to Information

When asked about whether participants felt like they had the same amount of access to information when people wore face masks, again those who felt that they could understand speech well with masks felt that nothing had changed in this sense. Contrastingly, those who did struggle with communicating with masks experienced missing information or feeling that they could not communicate well enough with masks to ask for information. One participant said, “If I wanted to go and find out something I probably wouldn’t, if I needed to, I probably wouldn’t”. When asked about watching news reports where the reporter is wearing a mask, most found that they were not limited by this as they used subtitles and could read the information. One participant commented further on this, stating, “they probably wouldn’t even think, oh we have deaf audience members so you need to take the mask off”, and adding that some people would think subtitles is enough, to which they commented, “It’s nice to have both, no mask and subtitles, because sometimes the subtitles aren’t perfect and they don’t match the passage of what someone is saying, and if there’s no lip pattern there, you can’t follow it so it’s harder”. Another participant found taking in new information in lectures difficult, stating, “sometimes when the lecturer’s have their masks on, I won’t get all of it, so yeah there are times that I’ve missed vital information”.

Emotional Experiences
A range of emotions were discussed by participants who felt their experiences of communicating were made harder by wearing face-masks. For one participant, there were no strong or negative emotions involved in the fact that masks were a communication barrier for them, as discussed in the following statement; “the fact that I’ve never see my hearing as a sort of disability or a challenge, probably leads to why I haven’t had a negative or upsetting emotion to those sort of situations”. Another participant discussed feeling exhausted by the additional strain masks put on communicating, stating, “I need to communicate with people (for work)… all the time, and yeah, you get far more exhausted by the whole thing”, and, “because anything that’s stressful makes you more fatigued”. Another emotion experienced was vulnerability with feeling less able to communicate; “I suddenly felt extremely vulnerable, really vulnerable. I suddenly thought, ‘oh my gosh, that’s just been taken away from me’”. One participant reflected on how it felt having to rely on their child to communicate due to masks; “all of a sudden I felt… I’m supposed to be the adult looking after my kid, and here’s my kid doing all the work for me”. Others noted feeling isolated from social situations, with statements such as, “I have had times when I feel excluded because they think I’m just not interested in them”, adding, “it makes me feel like a fool because I can’t hear anything, you know? And I think if it wasn’t for the face mask I may not have had to asked for her to repeat it”. Similarly, other participants also noted feeling concerned about how others think and feel when they struggle to communicate with masks with statements, “It must be very frustrating for somebody when I can’t hear them, because if you’re around them a lot, or working, it must be very frustrating for them not to get angry with you”, and, “People might perceive me as being sort of dismissive or not paying attention initially”. In addition to this, some felt concern for staff when they struggled to hear them in restaurants, feeling concerned because “the last thing they want to do is be worrying about a customer”. 
Removal of Mask Mandate

An interesting representation on just how participants felt masks affected their daily lives was when they were asked how they felt when the mask mandate was removed, during this research project. The overall consensus was relief and joy that masks were no longer required in all public settings, for some because they were a physical hassle and interactions were less personal, and for others because they could communicate freely again. For some participants who struggled to communicate with masks, their responses were along the lines of this one; “since this regulation has come up of not having to wear a mask, it’s just like, ‘oh, the sun’s come out’”. Another participant stated, “then of course with mask’s not being used so much now, and you can take them off. freedom, it’s like ‘ahh’”. All participants enjoyed the transition back, as “everything went back to normal” and felt that “we’ve shifted into a different place now, and it’s just so much … less stressful”.

Theme 4: The Attitudes and Cooperation of Others

Awareness of Hearing Loss and Assistive Listening Devices

A number of participants who struggled to understand people wearing masks had experiences with people who did not understand hearing loss or assistive listening devices. One participant reported an experience dealing with a customer service representative; “I said, ‘well I’ve got a cochlear implant’, and they didn’t have a clue what that is and didn’t want to know”. Others discussed experiencing people being confused at the concept that they could be deaf and still have good speech, stating, “If you’ve got good speech, I’ve had this a number of times, I say to people, ‘look, I’m deaf, I can’t hear very well, can you remove your mask’...And I get, ‘but hang on a second,
you’re talking, so how can you be deaf?’”. They further explained that this was a common experience; “It’s more common than I care to say… I think it’s just their perception of what a deaf person is…. There’s so many varieties of us, you know that’s a pool of them… but the bottom-line is we can’t hear”. Another participant also commented on this, stating, “I do see people looking a wee bit perplexed (because) I don’t match up with the stereotype that they would match up for deaf people, in terms of my speech it is… I had an incredible amount of speech rehab.”, and, “They wouldn’t say it openly… but I do get that sense from people, when they go ‘he’s deaf’, or I go, “I’m deaf”, the first thing they say is ‘oh your speech is really good’, or, ‘you speak really well’.”

