Confidence in the safety of standard childhood vaccinations in New Zealand

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Psychology, the University of Auckland, 2021.

Abstract

Understanding population perceptions of vaccine safety is crucial to maintain high vaccination coverage and prevent the outbreak of vaccine-preventable diseases. However, there is a lack of studies that assess vaccine safety perceptions in the unique context of New Zealand. The current thesis presents four studies that use data from a large, nationally representative survey to investigate group disparities and longitudinal changes in New Zealanders' confidence in the safety of standard childhood vaccinations. Study one assessed disparities in vaccine safety perceptions among 11 different groups of health professionals. Although most General Practitioners (GPs) expressed strong confidence in vaccine safety, midwives and practitioners of alternative medicine showed substantially lower levels of strong confidence. Study two investigated ethnic disparities in perceptions of GPs and vaccine safety. Relative to minority ethnic groups, Europeans showed greater positive perceptions of GPs and confidence in vaccine safety. Key correlates of stronger confidence in vaccine safety, including the role of GP perceptions, were found to differ across ethnic groups. Study three examined the distinct influence of maternal and paternal confidence in vaccine safety on their children's vaccination status. Mothers', but not fathers', level of confidence significantly predicted whether their children were fully vaccinated. Lastly, Study four assessed longitudinal changes in New Zealanders' confidence in vaccine safety from 2013 to 2017. Three subpopulations with differing directions and trajectories of changes in level of confidence were identified. The demographic profiles of these distinct subpopulations were also investigated. This thesis provides crucial and novel insight into the level and shaping of New Zealanders' confidence in childhood vaccine safety. They reveal high-risk groups more likely to exhibit low or decreasing confidence in vaccine safety and inform the development of tailored vaccination interventions for target groups.

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Comment on publications

This thesis is based on four manuscript publications listed below. All four manuscripts have been published in peer-reviewed journals. The publications are re-printed here with minor edits and changes in formatting to comply with the thesis guidelines. These publications will be referred to as Study one, Study two, Study three and Study four throughout the thesis, and form Chapter two, Chapter three, Chapter four, and Chapter five, respectively.

Lee, C. H. J., Duck, I., & Sibley, C. G. (2018). Confidence in the safety of standard childhood vaccinations among New Zealand health professionals. *The New Zealand Medical Journal, 131*(1474), 60-68.

Lee, C. H. J. & Sibley, C. G. (2020). Ethnic disparities in vaccine safety attitudes and perceptions of family doctors/general practitioners. *Vaccine, 38*(45), 7024-7032.

Lee, C. H. J., Overall, N. C. & Sibley, C. G. (2020). Maternal and paternal confidence in vaccine safety: Whose attitudes are predictive of children's vaccination? *Vaccine, 38*(45), 7057-7062.

Lee, C. H. J., & Sibley, C. G. (2020). Attitudes toward vaccinations are becoming more polarized in New Zealand: Findings from a longitudinal survey. *EClinicalMedicine*, *23*, 100387.

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Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work. Chapter 2: Lee, C. H. J., Duck, I., & Sibley, C. G. (2018). Confidence in the safety of standard childhood vaccinations among New Zealand health professionals. The New Zealand Medical Journal, 131(1474), 60-68.	
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CO-AUTHORS

Name	Nature of Contribution
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Dr. Isabelle Duck	Provided feedback on manuscript drafts, editing and proofreading.

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and
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CHAPTER ONE

General Introduction

General Introduction

Brief history of vaccinations

Widespread use of vaccinations began in the late 18th century following the work of Edward Jenner on the smallpox vaccine (Dubé, Vivion, & MacDonald, 2015). In l796, Jenner demonstrated that inoculating people with the cowpox virus, which only causes mild infections, can induce immunity against the deadly smallpox virus (Greenwood, 2014). This principle was used to develop the smallpox vaccine: the first vaccine to be widely used on humans. Although not without opposition, the smallpox vaccine was adopted as a preventative health measure by many European health authorities and significantly reduced the smallpox incidence rate (Greenwood, 2014). Despite this success, the 1871 Vaccination Act that called for compulsory childhood smallpox vaccinations in the United Kingdom (UK) was vigorously challenged by certain groups and provoked the formation of several anti-vaccination leagues (Greenwood, 2014). People contested the state's power to gain control over their bodies and violate their personal rights (Dubé, Vivion, & MacDonald, 2015). Similar uprisings occurred across Europe as governments pushed for the acceptance of vaccinations.

Scientists continued research on vaccinations in subsequent years, developing numerous new vaccines against deadly diseases (Greenwood, 2014). Improved methods of vaccine development enabled the creation of more effective and safe vaccines. In the 1950s and 1960s, universal vaccination programmes against poliomyelitis, measles, mumps and rubella were widely accepted among high-income countries (Dubé, Vivion, & MacDonald, 2015). Opposition to vaccinations still existed, but many parents complied with routine vaccinations, preventing outbreaks of various infectious diseases. During this period, most deaths and severe illnesses due to common childhood diseases were occurring in developing countries, where health resources were scarce and vaccination coverage was low

(Greenwood, 2014). To increase global vaccination coverage, the World Health Organization (WHO) introduced the Expanded Programme on Vaccinations in 1974 (WHO, 2013). This programme successfully increased vaccination coverage of routine vaccines from less than 5% to over 80% in many middle-to-low-income countries.

In the mid-1970s, there was a resurgence of anti-vaccination movements (Dubé, Vivion, & MacDonald, 2015). This resurgence was triggered by a UK report alleging that 36 children experienced neurological conditions after receiving the Diphtheria, tetanus toxoids and pertussis (DTP) vaccination (Kulenkampff et al., 1974). Pertussis vaccination coverage dropped from 77% in 1974 to 33% in 1977, prompting significant outbreaks of pertussis soon after. The safety of the DTP vaccine was validated once again by a large-scale study that assessed children hospitalized with neurological conditions in the UK (Miller et al., 1998) but controversies persisted. In the United States (US), anti-vaccination movements were exacerbated by the 1982 documentary entitled 'DTP: Vaccination Roulette' (Dubé, Vivion, & MacDonald, 2015). This documentary falsely claimed that the DTP vaccine's pertussis component caused severe brain damage, seizures, and mental retardation. Several lawsuits were made to vaccine manufacturers based on these allegations, resulting in the reduction of companies producing vaccinations. These events led to the establishment of the 1988 National Childhood Vaccine Injury Bill, which introduced a surveillance system that monitors the adverse side effects of vaccinations and lifted the liability of vaccine manufacturers for vaccine injury claims (Dubé, Vivion, & MacDonald, 2015).

Over the past decades, numerous controversies about different vaccines have resulted in decreased vaccination rates and disease outbreaks in multiple countries. For example, tetanus immunisation rates plummeted during the 1990s in the Philippines after pro-life Catholic groups induced fears that the tetanus vaccine could cause sterilization (Dubé, Vivion, & MacDonald, 2015; Larson et al., 2011). In 2003, there was a resurgence of polio in

Nigeria after vaccination rates dropped due to accusations that the polio vaccine campaign intended to sterilize and spread HIV among Muslims (Dubé, Vivion, & MacDonald, 2015). One of the most well-known controversies is Andrew Wakefield's notorious study that proposed a link between the measles, mumps and rubella (MMR) vaccine and autism (Wakefield et al., 1998). This study spurred great opposition against the MMR vaccine among activist groups and heightened fear about MMR vaccine safety around the world. MMR vaccination rates in the UK dropped from over 90% to less than 80% from 1997 to 2004 (Health and Social Care Information Centre, 2013), leading to a surge of measles outbreaks (Dubé, Vivion, & MacDonald, 2015). Despite the retraction of Wakefield's study and unanimous scientific evidence that MMR is not linked to autism (Deer et al., 2011), skepticism about the MMR vaccine is still prevalent and has contributed to the lead up to several measles outbreaks worldwide (Dubé, Vivion, & MacDonald, 2015).

Vaccinations today: The rise in vaccine hesitancy

To date, vaccinations remain one of the most cost-effective health interventions that protect public health (Dubé, Vivion, & MacDonald, 2015; Greenwood, 2014). Vaccinations are primarily responsible for the major decline in child mortality due to infectious diseases (Greenwood, 2014), and prevent around 2 to 3 million deaths each year (WHO, 2019a). Several countries currently administer National Immunisation Schedules that recommend and provide funded vaccinations to children at various ages (Bozzola et al., 2018). Routine vaccinations typically undergo rigorous testing before approval, and their safety is constantly monitored thereafter (Ministry of Health [MOH], 2019a; Oxford Vaccine group, 2020). Some countries have made certain childhood vaccinations mandatory to achieve high vaccination rates (Bozzola et al., 2018). For instance, the MMR, DTP, and Hemophilus influenza type B vaccine is compulsory in Bulgaria, France, Hungary, and Poland. Many parents accept and comply with standard childhood vaccinations, but there are ongoing debates surrounding

mandatory vaccinations (Dubé, Vivion, & MacDonald, 2015). Those opposing vaccination mandates commonly express doubts about vaccine safety or effectiveness, claim religious objections and advocate for personal liberty (Dubé, Vivion, & MacDonald, 2015). Such arguments are often linked to exposure to fraudulent information about vaccinations and the intentions of health authorities. Compared to those who accept mandates or are ambivalent, strong opposers showed a higher moral preference for purity (i.e., abhorrence of impurity of body) and lower moral preference for authority (i.e., deference for authorities; Rossen et al., 2019). Strong opposers appear to perceive that vaccinations inject "unnatural" toxins into their body and lack trust in authorities that administer these vaccinations.

The concept of 'herd immunity' posits that high vaccination coverage prevents the spread of diseases by providing direct protection for those vaccinated and indirect protection for those unable to be vaccinated (Dubé, Vivion, & MacDonald, 2015). Maintaining high vaccination rates are crucial to prevent the outbreak and resurgence of infectious diseases among the population. However, despite abundant scientific evidence on the effectiveness and safety of vaccinations (e.g., Maglione et al., 2014; Whitney et al., 2014), a growing number of parents have been refusing or delaying standard childhood vaccinations in recent years (Dubé et al., 2018; European Centre for Disease Prevention and Control [ECDC] 2015; Larson et al., 2018). Declines in vaccination rates have led to the resurgence of diseases that were previously declared eliminated in many countries. This includes the recent 2019 measles outbreak that killed more than 140,000 people worldwide (WHO, 2019b).

In 2019, WHO declared vaccine hesitancy as one of the top 10 threats to global health (WHO, 2019c). Vaccine hesitancy is defined by the WHO as the *delay in acceptance or refusal of vaccination despite the availability of vaccination services* (MacDonald, 2015). Many diverse factors contribute to this hesitancy. Some key contributors include doubts about vaccine safety, lack of vaccine knowledge, complacency, limited access to healthcare,

and distrust in health professionals or the government (Dubé, Vivion, & MacDonald, 2015; Fournet et al., 2018; MacDonald, 2015; Salmon et al., 2015). Among these factors, vaccine safety concerns are the most cited reason for missed or declined vaccinations (Giambi et al., 2018; Larson et al., 2018; Stefanoff et al., 2010). Several parents express worries about the risks and side effects of vaccinations, and the safety of receiving 'too many' vaccines at a young age. Such fears and doubts are prevalent even among parents who vaccinate their children (Dubé et al., 2018; Giambi et al., 2018; Kennedy et al., 2011; Salmon et al., 2015).

As confidence in vaccine safety is a key determinant of vaccination uptake (DeStefano et al., 2019; Gilkey, McRee et al., 2016), it is essential to constantly monitor and better understand the factors that shape one's vaccine safety perception. As with the concept of vaccine hesitancy, perception of vaccine safety is influenced by a wide range of factors. This includes one's exposure to anti-vaccine information, level of vaccine knowledge, access to trusted sources of vaccine information, and perceptions of or experiences with health professionals (Dubé, Vivion, & MacDonald, 2015; Gust et al., 2003; Tustin et al., 2018). In the digital age, misinformation about vaccinations have become more prevalent and easily accessible online (Davies et al., 2002; Dubé, Vivion, & MacDonald, 2015; Kata 2012). Those who lack accurate vaccine knowledge or access to trusted information sources are particularly susceptible to being influenced by such anti-vaccine content. Health professionals have a crucial role in reassuring and correcting misconceptions among those who develop misconceptions or concerns about vaccine safety (Benin et al., 2006; Brown et al., 2010; Smith et al., 2006).

It is essential to acknowledge that the level of or mechanisms underlying public confidence in vaccine safety can differ across countries. For instance, European and Western Pacific countries (e.g. France, Bosnia and Herzegovina, Greece, Japan) showed more negative views of vaccine safety compared to South East Asian countries (e.g., Bangladesh,

Indonesia, India, and Thailand; Larson et al., 2016). The unique historical, social, cultural, and political context of distinct countries can also lead to differences in contributors to vaccine safety perceptions among the public. Even within the same country, studies have noted disparities in vaccination attitudes between various demographic groups (e.g., gender, ethnicity, socio-economic status [SES]; see Larson et al., 2014). Thus, it is crucial to investigate vaccine safety perceptions and identify groups with greater vaccine safety concerns within a specific country to develop appropriate interventions that fit its cultural and social context.

Gaps in the literature and aims of the present thesis

Currently, there is a lack of studies on public perceptions of vaccine safety in the unique context of New Zealand. Few up-to-date studies have examined differences in the level and determinants of confidence in vaccine safety across distinct groups in New Zealand. There have also been no previous longitudinal studies on New Zealanders' vaccine safety perceptions. The present thesis is comprised of four studies that aim to address these gaps in research and increase insight into New Zealanders' confidence in the safety of standard childhood vaccinations.[1] It investigates both population level trends and group disparities in vaccine safety perceptions and helps identify high-risk groups most in need of focused vaccine education and tailored interventions.

Study one of this thesis investigates differences in level of confidence in vaccine safety among 11 different groups of health professionals in New Zealand. As health professionals have a pivotal influence on parental vaccine perceptions and decisions (Freed et al., 2011; Giambi et al., 2018; Paterson et al., 2016), it is vital to understand whether all

[1] Confidence in vaccine safety is measured using one's level of agreement to the statement that "It is safe to vaccinate children following the NZ Immunisation Schedule" in all four studies. In studies one, three and four, this concept is referred to as 'vaccine confidence'. In study two, this concept is described as 'vaccine safety agreement.' To report our study results more accurately and use consistent terminology, this concept is referred to as 'confidence in vaccine safety' or 'vaccine safety perception' when describing the four studies in this chapter (i.e. General Introduction).

groups of health professionals have strong confidence in vaccine safety, and can positively influence parental perceptions of and compliance with vaccinations. Subsequently, Study two examines ethnic disparities in perceptions of vaccine safety and family doctors/General Practitioners (GPs). This study seeks to understand the influence that GPs have on New Zealanders' level of confidence in vaccine safety and inform the development of target interventions for different ethnic groups.

The third and fourth studies of this thesis provide novel contributions to the international literature on vaccine safety perceptions. As most existing studies on vaccination attitudes focus on mothers, less is known about fathers' attitudes and their role in the vaccination decision-making process. To better understand the extent to which each parent determines their children's vaccination uptake, Study three assesses the differential influence of maternal and paternal confidence in vaccine safety on the likelihood of their children's full vaccination status. Additionally, there is a substantial lack of longitudinal studies that examine changes in level of public confidence in vaccine safety over time. This is an important gap to address, as vaccination attitudes are not static and can change according to many time-variant factors (e.g., political events, disease outbreaks, anti-vaccine campaigns; see Dubé, Vivion, & MacDonald, 2015; Ramsay et al., 2002). To gain insight into these longitudinal changes, Study four examines changes in New Zealanders' level of confidence in vaccine safety over the course of 5 years (2013-2017). This study uses a novel method to analyse longitudinal data that enables the identification of distinct groups that show differing trajectories of vaccination attitude change across time.

The four studies in this thesis specifically focus on assessing public confidence in the safety of childhood immunisations following the New Zealand Immunisation Schedule. However, to establish a more complete picture of the literature on vaccination attitudes, the first section of this thesis provides an overview of international research on a broader range

of factors that influence one's perception of and decision to comply with vaccinations. It discusses the impact of the ubiquity of anti-vaccination information online, insufficient or lack of vaccine knowledge among the public, and the role that health professionals play in shaping one's perception of vaccinations. This is followed by a brief review of previous international research on demographic group differences in vaccination perceptions and uptake, vaccination interventions and longitudinal changes in vaccination attitudes. The final section of this chapter provides a more focused discussion of vaccinations in the context of New Zealand and elaborates on the rationale for the four studies stated above.

Overview of international literature

A new era of anti-vaccination movements

In the 21st century, many parents do not merely follow doctors' recommendations but desire to engage in a shared decision-making process and make informed decisions about their children's vaccinations (Austvoll-Dahlgren & Helseth, 2010). They seek additional vaccine information through diverse sources, with many citing the internet as an important information source (Kata et al., 2010; Kennedy et al., 2011). Worryingly, the increase in global internet usage has provided anti-vaccination groups a new platform to disseminate their ideas to a broader audience (Dubé, Vivion, & MacDonald, 2015). As there are several anti-vaccine websites and activists on social media, parents are now more easily exposed to anti-vaccine information and prone to developing misconceptions about vaccinations (Davies et al., 2002; Kata 2012). Media coverage of celebrities declining or questioning the safety of vaccinations have also contributed to perceptions that there is social support for refusing vaccinations (Kata, 2012).

Negative vaccine information is easily accessible through popular internet search engines and receives greater attention from internet users than positive vaccination content. Across seven leading internet search engines, 43% of the first ten sites presented when

searching the term “vaccinations” were anti-vaccination sites (Davies et al., 2002). An analysis of YouTube videos on immunisations found that 32% included negative vaccine content, and 45% of these videos made unsubstantiated claims about vaccinations (Keelan et al., 2007). Concerningly, negative videos were more likely to receive higher ratings and had more views than positive videos. Of the top 30 vaccination related pages on Facebook, 43% were anti-vaccination pages and these pages showed greater activity compared to pro-vaccination pages (Buchanan & Beckett, 2014).

Anti-vaccine websites commonly present themselves as being “pro-safe vaccine” and insist they take a balanced and safe approach to vaccinations (Kata, 2012). Others portray themselves as neutral organizations or advocates of “natural health”, while some outrightly express their activist identities. Regardless of their approach to vaccinations, information on these websites tends to lack reputable scientific evidence and engender various misconceptions about vaccinations (Davies et al., 2002; Kata, 2010). Unwarranted claims that vaccines contain harmful ingredients and cause illness, damage, and even death are prevalent across multiple anti-vaccine websites (Bean, 2011; Davies et al., 2002; Kata, 2010; Wolfe et al., 2002). They present misinterpreted or false scientific findings and personal testimonials as evidence to support their arguments. Several websites also allege that vaccinations are prompted by the financial interests of pharmaceutical companies, undermining public trust in scientific authorities (Davies et al., 2002; Kata, 2010). They question the effectiveness and necessity of vaccinations and portray vaccine mandates as a gross violation of personal liberty and parental rights by the government.

As up-to-date health information is most readily accessed online, many people obtain and often trust health information on the internet (Betsch et al., 2012; Kata, 2010; Moon et al., 2019). Given the substantial amount of misinformation online, parents who search the internet for vaccine information are more likely to perceive that vaccines are not safe or

ineffective (Jones et al., 2012; Tustin et al., 2017). Those who lack the ability to differentiate between credible and fraudulent vaccination information are particularly susceptible to being influenced by anti-vaccine content (see Downs et al., 2008; Kortum et al., 2008). People with lower educational attainment and health literacy, distrust in the health system and positive views about alternative medicine were found more susceptible to health misinformation, including claims that HPV vaccines increase cervical cancer rates (Scherer et al., 2021). More generally, those younger, with lower education, stronger right-ring political views and minority group status tend to exhibit greater conspiracy beliefs (Galliford & Furnham, 2017; van Prooijen et al., 2018). Feelings of deprivation among minority groups can lead to cynical views of the social and political system, which in turn increases their susceptibility to conspiracy theories (van Prooijen et al., 2018).

Studies have shown that exposure to anti-vaccine information or conspiracy theories can negatively impact views of vaccinations as well as future vaccination intentions (Betsch et al., 2010; Jolley & Douglas, 2014; Nan & Madden, 2012). Betsch et al. (2010) found that viewing anti-vaccine websites for as little as five to ten minutes can increase perceived risk of vaccinations, while decreasing perceived risk of not vaccinating and intentions to vaccinate. By contrast, pro-vaccination websites had minimal influence on one's perception of vaccination risks (Betsch et al., 2010). A follow-up analysis five months later found that fewer parents exposed to the anti-vaccination website had vaccinated their children. Additionally, HPV vaccination coverage was found to be lower in US states that had higher proportions of twitter content that questioned HPV vaccine safety (Dunn et al., 2017). Taken together, these findings illustrate the substantial impact that exposure to and endorsement of anti-vaccination information can have on people's view of vaccine safety and vaccination decisions.

Insufficient or inaccurate vaccine knowledge

Although most parents generally support and comply with vaccinations, many lack adequate vaccine knowledge and continue to have questions or concerns about vaccinations (Bert et al., 2019; Kennedy et al., 2011). For instance, despite 96.2% of mothers in Quebec (*N*=2645) recognizing the efficacy of vaccinations, 28.6% expressed a moderate level, and 15% expressed a high level of vaccine hesitancy (Dubé et al., 2019). Seventy percent had a low level of knowledge about the illnesses that vaccinations prevent, and 56.8% mostly or totally disagreed that they were sufficiently informed about their child's vaccinations. Among a large sample of pregnant Italian women (*N* =1820), only 9% fully trusted vaccine efficacy, necessity, and safety (Bert et al., 2019). Around 30% did not agree that vaccine benefits outweigh the risks, or that vaccines are sufficiently tested before entering the market. Moreover, 15% disagreed and 53% were uncertain whether scientific studies prove that there is no link between autism and vaccination (Bert et al., 2019). As those living in high-income countries do not have first-hand experience of illnesses prevented by vaccines, they tend to underestimate the severity and threat of these illnesses (Dubé, Vivion, & MacDonald, 2015).

Internationally, a considerable proportion of parents express dissatisfaction with the amount of vaccine information they receive, especially during the prenatal period (e.g., Danchin et al., 2017; Dubé et al., 2019; Mendel-Van Alstyne et al., 2018; Wu et al., 2008). Parents frequently report wanting more information about vaccine ingredients, the safety of administering multiple vaccines to children from a young age, and the potential link between vaccines and various illnesses (Danchin et al., 2018; Mendel-Van Alstyne et al., 2018). Lack of vaccine knowledge is also a major reason for low vaccine confidence among vaccine-hesitant mothers (Mendel-Van Alstyne et al., 2018). Hesitant mothers commonly mentioned not having enough time to learn about specific vaccines and make informed decisions. They expressed having limited understanding of how vaccines worked and interacted with the

child's immune system, as well as the rationale of the immunization schedule (Mendel-Van Alstyne et al., 2018).

It is essential to ensure that parents are provided a satisfactory amount of vaccine information, as insufficient access to information can lead to increased skepticism about vaccinations and decreased vaccine acceptance (Gust et al., 2005; Mendel-Van Alstyne et al., 2018). Lack of vaccine understanding can also increase susceptibility to false vaccine information (Downs et al., 2018). Parents who feel less informed and desire more information are likely to search the internet, and those with little vaccine knowledge are more likely to be influenced by false information online (Downs et al., 2018). As discussed above, exposure to negative vaccine information may further decrease parental confidence in vaccine safety and future intentions to vaccinate their children. With increased accessibility of anti-vaccine information through mass media in recent years, lack of or inaccurate vaccine knowledge poses a great challenge to maintaining high public confidence in vaccine safety.

The role of health professionals

Across multiple studies, health professionals are cited as the main or most trusted source of vaccine information (Chow et al., 2017; Freed et al., 2011; Giambi et al., 2018; Stefanoff et al., 2010). Strong trust in a child's doctor and adequate doctor-parent vaccine discussions have been associated with positive views of vaccinations (Benin et al., 2006; Smith et al., 2006). Receiving a doctor's recommendation is a major determinant of parental compliance with vaccinations (Giambi et al., 2018; Wu et al., 2008). Health professionals have a crucial role in communicating the benefits of vaccinations and correcting misconceptions about vaccinations, especially to vaccine-hesitant parents (Bert et al., 2020; Smith et al., 2006). Satisfactory consultation with or recommendation by a health professional was found to be a significant contributor to why previously vaccine-hesitant parents decided to vaccine their children (Kornides. McRee, & Gilkey, 2018). Furthermore,

greater trust in the healthcare system and government have been linked to stronger parental confidence in vaccinations (Brown et al., 2010; Dubé, Vivion & MacDonald, 2015; Rozbroj et al., 2019).

On the flip side, having low levels of trust in health professionals or perceiving that authorities in charge of vaccinations do have the child's best interest at heart are associated with negative views of vaccinations (Benin et al., 2006; Brown et al., 2010; Dubé, Vivion & MacDonald, 2015). Those who trust in or obtain information from alternative health practitioners (e.g. homeopath/naturopath) are also more inclined to be hesitant about or refuse vaccinations (Benin et al., 2006; Chow et al., 2017; Hadjipanayis et al., 2020). These individuals are more likely to seek alternative vaccination schedules or prefer "natural" remedies that are deemed safer than vaccinations. Moreover, those who exhibit low trust in health professionals are more likely to source vaccine information from the internet (Jones et al., 2012). This increases the chances that they encounter and are influenced by anti-vaccination sentiments alleging that vaccinations are unsafe and driven by the financial interests of health authorities.

International studies have shown that confidence in and knowledge about vaccinations varies across health professionals (Dubé et al., 2018). A significant proportion of health professionals are reluctant to recommend certain vaccines to patients due to concerns about vaccine safety and efficacy (ECDC, 2015). Many also do not know how to communicate with and persuade vaccine-hesitant parents effectively. Doctors report lacking adequate time, confidence, or resources and are often not sufficiently trained to counteract anti-vaccine beliefs and convince vaccine-hesitant parents (Badur et al., 2020; Paterson et al., 2016). Additionally, high volumes of patients make it difficult for doctors to satisfactorily attend to specific vaccine concerns, which increases the likelihood that parents continue to have lingering doubts about vaccine safety. Given these findings, it is crucial to better

understand the degree of vaccination concerns among health professionals and ensure that sufficient resources are provided to those who lack knowledge or confidence about vaccinations. Improved confidence in vaccine safety and communication strategies among health professionals is likely to translate to greater confidence in and compliance with vaccinations among the public.

Group differences in vaccination attitudes and uptake

Attitudes towards vaccinations are not uniform across demographic groups. International studies have shown mixed findings on demographic group differences in vaccination attitudes and coverage (Larson et al., 2014). Contradictory findings are common even among studies conducted within the same country. Such inconsistencies may be partly due to disparities in sample characteristics and study methodologies but may also reflect variations in vaccination attitudes over time or based on contextual factors (see Stefanoff et al., 2010). As reasons for low confidence in vaccinations are diverse, it is also vital to recognize group differences in mechanisms driving their vaccination attitudes and decisions. Whereas financial or cultural barriers to healthcare may be key driving factors among some groups, greater exposure or susceptibility to anti-vaccine conspiracy theories may be a more vital contributor among other groups. Increased insight into these group differences will enable us to recognize target groups at higher risk of holding skeptical views of vaccinations and develop tailored interventions to prevent future declines in vaccination coverage.

Socio-economic status. The international literature on socio-economic (SES) group differences in vaccination attitudes does not show a clear pattern (Larson et al., 2014). Findings within the same country are also inconsistent. Among studies conducted in the US, Nigeria, and Bangladesh, some suggest that high SES is linked with negative views or refusal of vaccinations (e.g., Wei et al., 2009 versus Wu et al., 2008 in the US). In contrast, others find that high SES is a facilitator of positive views and acceptance of vaccinations (see

Larson et al., 2014). Mechanisms driving the effects of SES are not always clear but are likely associated with factors such as perceived vaccine knowledge and level of healthcare access. A study conducted in Perth found that vaccine-hesitant parents with high income believed that they were well-equipped to make competent vaccine-decisions due to their high level of education and perceived vaccine understanding (Swaney & Burns, 2019). However, strong confidence in their own judgments did not coincide with accurate vaccine knowledge. Many undermined the severity and risk of vaccine-preventable illnesses and had little or incorrect understanding of vaccinations. The accuracy of vaccine knowledge held by high SES individuals may be an important determinant of whether they oppose or support vaccinations.

On the contrary, those with lower SES are less likely to have strong confidence in their vaccine knowledge. Low SES individuals typically encounter greater financial or time-related barriers to healthcare (Arpey et al., 2017), suggesting they have little opportunity to consult doctors about their vaccine concerns and build on their vaccine knowledge. Low SES is commonly associated with decreased trust in health professionals and the government (Foster & Frieden, 2017; Richardson et al., 2012). Lack of trust in health authorities can be a barrier to having satisfactory vaccine conversations with doctors and positive views of public health services, including the safety and efficacy of vaccinations (Dubé, Vivion, & MacDonald, 2015). Hence, doubts about vaccinations among low SES groups may reflect their reduced access to trusted sources of vaccinations, lack of vaccine knowledge and distrust in health professionals.

Education level. Research on the relationship between education and vaccination attitudes or uptake across different countries has produced contradictory results (Larson et al., 2014). Studies in China, Lebanon, Israel, and the US found that higher education was a barrier to vaccine acceptance, whereas studies in Greece, the Netherlands and Nigeria found

it to be a promoter of vaccine acceptance (Larson et al., 2014). Low education was associated with decreased vaccine acceptance in Nigeria, India, Kyrgyzstan, and China, but showed mixed findings in the US. Key reasons for low confidence in vaccinations or immunisation rates also tend to differ across countries. For instance, low education has been tied to issues of low literacy, lack of vaccine knowledge, and healthcare system barriers in India (Kumar & Gomber, 2010; Patel & Pandit, 2012). On the other hand, those with low education in Kyrgyzstan not only show negative beliefs about vaccine safety, but also exhibit greater anti-vaccine attitudes (Akmatov et al., 2009).

Education level can be linked to differences in cognitive ability to comprehend vaccine information and communicate effectively with health professionals. Those more educated may be better able to understand scientific evidence on vaccinations and differentiate between fraudulent and evidence-based research on vaccinations (see Rowlands, 2014). Their enhanced ability to comprehend vaccine information may further enable them to have more sophisticated and satisfactory conversations with doctors. Oppositely, those with lower education are more likely to have lower health literacy (Sorensen et al., 2015), reduced understanding of the science behind vaccinations and be more susceptible to anti-vaccine conspiracy theories (Diviani et al., 2015; van Prooijen, 2017). Similar to high SES individuals, those more educated may express greater confidence in their own vaccine knowledge even when it is inaccurate. Highly educated individuals with inaccurate beliefs about vaccinations may exhibit stronger opposition to vaccinations, while highly educated individuals with accurate knowledge tend to be strongly supportive. Political partisanship and level of trust in science contribute to whether one holds accurate vaccine beliefs. In the US, the proportion of more educated people with accurate vaccine beliefs was considerably greater among Democrats, who tend to exhibit greater trust in science, compared to Republicans (79% vs 58%; Joslyn & Sylvester, 2019).

Ethnic groups. Ethnic differences in vaccination attitudes must be examined in consideration of the unique historical and cultural contexts within each country. This includes ethnic inequalities in social or health outcomes and disparities in level of trust in health professionals or the government. A common finding in multicultural countries is that minority ethnic groups tend to exhibit more negative views of vaccinations and lower vaccination uptake (Marlow et al., 2009; Quinn et al., 2019; Shui et al., 2006). These findings can be partly explained by the fact that minority groups tend to have lower SES, lower educational attainment, and report greater barriers to healthcare. These characteristics can reduce one's level of healthcare access and vaccine awareness and hinder their ability to build positive relationships with healthcare providers (see Marlow et al., 2009; Shui et al., 2006). For example, African Americans were found to be less accepting of vaccinations and express greater concerns about the risks and safety of vaccinations compared to White or Hispanic Americans (Cates et al., 2009; Constantine et al., 2007; Shui et al., 2006). This can be linked to their lower level of educational attainment and healthcare access, low vaccine knowledge, and negative perceptions of health professionals (Cates et al., 2009; Gelman et al., 2011; Jacobs et al., 2006).

Lack of trust in health professionals is an important contributor to skeptical views of vaccination among ethnic minorities (Shui et al., 2005, 2006). Due to cultural or language barriers, ethnic minorities may find it more difficult to build rapport with and have satisfactory vaccination discussions with mainstream doctors (see Ferguson & Candib, 2002). Some even report feelings of racism by health professionals, which can impact whether one regards their doctor as their primary or most trusted source of vaccine information. Previous history of unethical treatment can also act as a barrier to building trusting relationships with health professionals among ethnic minorities. For instance, due to the loss of cultural identity, land, and resources during colonization, the indigenous people of New Zealand (Māori)

continue to experience lower access to healthcare and have negative perceptions of government or health authorities (Jansen et al., 2008; Zambas & Wright, 2016). Māori have persistently been subject to institutional racism in the health system and report higher feelings of discrimination from health professionals than other ethnic groups (Harris et al., 2012; Harris et al., 2019). Hence, doctors are not likely to be seen in the same way or have uniform influence on vaccination attitudes of ethnic groups with differing histories and cultural values.

Moreover, some ethnic groups prefer using traditional remedies over modern medicine or have strong cultural or religious beliefs that are considered incompatible with vaccinations (Fournet et al., 2018; Marlow et al., 2009; Metha, 2012). Many Muslim communities in Southeast Asia are reluctant to receive vaccinations as they believe vaccines contain aborted foetal DNA and animal cells (Wong et al., 2020). Some favour natural remedies such as homeopathy or believe that adopting a healthy diet and lifestyle is sufficient to protect one against diseases. Consequently, there are likely to be important disparities in the level of trust in vaccine safety and major determinants of vaccination attitudes across ethnic groups. Understanding such differences is crucial to identify the most effective ways to increase confidence in vaccinations and improve vaccination uptake among specific ethnic groups.

Gender. Despite somewhat mixed findings on gender differences in vaccination attitudes (e.g., Lee et al., 2017; Ren et al., 2018; Rozbroj et al., 2019; Shapiro et al., 2018), anti-vaccine movements have typically been linked to feminist ideologies and support for women's rights (Conis, 2013). Recent anti-vaccine movements on Facebook were found to be led by and comprised mainly of women (Smith & Graham, 2019). As childcare is still primarily regarded as the mother's responsibility (Bianchi, 2011; Hori, 2017), women are more likely to have concerns and questions about vaccinations and seek vaccination

information through multiple sources. Studies have shown that mothers frequently use the internet and social media as health information sources (Kummervold et al., 2008; Moon et al., 2019). With the abundance of anti-vaccine information online, mothers are more likely to be exposed to negative information about vaccinations than fathers. Furthermore, Freed et al. (2011) found that women are more likely to trust informal sources of vaccine information, suggesting that women are not only more likely to be exposed to but are also more susceptible to being influenced by anti-vaccine information.

In the current literature, most studies on vaccination attitudes, barriers to vaccination and reasons for hesitancy focus on mothers (e.g., Bert et al., 2020; Wu et al., 2008; Yarword et al., 2005). There is a lack of studies on fathers' perceptions of vaccinations and the role they play in the vaccination decision-making process. The few existing studies suggest that fathers are generally supportive of vaccinations despite not having in-depth knowledge about vaccines or illnesses it prevents. For example, Kornfeld et al. (2013) found that most Hispanic fathers were willing to vaccinate their son (87.5%) or daughter (78.8%) against HPV but many exhibited low awareness and knowledge about HPV. Prosser et al. (2016) found that Australian fathers (89%) showed positive attitudes towards vaccinations. Such positive attitudes were associated with lower self-reported knowledge of pregnancy issues but a higher likelihood of consulting doctors about vaccinations as opposed to sourcing the internet. Compared to mothers, fathers appear more likely to fully trust their child's doctor and are less likely to seek additional vaccine information through alternative sources. Nevertheless, further research is crucial to better understand the extent to which fathers participate in and influence their children's vaccination decisions relative to mothers.

Vaccination Interventions

Several educational and informational interventions (e.g., pamphlets, videos, presentations/lessons) have been implemented to improve parental perceptions and

acceptance of vaccinations (Dubé, Gagnon & MacDonald, 2015). However, evidence has been inconsistent, and many educational tools were found to have little impact on vaccination attitudes or degree of vaccine hesitancy (Dubé, Gagnon & MacDonald, 2015; Sadaf et al., 2013; Fu et al., 2014). Interventions targeting health professionals through methods such as education and training, audit, feedback, and/or electronic support systems have also been implemented (Niccolai & Hansen, 2015). Although findings have been mixed, some of these physician-focused interventions have resulted in significant increases in vaccination coverage (Dempsey et al., 2018; Fiks et al., 2013; Moss et al., 2012). Practice-based interventions such as reminder and recall systems have generally been found to improve immunisation rates (Szilagyi et al., 2002; Szilagyi et al., 2011; Vann & Szilagyi, 2005). Nevertheless, as compliance with vaccinations does not always indicate strong confidence in vaccinations, it is important to investigate further and identify the most effective strategies to improve public confidence in vaccine safety.