Participant’s also reported noticing a number of people that “think, ‘oh my gosh now I need to know sign language to be able to communicate with this person… sign language is helpful but not the only way to facilitate communication with a deaf person”. With regard to sign language, a participant commented that having a sign language interpreter for COVID-19 updates has raised awareness, and that people have mentioned to them that “it’s been quite cool to them that New Zealand language is an official language of New Zealand, I never knew that before,”.

**Attitudes of Others**

Participants explained that they felt their experiences with trying to communicate through masks with people showed their awareness of hearing loss, in terms of whether they were willing to accommodate their hearing needs or were understanding of their hearing levels. One participant explained that they noticed themselves subconsciously putting people into categories ; “you know, ‘oh you’re one of those that just doesn’t understand’”, and that, “you get some people that just don’t comprehend what the word lip-reading means, never heard of it before, just don’t know what
you’re talking about”. Another stated, “there are people in life that understand, and those that don’t understand”. They also mentioned feeling concern that those who didn’t understand their hearing loss would think they are rude, stating, “of course they’ll probably think I’m rude, but it’s like no, it’s just really, really hard to understand you”. Preparing for which attitude they would get from others was described as exhausting or stressful by some participants, with statements such as thinking, “what am I gonna get today?”, and, “it just made me think, I don’t really feel like going to a shop at the moment, it just really put me off. Just because people were not educated”.

Some found others attitudes negative towards them, mentioning people “not bothering to talk to me when they realise I don’t hear very well”. Despite this, the most common attitude was to not let this affect them; “I think to sort of survive in a hearing world, you just sort of have to brush it off and keep going”. At the same time, some still found it frustrating when people were not understanding or accommodating; “If you had a blind person… you know maybe you want to try and help them through the door, or maybe you might lead them somewhere that they need to be, so why not do that for a deaf person”.

**Friends and Family**

Participants who struggled communicating with masks mentioned that being around people that understood, such as their friends and family, was helpful for communication. Throughout multiple interviews it was mentioned that friends and family were accommodating of their hearing loss, as they would pull their mask down to speak to them, or happily repeat themselves; “If I was in family situations, or going out with friends, and we were walking through places, a lot of people would just take their mask off, simply just for me, and then chuck it back on”. Another participant said
that having their family see how much they struggled to understand speech with masks was a reminder of their hearing loss for the family. They stated, “I had to keep reminding (them), pull it down, I can't understand you. I think it was good for them as well. it's kind of like, oh that's right mum can't hear.”. They also referred to the impact this had on their family members, stating “I think it was a bit of a barrier for them as well, they suddenly had to repeat or think ahead and pull it down while they were talking and stuff like that”. Although the general consensus was that “it depends on how well you know a person and how much they appreciate that you can’t hear”, there were also comments made implying that not all people close to them were particularly accommodating in their communication, such as, “they don’t turn around and talk to you, so that is really hard, and it can be one of your best friends”.

Strategies to Accommodate Communication

The appreciation those who had difficulty communicating with masks felt for people who adopted strategies to accommodate communicating was also acknowledged. They discussed how much they relied on other people to assist their communication, as they had no visual cues to assist them. One participant discussed this with the statement, “For years… I’ve got around it, because I can see the lips, or I can ask them to repeat it again… But with masks, you can’t. They have to do their job or I’ve got nothing”. As discussed, people pulling their masks down to facilitate communication was helpful and appreciated by all participants who were more reliant on visual cues for communicating. Another helpful strategy discussed was the use of hand gestures, for example using fingers to describe numbers. One participant explained strategies they found helpful; “take a step back, pull a mask down, talk to you, accommodate that in a really good way. Or just sometimes more facial expressions, or putting their hand up or something, that sort of thing,
and that all helps”. They also mentioned getting closer to the speaker, holding eye contact, raising your voice, calmly repeating sentences, and turning to face them when speaking as strategies that were appreciated and helpful. In saying this, it was also mentioned that different people will have different needs, and speaking loudly doesn’t always help; “what I go through is not what the next person is gonna go through, someone else might need the volume”. One participant stated, “you’ve learnt to appreciate the whole nine miles of everything and work out what makes it easier for you… you’re looking after yourself”.

**Explaining Hearing Needs**

Following on from this, participants discussed that they often needed to explain about their hearing loss and how this was impacting their communication with masks. Some participants felt that they often avoided explaining this; “you don’t like saying, ‘hey, I have a cochlear implant, please would you speak more clearly to me’. You don’t like doing that either, because you try and be normal”. For another participant, they said that in restaurants, “I don’t really bother giving them too much of a heads up, and I’m happy enough just sort of relying on friends to order for me”.

For others though, they found that explaining their needs was a necessary part of maintaining their communication throughout the mandated mask period. They discussed that because not everybody understands what it is like to have hearing loss, it often required explaining; “if all the hearing people in the world… just for 24 hours, were deaf, then everybody would get it because they’ve gone through it. But until they do, that sort of mentality doesn’t change. You’ve just gotta keep at them”. They explained finding having to repeat this explanation tiring, saying, “every single time you go in you think, ‘right, what do I normally say again?’”. They also mentioned feeling
“uncertain” on whether or not they should be asking people to pull their masks down, given the health risks and rules, stating, “I can’t be that person that would turn around and say look, I’m deaf, you need to communicate with me, I come first so none of you are allowed to wear masks, that wouldn’t be right”.