Interventions that have gained success in improving vaccination attitudes or uptake tend to focus on the specific needs of a target individual or group. For instance, to address the physical and informational barrier to vaccinations among minority ethnic groups, a community-wide reminder, recall, and outreach system was implemented in the US (Szilagyi et al., 2002). This intervention resulted in a marked increase in vaccination coverage among minority groups and a decrease in ethnic inequality in vaccination uptake. Additionally, training health professionals on ‘motivational interviewing’ has been identified as a useful tool in facilitating parental acceptance of vaccinations (Gagneur et al., 2018; Reno et al., 2018). This patient-centred communication strategy involves enhancing parents’ own motivation and self-efficacy to change their attitudes and work towards vaccine acceptance (Reno et al., 2018). Parents are encouraged to discuss their reasons for vaccine hesitancy and specific concerns and explore ways to overcome their barriers to vaccination uptake. Such

open discussions enable health professionals to provide tailored support and information based on the needs of parents.

The levels of confidence in vaccinations, determinants of vaccination attitudes and barriers to healthcare access can differ between distinct groups within a country. Thus, taking a one-size-fits-all approach or simply providing standard vaccination information to all groups would not an effective strategy to improve vaccination attitudes. As discussed above, it is crucial to first understand the specific concerns and barriers encountered by different individuals and groups to provide tailored support based on their needs. To design contextually and culturally appropriate interventions for a target group, we must understand their cultural values, the unique contributors to their vaccination attitudes, their relationship with health professionals, and the barriers they encounter to vaccination uptake (Thomson et al., 2018). As many parents seek vaccine information from health professionals (Chow et al., 2017; Freed et al., 2011; Giambi et al., 2018; Stefanoff et al., 2010), it is vital to ensure that health professionals are both confident in vaccine safety themselves and are well equipped to provide tailored support for diverse groups.

Longitudinal research on vaccination attitudes

Beliefs about and perceptions of vaccinations evolve and change over time. Fluctuations in vaccination attitudes may occur due to political or social events, anti-vaccination movements, vaccination content on mass media or outbreaks of diseases (see Dubé, Vivion, & MacDonald, 2015). Thus, it is important to monitor changes in vaccination attitudes across time, including whether those who previously exhibited negative attitudes or low confidence in vaccine safety show improvements or worsening perceptions of vaccinations over the years. Such information is vital to guide health policies and inform any necessary changes or developments to vaccination interventions.

Changes in public perceptions and acceptance of the MMR vaccine over time illustrate the importance of conducting longitudinal research on vaccination attitudes. A study on UK mothers found that the decrease in MMR coverage from late 1997 to 2001 coincided with the decline in maternal confidence in the MMR vaccine safety during this period (Ramsay et al., 2002). This decline can be linked to the rise in suspicions that the MMR vaccine causes inflammatory bowel disease and autism in the late 1990s. Improvements in perceptions of the MMR vaccine were noted in later years when controversies started to die down. As a result, the proportion of mothers believing that the MMR vaccine itself is a greater threat than the disease it protects against fell from 24% in 2002 to 14% in 2006 (Smith et al., 2007). The trajectory of maternal vaccine confidence and MMR vaccination coverage in the UK appears to have been driven mainly by shifts in the prevalence and popularity of MMR controversies across time.

A 2013 to 2015 survey of mothers in Washington State found that the proportion of those showing vaccine hesitancy significantly decreased during the first two years of the child's life (9.7% to 5.9%; Henrikson et al., 2017). Maternal confidence in vaccine safety and efficacy increased as the child developed, which may have been a factor that facilitated improvements in their level of vaccine acceptance. Taking a more global approach, an analysis of WHO data on 184 to 190 countries from 2014 to 2016 indicated that over 90% of countries reported some degree of vaccine hesitancy (Lane et al., 2018). Reasons for hesitancy were diverse and differed by country income level and region. However, concern about the risks and safety of vaccinations was consistently identified as the most cited reason for hesitancy (22%, 23%, 23% in 2015-17 respectively).

There is currently a lack of up-to-date longitudinal studies in the international literature that assess the trajectory of changes in perceptions of vaccine safety at a population level. Many studies only focus on mothers' attitudes (e.g., Bert et al., 2020; Wu et al., 2008;

Yarword et al., 2005) or assess trends in vaccination coverage rates (e.g., Bechini et al., 2019; César et al., 2020; de Figueiredo et al., 2016) as opposed to examining changes in perceptions of vaccine safety over time. This is an important gap to address as those who vaccinate their children may still hold some degree of doubt about vaccine safety. If these concerns are not addressed promptly, their confidence in vaccinations may potentially further decrease over the years and lead to declines in vaccination rates. Hence, it is crucial to identify those most likely to show persistent or increasingly negative perceptions of vaccinations and implement prompt interventions to improve their confidence in vaccine safety.

Vaccinations in the context of New Zealand

The New Zealand MOH (2020a) administers a national immunisation schedule that offers a series of funded standard immunisations for children and adults at various ages. Vaccinations included in the schedule are carefully selected after rigorous testing, and their safety is continuously monitored thereafter. The current schedule includes the MMR vaccine at 15 months and 4 years and the HPV vaccine at 11 or 12 years of age (MOH, 2020a). These vaccines are strongly recommended but not mandatory. As of the end of September 2020, the 12-month vaccination coverage of children aged 6 months, 8 months, 12 months, 18 months, 2 years and 5 years was 77%, 90%, 92%, 84%, 91% and 89% respectively (MOH, 2020b). These vaccination coverage rates do not reach the national target of ensuring that 95% of all children are fully immunised by 8 months. Around 4 to 5% of parents refused at least one vaccination during this 12-month period (MOH, 2020b), suggesting that a small subgroup of the population strongly oppose vaccinations.

Concerns about the risk and side effects of vaccinations are frequently cited as reasons for delaying or refusing vaccinations in New Zealand (Hamilton et al., 2004; Litmus, 2013; MOH, 2007). Many parents desire more information about potential side effects or

express specific concerns about the MMR vaccine and autism link. Primary care factors and doctors' vaccine attitudes have also been associated with timely childhood vaccination uptake. Vaccination timeliness was higher in practices without staff shortages, where doctors were confident in their vaccine knowledge or acknowledged that parental access was a barrier to immunisation (Grant et al., 2011; Petousis-Harris et al., 2012). From the perspective of health professionals, lack of vaccine-related education and understanding of disease severity, anti-vaccine beliefs, and competing priorities among parents were reported as barriers to childhood immunisation (Turner et al., 2017).

In New Zealand, those of Māori or Pacific ethnicity and low SES generally exhibit lower immunisation rates (MOH, 2020b; Mueller et al., 2011). These groups encounter greater barriers to accessing healthcare and tend to exhibit lower levels of education and health literacy (Jansen et al., 2008; Mauri Ora Associates, 2010; MOH, 2010, 2019b). Consequently, they are less likely to have adequate access to vaccine information or the ability to comprehend scientific evidence on vaccinations. Cultural misunderstandings and feelings of discrimination may be an additional barrier to having satisfactory vaccination conversations with doctors (see Harris et al., 2012, 2019; Jansen et al., 2008). Due to the impact of colonization and ongoing systematic racism, Māori are especially likely to report negative experiences with, or perceptions of, health or government authorities (Jansen et al., 2008). Such perceptions can decrease their level of trust in health professionals and the vaccinations they recommend. On the other hand, high vaccination coverage among Asian New Zealanders has been linked to their general positive attitudes towards immunisations and encouragement of immunisation service use, fewer barriers to healthcare access, and awareness of vaccine importance (Pal et al., 2014).

Exposure to information discouraging vaccination is another important barrier to child vaccination decisions among New Zealand parents (Grant et al., 2011; Petousis-Harris et al.,

2012). Receiving negative vaccine information was found to reduce the likelihood of timely vaccination uptake, regardless of whether one had also received positive vaccine information (Veerasingam et al., 2017). The stronger impact of negative information is a worrying finding as many parents search online for vaccine information and are thus prone to encounter anti-vaccine messages (Kata, 2012). To illustrate, a google search using the phrase: "Should I vaccinate my child NZ" lead to seven pro-vaccination websites, but two were anti-vaccine websites and the other two claimed to present a balanced view of both sides (Allen & Clarke, 2019). Moreover, anti-vaccination groups in New Zealand continue to disseminate information discouraging vaccination to the public, engendering doubts about vaccine safety. This includes the 2017 screening of the anti-vaccine film '*Vaxxed: from cover-up to catastrophe*' in Northland, which led to reductions in up-to-date vaccination coverage of under 5-year olds in that region (79.9% in Dec 2016 to 65% in Dec 2017; Allen & Clarke, 2019).

Despite having relatively high vaccination coverage rates, a considerable proportion of the New Zealand population hold doubts about vaccine safety. The 2013 New Zealand Attitudes and Values Study (NZAVS) indicated that 68.5% of the New Zealand population were confident in the safety of standard childhood vaccinations, whereas 26% showed moderate and 5.5% showed low confidence (Lee et al., 2017). Māori individuals and those living in more deprived areas showed lower confidence than counterparts (Lee et al., 2017), suggesting that low confidence in vaccine safety may be contributing to lower vaccination uptake among these groups. Women, parents, those less educated, people lower on Conscientiousness and Agreeableness, but higher on Openness and subjective health satisfaction also exhibited lower confidence in vaccine safety (Lee et al., 2017). In addition to disparities in vaccination coverage, these findings indicate that there are various groups in New Zealand that exhibit lower confidence in vaccine safety and require target interventions.

Lower confidence in vaccine safety among women is particularly concerning as mothers generally take the lead in making decisions about their child's vaccinations (Litmus, 2013).

Health professionals have a vital role in alleviating vaccine safety concerns and promoting vaccinations to New Zealanders. Building trusting doctor-patient relationships and ensuring that health professionals are sufficiently trained to communicate effectively with vaccine-hesitant parents are important strategies to encourage vaccination uptake (Rumball-Smith & Kenealy, 2016; Turner et al., 2017). However, there appears to be a lack of vaccine knowledge or confidence among some New Zealand health professionals, which may hinder their ability to address parental vaccination concerns adequately. A 2004 survey of health professionals in Rotorua (N=188) found that although most were supportive of vaccinations, 11% believed and 17% were unsure whether 'immunisations had unacceptable dangers' (Jelleyman & Ure, 2004). Disparities in vaccination perceptions between different groups of health professionals were also noted. While 80% of nurses and doctors disagreed or strongly disagreed that 'immunisations have unacceptable dangers', only 45% of midwives disagreed (Jelleyman & Ure, 2004). Moreover, a higher proportion of nurses (41%) and midwives (45%) were uncertain that 'MMR is implicated as a cause of autism and/or Crohn's disease' relative to doctors (21%).

Summary and overview of studies

Vaccine hesitancy poses a serious threat to global public health. Although there are diverse reasons for vaccine hesitancy, concerns about the risks and safety of vaccinations are repeatedly found to be among the top contributing factors (Giambi et al., 2018; Gidengil et al., 2019; Lane et al., 2018). Vaccine safety concerns have been exacerbated by the increased accessibility and ubiquity of anti-vaccination information online in recent years (Dubé, Vivion, & MacDonald, 2015). Although there are individual differences in susceptibility to misinformation, even brief exposures to anti-vaccine content can spur doubts and decease

one's likelihood of vaccination uptake (see Betsch et al., 2010). One's level of vaccine knowledge, relationship with health professionals as well as cultural or contextual factors influence their perception of vaccine safety. Given that the shaping of people's vaccination attitudes can differ across countries (see Lane et al., 2018; Larson et al., 2016), it is vital to investigate the level of confidence in vaccine safety and determinants of vaccine safety perceptions within a specific country. Such research would enable the identification of high-risk groups with greater doubts about vaccine safety within the localized context of that country and the most culturally appropriate strategies to improve public perceptions of vaccine safety.

Presently, there is a lack of up-to-date New Zealand studies on public perceptions of the safety of standard childhood vaccinations. In comparison to research on vaccination coverage (e.g., Charania et al., 2018; Grant et al., 2010; Mueller et al., 2010), fewer studies have focused on the vaccine safety perceptions of New Zealanders, especially at a population level. It is imperative to advance research in this area, as compliance with vaccinations does not necessarily indicate strong confidence in vaccine safety. Those who currently vaccinate their children may still have lingering doubts about vaccine safety and decline vaccinations in the future if their concerns are not adequately addressed. Using a national sample of New Zealand adults, the four studies in this thesis intend to increase insight into New Zealanders' confidence in the safety of standard childhood vaccinations and inform the development of vaccination interventions. The following section provides an outline of the specific research gaps that each study aims to address:

(1) Despite repeated findings that health professionals have a vital influence on parental vaccination attitudes (e.g., Chow et al., 2017; Freed et al., 2011; Giambi et al., 2018; Stefanoff et al., 2010), limited studies have assessed vaccine safety perceptions among different groups of health professionals in New Zealand. The previous study on health

professionals in Rotorua (Jelleyman & Ure, 2004) was conducted back in 2004 and only focused on one region of New Zealand. As vaccination safety perceptions can change over time, updated research on the vaccine safety perceptions of health professionals is needed to identify whether certain groups continue to exhibit greater doubts about vaccine safety. Study one of this thesis uses data from the 2013 NZAVS to assess the level of confidence in vaccine safety among health professionals. Extending on past studies, it investigates differences in vaccine safety perceptions between a broader range of health professionals across the whole country. This includes doctors, nurses, pharmacists, dentists, practitioners of alternative medicine, and midwives. This study aims to identify whether all health professionals exhibit strong confidence in vaccine safety or if there are specific groups that exhibit low confidence and require focused training or additional resources about vaccine safety.

(2) Persistent disparities in healthcare access and vaccination coverage have been noted across the four major ethnic groups in New Zealand (European, Māori, Pacific and Asian; MOH, 2019b, 2020b). Māori and Pacific peoples are typically found to experience greater barriers to healthcare access and lower vaccination uptake. However, little is known about the differences in perceptions of vaccine safety or key predictors of these perceptions across ethnic groups. As each ethnic group has a unique history, cultural values and health beliefs (Jansen et al., 2008; Medical Council of New Zealand, 2017; Wong, 2015), they are likely to have differing views of vaccinations and reasons for vaccine safety concerns. Due to disparities in level of trust in and experiences with health professionals, the degree of influence that doctors have on the vaccine safety perceptions of those with different ethnic backgrounds may also differ. To increase insight into this ethnic disparity, Study two investigates the level of confidence in vaccine safety and differential predictors of vaccine safety perceptions among European, Māori, Pacific and Asian New Zealanders. In addition to general demographic factors, we include perceptions of GP ethnic similarity, GP cultural

respect and general GP satisfaction as predictors in our study. Findings from this study will guide future research on the development of tailored interventions for specific ethnic groups.

(3) Most of the literature on vaccination attitudes to date has largely focused on mothers' attitudes. Consequently, less is known about fathers' perceptions of vaccinations and their role in the vaccination decision-making process, especially within the context of New Zealand. Previously, women were found to exhibit lower confidence in vaccine safety (Lee et al., 2017), and maternal antenatal vaccination intentions showed a stronger association with timely infant immunisation than paternal vaccination intentions (Grant et al., 2016). Given these findings, it is important to investigate the extent to which low confidence in vaccine safety among mothers may influence their child's likelihood of vaccination uptake and whether mothers' vaccine safety perceptions may override the influence of fathers' perceptions. To address this gap in research, Study three uses a sample of 68 New Zealand couples to investigate the differential influence of mothers' and fathers' level of confidence in vaccine safety on whether their children are fully vaccinated. This study aims to increase insight into the differential role of each parent in making child vaccination decisions and inform the development of target interventions for both mothers and fathers.

(4) Perceptions of vaccine safety are not static and can change over time based on various events at different time points (see Dubé, Vivion, & MacDonald, 2015). It is thus essential to monitor changes and consistencies in public views of vaccinations over time. A considerably high proportion of New Zealanders express doubts about vaccine safety (Lee et al., 2017) and anti-vaccine information has become increasingly accessible online (Dubé, Vivion, & MacDonald, 2015). Yet, previous studies have not investigated New Zealanders' perception of vaccine safety using longitudinal data. Study four bridges this gap in the literature by examining the trajectory of New Zealanders' level of confidence in vaccine safety over a period of 5 years (2013-2017). As there are important group differences in

perceptions of vaccinations, this study investigates whether New Zealanders collectively show increasing or decreasing confidence over time or whether there are distinct subpopulations with differing trajectories of confidence level. On the occasion that multiple subpopulations are identified, the demographic profile of these subpopulations will also be examined. This study aims to understand changes in the level of confidence in vaccine safety at a population level and identify groups at higher risk of holding persistent or increasingly negative views of vaccine safety over time.

Bridging statement

The following chapters each present the four studies outlined in Chapter One. Chapter Two presents the first of these studies. As reviewed in Chapter One, 68.5% of the New Zealand public showed strong confidence in the safety of standard childhood vaccinations (Lee et al., 2017). However, it is yet unknown whether health professionals collectively show the same level of confidence in vaccine safety or whether there are important differences in confidence levels between distinct groups of health professionals. To address this research gap, Study one investigates the level of vaccine confidence among various classes of health professionals in New Zealand. This includes GPs/doctors, pharmacists, dentists, nurses, midwives, and practitioners of alternative medicine.

The research article that follows is the author's copy of a manuscript published in the New Zealand Medical Journal. Please see:

Lee, C. H. J., Duck, I., & Sibley, C. G. (2018). Confidence in the safety of standard childhood vaccinations among New Zealand health professionals. *The New Zealand Medical Journal, 131*(1474), 60-68.

CHAPTER TWO

Confidence in the safety of standard childhood vaccinations among health professionals in New Zealand

Introduction

Skepticism about the safety of childhood vaccinations is an issue of pressing concern (Dubé, Vivion, & MacDonald, 2015). Despite the abundance of comprehensive and reliable scientific evidence on the safety and effectiveness of standard vaccinations (Plotkin et al., 2009; Velzquez et al., 2017; Vichnin et al., 2015), many parents continue to express fear and mistrust of vaccinations (Dubé, Vivion, & MacDonald, 2015). Such skepticism may be fostered or enabled by the increased accessibility of pseudo-scientific anti-vaccination information online and previous fraudulent studies on vaccinations (Dubé, Vivion, & MacDonald, 2015). This includes Andrew Wakefield's now retracted study on the unwarranted link between the Measles, Mumps and Rubella vaccine (MMR) and autism (Deer, 2011). In order to maintain high vaccination coverage, it is essential to correct current misconceptions about vaccinations and increase vaccine confidence among the general public.

Health professionals have crucial impact on parental decisions regarding their children's vaccinations. Numerous studies suggest that physician recommendation and positive communication with doctors are associated with an increased likelihood of vaccination uptake (Gargano et al., 2013; Marlow et al., 2007; Smith et al., 2006; Swennen, et al., 2001). Smith et al. (2006) found that parents who express vaccine safety concerns were much more likely to vaccinate their child when their decisions were influenced by their health professional. Hence, it is essential to ensure that health professionals have strong vaccine confidence and an accurate vaccine knowledge to positively influence parental vaccination decisions.

Vaccinations in the context of New Zealand

The New Zealand National Immunisation Schedule offers publicly funded vaccinations to all New Zealanders at various recommended ages (Ministry of Health [MOH], 2020a). This includes the influenza and whooping cough vaccine for pregnant women, and rotavirus and Diphtheria-Tetanus-Pertussis vaccine for babies 6-weeks after

birth. Immunisation Coverage for children who turned one of the milestone ages during 2017 are relatively high (from 78.7% to 93.4%), but a small subset (around 4%) of parents continue to decline at least one vaccination every year (MOH, 2020b). Somewhat in line with these coverages rates, a recent study using data from the 2013/14 NZAVS found that the majority of New Zealand adults (68.5%) strongly agree that the standard vaccinations following the National Immunization Schedule are safe, but 26% express uncertainty and 5.5% are strongly opposed (Lee et al., 2017).

Unsurprisingly, parents who receive discouraging information on vaccinations are less likely to immunise their children (Growing Up in New Zealand, 2015; Petousis-Harris et al., 2012). The Growing Up in New Zealand Study (2015) found that information which encourages vaccinations did not increase the likelihood of timely vaccination uptake, suggesting that exposure to negative information has a particularly salient impact on parental vaccination decisions. On the contrary, Wroe et al. (2005) found that, in comparison to parents who received standard immunisation information, those who received more sophisticated decision-making aids showed a significantly higher likelihood of timely immunisations and decreased risk perceptions of vaccinations. This finding suggests that the comprehensiveness and adequacy of the way in which positive vaccination information is provided determines its impact on parental vaccination decisions.

Health professionals in New Zealand

Similar to past international research (Gargano et al., 2013; Swennen et al., 2001), earlier New Zealand studies suggest that characteristics or attitudes of health professionals influence parental decisions on childhood vaccinations (Grant et al., 2011; Petousis-Harris et al., 2005, Petousis-Harris et al., 2012). For instance, the belief that parental apathy is a barrier to immunisation among nurses has been associated with increased timeliness of vaccinations (Petousis-Harris et al., 2012), and practices with doctors who were confident in their

vaccination knowledge had higher vaccination coverage (Grant et al., 2011). As the way in which health professionals present pro-immunisation information is likely to determine its effectiveness, it is vital they have sufficient vaccine knowledge and can adequately communicate their confidence in vaccine safety to encourage parents to vaccinate their children.

Previous studies indicate inconsistencies in perceptions of vaccinations across different classes of health professionals in New Zealand. A 2002 survey on health professionals in Rotorua (*N*=200) which assessed participants' level of agreement to various statements about immunisations (1= strongly disagree, 5= strongly agree) found that most health professionals agreed that childhood immunisations should be recommended (95%, Jelleyman & Ure, 2004). However, 41% of nurses (35/86), 45% (13/29) of midwives and 21% of doctors (16/76) were unsure whether the MMR vaccine is 'implicated as a cause of autism and/or Crohn's disease.' Moreover, while 80% of doctors and nurses disagreed that 'immunisations have unacceptable dangers,' only 45% of midwives disagreed with 28% being uncertain and 28% agreeing (Jelleyman & Ure, 2004). In other studies, General Practitioners (GPs) identified inaccurate vaccine information distributed by midwives as a barrier to childhood vaccination (Petousis-Harris et al., 2004), and a higher proportion of pregnant women reported receiving vaccine discouraging information from midwives (11%) compared to GPs (3%; Growing Up in New Zealand, 2015). Yet, a greater number of mothers also reported receiving vaccine encouraging information from their midwife (62%) compared to GPs (36%, Growing Up in New Zealand, 2015).

Extending on past research, the current study leverages data from the 2013/14 New Zealand Attitudes and Values Study (NZAVS) to directly assess up-to-date differences in levels of confidence in the safety of standard immunisations across different classes of health professionals in New Zealand. In line with international research (e.g., Ren et al., 2018;

Rozbroj et al., 2019; Shui et al., 2005), Lee et al. (2017) found that demographic factors have significant influence on New Zealanders' level of confidence in vaccine safety. We will thus investigate whether differences in confidence levels remain significant after controlling for a range of key demographic variables. This allows us to capture the more unique impact of healthcare occupation on vaccine safety perceptions, rather than differences that may arise due to individual characteristics (e.g., gender, age ethnicity, religiosity). We aim to identify which classes of health professional's exhibit strong confidence in vaccine safety, and which classes may require greater access to training and resources about vaccine safety.

Methods

Sampling procedure

The NZAVS is a longitudinal panel study with a probability sample of New Zealand adults. This study is reviewed by The University of Auckland Human Participants Ethnics Committee every 3 years and has most recently been approved on 03-June-2015 until 03-June-2018 (014889). Time 1 (2009) wave of the NZAVS was initially sampled from the electoral roll (response rate: 16.6%), with various booster samples collected during Time 3 (2011), 4 (2012) and 5 (2013) to increase representativeness of our sample (Sibley, 2020). The current study employed the Time 5 sample containing 18,261 participants (retention rate from Time 4: 81%), specifically focusing on health professionals who completed the item assessing level of confidence in vaccine safety (N=1032).

Participants

As seen in Table 1, most health professionals in our sample were European (86.7%) and female (84.1%). The median age for all health professionals was 48 years (SD = 11.76). Doctors who listed a speciality other than GP ($150,000) and those describing their occupation as GP or simply 'doctor' ($120,000) had the highest median personal income,

whereas midwives ($50,000) and practitioners of alternative medicine ($52,000) had the lowest median income.

Measures

Occupation was assessed using the open-ended question "What is your occupation?" Health professionals were identified using the statistical standard provided by the Australian and New Zealand Standard Classification of Occupations (Statistics New Zealand, 2013a). This measure was validated by matching participants' self-reports against their occupation as listed in the original sample frame drawn from the electoral roll. We then created our own coding scheme within this Level 3 tier to classify health professionals into the 11 categories described in Table 1. Participants simply listing 'doctor' as their occupation were included in the GP category, as more specific information about their medical speciality was not available. Doctors listing a specific speciality other than GP (e.g., anaesthetist, surgeon) were grouped into a category representing 'other specialist doctors.' Participants were also asked to provide information about their demographic characteristics.

Confidence in vaccine safety was assessed using the Likert item (1 = Strongly Disagree, 7 = Strongly Agree); "It is safe to vaccinate children following the standard NZ immunization schedule." This item was developed for the NZAVS in consultation with medical professionals (Lee et al., 2017) and is referred to as a measure of 'vaccine confidence' in this study.

Statistical analyses

A one-way ANOVA was conducted to assess mean differences in levels of vaccine confidence across different classes of health professionals. This was followed by an ANCOVA which included participants' age, gender, ethnicity, parental and partner status, religiosity and region of residence as covariates. Lastly, a Chi-square test was conducted to investigate

differences in proportions of strong vaccine confidence across the different classes of health professional. All analyses were conducted on SPSS.

Results

Analysis of mean differences

The ANOVA assessing differences in agreement with the Likert item "It is safe to vaccinate children following the standard NZ immunization schedule" across the 11 classes of health practitioners was significant ($F_{(10,1021)}$=18.64, p < .001, partial eta squared = .154). Observed power for the F-ratio was > .99. Mean levels of vaccine confidence for each class of health professionals are presented in Figure 1.

GPs expressed the highest level of agreement that vaccinations following the standard schedule were safe (M = 6.84). Bonferroni post-hoc tests[2] indicated that midwives expressed significantly lower levels of belief in the safety of vaccinations relative to GPs (p <.001), pharmacists (p <.001), nurses (p =001), dentists (p = .01), physiotherapists (p = .005), and other specialist doctors (p = .025). Midwives' mean level of belief in the safety of vaccinations following the standard schedule was (M = 5.30) was marginally lower than that of the general population (M = 5.72). However, this was not a significant difference.

Practitioners of alternative medicine (e.g. homeopathy and osteopathy) expressed the lowest level of vaccine confidence (M = 3.18). Bonferroni post-hoc tests indicated that they showed significantly lower agreement that vaccinations are safe relative to all other classes of health professionals (p <. 001).

[2] We opted to use Bonferroni post-hoc tests for both our ANOVA and ANCOVA to stay consistent across models. However, it is important to note that there were slight differences in results between Bonferroni and Games Howell post-hoc tests for the ANOVA when covariates were not included. The Games Howell test does not assume that group have equal variances. Midwives only showed significantly lower levels of vaccine confidence compared to GP's, pharmacists, dentists and physiotherapists when conducting a Games Howell post-hoc test.

The ANCOVA assessing differences in levels of vaccine confidence across health professionals was significant ($F_{(10, 958)}$=16.57, p < .001, partial eta squared = .147). Observed power for the overall F-ratio was > .99. Age, gender, ethnicity (Māori, Asian, Pacific or European), parental and partner status, religiosity and region of residence were included as covariates. GP's continued to show the highest mean level of vaccine confidence (M = 6.78), while Midwives (M = 5.53) and Practitioners of Alternative Medicine (M= 3.13) showed the lowest level of confidence. Bonferroni post-hoc tests indicated that midwives expressed significantly lower vaccine confidence relative to GPs (p <.001) and pharmacists (p = .008). However, practitioners of alternative medicine continued to show significantly lower levels of vaccine confidence compared to all other health professionals (p<. 001).

Strong vaccine confidence

The number of participants who selected each rating on our measure of vaccine confidence is presented in Table 2. The distribution of confidence in vaccine safety tended to be skewed toward strong agreement for most classes of health professionals. Following the coding scheme proposed by Lee et al., (2017), ratings of 6 or 7 on the vaccination item were described as *strong vaccine confidence.* A chi-square test indicated that there were reliable differences across the classes of health professional in strong support for vaccinations ($\chi^2_{(10;\, N = 1032)}$ = 107.73, p < .001). As shown in Figure 2, GPs exhibited the highest proportion of strong vaccine confidence (96.7%), while practitioners of alternative medicine (13.6%) and midwives (65.1%) showed the lowest proportions.

Table 2.1. Demographic details of participants within each class of health professionals and the full sample of participants in the 2013 wave of the New Zealand Attitudes and Values Study.

	Female		European		Religion		Urban		Age		Personal Income	
	N	%	N	%	N	%	N	%	Median	SD	Median	SD
GPs	68	55.7%	99	81.1%	48	41.0%	74	69.8%	45.00	12.44	$120,000	$106,595
Pharmacists	32	74.4%	33	76.7%	24	58.5%	29	67.4%	45.00	13.45	$72,000	$46,242
Dentists/Dental Surgeons	17	58.6%	25	86.2%	9	32.1%	23	82.1%	45.00	13.29	$112,500	$99,028
Doctors - Other Specialists	14	43.8%	29	90.6%	10	31.3%	25	78.1%	51.10	9.31	$150,000	$137,497
Physiotherapists	51	85.0%	55	91.7%	18	31.0%	46	78.0%	41.00	10.85	$50,000	$29,109
Nurses	495	94.5%	457	87.2%	236	47.3%	328	63.0%	50.00	11.51	$58,000	$22,796
Radiographers	23	85.2%	27	100.0%	9	33.3%	20	76.9%	41.00	12.38	$80,000	$21,745
Health Professionals - Other	85	78.0%	92	83.6%	48	41.0%	74	69.8%	45.50	12.03	$59,000	$27,903
Occupational Therapists	21	100.0%	21	95.5%	7	33.3%	15	68.2%	52.00	9.08	$63,000	$20,097
Midwives	43	100.0%	38	88.4%	17	44.7%	28	65.1%	50.00	11.47	$50,000	$29,716
Practitioners of Alt. Medicine	20	90.9%	21	95.5%	3	13.6%	16	72.7%	45.50	9.98	$52,000	$21,452
Total - Health Professionals	870	84.1%	897	86.7%	429	43.2%	692	67.8%	48.00	11.76	$62,000	$67,535
Total - Full Sample	11,460	62.80%	15,607	85.50%	6,879	39.40%	12,151	67.20%	49.00	14.07	$48,000	$52,470

Note: ‘N’ and ‘%’ refer to the number of people classified within each demographic category for the different classes of health professionals. The median age and median personal income for people within each class of health professionals, all health professionals together and the full sample of the 2013/14 NZAVS (including health professionals) are also reported.

Table 2.2. Descriptive statistics for ratings of agreement with the Likert scale item "It is safe to vaccinate children following the standard NZ immunization schedule" among different classes of health professionals and in the full sample of participants in the 2013 wave of the New Zealand Attitudes and Values Study.

	Mean	SD	Lower 95% CI	Upper 95% CI	N	Percent Support	Frequency count of Likert scale ratings (1 = Strongly Disagree, 7 = Strongly Agree)						
							1	2	3	4	5	6	7
GPs	6.84	0.49	6.74	6.92	122	96.7%	0	0	0	1	3	11	107
Pharmacists	6.65	0.72	6.41	6.85	43	90.7%	0	0	0	1	3	6	33
Dentists/Dental Surgeons	6.48	1.15	5.96	6.86	29	86.2%	0	1	0	1	2	3	22
Doctors - Other Specialists	6.38	1.41	5.77	6.84	32	87.5%	1	0	1	2	0	4	24
Physiotherapists	6.33	1.05	6.04	6.60	60	85.0%	0	0	3	1	5	15	36
Nurses	6.22	1.34	6.10	6.34	524	83.6%	9	11	13	23	30	119	319
Radiographers	6.19	1.24	5.66	6.64	27	77.8%	0	0	2	1	3	5	16
Health Professionals - Other	5.83	1.60	5.52	6.13	109	72.5%	3	4	5	8	10	25	54
Occupational Therapists	5.62	1.91	4.63	6.40	21	81.0%	2	0	2	0	0	9	8
Midwives	5.30	1.77	4.74	5.81	43	65.1%	2	3	3	3	4	17	11
Practitioners of Alt. Medicine	3.18	1.89	2.41	4.00	22	13.6%	6	3	4	3	3	2	1
Population estimate	5.71	1.54	5.69	5.73	18154	68.5%	543	455	664	2054	2010	4885	7543

Notes. The estimate of 'percent support' represents the percentage of people rating a '6' or '7' (i.e., strong agreement) with the Likert scale item "It is safe to vaccinate children following the standard NZ immunization schedule." The confidence intervals represent bias corrected and accelerated estimates of the 95% interval of the mean using 5000 bootstrap resamples. After applying the standard NZAVS post-stratification sample weighting adjustment the population estimate was 5.72 and associated 95% confidence interval was 5.70, 5.74 (These estimates are different to the values presented in the table as bootstrapping was not possible in conjunction with weighting).

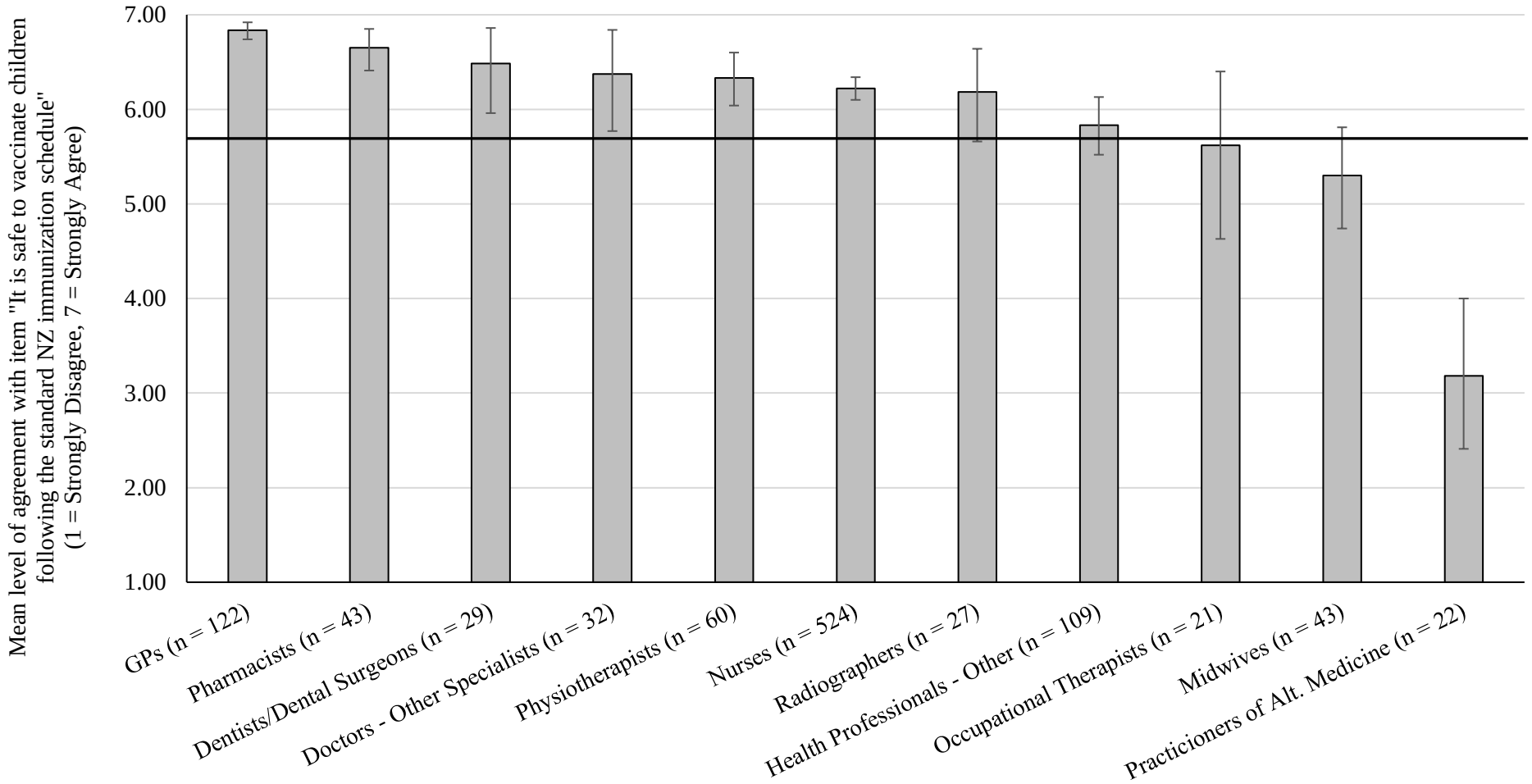

Figure 2.1. Mean level of agreement with the Likert item "It is safe to vaccinate children following the standard NZ immunization schedule" for different classes of health professional. (Note. Error bars represent bias corrected and accelerated estimates of the 95% confidence interval of the mean using 5000 bootstrap resamples. The bold horizontal line represents the estimated population mean level of vaccine confidence. The population estimate is based on all respondents in the 2013 wave of the NZAVS (N = 18153) and applying the standard NZAVS post-stratification sample weighting adjustment).