As the pandemic went on and masks continued to have a presence in most public conversations, one participant thought “no, I think these people understand now that there’s other people out there that just need that help, so we really should be doing it”. They discussed that they had considered laminating a card with an explanation would have been a good idea in hindsight; “There should have been something that we as a group should have made”, “I think something like that could be helpful, for me having to repeat, but also for them to go ‘oh okay, that’s kind of cool’. I wish I’d done that now but I just didn’t get round to it”.

Summary

Overall, masks gave participants a general sense that they were “complying with what the experts said was one of the best ways, to deal with this problem”. The majority were in favour of mask-wearing to protect people, “that’s the bottom line, safety”. There were mixed experiences of communicating with face masks; some found them a barrier to doing so, some found they did not affect communication at all, other than covering facial expressions. For those who found that masks were a barrier to communication, there were many factors involved and varying experiences on the topic. The main factor people had found that made communicating difficult with masks, was the obscured visual cues meaning that they could not lip-read to assist speech perception. Despite having mixed experiences on how others handled this when communicating with them,
and how this affected their own daily lives, they shared an understanding that it was important to respect people’s choices to protect themselves. This was expressed through statements such as, “it’s not so much about them respecting me, it’s them fearing their environment… it would be disrespectful for me to want to overrule that”. However, they also agreed that there are other strategies, aside from pulling down the mask, that could assist with communication, and they appreciated it when people were understanding and made an effort to accommodate their hearing needs. The following chapter considers these findings with reference to previous literature on this topic, addressing similarities and differences in the findings across the various relevant studies.
Chapter 5. Discussion

This study set out to explore the experiences of users of hearing aids and/or cochlear implant(s) communicating while wearing face masks throughout the Covid-19 pandemic. Wearing face masks in public spaces altered communication by blocking the visual cues and muffling the sound of speech, both of which degraded speech understanding for individuals with more severe hearing loss (Chodosh et al., 2020; Homans & Vroegop, 2021). The added challenge resulted in adjustments to the social interactions and lives of individuals, such as avoiding social situations, and additionally caused negative emotional experiences (Poon & Jenstad, 2022; Saunders et al., 2021).

The experiences discussed by participants outline how much these factors, and other points discussed, impacted their communication experiences and their quality of life in various environments. Findings that the use of face masks create additional difficulty in communicating for people with significant hearing loss are consistent with the findings of recent literature on this topic (Chodosh et al., 2020; Homans & Vroegop, 2021; Poon & Jenstad, 2022; Saunders et al., 2021). Additionally, results showing that assistive listening device users with less severe hearing loss noticed minor or no issues communicating with face masks is also supported by previous literature (Poon & Jenstad, 2022).

Of the nine participants interviewed, there was a noticeable variety in the experiences of communicating with face masks. This was predominantly linked to the variety of hearing levels described by each participant. Participants with hearing levels which meant they could not hear speech enough to understand it without their assistive listening device, all mentioned experiencing
difficulty without visual cues, localising the speaker, and increased difficulty in noisier environments. This aligns with the hypothesis that face masks would have a larger effect on assistive listening device users with hearing losses of higher severity, as these individuals tend to be more reliant on lip reading for communication (Atcherson et al., 2017; Wieczorek, 2012). This finding is also supported by a recent study by Poon and Jenstad (2022), where it was reported that “experiences of difficulty understanding others with face masks became more pronounced with increasing severity of hearing loss” (p. 7). Of the participants who reported that face masks were a barrier to communication, the majority were cochlear implant users. This correlates with the concept that cochlear implants are designed to aid severe to profound hearing losses, and we can expect cochlear implant users to rely more on their assistive listening devices and visual cues for hearing (Moberly et al., 2020). For some, they began to expect that they wouldn’t understand speech if someone was wearing a mask, as indicated in one participant’s statement, “if they’ve got a mask on, perhaps my mind’s saying, “you’re not going to understand””.