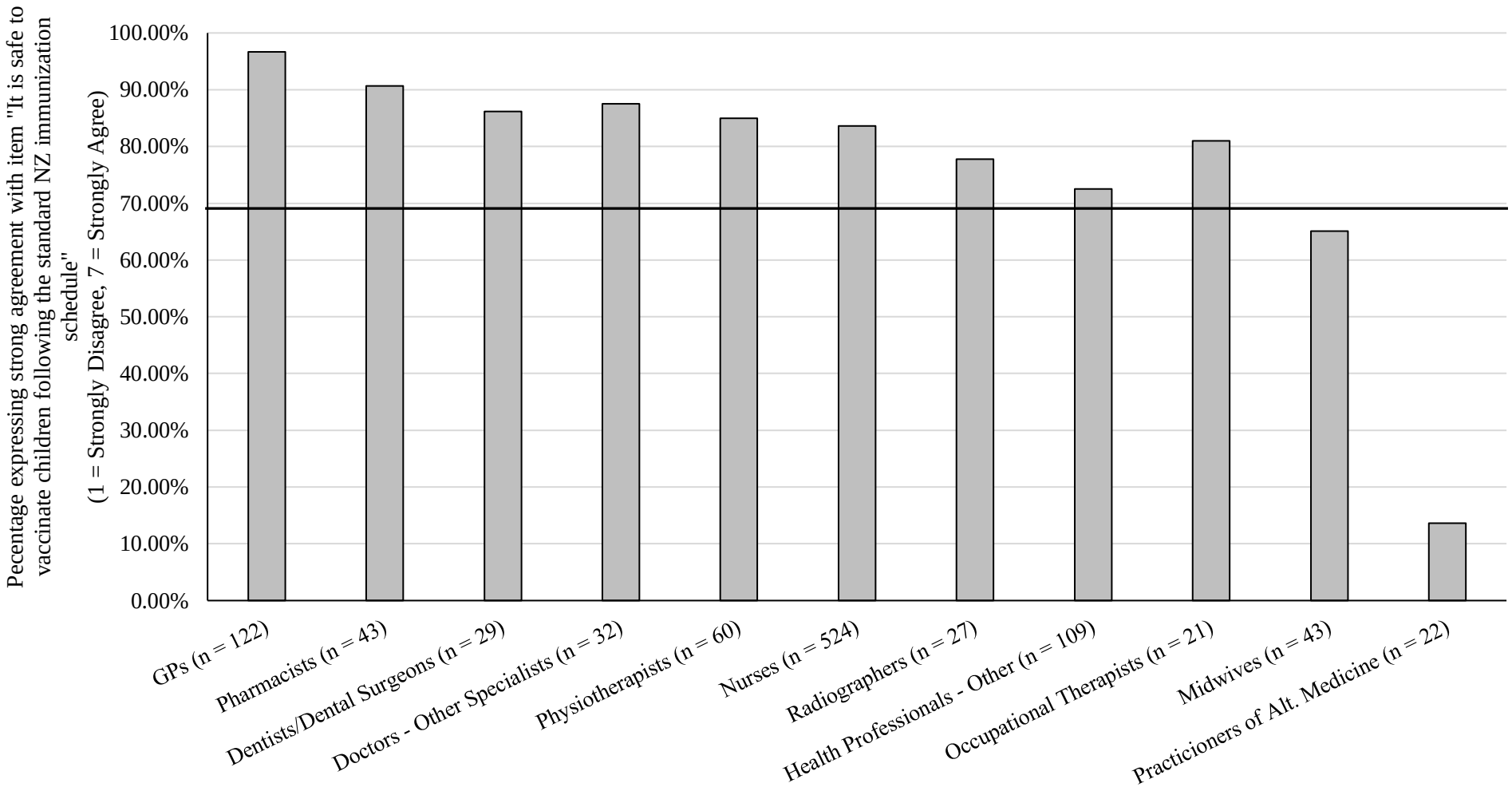

Figure 2.2. Percentage of different classes of health professional expressing strong support (rating of 6 or 7) on the Likert item "It is safe to vaccinate children following the standard NZ immunization schedule." (Note: The bold horizontal line represents the estimated percentage of the population expressing strong support. The population estimate is based on all respondents in the 2013 wave of the NZAVS (N = 18153) and applying the standard NZAVS post-stratification sample weighting adjustment).

Discussion

The current study used data from the 2013/14 NZAVS to investigate the level of confidence in the safety of standard childhood vaccinations among different classes of health professionals. We found that GPs (96.7%), pharmacists (90.7%) and dentists (86.2%) exhibited the highest levels of strong vaccine confidence, while midwives (65.1%) and practitioners of alternative medicine (13.6%) exhibited the lowest level of strong confidence. As reported by Lee et al. (2017), the 2013/14 NZAVS data suggests that the majority of New Zealanders believe in the safety of vaccinations (68.5%). Although most health professionals exhibit considerably higher levels of vaccine confidence compared to the general public, practitioners of alternative medicine show substantially lower and midwives show marginally lower levels of strong confidence.

Irrespective of whether we controlled for key demographic factors, practitioners of alternative medicine showed a significantly lower mean level of vaccine confidence compared to all other health professionals (see Appendix A for effect sizes). Moreover, midwives showed a significantly lower level of confidence compared to most other health professionals and continued to exhibit lower confidence than GPs and pharmacists after controlling for demographic factors. This finding is consistent with previous studies in which a greater proportion of midwives were found to exhibit vaccine safety concerns or distribute negative vaccine information (Growing Up in New Zealand, 2015; Jelleyman & Ure, 2004). The large effect size of our analyses suggest that the type of occupation held by a health professional has important influence on their level of vaccine confidence. Further research is needed to gain a more accurate understanding of the specific factors, such as differences in vaccination education or working environments that may be driving these disparities in confidence.

Interestingly, the mean level of confidence in vaccine safety closely followed the mean income level of health professionals. Health professionals that showed the highest confidence

in vaccine safety (i.e., GPs, pharmacists, specialist doctors, dentists) were on the higher end of the income scale, while those with the lowest confidence (i.e., midwives, alternative practitioners of medicine) were on the lower end of the scale. As the current healthcare system is founded on a biomedical model of health (Sheridan et al., 2011; Simmonds et al, 2020), healthcare jobs that use Western medicine to diagnose and/or treat physical illnesses tend to receive higher income. These professions require extensive medical knowledge which is based on scientific research and focus on managing and preventing diseases or ill health (see The Royal New Zealand College of General Practitioners [NZCGP], 2014). Hence, GPs, pharmacists and specialist doctors may exhibit greater trust in science and strongly support vaccinations, an evidence-based Western medical practice, that reduces the risk of diseases. On the other hand, philosophies of midwifery and alternative medicine are based on 'natural' processes and empowering patients (Attwell et al., 2018; Hoenders et al., 2008). These groups are more likely to be concerned about individualised or minor risks of vaccinations and believe that parents should be given the autonomy to make their own vaccination decisions.

Strong vaccine confidence among GPs

According to Freed et al. (2011), most parents tend to view their children's doctors as a highly trusted source of vaccine information. Parents are more likely to vaccinate their children when their doctor is confident in their vaccine knowledge and take their vaccine concerns seriously (Grant et al., 2011; Marlow et al., 2007; Petousis-Harris et al., 2005). Hence, the consensus of belief in the safety of vaccinations among New Zealand GPs is an encouraging finding that is likely to have a positive impact on parental vaccination decisions. If GPs can adequately communicate their confidence in vaccine safety, they may be able to encourage parents who are skeptical of vaccines to immunise their children.

Simply distributing information about vaccine safety does not appear to be the best strategy to promote vaccinations (Horne et al., 2015; Litmus, 2015). To sufficiently influence

parental vaccination attitudes, Wroe et al. (2004) suggest that it is important to address omission bias; the tendency of people to exhibit greater fear regarding the harm resulting from action (i.e. immunisation) than from inaction (i.e. non-immunisation). Accordingly, providing parents with a comprehensive information aid that addressed omission bias, and enabled more accurate comparisons between the risks of adverse immunisation side effects versus serious illnesses was found to increase positive perceptions of vaccinations and the likelihood of timely vaccinations (Wroe et al., 2005). Thus, it may be useful to inform and train health professionals about how to effectively convey their confidence in vaccine safety and emphasize the risks of not immunising.

Additionally, explicitly stating to parents the statistic that '96.7% of GPs agree that standard childhood vaccinations are safe' may help provide further reassurance to parents. In the context of climate change, people were found more likely to believe that climate change is real and caused by humans after being informed that the vast majority of climate scientists support this view (Lewandowsky et al., 2012). In a similar way, the fact that the view of GPs, a highly trusted source of vaccine information (Freed et al., 2011), are consistent with the large body of high-quality scientific research showing that standard vaccinations are safe (e.g. Plotkin et al., 2009; Velzquez et al., 2017; Vichnin et al., 2015) may help alleviate vaccine safety concerns among some parents.

Lower vaccine confidence among midwives

In contrast to GPs, only two in three midwives showed strong vaccine confidence in our study. The 2002 survey in Rotorua had also found that midwives show a wide spectrum of beliefs regarding the dangers of vaccinations (Jelleyman & Ure, 2004), suggesting that a fair proportion of midwives persistently exhibit uncertainty about vaccine safety. Perhaps due to this uncertainty, some midwives are hesitant about recommending vaccinations to mothers. A midwife interviewed by Litmus (2015) stated believing that it is up to parents to make

vaccination decisions, with another stating that they preferred not to be involved in such a controversial issue and desired more vaccination information. From the perspective of parents, while some reported having informed conversations with their midwife, others felt that their midwife did not sufficiently explain the benefits of vaccinations and therefore were not motivated to vaccinate their child (Litmus, 2015).

Midwives are chosen by most New Zealand women to be their lead maternity carer and are most directly involved with parents in the lead up to birth (MOH, 2017). As most parents make vaccination decisions during pregnancy (Growing Up in New Zealand, 2015), this is an important time to educate parents-to-be about the benefits of vaccinations. Hence, the relatively low level of vaccine confidence among midwives may have important implications for understanding the resistance to change of anti-vaccination attitudes in the population. Previously, Lee et al. (2017) found that skepticism about vaccine safety tends to be higher amongst Māori individuals, those living in rural areas, those with lower education and income, and those with higher subjective health and Openness to Experience. In addition to these factors, the lack of vaccine confidence among midwives may also be contributing to the persistence of public skepticism about vaccine safety in New Zealand.

Over the years, there has been a substantial improvement in vaccination coverage rates (Turner, 2012) and currently, there are numerous vaccination training courses available for health professionals (Immunisation Advisory Centre, 2017). However, the lower level of vaccine confidence among midwives suggests there is a need to provide increased resources for this particular group. Further research on the vaccination attitudes of midwives is crucial to more accurately assess the factors driving their vaccine beliefs and the impact that their attitudes have on parental vaccination decisions. Such findings will be useful in developing focused training protocols that address the specific concerns of midwives and increase their confidence in vaccine safety.

Limitations

As the current study used cross-sectional data and a single-item measure to assess vaccine confidence, we were unable to track changes in attitudes of health professionals over time or identify the reasons why they expressed high or low confidence. There may also have been disparities in the way health professionals interpreted the term 'safety'. Midwives may not regard vaccinations as entirely safe as they are concerned about any sort of harm caused by vaccinations, including minor side effects. Conversely, doctors may view transitory side effects of vaccinations as insignificant when compared to more serious health issues such as heart attacks or broken bones.

As noted by Robertson and Sibley (2018), people with different demographic characteristics (e.g., gender, occupation) are not equally likely to respond to the NZAVS. For instance, women and those with professional occupations tend to show higher response rates. This suggests that there may be some degree of response bias in our study, and certain groups may have been over-represented or more heavily determined the types of occupations held by those in our sample of health professionals. On the other hand, as the NZAVS does not solely focus on health-related issues or specifically target health professionals, health professionals are less likely to have made participation decisions based on their health beliefs or consciously answered questions in a way deemed appropriate for someone in their profession.

Concluding comments

Using data from the 2013/14 NZAVS, the present study investigated the level of confidence in standard childhood immunisations among New Zealand health professionals. Most health professionals, especially GPs (96.7%) and pharmacists (90.7%), showed high levels of strong vaccine confidence, but midwives (65.1%) and practitioners of alternative medicine (13.6%) exhibited relatively lower levels of strong confidence. The consensus of belief in the safety of vaccinations among GPs is an encouraging finding and could be used to

provide reassurance to vaccine skeptical parents. However, the low level of confidence among midwives is a major concern and may be contributing to the persistence of skepticism about vaccine safety among the general public. Further research is warranted to identify the most effective ways GPs can convey their vaccine confidence to parents, as well as how to increase vaccine confidence among midwives.

Bridging statement

Study one revealed notable differences in vaccine safety perceptions across different classes of health professionals in New Zealand. Whereas GPs (96.7%) and pharmacists (90.7%) showed high levels of strong confidence in vaccine safety, midwives (65.1%) and practitioners of alternative medicine (13.6%) exhibited substantially lower levels of strong confidence. As most New Zealand women choose midwives to be their lead maternity carer (Ministry of Health, 2017c), the low level of confidence among midwives is a particularly concerning finding. On a more positive note, our results indicate a consensus of belief in vaccine safety among GPs; those who are generally found to have a primary influence on parental vaccination decisions (Chow et al., 2017; Freed et al., 2011; Giambi et al., 2018).

Although the consensus of strong confidence in vaccine safety among GPs is an encouraging finding, little is known about potential differences in the degree to which GPs influence vaccine safety perceptions of those from distinct ethnic groups. Minority ethnic groups tend to encounter cultural or language barriers when communicating with their GP (Jansen et al., 2008; Mauri Ora Associates, 2010; Wong, 2015). Thus, they may have lower levels of GP satisfaction or may not regard GPs as their most trusted source of vaccine information. Moreover, distinct ethnic groups have a different set of health beliefs, cultural values, experiences, and expectations of healthcare (Harris et al., 2019; Jansen et al., 2008; MOH, 2007; Wong, 2015), and may also exhibit differing health information-seeking behaviour (Ball-Rokeach & Wilkin, 2009). As all these factors contribute to one's vaccine safety perception, there are likely to be important ethnic differences in the level and key determinants of confidence in vaccine safety. It is essential to understand these ethnic differences to develop target interventions that effectively improve vaccine safety perceptions among specific ethnic groups.

To bridge this gap in knowledge, Study two investigates disparities in perceptions of GPs and key predictors of level of confidence in childhood vaccine safety across the four main ethnic groups in New Zealand. Firstly, it assesses the level of general satisfaction with GP service, perceived GP cultural similarity, and GP cultural respect among Māori, Pacific, Asian and European New Zealanders. Subsequently, it assesses the correlation between confidence in vaccine safety and GP perceptions, along with healthcare access satisfaction and diverse demographic factors, among the four ethnic groups separately.

The research article that follows is the author's copy of a manuscript published in the Vaccine. Please see:

Lee, C. H. J. & Sibley, C. G. (2020). Ethnic disparities in vaccine safety attitudes and perceptions of family doctors/general practitioners. *Vaccine, 38*(45), 7024-7032.

CHAPTER THREE

Ethnic disparities in vaccine safety attitudes and perceptions of family doctors/general practitioners

Introduction

With declining vaccination rates and recurrent vaccine-preventable disease outbreaks worldwide, vaccine hesitancy has become one of the biggest threats to global public health (Strategic Advisory Group of Experts on Immunization, 2018; World Health Organization [WHO], 2019). Vaccine hesitancy is defined by WHO as the "reluctance or refusal to vaccinate despite the availability of vaccines" (WHO, 2019). Although there are a wide range of reasons for hesitancy (e.g. mistrust in government or pharmaceutical companies, disbelief in vaccine necessity or effectiveness), concerns about the risks and safety of vaccinations are frequently cited as one of the top contributors (Giambi et al., 2018; Gidengil et al., 2019; Lane et al., 2018). Doubts about vaccine safety continue to circulate among the public despite abundant scientific evidence on the safety and effectiveness of childhood vaccinations (DeStefano et al., 2019). Skeptical views of vaccine safety can be linked to multiple factors including exposure to anti-vaccine sentiments, religious beliefs, inadequate vaccine knowledge, low healthcare access and distrust in health professionals (Dubé, Vivion, & MacDonald, 2015).

As vaccine attitudes are influenced by many contextual and cultural factors, the level of and reasons for vaccine safety concerns can differ across countries and demographic groups (Stefanoff et al., 2010). A large-scale survey on 67 countries found that the global average of vaccine skepticism was 13% but this vastly varied across countries (0.2-45%) (Larson et al., 2016). In New Zealand, the 2013 New Zealand Attitudes and Values Study (NZAVS) found that 68.5% of the general public strongly agreed that standard childhood vaccinations are safe, while 26% were skeptical and 5.5% strongly disagreed (Lee et al., 2017). Having higher subjective health satisfaction and Openness to Experience, living rurally, being female, Māori (i.e. indigenous people of New Zealand), single, employed and not a parent was associated with reduced vaccine safety agreement. Conversely, higher

income and educational attainment, and being more Agreeable and Conscientious were associated with higher agreement.

Vaccinations and ethnic groups in New Zealand

The New Zealand Immunisation Schedule provides a series of publicly funded vaccinations to New Zealanders from 6 weeks to 65 years of age (Ministry of Health [MOH], 2020a, see Appendix B for full Schedule). High rates of immunisations are essential to protect the community and reduce the spread of infectious diseases (MOH, 2020a). The national target is ensuring that 95% of children are fully immunised according to the Schedule by 8 months. However, during the one-year period ending 30 June 2020, only 79%, 91%, 92%, 84%, 91% and 89% were fully immunised at each of the six childhood milestone ages respectively[3] (MOH, 2020a). Around 4 to 5% of parents declined any one vaccination at each milestone age during this period.

It is important to note that vaccination rates are not uniform across ethnic groups. Asian children typically show the highest rate of full vaccination status followed by European, Pacific and Māori children (MOH, 2020a). A qualitative study on Asian parents indicated that general positive attitudes towards immunisation, adequate healthcare access and high vaccine awareness appear to be linked to their high coverage rates (Pal et al., 2014). On the other hand, barriers to healthcare access, lack of vaccine knowledge, low confidence in vaccine safety and poor experiences with healthcare professionals (Jansen et al., 2008; Lee et al., 2017; Litmus, 2013; MOH, 2019b) are likely contributing to low vaccination rates among Māori.

Given that safety concerns are a major reason for vaccine hesitancy (Giambi et al., 2018; Gidengil et al., 2019; Lane et al., 2018), it is vital to monitor public perceptions of vaccine safety and understand the extent to which it threatens population vaccine acceptance

[3] The six childhood milestone ages are 6, 8, 12, 18 and 24 months, and 5 years.

and uptake. Investigating group differences in vaccine safety perceptions further enable us to identify target groups with greater vaccine safety concerns and/or in need of tailored interventions. Understanding group disparities can also inform the prioritization process of vaccination interventions, as addressing vaccine safety concerns among certain groups (e.g. women/mothers (Lee et al., 2017; Lee & Sibley, 2020a), those with less education (Lee & Sibley, 2020b) can have particularly important implications for improving childhood vaccination coverage.