The majority of hearing aid users had little difficulty communicating with masks, and it is important to note that these participants were hearing aid users who did not report having severe or profound hearing losses. They expressed feeling that their experiences of communicating with masks were little to no different than others with normal hearing levels, and it was easier to communicate than before they had hearing aids. This is in line with previous research which, again, reported that communication experiences with masks were correlated with the degree of hearing loss of the participant (Poon & Jenstad, 2022). It can be seen as a positive sign that these particant’s hearing aids are benefiting them well and as expected. However, a hearing aid user can also have a severe to profound hearing loss, and these individuals reported experiencing significantly more
difficulty communicating with masks. Hearing aids amplify these acoustic signals into the inner ear, however for more severe hearing losses the sound can be particularly distorted. One hearing aid user in this study with a self-described severe to profound hearing loss emphasised this and the impact mask use has on their speech perception abilities with the statement, “there’s nothing positive about not having access to communication”, indicating that masks render speech near impossible to understand. This emphasises the idea that users of assistive listening devices cannot be categorised by the type of device they wear, as there is a wide spectrum of hearing levels, and hearing levels can be considerably different between users of the same assistive listening device. Additionally, assistive listening devices do not restore the user’s hearing back to the levels of someone with normal hearing levels (Cox et al., 2014; Lesica, 2018; Magnusson et al., 2013; Wu et al., 2019; Wong et al., 2018). Therefore, although some found their hearing is improved enough to understand speech covered by masks, a large portion with more severe hearing loss found this communication difficult. This finding is supported by results of a study by Poon and Jenstad (2022), which stated, “some participants commented that use of hearing aids or cochlear implants in and of themselves was not always sufficient to facilitate hearing or understanding others with masks, because they were still prevented from lipreading/speechreading” (p. 4).

Recent literature has investigated the difference in sound attenuation and downstream speech intelligibility between each of the main mask types (Atcherson et al., 2017; Brown et al., 2021; Goldin, 2020; Magee et al., 2020; Homans & Vroegop, 2022; Rahne et al., 2021; Toscano & Toscano, 2021). Evidence from the growing base of literature assessing the differences of speech intelligibility between mask types have found that there are differences in the attenuation of speech sound through each mask material (Brown et al., 2021; Goldin, 2020; Magee et al., 2020).
masks have been show to attenuate more high frequency sound, close to 12dB, compared to simple medical masks which attenuate between 3-4dB (Goldin, 2020). Some studies have reported that, in line with this, speech intelligibility for hearing impaired individuals is worse through N95 masks, compared to surgical masks (Rahne et al., 2021; Tofanelli et al., 2022; Toscano & Toscano, 2021). The majority of participants in the current study supported this conclusion, mentioning that the N95 masks made speech more difficult to understand than cloth masks and surgical masks. Alternatively, Brown et al. (2021) reported that the cloth mask with a filter and transparent face masks resulted in the poorest speech perception and highest listening effort rating for all individuals. Some participants in the current study reported also finding that cloth masks were the most difficult for understanding speech, mostly because they were the tightest fit against the mouth. Interestingly, in line with the findings of the majority of the aforementioned relevant studies, surgical masks were the least controversial mask types when looking at the varied opinions of all nine participants.

In summary, the finding that speech quality is degraded when communicating through face masks, and that all face masks interfere with speech understanding, has been presented in all of these studies. This overall conclusion was supported by the majority of participants in the current study, particularly those with more severe hearing loss. However, in terms of the difference in intelligibility through each mask type, research by Magee et al. (2020) found that despite finding variation in frequency attenuation between mask types, there were no differences observed in speech intelligibility between them. The study summarised this by stating, “our small dataset suggests mask type does not systematically impact intelligibility in controlled environments” (Magee et al., 2020). This finding was supported in the results of the current study by four of the
nine participants, who reported noticing no difference in speech intelligibility through the different mask types.

Participants not only mentioned the difference in perceived sound through each mask type, but even more emphasis was made on the amount of movement each mask provided with speech, by those who reported having difficulty communicating with masks. This was a finding not discussed in other literature assessing communication with different mask types, as previous studies have used quantitative methods to obtain results. Through the qualitative nature of this study, the additional factor of movement of the mask on a person’s face has been highlighted as an important factor in assessing the communication disadvantages of the mask types. The participants who discussed this factor, all without any prompting to do so, reported N95 masks as the most difficult to understand speech and localise the speaker through due to its lack of movement with speech. Furthermore, most of these participants reported that the cloth mask and surgical masks provided an advantage for noticing when somebody was speaking, allowing them to focus on understanding or informing them that they could not understand them. These findings are supported by research in the field of Visual Speech Recognition (VSR), which incorporates not only lip-reading, but the role the rest of the facial area plays in visual speech understanding (Zhang et al., 2020). Despite this, the majority of participants also described the N95 mask as their preference, as they considered it most efficient at preventing the spread of the virus. Although some controversial evidence on whether the N95 masks provide any additional protection than surgical masks has been presented, the majority of evidence and general advice indicated that N95 masks provided the highest level of protection to the virus of all mask types (Arellano-Cotrina et al., 2021; Johnson et al., 2009).
Face shields were regarded by participants as a good solution for the issue face masks create in blocking visual cues, however, overall the majority felt they came with more disadvantages than advantages. The disadvantages noted were their lack of efficiency in preventing viral transmission, their strange appearance, and not being able to use sign language in them. These perspectives were interesting, given that many felt communication was much more difficult without visual cues when people wore face masks, yet this option of clear face shields remained unpopular. The largest factor in this was the health factor, which indicates that the most important factor in face coverings for individuals was keeping safe from the virus. Brainard et al. (2022) produced results supporting this health concern, stating that “all face shields provided some protection but none gave high levels of protection against external droplet contamination”. The same study also gathered information from prospective users on the features most important to them in protective face coverings against the virus, to which they responded good communication, secure, comfort, visibility, fashion, and published data on the validated protectiveness; similar to the participants of the current study (Brainard et al., 2022).