Currently, little is known about differences in vaccine safety perceptions or key correlates of safety perceptions across ethnic groups in New Zealand. Each ethnic group has a unique history, set of health beliefs, cultural values, and distinct experiences of healthcare (Harris et al., 2019; Jansen et al., 2008; MOH, 2007, 2019b; Wong, 2015). Such disparities in characteristics and healthcare experiences can lead to important differences in level of confidence in vaccine safety, as well as the main determinants of vaccine safety perceptions. For instance, limited healthcare access and cognitive difficulty interpreting vaccine information due to lower education may lead to greater negative views of vaccine safety among Māori and Pacific peoples. Poor health literacy (MOH, 2010) and negative experiences with or perceptions of health professionals (Allen and Clarke, 2019) may also be important contributors to skeptical attitudes among Māori. Oppositely, European and Asian New Zealanders may express greater confidence in vaccine safety due to their greater healthcare access, higher education level and positive relationships with health professionals (MOH, 2019; Pal et al., 2014; Statistics New Zealand, 2015b). It is essential to increase insight into these ethnic differences to be able to develop target interventions that tailor to the specific needs and concerns of distinct ethnic groups.

The role of Family Doctors/General Practitioners

Family doctors/General Practitioners (GP) are primary health professionals that many New Zealanders most frequently interact with and receive health information from (MOH, 2020c). Across multiple countries, GPs are cited as parents' main source of vaccine information and are found to have positive influence on vaccination uptake (Chow et al., 2017; Freed et al., 2011; Kornides, Fontenot et al., 2018). However, different ethnic groups tend to have disparate health seeking behaviours (Ball-Rokeach & Wilkin, 2009), and experiences with healthcare services and GPs (Harris et al., 2019; Paine et al., 2018). As ethnic minorities in New Zealand often perceive that their GP lacks cultural competence and even report experiences of racism in healthcare (Harris et al., 2019; Jansen et al., 2008; Paine et al., 2018), it is likely that GPs are not perceived the same way by all ethnic groups. With the majority of New Zealand GPs (76%) identifying as being European (NZCGP, 2019), ethnic minorities may be less likely to regard their GP as a preferred or most trusted source of vaccine information due to cultural barriers. Perceptions that their GP does not share a similar cultural background or respect their cultural background may prevent one from having high-quality or satisfactory vaccine-related conversations with their GP. Low GP satisfaction or lack of perceived cultural respect may also have detrimental effects on patient-doctor relationships, leading to reduced confidence in the safety of vaccinations GPs recommend.

Stepping beyond standard demographic characteristics, the present study investigates the extent to which GP perceptions contribute to New Zealanders' level of agreement to the statement that "It is safe to vaccinate children following the standard New Zealand Immunisation Schedule." Rather than treating the population as a single homogenous group, we assess the differential influence of GP satisfaction, perceived GP cultural similarity, GP cultural respect, healthcare access and diverse demographic factors on vaccine safety perceptions across the four main ethnic groups in New Zealand (Māori, Pacific, Asian,

European). Gender, education, deprivation, region of residence, and partner and parent status were previously found to be significant correlates of vaccine safety perceptions (Lee et al., 2017), and were thus included as demographic covariates in our model. The effect of age, religiosity and being 'born in New Zealand' were also examined, as these characteristics have significant influence on the cultural values and healthcare expectations or experiences of minority ethnic groups (see Mauri Ora Associates, 2010; Metha, 2012).

As the overwhelming majority of New Zealand GPs (96%) are strongly confident in vaccine safety (Lee et al., 2018), it is highly unlikely that patients, especially those with strong anti-vaccine views, were able to select their GP based on whether they have similar views of vaccinations as themselves. Therefore, if GP perceptions do have a significant influence on vaccine safety perceptions, it would be reasonable to expect that positive GP perceptions will predict increases in level of vaccine safety agreement. Ultimately, our study aims to identify potential differences in the role that GPs as well as demographic factors have in shaping vaccine safety perceptions of distinct ethnic groups. Being the first New Zealand study to assess differences in the effect of such a broad range of variables, it seeks to provide a framework for future research on the key determinants of vaccine safety attitudes for specific ethnic groups.

Method

Sampling procedure

The NZAVS is a longitudinal panel study of a national probability sample of New Zealand adults. This study is reviewed by the University of Auckland Human Participants Ethics Committee every three years and has most recently been approved from 5 September 2017 until 3 June 2021 (Reference Number: 014889). In Time 1 (2009), the NZAVS recruited participants from the entire country by randomly selecting samples from the New Zealand electoral roll (response rate: 16·6%) (Sibley, 2020). A booster sample was later

recruited at Time 3 (2011) through an unrelated survey posted on the website of a major New Zealand newspaper. Further booster samples were recruited from the 2012 and 2014 Electoral Roll in subsequent Time periods. This study uses data from Time 9 (2017) NZAVS (N=17,072), which included items on participants' perception of vaccine safety and their family doctor/GP (See Appendix B for details on response and retention rates at each time point).

Participants

Time 9 participants (*N*=17,072) had a mean age of around 51 years (age range: 17-98) and median household income of $98,000.[4] Sixty three percent of the total sample were female, with 82.3% being European, 11.9 % being Māori, 1.9% being of Pacific and 3.9% being of Asian ethnicity (Prioritized ethnicity in following order: Māori, Pacific, Asian, European). Around 74% of participants were parents and 79.7% were born in New Zealand. Ninety one percent of participants had a regular family doctor/GP (Māori: 88.7%, Pacific: 87.5%, Asian: 86.6%, European: 91.3%). See Appendix B for details on sociodemographic characteristics of each ethnic group.

Measures

Vaccine safety perception. As in the 2013 NZAVS (Lee et al., 2017), vaccine safety perception was assessed using the likert item (1 = Strongly Disagree, 7 = Strongly Agree); "It is safe to vaccinate children following the standard NZ Immunisation Schedule." This item was developed for the NZAVS in consultation with medical professionals.

GP perception items. Participants were initially asked "Do you have a regular family doctor/GP" with a 'yes' and 'no' response. If they did have a regular GP, they were asked to rate on a scale of 1 to 7 to what extent (only first and last numbers of scale were labelled):

[4]The medium household income of New Zealanders in the 2013 NZ Census was $63,800.

(1) “Are you satisfied with the service and care you receive from your family doctor/GP?” (1=not satisfied, 7=very satisfied)

(2) “Do you think your doctor/GP shares a similar cultural background to you?” (1=definitely NO, 7=definitely YES)

(3) “Does your doctor/GP respect your cultural background when you are discussing health issues with them?” (1=definitely NO, 7=definitely YES)

Demographics. Participants were asked to report their demographic characteristics which included their gender, date of birth, ethnicity, region of residence and education level. Ethnicity was measured using the standard New Zealand Census item, in which participants could indicate each ethnic group they identified with. Education was coded into an 11-level ordinal variable (0 = No qualification, 1=level 1 Certificate [basic knowledge/skills for work] to 10 = doctoral degree) based on the ten tertiary qualification levels in New Zealand. Deprivation level was measured using the 2013 New Zealand Deprivation Index, which uses census information (e.g. home ownership, income, employment rate) to assign a decile-rank index from 1 (least deprived) to 10 (most deprived) to each small geographical area in New Zealand (Atkinson et al., 2014). Religion was coded as a binary variable (0 = non-religious, 1= religious).

Statistical Analyses

A wide range of demographic variables (e.g., age, gender, education level), healthcare access, GP satisfaction, GP similarity and GP cultural respect were simultaneously included as predictors of vaccine safety agreement in a series of multiple regressions. Vaccine safety perception (measured on a scale of 1 to 7) was used as the outcome variable. All items were used on their original scale of measurement. Separate regression analyses were conducted for European, Māori, Pacific and Asian peoples in a multi-group model representing the four ethnic groups. We limited our analyses to those who indicated that they have a regular family

doctor/GP. Missing data for exogenous variables were estimated using Rubin's procedure for multiple imputation. Final parameter estimates were obtained by averaging 10,000 imputed datasets (thinned using every 200th iteration) generated based on information in the existing data and random elements. Descriptive statistics were calculated on SPSS after applying standard NZAVS weighting procedure based on ethnicity and region of residence for males and females separately (see technical document for details; Sibley, 2017).

Results

Most New Zealanders expressed high vaccine safety agreement (ratings 6-7; 72%), whereas 23.3% expressed moderate (ratings 3-5) and 4.8% expressed low levels of agreement (ratings 1-2; see Table 1). The largest proportion of Europeans showed high vaccine safety agreement (74.7%), followed by Asian peoples (72.3%), Pacific peoples (65.8%) and Māori (59.4%). Māori showed a relatively higher proportion of low (8.3%) and moderate agreement (32.2%). Māori and Asian peoples reported a lower proportion of high satisfaction with healthcare access (both 63.9%) compared to Europeans and Pacific peoples (both 72%). Māori showed a particularly high proportion of low satisfaction (9.1% vs 4.9-5.6%).

As illustrated in Table 2, a higher proportion of Europeans reported having a GP with a highly similar cultural background (58%) compared to ethnic minorities (Māori: 26.8%, Pacific: 27.9%, Asian: 28.9%). Additionally, more Europeans were highly satisfied with the service provided by their GP (67.8%) and reported high GP cultural respect (74.1%). Pacific peoples reported a slightly greater proportion of high GP satisfaction (64.8%) and GP cultural respect (65.2%) relative to Māori (60.7% and 62.5% respectively) and Asian peoples (59% and 60.8% respectively). However, Pacific peoples also reported the highest proportion of low GP cultural respect (5.9%).

Table 3.1. Ethnic differences in level of agreement that childhood vaccinations are safe.

	Vaccine safety agreement						
	Low (1-2)		Moderate (3-5)		High (6-7)		Mean (SD)
	N	%	N	%	N	%	*N*
European	489	4.3	2370	21	8438	74.7	5.93 (1.42) *N* = 11297
Māori	167	8.3	645	32.2	1189	59.4	5.43 (1.68) *N*=2001
Pacific	37	5.0	219	29.2	494	65.8	5.74 (1.51) *N*=750
Asian	59	2.9	515	24.9	1497	72.3	5.93 (1.30) *N*=2072
Total	778	4.8	3807	23.3	11779	72.0	5.86 (1.46) *N*=16364

Note: Standard NZAVS sample weighting on gender, ethnicity and region of residence applied (see NZAVS technical documents for further details, Sibley, 2017).

Table 3.2. Healthcare access, GP similarity, GP satisfaction and GP respect across ethnic groups

	Healthcare access							GP similarity						
	Low		Moderate		High		Mean (SD)	Low		Moderate		High		Mean (SD)
	N	%	N	%	N	%	*N*	*N*	%	N	%	N	%	*N*
European	650	5.6	2619	22.4	8405	72.0	8.02 (2.09) *N* = 11673	1120	10.3	3431	31.7	6276	58.0	5.28 (1.73) *N* = 10828
Māori	193	9.1	572	27.0	1352	63.9	7.55 (2.42) *N*=2117	678	34.9	746	38.3	522	26.8	3.76 (2.09) *N* = 1946
Pacific	39	4.9	181	23.1	567	72.0	8.03 (2.18) *N*=787	279	38.5	244	33.6	203	27.9	3.68 (2.19) *N* = 726
Asian	120	5.5	660	30.6	1380	63.9	7.71 (2.12) *N*=2159	632	32.1	768	39.0	569	28.9	3.89 (2.05) *N* = 1969
Total	1016	6.0	4124	24.3	11860	69.8	7.91 (2.15) *N*=16999	2767	17.7	5261	33.6	7629	48.7	4.83 (1.97) *N*=15657

	GP satisfaction							GP cultural respect						
	Low		Moderate		High		Mean	Low		Moderate		High		Mean
	N	%	N	%	N	%	(SD)	N	%	N	%	N	%	(SD)
European	338	3.1	3122	29.0	7300	67.8	5.75 (1.42) *N*=10760	92	.9	2693	25.0	7982	74.1	6.02 (1.18) *N*=10767
Māori	106	5.5	649	33.8	1167	60.7	5.56 (1.50) *N*=1922	84	4.4	641	33.1	1210	62.5	5.64 (1.49) *N*=1936
Pacific	18	2.5	233	32.7	463	64.8	5.72 (1.36) *N*=714	43	5.9	211	34.8	475	65.2	5.70 (1.57) *N*=729
Asian	83	4.3	708	36.7	1138	59.0	5.44 (1.37) *N*=1930	80	4.1	688	35.2	1188	60.8	5.60 (1.40) *N*=1956
Total	557	3.6	4784	30.8	10177	65.6	5.68 (1.36) *N*=15517	303	1.9	4299	27.6	10967	70.4	5.90 (1.29) *N*=15569

Note: Healthcare access: low (0-3), moderate (4-7), high (8-10), All GP-related variables: low (1-2), moderate (3-5), high (6-7). Sample weighting applied.

Correlates of vaccine safety perception

Four separate regression analyses were conducted to assess the correlates of vaccine safety perception (i.e., agreement that childhood vaccinations are safe) among European, Māori, Pacific and Asian New Zealanders. We limited our analyses to those who indicated that they have a regular family doctor/GP. Only key findings are reported in-text (see Appendix B for detailed results).

Europeans

Increased healthcare access (B=.054), GP satisfaction (B=.082), GP similarity (B=.016) and GP cultural respect (B=.068) were associated with higher vaccine safety agreement. Men (B=.182), those with partners (B=.131), higher education (B=.060) and living in urban areas (B=.268) also expressed higher agreement. In contrast, older (B=-.004), religious (B=-.151) and employed individuals (B=-.080), parents (B=-.095) and those living in more deprived areas (B=-.015) showed decreased agreement. Education showed the strongest association with vaccine safety agreement (β=.117). The model explained 6.7% of the variance in vaccine safety agreement among Europeans.

Māori

Increased healthcare access (B=.060) and GP satisfaction (B=.155) were associated with higher vaccine safety agreement. Men (B=.221), those with higher education (B=.032) and living in urban areas (B=.287) expressed higher agreement, whereas parents (B=-.286) and religious people (B=-.296) reported lower agreement. GP satisfaction (β=.135) showed the strongest association with vaccine safety agreement. GP similarity and respect were not significant. The model explained 8.6% of the variance in vaccine safety agreement among Māori.

Pacific peoples

Those with a partner (B=.607) reported higher vaccine safety agreement, whereas religious individuals (B=-.700) and those born in New Zealand (B=-.607) reported lower vaccine safety agreement. All three variables had a standardized beta value larger than .1 (β=.191, -.216, -.189 respectively). Religion showing the strongest association with agreement ratings. Healthcare access and GP-related variables were non-significant. The model explained 12.2% of the variance in vaccine safety agreement among Pacific peoples.

Asian peoples

Greater perceived GP cultural respect (B=.092), higher education (B=.061) and being male (B=.330) were associated with higher vaccine safety agreement. Conversely, older age was associated with lower agreement (B=-.021). GP cultural respect (β=.105), education (β =-.111), and gender (β=.123) had a standardized beta value larger than .1. Gender showed the strongest association with vaccine safety agreement. The model explained 11.5% of the variance in vaccine safety agreement among Asian peoples.

Discussion

During 2013 to 2017, the proportion of New Zealanders who strongly agree that standard childhood vaccinations are safe increased (68% to 72%), while those who are skeptical (26% to 23.3%) or strongly disagree decreased (5.5% to 4.8%). Although this is an encouraging finding, it is essential to investigate group differences in vaccine safety perceptions to identify specific groups that have greater vaccine safety concerns and require tailored interventions. In terms of ethnic differences, Europeans (74.7%) and Asian peoples (72.3%) reported higher rates of high vaccine safety agreement than Māori (59.4%) and Pacific peoples (65.8%). Compared to ethnic minorities, Europeans reported increased ratings of high GP similarity, GP cultural respect, GP satisfaction and healthcare access. Due to their positive perceptions of GPs, Europeans may be more likely to regard GPs as their main source of vaccine information and alleviate their vaccine concerns by consulting GPs. On the other hand, as ethnic minorities encounter greater cultural or financial barriers to healthcare (Harris et al., 2019; Jansen et al., 2008; Wong, 2015), they are less likely to consider GPs as their most trusted or accessible source of vaccine information. Limited healthcare access and dissatisfaction with GPs may in turn be contributing to their reduced confidence in vaccine safety.

Ethnic disparities in correlates of vaccine safety perception

Europeans. As expected, there were notable ethnic differences in key correlates of vaccine safety perception. Relative to ethnic minorities, a larger range of variables were associated with higher vaccine safety agreement among Europeans. Europeans were the only ethnic group in which all healthcare-related variables; higher GP satisfaction, GP similarity and GP cultural respect, and better healthcare access, were significantly associated with higher agreement ratings. Demographic correlates of vaccine safety agreement in this group were similar to those previously linked with high agreement when assessing the New Zealand

population as one homogenous group (Lee et al., 2017). These included being male, younger, non-religious, not a parent, unemployed, having a partner, higher education, lower deprivation and living in an urban area. Overall, education showed the strongest association with vaccine safety agreement. Europeans with higher education may have greater vaccine knowledge and the cognitive ability to differentiate between evidence-based vaccine information and fraudulent conspiracy theories (van Prooijen, 2017), leading to stronger confidence in vaccine safety.

A novel finding was that GP satisfaction and healthcare access showed stronger associations with vaccine safety agreement than most demographic factors. In addition to high educational attainment, our findings suggest that high GP satisfaction and healthcare access may be vital contributors to positive views of vaccine safety among Europeans. As European New Zealanders encounter less financial or cultural barriers to healthcare (Harris et al., 2019; MOH, 2019), their ability to more easily consult GPs and have satisfactory vaccine conversations with GPs increases the likelihood that their vaccine concerns are addressed. On the flip side, limited healthcare access, low GP satisfaction and low educational attainment appear to be key characteristics of Europeans who exhibit low vaccine safety agreement. To further increase and maintain strong confidence in vaccine safety among this group, it is essential to develop target interventions for these high-risk groups and implement educational campaigns that build on their vaccine knowledge and ability to interpret vaccine information. GPs should also be aware of and attend to the many diverse factors that can influence Europeans' vaccine safety perception when consulting European patients.