Participant’s perspectives on transparent face masks were equally counterintuitive, as the main issue of lack of visual cues seems to be solved with this option (Erber, 1969; McKee et al., 2020). However, although participants were all in favour of the idea of gaining visual cues to allow for better speech understanding and deeper connection through facial expression, the overall opinion was that they were not feasible. Participants noted various factors to support this, a main point being the fogging of the transparent material with speech, as condensation forms, obscuring the visual information (Brown et al., 2021; Poon & Jenstad, 2022; Thibodeau et al., 2021). A factor noted in a study by Brown et al. (2021), was the added acoustic challenge transparent masks create with the plastic material used, yet this was not noted by participants in the current study. This is
likely due to the criteria that all participants had hearing loss and wore assistive listening devices, therefore the sound quality of the mask is less important to those who would benefit from transparent masks than the visual cues are for speech understanding. For example, one participant noted that even with their assistive listening device, they are unable to differentiate a female voice from a male voice, or hear high frequency aspects of speech, therefore the visual cues in speech are inherently more important for speech understanding for individuals with similar hearing levels. Additionally, the study by Brown et al. (2021) went on to say that despite the proven poorer sound quality through the transparent mask used in the study, the listeners benefitted enough from the available visual cues to outweigh this additional acoustic attenuation.

Currently there is not a wide range of transparent masks available that are approved under surgical mask standards, however there is at least one mask type with a transparent mouth covering currently approved for medical use (McKee et al., 2020). Some individuals have taken to fashioning their own clear masks, in an effort to make this a normal look to bring back deeper connections and access to visual cues, yet there is a need for further innovation in the field to ensure safe and functional options (Taylor-Coleman, 2020). These deeper connections were also discussed by participants in this study, expressing that emotion in speech with others was lacking due to the covering of mouths. Recent literature has also reported similar findings, discussing the importance of visualising facial expressions in social regulation, stating that “perceived emotion intensity and interpersonal closeness were reduced for masked faces” (Kastendieck et al., 2022, p. 59).

Brown et al. (2021) raised a summarising point relevant to the findings of this study around mask types and opinions, stating that “specific populations may differentially benefit from various mask types”. As discussed, there were various factors and specific experiences for each individual in this study which led to their personal mask type preferences, indicating that depending on one’s
hearing or communication needs and personal preferences, different mask types will be most suitable to different individuals. The overall opinion that the protective aspect of the masks is the most important factor, despite the challenges that come with each mask type, was a finding also reported in similar recent studies (Poon & Jenstad, 2022; Saunders et al., 2021).

It is well known that individuals with hearing loss are more exposed than others to emotional burdens and social limitation due to difficulties experienced in speech understanding (Tofanelli et al., 2022; Trecca et al., 2020). Participants of this study provided an overall consensus that any effects on communication due to mask wearing did not impact their quality of life, whether this be because they did not experience any impact on communication, or because they did not let it. However, the daily lives of those who experienced difficulty communicating with masks was impacted, and this resulted in emotional burdens and social limitations. Affected participants reported experiencing limited access to communication, altering their own social behaviour, and feeling less engaged in social interactions at times. This was suggested by participants statements such as, feeling “less inclined to try and drag out social interactions… I’d basically just try and get the minimal amount out of people”. This is similar to the findings reported in a study by Saunders et al. (2021), which stated, “face coverings impacted communication content, interpersonal connectedness, and willingness to engage in conversation; they increased anxiety and stress, and made communication fatiguing, frustrating and embarrassing”. It is important to note that the current study’s participants all felt that their hearing loss did not affect their daily life when masks were not involved, yet with everybody wearing face masks, some became exposed to the aforementioned social and emotional burdens commonly associated with hearing loss (Tofanelli et al., 2022; Trecca et al., 2020). This emphasises the wider impact that face masks can have on communication for individuals with hearing loss (Saunders et al., 2021). Despite this impact, all
participants demonstrated resilience through the added challenges in social interactions, determined not to allow this to impact their quality of life.

Aside from the communication itself, a challenging aspect raised was the constant cycle of explaining the difficulty understanding speech with masks, and frequently experiencing a lack of awareness and understanding as to what this means and how best to accommodate hearing loss. Predicting the attitudes of others was described as stressful by some participants, with some negative attitudes knocking their confidence, as suggested by participant’s statements such as, “you’d get really stressed about thinking I’m not going to hear properly, and people can get quite, should I say, nasty about it”. However, all participants felt it was most important to respect other people’s choices. This meant if somebody was not comfortable pulling their mask down to accommodate easier communication, participants emphasised that this came down to protecting their safety and this was the most important thing for them. At the same time, when the speaker was able to step back and pull the mask down while speaking safely, this was the most popular strategy to assist communication. This was also reported as the preferred strategy for accommodating communication in a similar recent study by Poon and Jenstad (2022). Other strategies reported by participants were noting things down on paper or a phone, moving to a quiet part of the room, hand gestures, and facing the person when speaking. Mheidly et al. (2020) produced a report on the challenges face masks cause for interpersonal communication, and discussed similar strategies to these. They mentioned the importance of utilising movement of the upper face in communication, body language, facing the communication partner, and talking louder and slower (Mheidly et al., 2020).

Family and close friends were often described as easier to communicate with given their awareness and understanding of the person’s hearing loss, and the familiarity of their voice. This was
described in a participant’s statement, “If people knew me well, they would just adjust what they were doing… a lot of my friends would just give up on the mask, just for that five seconds of asking me a question”. In some cases, participants felt that it was a lack of awareness of hearing loss and the potential difficulty this can cause with speaking to somebody wearing a mask that made social interactions most challenging. This uncertainty of attitude, along with the main concern that they wouldn’t be able to communicate effectively with someone wearing a mask, added to the general feelings of anxiety and fear caused by the pandemic for some people (Mörchen et al., 2020). Finding the inflexibility to accommodate their needs to be stressful or frustrating at times is also supported in the results of a recent study by Poon & Jenstad (2022).

**Study Limitations and Future Research Directions**

With respect to study limitations, the results were determined through open-ended interview questions requiring interpretation by the researcher. Although this interpretation is an integral part of thematic analysis, it is an important consideration when looking at the findings of the study. Additionally, the sample size of study participants was small and recruitment methods used did not enable recruitment of a completely diverse study group, therefore this is not representative of the entire population of individuals in New Zealand using assistive listening devices. However, the sample did consist of participants of a wide range of age, and an equal range of gender and assistive listening device group. There is uncertainty in the hearing levels of the participants, as this was self-reported through the interview format, therefore the severity of their hearing loss could only be estimated. However, the researcher conducting these interviews has a background in audiology and through speaking to each participant for 25-60 minutes, along with assessing their self-reported hearing levels, could make an educated estimation on this. For future research in this field, similar research using a larger sample size, recruited from a wider pool of individuals,
would be beneficial to gaining results that are more representative of the wider population using assistive listening devices. Additionally, experiments involving different mask types and participants with hearing loss would be beneficial to gaining information on which masks are most best for communicating whilst providing protection. Further research into creating a communication-friendly and safety approved transparent mask option would also be beneficial, as normalisation of and access to this mask type would minimise the communication deficit caused by face masks.

The results of this study indicate the need for increased awareness on the communication challenges that arise for people with hearing loss when face masks are used, which resonates with the indicated future directions of previous research in this field (Poon & Jenstad, 2022). Additional research has been produced discussing this, going further to say that communication needs to be more accessible to all individuals, pen and paper should be made available to assist communication, and that businesses and experts can play a role in promoting this greater awareness and best practice guidelines (Mheidly et al., 2020; Mörchen et al., 2020; Poon & Jenstad, 2022). A suggestion for future direction to help accommodate the needs of the affected individuals when communicating with face masks in public places is a public education programme to create awareness on this topic.
Conclusion

The aim of the study was to describe the real-world experiences of adult assistive listening device users in communicating with people wearing face masks during the COVID-19 pandemic. The reported experiences reported show that face masks had a detrimental effect on speech perception for some assistive listening device users, and the proportion of those experiencing difficulty tended to increase with the reported severity of the hearing loss, similar to the findings of previous research in this field (Poon & Jenstad, 2022; Saunders et al., 2021; Tofanelli et al., 2022). Additionally, for those who found communication challenging at times, an additional challenge was the lack of awareness and accommodation from others. This emphasises the importance of being communication-aware when wearing face masks, to minimise stress and exhaustion in these communication experiences (Saunders et al., 2021). A further finding similar to other recent studies, was despite these communication challenges, participants highlighted that health was the priority (Poon & Jenstad, 2022). The overall findings of the study are suggestive that there is a need for guidance and education to create increased public awareness on ways to communicate, while wearing a face mask, with adults using assistive listening devices for hearing loss.
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Appendices

Appendix A: Ethics Approval

HUMAN RESEARCH ETHICS COMMITTEE

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

Ref: HREC 2022/19/LR

24 May 2022

Olivia Mander
School of Psychology, Speech and Hearing
UNIVERSITY OF CANTERBURY

Dear Olivia

Thank you for submitting your low risk application to the Human Research Ethics Committee for the research proposal titled “Experiences of Communicating with Face Masks for People using Assistive Listening Devices during Covid-19”.

I am pleased to advise that this application has been reviewed and approved.

Please note that this approval is subject to the incorporation of the amendments you have provided in your email of 18th May 2022.

With best wishes for your project.