Māori. Among Māori, higher GP satisfaction and healthcare access, being male, non-religious, not a parent, having higher education, lower deprivation and living in an urban area were associated with increased vaccine safety agreement. These demographic correlates are largely in line with those identified among Europeans, but the strength of associations slightly

differed. Compared to Europeans, Māori education level showed a weaker and Māori religiosity showed a stronger association with vaccine safety agreement. As spirituality is an important aspect of Māori identity and culture (Houkamau & Sibley, 2010), perhaps religious beliefs have greater influence on perceptions of and confidence in vaccine safety than scientific vaccine knowledge. In terms of healthcare access, Māori typically report greater financial and cultural barriers to healthcare (Harris et al., 2019; Jansen et al., 2008; MOH, 2019) and showed the highest proportion of low healthcare access in our study (9.1%). Due to limited healthcare access, Māori may be more likely to have insufficient or inaccurate vaccine knowledge and fewer opportunities to consult health professionals about vaccine safety concerns. Improving access to healthcare and accurate vaccine information would hence be a crucial step to improving Māori perceptions of vaccine safety.

Māori individuals often report negative experiences with and perceptions of health professionals, especially non-Māori doctors (Harris et al., 2012, 2019; Jansen et al., 2008). Interestingly, GP similarity and GP cultural respect were not significant in our analysis. Our results suggest that general GP satisfaction is a more crucial determinant of Māori vaccine safety perception than whether one perceives that their GP shares a similar cultural background or shows cultural respect. Given that 39.3% of Māori do not report high GP satisfaction, unsatisfactory GP consultations may potentially be contributing to their negative views of vaccine safety. On a more positive note, our findings indicate that satisfactory healthcare services provided by non-Māori doctors can still have a positive influence on Māori vaccination attitudes. This is a promising finding as there is currently a substantial lack of Māori doctors (NZCGP, 2019). Perceptions that GPs are understanding and have good interpersonal and communication skills are fundamental to Māori healthcare satisfaction (Jansen et al., 2008). It is thus vital to ensure that GPs acquire effective communication skills

and are trained to provide high-quality services that adequately address the healthcare needs and concerns of Māori patients.

Pacific peoples. Unexpectedly, GP satisfaction, GP perceptions nor healthcare access were significantly associated with Pacific peoples' level of vaccine safety agreement. In contrast to the several correlates identified among Europeans and Māori samples, only three variables showed significant relations with higher agreement – being non-religious, born overseas and having a partner. All three variables, particularly religiosity, showed strong associations with vaccine safety agreement. Due to their lack of access to quality healthcare in Pacific Island countries (Soakai et al., 2016), Pacific-born Pacific peoples may be more grateful for healthcare provision in New Zealand and more satisfied with or trusting of New Zealand public healthcare services. As for the effect of having a partner, partnered individuals may exhibit higher vaccine safety agreement as they are more likely to express concern about each other's health and feel motivated to keep their family safe. This may be particularly pronounced among Pacific peoples as caring for one's family is a crucial aspect of Pacific culture (Mauri Ora Associates, 2010). Increased insight into the mechanism of these effects will help inform culture-based interventions that foster stronger confidence in vaccine safety.

The relationship between religion and vaccine safety agreement among Pacific peoples was even stronger than that among Māori. Although New Zealand is becoming an increasingly secular country, Pacific peoples continue to show high proportions of religious affiliation (Statistics New Zealand, 2015a). As religious teachings emphasize purity and treating the body as a temple, the safety of vaccines and origin of its ingredients may be of particular concern to religious people (Grabenstein, 2013). However, Grabenstein (2013) suggests that the refusal of vaccines among religious groups generally reflect social traditions (e.g. rejection of modernity or science) or concern about vaccine safety rather than

theological objections. Some aspects of religious beliefs, such as caring for the community, are in fact consistent with the purpose of vaccinations. Health professionals need to work in partnership with Pacific and Māori religious leaders to correct misconceptions about vaccines in their community and promote vaccinations in a way that is congruent with their religious teachings. Investigating differences in the types and reasons for vaccine concerns across distinct religious groups will further help identify the most appropriate intervention methods that should be employed.

Asian peoples. Only four variables showed significant relationships with high vaccine safety agreement among Asian peoples. These included being male, younger, more educated and perceiving greater GP cultural respect. Interestingly, religiosity was not significant. In contrast to Māori, the degree to which one perceives that their GP respects their cultural background rather than general GP satisfaction or GP ethnic similarity was found to have a more important influence on Asian peoples' vaccine safety perception. Given that some Asian peoples encounter racism in healthcare (Harris et al., 2019) and that Asian peoples reported the lowest rate of high GP respect (60.8%), it is crucial to ensure that New Zealand GPs are sufficiently trained to provide culturally relevant healthcare to Asian patients. Opposed to scientific Western models of health, traditional Chinese models of health are more holistic and posit that good health is achieved by being in harmony with one's surroundings (Medical Council of New Zealand, 2017). Such differences in health beliefs can lead to disparities in the way people display illness symptoms or express health concerns. Health professionals need to be aware of these differences and be able to communicate with Asian peoples in a culturally competent and respectful manner. Culturally sensitive approaches of GPs may help foster a safe and trusting environment where Asian patients feel comfortable discussing and re-evaluating vaccine concerns with their GP.

Asian peoples in New Zealand commonly use traditional or herbal medicine, sometimes in conjunction with Western medicine (Medical Council of New Zealand, 2017). Older Asian peoples may be especially inclined to use or prefer traditional medicine as they may be less familiar with or knowledgeable about the scientific basis of Western medicine. Consequently, older Asian peoples may be less likely to trust modern medicine and thus express greater concern about the safety of childhood vaccinations. The strong association between gender and vaccine safety agreement may be linked to the fact that traditional gender roles are more strongly embedded within Asian cultures (Hori, 2017; Raymo et al., 2015). As childrearing is regarded as the main responsibility of women, women are generally the primary caregivers who take care of and are more concerned about their child's health. As a result, women may be more likely to be aware of and troubled about the controversy surrounding vaccinations and exhibit lower vaccine safety agreement. Although the current study treated Asian peoples as one large group, it is important to recognise that there are many diverse sub-groups within the Asian population in New Zealand. Further investigation of the specific vaccine concerns and beliefs held by distinct Asian populations is needed to better identify strategies to improve vaccine safety perceptions among specific groups.

Differences in predictors across ethnic groups

Our findings reveal that GPs do not have uniform influence on vaccine safety attitudes of distinct ethnic groups. Whereas GP respect was a significant predictor for Asian peoples, and GP satisfaction was a significant predictor for Māori, only demographic predictors were significant for Pacific peoples. All three GP perception variables were significant in the European sample, but given the relative strength of associations, GP factors appear to have greater influence on vaccine safety perceptions of Māori and Asian peoples. Moreover, the overall strongest predictor of lower confidence in vaccine safety differed for each ethnic group. Lower education was the strongest predictor among Europeans, lower GP

satisfaction among Māori, being religious among Pacific peoples and older age among Asian peoples. Given these differences, it is vital to develop target vaccination interventions tailored to the specific needs of each ethnic group rather than taking a one-size-fits-all approach. Focused research is needed on the reasons for low confidence among high-risk groups within each ethnicity. This includes assessing group level of exposure to anti-vaccine information and trust in health professionals and investigating why vaccinations may be viewed as incompatible with one's religious beliefs. Gaining accurate insight into the mechanisms of low confidence will enable the development of more sophisticated and effective interventions.

Limitations and future research

The current study used cross-sectional data from one time point and therefore cannot infer causality from its results or assess changes across time. As we only asked about peoples' level of agreement that standard childhood vaccinations are safe, we were unable to identify the specific types of concerns people held, including whether these were about particular vaccines. Similarly, the single items used to measure healthcare access, GP satisfaction and GP perceptions provided limited insight into the specific barriers experienced by different ethnic groups, and the reasons for disparities in GP perceptions. There may also have been some degree of social desirability bias in response to questions asking about one's satisfaction with or trust in services provided by the government or health authorities (e.g., GP service, National Immunisation Schedule). This may have skewed ratings towards the upper end of the scale (i.e., 5-7). In addition to vaccine safety perceptions, future studies should further investigate the impact of other contributing factors (e.g., trust in science, healthcare professionals or the government, belief about vaccine efficacy) to one's broader level of vaccine confidence. This will enable a more comprehensive understanding of the

mechanisms that shape vaccination attitudes and lead to vaccine hesitancy among different ethnic groups.

As our survey was only conducted in English, our sample is not representative of those who have limited English abilities. Ethnic minorities who speak limited English may in fact be the ones most likely to hold traditional health beliefs, encounter cultural or communication barriers to healthcare and value GP cultural respect. It is thus essential to examine the unique barriers to strong confidence in vaccine safety faced by this group. Moreover, some international studies have identified ethnic differences in health information seeking behavior and preferred sources of health information (Ball-Rokeach & Wilkin, 2009; Moran et al., 2016). Likewise, ethnic groups in New Zealand may exhibit differing levels of trust in GPs, the internet or social groups as sources of vaccine information. This may subsequently lead to disparities in vaccine concerns. Investigating the differential impact of diverse sources will help better understand the origins of people's vaccine beliefs and identify the most effective channels to promote vaccinations to different groups. Nevertheless, given the exploratory nature of this study, our findings provide a novel contribution to the literature and strong foundation for future research on the differential determinants of vaccine safety perception across ethnic groups in New Zealand.

Concluding comments

According to 2017 NZAVS data, Europeans and Asian peoples exhibit greater confidence in the safety of childhood vaccinations relative to Māori and Pacific peoples. Compared to ethnic minorities, Europeans showed greater rates of high GP ethnic similarity, GP cultural respect, GP satisfaction and healthcare access. Our results also revealed important ethnic differences in key correlates of vaccine safety perception. Out of a wide range of significant variables, GP satisfaction, healthcare access and education showed the strongest associations with higher vaccine safety agreement among Europeans. GP

satisfaction showed an even stronger relation with higher agreement among Māori, followed by religion and healthcare access. In the Pacific sample, being non-religious, born overseas and having a partner showed robust relations with high vaccine safety agreement. Men, younger and more educated individuals, and those with greater perceived GP cultural respect showed higher agreement among Asian peoples. Our findings highlight specific areas that future studies should focus on to better understand vaccine safety attitudes of each ethnic group. Increasing insight into these ethnicity specific perspectives is crucial to develop tailored and culturally- appropriate interventions that can effectively improve public confidence in vaccine safety. This is especially important for Māori and Pacific peoples as they are more likely to hold negative views of vaccine safety.

Bridging Statement

As expected, Study two found that perceptions of GPs and vaccine safety are not uniform across ethnic groups. It identified ethnic differences in level and key correlates of confidence in vaccine safety. Europeans showed greater positive perceptions of GPs and strong confidence in vaccine safety relative to minority ethnic groups. General satisfaction with GP services and healthcare access had a key influence on vaccine safety perception among Europeans and Māori, while perceived GP cultural respect was more important among Asian peoples. Unexpectedly, healthcare access and GP perceptions were not significantly associated with vaccine safety perception for Pacific peoples. Religiosity showed a particularly strong association with their vaccine safety perception, suggesting that religious beliefs are a more critical determinant of their views of vaccinations than healthcare experiences. Future studies should use multi-level modelling to better understand differences in the strength of relationship between demographic factors and vaccine safety perceptions across ethnic groups. A more accurate insight into these ethnic differences will better inform the development of both national vaccination campaigns and interventions for specific ethnic groups.

Being female and having low education were significantly associated with lower confidence in vaccine safety among all but the Pacific sample. The effect of gender is consistent with findings from our initial study on the general New Zealand population (Lee et al., 2017). Lower confidence among women has crucial implications regarding childhood vaccination rates as mothers are generally more involved in childcare and tend to make most decisions about vaccinations (Litmus, 2013; Statistics New Zealand, 2013). Compared to mothers, fathers tend to spend less time in childcare and lack confidence in acting as primary caregivers (Garfield & Isacco, 2012; Statistics New Zealand, 2013). Consequently, mothers'

vaccination attitudes may have a more significant influence on their child's vaccination status than fathers' attitudes.

Presently, little is known about the extent to which parental vaccine safety attitudes predict childhood vaccination uptake in New Zealand. Given the gender difference in level of confidence in vaccine safety, it is crucial to understand potential disparities in mothers' and fathers' role in the vaccination decision-making process. Study three aims to increase insight into this issue by investigating the differential influence of mothers' and fathers' level of vaccine confidence on the likelihood of their children's full vaccination status. We use an actor-partner independence model to calculate the unique effect of mothers' and fathers' vaccine safety perceptions on their reported child vaccination status.

The research article that follows is the author's copy of a manuscript published in the Vaccine. Please see:

Lee, C. H. J., Overall, N. C. & Sibley, C. G. (2020). Maternal and paternal confidence in vaccine safety: Whose attitudes are predictive of children's vaccination? *Vaccine, 38*(45), 7057-7062.

CHAPTER FOUR

Maternal and paternal confidence in vaccine safety: Whose attitudes are predictive of children's vaccination?

Introduction

Vaccinations are one of the most effective strategies to protect children against several infectious diseases (Dubé, Vivion, & MacDonald, 2015). However, vaccine hesitancy was highlighted as a major threat to global health by the World Health Organisation (WHO) in 2019 (WHO, 2019) and declines in vaccination rates have led to vaccine-preventable disease outbreaks worldwide (Dubé, Vivion, & MacDonald, 2015). Reasons for vaccine hesitancy are diverse; these include limited healthcare access, inaccurate vaccine knowledge, complacency, and distrust in health professionals or vaccine safety (Dubé, Vivion, & MacDonald, 2015; MacDonald, 2015). Increased access to anti-vaccination information online has heightened public concern about vaccine safety, posing significant challenges to the success of vaccination programs (Dubé, Vivion, & MacDonald, 2015). In New Zealand, the national target is a vaccination coverage rate of 95% by the 8-month milestone (Ministry of Health [MOH], 2018). However, during the one-year period ending 30 June 2020, 79%, 91%, 92%, 84%, 91% and 89% of children were fully immunised at 6, 8, 12, 18, 24 months and 5 years, respectively (MOH, 2020b). Within this same period, 3.9% to 5.4% of parents declined any one vaccination for their child. As parental vaccination attitudes are important determinants of vaccination uptake (Gilkey, McRee et al., 2016), it is essential to increase insight into the level of vaccine confidence among New Zealand parents and the impact of this confidence on actual vaccination uptake.

Although egalitarian gender roles have become more prevalent in the 21st century, women continue to spend more time on childcare than men (Dush et al., 2018). The 2009/10 New Zealand Time Use Survey[5] indicated that partnered fathers spend around two-thirds of

[5] The 2009/10 New Zealand Time Use Survey was carried out by Statistics New Zealand on New Zealanders aged 12+ (N=9,159). It involved questionnaires, diary entries and an interview. Link to website: http://archive.stats.govt.nz/browse_for_stats/people_and_communities/time_use.aspx#gsc.tab=0

the time partnered mothers do on childcare, and most fathers provide care with mothers rather than on their own (Statistics New Zealand, 2013b). Among male partners of pregnant women, only 43.7% saw themselves taking up direct responsibility of childcare (e.g., making day-care decisions, attending to sick child) most or all of the time, but 94.7% expected their female partner to be directly involved most or all of the time (Pryor et al., 2014). As mothers typically undertake most childcare duties, they generally make all decisions and arrangements regarding immunisation (Litmus, 2013). Given these differences in parental involvement in childcare, it is likely that mothers and fathers do not have the same degree of influence on the likelihood of their children's vaccination uptake. Consistent with this idea, Grant and colleagues' study (Grant et al., 2016) on a New Zealand sample found that both mothers' and fathers' antenatal vaccination intentions were independently associated with the timeliness of their infant's immunisations, but mother's intentions showed a stronger effect.

Currently, little is known about the differential impact of maternal and paternal perceptions of vaccine safety on their children's vaccination status. Most of the literature on vaccination attitudes have focused on mothers and hence, the role of paternal attitudes remains largely unexamined. Although Grant and colleagues (2016) provide important insight into the role of antenatal vaccination intentions, it does not directly assess the impact of maternal and paternal *vaccine confidence* on child vaccination status. Vaccination intentions and uptake are determined by a complex interplay of diverse factors (Tabacchi et al., 2016; van Keulen et al., 2013) and complying with vaccinations does not necessarily reflect strong confidence in vaccine safety (Kennedy et al., 2011).

Previously, New Zealand women were found to exhibit lower confidence in vaccine safety than men (Lee et al., 2017) and more likely to show a decreasing trend in confidence over time (Lee & Sibley, 2020b). As mothers tend to make most child healthcare decisions, it

is vital to understand the extent to which low maternal vaccine confidence may be negatively influencing children's likelihood of vaccination uptake. It is also important to investigate the role of fathers' vaccine confidence, including whether mothers' attitudes have a substantially stronger impact or perhaps override the influence of fathers' attitudes. To address this gap in research, the present study uses a sample of 68 New Zealand couples to investigate the differential influence of mothers' and fathers' vaccine confidence on whether their children are fully vaccinated. Our study aims to increase insight into the effect of parental vaccine confidence on children's vaccination status in New Zealand and inform the development of target interventions.

Method

Sampling Procedure

The New Zealand Attitudes and Values Study (NZAVS) is a longitudinal panel study of a national probability sample of New Zealand adults (See Appendix C for response and retention rates). This study is reviewed by the University of Auckland Human Participants Ethics Committee every three years and has most recently been approved from 5 September 2017 until 3 June 2021 (Reference Number: 014889). In Time 1 (2009), the NZAVS recruited participants from the entire country by randomly selecting samples from the New Zealand electoral roll[6] (response rate: 16·6%; see Sibley [2020] for details on sampling procedure). A booster sample was later recruited at Time 3 (2011) through an unrelated survey posted on the website of a major New Zealand newspaper. Further booster samples were recruited from the 2012 and 2014 Electoral Roll in subsequent Time periods (See Sibley

[6] There were approximately 3 million registered voters in the NZ electoral roll in 2009, 2012 and 2014. Refer to NZ electoral commission website for further information: https://elections.nz/stats-and-research/enrolment-statistics/

[2014] for comparisons to New Zealand Census). This study uses dyadic data from Time 7 (2015), Time 8 (2016) and Time 9 (2017).

Identifying Dyads

The NZAVS aimed to sample individuals, but over time some people's partners have self-selected to join the study and in other cases both partners were randomly sampled. As couples were not initially sampled together, a stringent criterion was used to identify couples that were cohabiting and in serious relationships within our dataset. First, we identified people who shared a postal address (or in the case of one person providing a residential address and other a postal box in the same region, those sharing a landline or email address). Of those sharing these contact details, to be flagged as a dyad, both couple members must have also reported one or more of the following characteristics: (a) same relationship type and similar relationship duration, (b) if married, then same date of marriage, (c) both partners' genders consistent with reported sexual orientation. If there were more than 12 years difference in age (increasing the possibility of a parent-adult child dyad), then one or more of the following additional factors was also required to be considered a dyad: (a) same date of marriage, or (b) if parents, same birthdate of one or more children.