Yours sincerely

pp. R. Robinson

Professor Geoffrey Rodgers
Deputy Chair, Human Research Ethics Committee
Appendix B: Interview Information Sheet, Consent Form, and Questions

Information Sheet:

Te Kura Mahi ā-Hirikapo | School of Psychology, Speech and Hearing
Phone: 03 369 5090
Email: oma75@uclive.ac.nz

24 May, 2022
HREC Reference: HREC 2022/19/LR

Experiences of Communicating with Face Masks for People using Assistive Listening Devices during Covid-19
Information Sheet

Tēnā koe/ Hello,

My name is Olivia Mander and I am studying for a Master’s of Audiology at Te Whare Wānanga o Waitaha | the University of Canterbury. I am doing a research project that aims to find out about the experiences of listeners who use assistive listening devices (hearing aids/cochlear implants) in understanding speech while communicating with people wearing masks. This study is being supervised by Dr. Dean Sutherland.

Why have you received this information?
This information has been forwarded to you as you have responded to an advertisement about the study. Your participation is voluntary (your choice). If you decide not to participate, there are no consequences. Your decision will not affect any relationship with me, the University of Canterbury, or any member of the research team.

Who can participate?
Any person aged 18 years or over who uses a form of assistive listening technology such as hearing aids or cochlear implants. All participants are required to be residents/citizens of NZ.

What is involved in taking part?
Taking part in the study will involve being interviewed by me. This will either be online (via Zoom) or in-person at a suitable location (e.g., a quiet room at the University of Canterbury or in your own home if preferred). The interview will take between 30-60 minutes. The interview will involve me asking some questions about your experiences and what you think about communicating while wearing face masks in various environments over the past two years. I may also ask you to provide more information about some points you raise.
If you consent to being recorded, the interview will be audio-recorded (and video-recorded for Zoom interviews) so I can create an accurate written record of what was said. At the end of the interview, I will provide you with a $20 supermarket voucher to acknowledge your contribution to the study. If the interview is via Zoom, I will send the voucher via post if you are willing to let me know your postal address.

**What happens after the interview?**
Following the interview, I will create a transcript (word for word record) of the interview. If you choose to review your transcript, I will e-mail this to you within 14 days. Then, if you want to make any changes (e.g., delete words) or add new information you can send these to me within 14 days.

**What are the risks?**
Being asked questions about your communication experiences during the Covid-19 pandemic might be upsetting for some people. Answering some questions might involve you sharing personal or sensitive information. You can choose not to answer any question. If you feel uncomfortable or upset, you can choose to stop or reschedule the interview. You can also withdraw from the study. I may suggest you consider contacting a support agency (e.g., [www.1737.org.nz](http://www.1737.org.nz)).

**What happens to the information I provide?**
If you consent to recording, the interview will be audio-recorded (and video recorded for Zoom interviews) on a dedicated device. As soon as possible after the interview, the audio file will be uploaded to a password protected file on UC servers. The file will then be deleted from the recording device. The recorded file will be deleted at the end of the study. All other data (e.g., interview transcript) will be destroyed 5 years after the end of the study.

You may ask for your raw data (audio file and transcript) to be returned to you or destroyed at any point. If you withdraw, I will remove all information relating to you. However, once the analysis of data commences (31st August 2022), it will be increasingly difficult to remove the influence of your data on the results. If you decide to withdraw from the study you will still receive the $20 koha.

To ensure confidentiality, participants will be identified using a code (e.g., participant 1). Access to data will be restricted to the primary researcher (Olivia Mander) and supervisor (Dean Sutherland). If you consent, some direct quotes may be included anonymously in the project report.

The results of this project may be published in an academic journal article, conference or lecture presentation. To ensure confidentiality, your name or identifying information will not be used in the project report or any publication.

**Can I have a copy of the results?**
Yes. Please indicate on the consent form if you would like to receive a copy of the summary of results.

**Who can I contact regarding any questions or complaints?**
If you have any questions, please contact me or my supervisors, Dean Sutherland (dean.sutherland@canterbury.ac.nz).

This project has been reviewed and approved by the University of Canterbury | Te Whare Wānanga o Waitaha Human Research Ethics Committee. Participants should address any complaints to The Deputy Chair, Human Research Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you agree to participate in the study, please complete the consent form and either return via email to Olivia (oma75@uclive.ac.nz) or bring to your interview.

Ngā mihi,

Olivia Mander

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**Consent Form:**

Te Kura Mahi ā-Hirikapo | School of Psychology, Speech and Hearing
Phone: 03 369 5090
Email: oma75@uclive.ac.nz

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**Experiences of Communicating with Face Masks for People using Assistive Listening Devices during Covid-19**

**Consent Form**

☐ I have been given a full explanation of this project and have had the opportunity to ask the researcher any questions I have.

☐ I understand what is required of me if I agree to take part in the research.

☐ I understand that participation is voluntary and I may withdraw at any time without penalty. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain practically achievable.

☐ I understand that any information or opinions I provide will be kept confidential to the researcher and that any of my comments or quotes published or reported will not be identifiable.
☐ I understand that this interview will be audio recorded (and video recorded for Zoom interviews, where I will be able to turn off my camera if I wish) on a portable recording device, and the recorded file will be securely stored at the end of the project.

☐ I understand that all other data (e.g., the transcript) in the study will be kept in password protected electronic form, and will be deleted 5 years after the end of the project.

☐ I consent to the anonymous use of direct quotes in publications of the project.

☐ I understand the risks associated with taking part and how they will be managed.

☐ I understand that I can contact the researcher (Olivia Mander oma75@uclive.ac.nz) or supervisor (Dr. Dean Sutherland dean.sutherland@canterbury.ac.nz) for further information. If I have any complaints, I can contact the Deputy Chair of the University of Canterbury Human Research Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

☐ By signing below, I agree to participate in this research project.

☐ I would like to review the transcript of the interview.

☐ I would like a summary of the results of this project.

Name: ___________________________ Date: _______________

Signature: ________________________

Email address (for summary of results if applicable):
__________________________________

Please email this completed form to Olivia Mander oma75@uclive.ac.nz.

**Interview Questions Outline**

Thank you for agreeing to take part in this research project. Have you had a chance to read the information about the project? Are there any questions you have before we start? So I will ask you some questions about your experiences with hearing aids/cochlear implants and about communicating in the last few years with people wearing face masks... you can take a break at any stage...Sometimes it might not feel like a normal conversation as I will be trying not to talk too much, so will sometime stay quiet and provide you time to think or consider more information. Are you okay to start? and are you okay for me to record our discussion?

R: Could you tell me a bit about your use of *assistive listening devices* for example, how long you have had these...
R: I’m interested in finding out more about how have you have found communicating with people wearing face masks during the Covid-19 pandemic response?

R: Does mask wearing, in terms of communicating, affect your social life in any way?

R: Have you found yourself changing any activities (e.g., avoiding any settings) as a result of widespread use of masks? If yes, please elaborate.

R: Why do you think that is?

R: Do you feel that your quality of life has been impacted in any way by having to wear face masks in public places?
R. Has mask-wearing had any effect on your access to information? ... For example a new reporter wearing a mask. e.g. News reporter wearing a mask

R: How have you found other people’s behaviour towards you when communicating wearing masks?

R: Has this behaviour been any different since before masks were worn?

R: Has your perception of your own hearing /communication shifted since communicating wearing masks?

R: What are your thoughts on clear/transparent face masks instead of the common medical masks to help with communication?

R: can you recall situations where you had negative experiences communicating with masks?

R: can you recall situations where you have had positive experiences communicating with masks?
R. are there any things that have helped your communication when people are wearing masks?

R: On a scale of 1-10, how much do you feel you rely on lip-reading and facial expression when communicating? 1 being not at all, 10 being completely.

R: Do you think you would have rated this the same before we started wearing masks? If not, what would you have rated it before mask-wearing?

R: Before masks, how much did your hearing loss impact your communication on a scale of 1 – 10, 1 being not impacted, 10 being significantly impacted?

R: How does your hearing loss impact your communication now, while wearing a mask, on that same 1-10 scale?

R: Would you say your quality of life has shifted since the pandemic as a result of mask-wearing, in any way?

R: So there are three main types of masks ; cloth masks, surgical masks, and N95 masks (beak-like). Do you notice a difference in communicating?

R: In a noisy situation, would you prefer the safety of wearing a mask and managing without visual cues, or would you prefer to have no masks and risk getting Covid to be able to hold a conversation better?

R: Has your opinion of this shifted at all over the course of the pandemic?

R: Is there anything else you would like to add, or anything you feel like we haven’t covered on the topic?

Thank you for your time
- Provide gift voucher
- Remind they will have the opportunity to receive and review the interview transcript.

At the end of the interview, participants will be asked if they would like to add anything further to the interview that they feel we have not covered on the topic, be thanked for their time, provided with a gift voucher, and reminded that they will have the opportunity to receive and review the interview transcript.

Appendix C: Study Advertisement

Experiences of Communicating with Face Masks for People using Assistive Listening Devices during Covid-19

Kia ora, my name is Olivia Mander and I am studying for a Master’s of Audiology degree at Te Whare Wānanga o Waitaha | the University of Canterbury.

I am doing a research project that aims to describe the experiences of people who use assistive listening devices when communicating with people wearing face masks.

I am looking for people aged 18 years or over who use assistive listening devices (hearing aids or a cochlear implant/s).

Taking part will involve being interviewed (estimated 30-60 minutes either in-person in Christchurch or via Zoom) about your experiences and perspectives of communicating with face masks while using an assistive listening device.

A koha of a $20 petrol voucher will be provided as acknowledgement of your participation.

If you are interested in this study, please email me at oma75@uclive.ac.nz and I will forward the full study information and consent form to you for your consideration.

This study has been approved by the University’s Human Research Ethics Committee.