Participants

Our sample comprised 68 heterosexual couples (i.e., 68 men and 68 women) who had children under 18 years of age. Only heterosexual couples were included in this analysis given the aims to test differential influence of mothers' and fathers' vaccine confidence on whether their children are fully vaccinated. As we did not initially sample couples and used a stringent dyad criterion, our sample size is small compared to our original dataset (see Appendix C, Table C1). Data for 25 couples were drawn from Time 7, data for 38 couples were drawn from Time 8 and data for 5 couples were drawn from Time 9. The mean age was 41.35 years (SD=6.68, age range=22-56) for women and 42.68 years (SD=7.11, age

range=35-58) for men. Most women identified as European (88.1%) followed by Māori (9%), Pacific (1.5%) and Asian (1.5%). Similarly, most men identified as European (88.1%) followed by Māori (6%), Pacific (4.5%) and Asian (1.5%). The mean socio-economic deprivation level[7] (1=lowest to 10=highest) for the 68 couples was 4.88 (SD=2.86).

Measures

Vaccination items. At all three time points, vaccine confidence was assessed using the likert item; "It is safe to vaccinate children following the standard NZ immunisation schedule" (1 = Strongly Disagree, 7 = Strongly Agree; only 1 and 7 were labelled). This item was developed for the NZAVS in consultation with medical professionals (Lee et al., 2017). Vaccination status of participants' children was measured using the item; "If you have children under 18, are their vaccinations up-to-date, as per the recommendations of your doctor/GP?" There were four response options; (1) Yes-fully, (2) No-partially, (3) No-none, (4) Don't know. Those who did not respond were coded as (5) unreported.

Demographics. Participants were asked to report their gender, date of birth, ethnicity, region of residence and education level. Ethnicity was measured using the standard New Zealand Census item, in which participants could indicate each ethnic group they identified with. This item was then priority coded into mutually exclusive categories (order of prioritization: Māori, Pacific, Asian, NZ European). Education was coded into an 11-level ordinal variable (0 = No qualification, 1=level 1 Certificate [basic knowledge/skills for work] to 10 = doctoral degree) based on the ten tertiary qualification levels in New Zealand. Socio-economic deprivation level was measured using the 2013 New Zealand Deprivation Index, which assigns a decile-rank score between 1 (least deprived) to 10 (most deprived) to each small geographical area in New Zealand (Atkinson et al., 2014). Scores are calculated based

[7] Deprivation level was measured using the 2013 New Zealand Deprivation Index, which assigns a decile-rank score between 1 (least deprived) to 10 (most deprived) to each small geographical area in New Zealand. Scores are based on census information (e.g. home ownership, income, employment rate).

on census information relating to home ownership, income level, employment rate, qualifications, family structure and access to transport and communications.

Statistical Analyses

Children's vaccination status was recoded into a binary variable; those that indicated their children were fully vaccinated was coded '1' and all else (i.e., 'partially,' 'no-none, 'don't know' and 'unreported') was coded as '0'. Regardless of the number of time points a couple responded to, we only used their reported vaccine confidence and children's vaccination status from the first time they responded to these items. Hence, data from only one time point were used for each couple. If a couple reported data in Time 7, these data were used (N = 25 couples). If a couple did not report data in Time 7 but did in Time 8, Time 8 data were used (N = 38 couple). If a couple reported data in Time 9 for the first time, then Time 9 data were used (N = 5 couples). For consistency, we used the same procedure to identify demographic characteristics.

Following a standard Actor-Partner Interdependence Model (APIM; Kenny et al., 2006), both partners' vaccine confidence levels were entered as simultaneous predictors of both partners' reports of their children's vaccination status. This dyadic model calculates actor effects (e.g., the association between *mothers'* vaccine confidence and *mothers'* reports of vaccination status) and partner effects (e.g., the association between *mothers'* vaccine confidence and *fathers'* reports of vaccination status) adjusting for the covariance between both partners' vaccine confidence to ensure that any partner effects (e.g., mothers' vaccine confidence on fathers' reports of vaccination status, or vice versa) are not simply because partners hold similar levels of vaccine attitudes. As our data was not drawn from a single survey year, the 'time point' (wave 7, 8 or 9) that each couple's data were drawn from was included as a covariate in our model, which adjusted for the chronological year of measurement. This is due to potential differences in reported parental vaccine confidence

level or children's vaccination status due to vaccine-related events (e.g. coverage of anti-vaccination material on media) that occurred during the different time points. Given the limited sample size, no other covariates were included.

Results

As seen in Table 1 below, the mean level of vaccine confidence was slightly higher among men (5.94) compared to women (5.72). Most women and men reported that their children had been fully vaccinated (82.4% and 80.9% respectively). There was a total of 7 cases in which couples' reported child vaccination status did not match. In all except one of these mismatching cases, one parent reported full vaccination status while the other selected 'don't know' or did not respond. See Appendix C for details on vaccine confidence level, reported child vaccination status and demographics of full sample.

Table 4.1. Mean and standard deviation of vaccine confidence level, and proportion of fully vaccinated children reported by women and men.

	Vaccine Confidence *M (SD)*	Full vaccination status *Count (%)*	Incomplete vaccination status *Count (%)*
Women (*N*=68)	5.72 (1.57)	56 (82.4%)	12 (17.6%)
Men (*N*=68)	5.94 (1.40)	55 (80.9%)	13 (19.1%)

Logistic regression predicting children's vaccination status

The results from the APIM shown in Table 2. The top section presents the actor and partner effects for *women's reported child vaccination status*. Women's vaccine confidence was significantly associated with an increase in the likelihood of women reporting that their children were fully vaccinated (OR =2.779, SE=.336, p=.002). Men's vaccine confidence did not significantly predict women's reported vaccination status of their children.

The bottom section of Table 2 presents the actor and partner effects for *men's reported child vaccination status*. Women's vaccine confidence was significantly associated with an increase in likelihood of men reporting that their children were fully vaccinated (OR =2.056, SE=.284, p=.011). By contrast, men's own vaccine confidence was not significantly associated with men's reported child vaccination status. Thus, both women's and men's reported child vaccination status was influenced by women's, but not men's, vaccine confidence.

Table 4.2. Women's and Men's vaccine confidence predicting Women's and Men's reported vaccination status of their children.

	OR	Lower 95% CI	Upper 95% CI	B	SE	t-value	P-value
Predicting Women's Reported Child Vaccination Status							
Women's Vaccine confidence	**2.779**	**1.438**	**5.369**	**1.022**	**0.336**	**3.041**	**0.002**
Men's Vaccine Confidence	1.343	0.749	2.407	0.295	0.298	0.989	0.323
NZAVS Time point	0.857	0.313	2.349	-0.154	0.514	-0.299	0.765
Predicting Men's Reported Child Vaccination Status							
Women's Vaccine confidence	**2.056**	**1.179**	**3.584**	**0.721**	**0.284**	**2.541**	**0.011**
Men's Vaccine Confidence	1.548	0.882	2.718	0.437	0.287	1.522	0.128
NZAVS Time point	0.857	0.313	2.349	-0.154	0.514	-0.299	0.765

Note: Confidence intervals for ORs reported. Significant ORs (p<.05) bolded.

Discussion

Our results revealed that mothers', but not fathers', vaccine confidence predicted whether their children were fully vaccinated, regardless of who reported their children's vaccination status. Higher maternal vaccine confidence increased the likelihood of child full vaccination status, but paternal vaccine confidence showed no significant effects. The apparent influence of maternal confidence in determining vaccination status is important given that women among the general population (Lee et al., 2017), and in the current sample, showed lower vaccine confidence relative to men. Moreover, women have been found to be more likely to show decreasing vaccine confidence over time (Lee & Sibley, 2020b), highlighting the danger that their confidence levels may continue to decrease and lead to further declines in childhood vaccination uptake.

Disparities in exposure to negative vaccine information may be an important contributor to the gender difference in confidence level. Although most mothers receive vaccine encouraging information from doctors, many are also exposed to anti-vaccination information through media and friends or family (Veerasingam et al., 2017). As mothers play the main role in making vaccination decisions (Litmus, 2013), they may be more inclined to desire and actively seek further vaccine information relative to fathers. With more people searching the internet for health information (Kata, 2012), this increases the chances that they encounter fraudulent claims about vaccinations on anti-vaccine websites. Worryingly, an American study found that women showed a greater tendency to trust non-professional sources of vaccine safety information than men (Freed et al., 2011). These findings raise the potential that perhaps New Zealand mothers are not only more likely to be exposed to but are also more susceptible to being influenced by informal or inaccurate sources of vaccine information.

In terms of paternal attitudes, a study on expectant Australian fathers found that those with positive vaccination attitudes (89%) reported lower self-reported knowledge of pregnancy issues but were more likely to discuss such issues with healthcare providers rather than searching the internet (Prosser et al., 2016). Likewise, New Zealand fathers may generally feel less knowledgeable about child vaccinations but are more likely to trust in vaccine safety after consulting health professionals. However, our findings indicate that paternal attitudes are largely excluded from the vaccination decision-making process, with the mothers' attitudes taking preference over the fathers. This may be partly due to fathers' general lack of confidence and self-efficacy in acting as a primary caregiver in health situations, and their tendency to rely on or work together with mothers when faced with child healthcare issues (Garfield & Isacco III, 2012). Fathers may also believe that mothers are more knowledgeable and well-suited to make child healthcare decisions, and thus simply follow or trust the decision of their partner.

To maintain high childhood vaccination rates, it is imperative to develop target interventions for mothers that enhance and consolidate their confidence in vaccine safety. As health professionals are trusted sources of vaccine information with key influence on vaccination uptake (Freed et al., 2011; Leask et al., 2006; Tafuri et al., 2014), they have a pivotal role in providing reassurance to and addressing the concerns of mothers. First and foremost, health professionals need to build strong rapport and a trusting relationship with mothers. Mothers who do not consider their child's health provider as a reliable source of information are more likely to resort to the internet for vaccine information, which can negatively impact their vaccine attitudes (Jones et al., 2012). Furthermore, health professionals need to go beyond simply providing pro-vaccine information when recommending vaccinations. They need to take the time to understand the specific concerns,

misconceptions, and sources of misinformation among mothers and communicate accurate vaccine information in an easily comprehensible way (Healy & Pickering, 2011).

Encouraging fathers' involvement in making children's vaccination decisions may also be beneficial in increasing the likelihood of vaccination uptake. Not only do fathers show higher vaccine confidence than mothers, but partner support during vaccinations can impact on the timeliness of vaccinations. That is, mothers who were not supported by their partner or family member for their child's six-week immunisation tended to have a prolonged history of delaying their child's immunisation (Litmus, 2013). Intervention for fathers should focus on further strengthening their vaccine confidence, educating them about trusted sources of vaccine information and enhancing their self-efficacy in being involved in child healthcare. Through greater engagement in the vaccination decision-making process, fathers may be able to positively influence their partners' vaccine attitudes and in turn, the likelihood of their child's vaccination uptake.

This study has a number of limitations. Firstly, we assessed vaccine confidence using a single-item measure and did not differentiate between children who were partially or fully vaccinated and not vaccinated at all. Parents were asked to report the vaccination status of their 'children' so we could not distinguish whether specific children were fully vaccinated and other children were not fully vaccinated within the same family. As our study aimed to focus on the influence of maternal and paternal vaccine confidence, and we had a small sample of couples, we did not include control variables in our analysis. Future studies should investigate whether mothers' and fathers' demographic characteristics (e.g., employment, age and ethnicity) impact the degree to which their vaccine confidence influences children's vaccination status. As we had a limited sample, consisting mostly of middle-aged European couples, it is vital that subsequent studies use a broader sample to investigate potential disparities in results between distinct ethnic groups and those with children of different age

groups. Qualitative research on fathers' vaccination attitudes is also needed to increase insight into the key drivers of their higher vaccine confidence. Perhaps due to their limited involvement in child healthcare decisions, they are less likely to seek and critically assess vaccine information.

The present study provides novel insight into the differential influence of mothers' and fathers' vaccine confidence on children's vaccination status in New Zealand. It revealed that maternal but not paternal vaccine confidence predicts whether one's child is fully vaccinated. As women are more likely to exhibit low or decreasing confidence in vaccine safety (Lee et al., 2017; Lee & Sibley, 2020b), it is imperative to further investigate the key drivers of their vaccination attitudes and develop target interventions that effectively address their concerns. Interventions should also aim to enhance fathers' self-efficacy in child healthcare and encourage their involvement in making vaccination decisions. Interactions with health professionals are a critical factor shaping parental vaccination attitudes and thus, they should be sufficiently trained to provide effective and targeted support for both mothers and fathers.

Bridging statement

Study three provided essential and novel insight into mothers' and fathers' differential role in the vaccination decision-making process. Maternal but not paternal confidence in vaccine safety was significantly associated with a higher likelihood of child full vaccination status. As women tend to express greater skepticism about vaccine safety relative to men, it is crucial to develop target interventions for mothers that address their specific concerns and strengthen their confidence in vaccine safety. Improving fathers' self-efficacy in childcare and encouraging their involvement in vaccination decision-making may also be an effective strategy to increase childhood vaccination uptake.

A subsequent research question that arises is how and whether people's attitudes towards vaccinations are changing over time. Previous studies have not assessed longitudinal changes in vaccine safety perception in a New Zealand context. This is an important research gap to address as perceptions of vaccinations are not static and subject to change in response to diverse time-related factors (e.g., media coverage of anti-vaccination content, disease outbreaks or political events; see Dubé, Vivion, & MacDonald, 2015). Opposed to assessing vaccine confidence at one given point in time, assessing data across multiple time points will provide a more complete picture of the state and trend in population confidence in vaccine safety. It is also crucial to understand disparities in the trajectory of vaccine safety attitudes between distinct subgroups within the population. There may be notable differences in attitude trajectories between men and women or distinct ethnic groups.

Accordingly, Study four assesses changes and consistencies in New Zealanders' level of confidence in the safety of childhood vaccinations across a period of 5 years (2013 – 2017). It aims to investigate whether the New Zealand public collectively exhibits decreasing or increasing confidence over time or whether there are distinct groups within the population

that show differing patterns of changes in level of confidence. If multiple subpopulations are detected, Study four also aims to identify demographic risk factors associated with low or decreasing confidence in vaccine safety. This is the first study to use latent growth models to explore the longitudinal trajectory and demographic profile of distinct vaccine safety attitude groups in New Zealand.

The research article that follows is the author's copy of a manuscript published in EClinicalMedicine. Please see:

Lee, C. H. J., & Sibley, C. G. (2020). Attitudes toward vaccinations are becoming more polarized in New Zealand: Findings from a longitudinal survey. *EClinicalMedicine*, *23*, 100387.

CHAPTER FIVE

Attitudes toward vaccinations are becoming more polarized in New Zealand: Findings from a longitudinal survey

Introduction

Childhood vaccinations are a crucial public health intervention that protects people against harmful infections (Ministry of Health [MOH], 2018; Strategic Advisory Group of Experts on Immunization [SAGE], 2018). However, vaccine hesitancy has been highlighted as a major threat to global health by the World Health Organization in 2019 (World Health Organization, 2019). The refusal or delay in vaccinations can be linked to a diverse range of factors, including limited healthcare access, distrust in health professionals, complacency and vaccine safety concerns (Dubé, Vivion, & MacDonald, 2015; MacDonald, 2015). Standard vaccinations undergo rigorous safety testing before approval and are constantly monitored thereafter (MOH, 2020a). Nonetheless, with the recent increase in anti-vaccination movements and dissemination of anti-vaccine information, public concern about vaccine safety seem to be on the rise (Dubé, Vivion, & MacDonald, 2015; Larson et al., 2014). Many express concerns that vaccines contain harmful substances and may cause various illnesses (Dubé, Vivion, & MacDonald, 2015; MOH, 2020a). Specific fears about the Mumps, Measles and Rubella (MMR) vaccine can be traced back to Wakefield's (1998) fraudulent study on the link between MMR and autism (Dubé, Vivion, & MacDonald, 2015). Despite the retraction of this study and multiple epidemiological studies disproving its proposed association, MMR-autism myths continue to circulate and cause fear among parents (Dubé, Vivion, & MacDonald, 2015; Hviid et al., 2019; MOH,2018). Such doubts about vaccine safety challenge vaccination uptake and have contributed to the resurgence of measles outbreaks in multiple countries (Dubé, Vivion, & MacDonald, 2015; SAGE, 2018), including New Zealand (The Institute of Environmental Science and Research Ltd., 2015).

In New Zealand, the National Immunisation Schedule offers a series of free standard vaccinations for New Zealanders from six weeks to 65 years of age (see Appendix D for full Immunisation Schedule; MOH, 2020a) To achieve herd immunity and prevent disease

transmission, it is important to ensure that 92-94% of the population have been immunised (MOH, 2020a). Yet, during the 12-month period ending 31st December 2019, children who were fully immunised for their age at the six milestone ages (6, 8, 12, 18, and 24 months, and 5 years) were 79%, 90%, 92%, 84%, 91% and 88% respectively (MOH, 2020b). The proportion of fully immunised children was particularly low among Māori; the indigenous peoples of New Zealand (63.3% to 87.8%), and children living in highly deprived areas (69.6% to 89.7%). At each of the milestone ages, 4.3 to 5.4% of parents declined any one vaccination during the year 2019 (MOH, 2020b). Although reasons for declines are complex and cannot be explained by a single factor, they are often linked to concern about vaccine safety (Dubé, Vivion, & MacDonald, 2015; Litmus, 2015).

Among parents who delayed or missed immunisations, concerns about the risk or side effects of vaccinations are frequently cited as one of the main reasons for incomplete immunisations (Litmus, 2015; MOH, 2007). Some parents hold misconceptions that vaccines can cause illnesses such as autism or cot death (MOH, 2020a), while others undermine vaccine necessity or desire more vaccine information (Litmus, 2015; MOH, 2007). As for the general population, the 2013 New Zealand Attitudes and Values Study (NZAVS) found that 68.5% of New Zealanders expressed strong confidence in the safety of the New Zealand childhood immunisation schedule but 26% showed moderate and 5.5% showed low confidence (Lee et al., 2017). Māori individuals, women, parents, those less educated and living in more deprived areas reported decreased levels of vaccine confidence. Among Māori and those with high deprivation, increased healthcare barriers and negative experiences with health professionals (Allen and Clarke, 2019; Jansen et al., 2008) may be contributing to their low vaccine confidence. Given that belief in vaccine safety is an important determinant of vaccination uptake (Gilkey, McRee et al., 2016; Kornides, McRee & Gilkey, 2018), it is essential to track changes in and constantly monitor public vaccine confidence. However, due to the scarcity of

large-scale panel data, little is currently known about the trajectory of change in New Zealanders' vaccine confidence over time.

The present study addresses this gap in research by assessing New Zealanders' confidence in the safety of standard childhood vaccinations during a period of heightened anti-vaccine controversies. With increased accessibility to anti-vaccine information online (Dubé, Vivion, & MacDonald, 2015), vaccine confidence among those who previously held vaccine safety concerns may have further decreased throughout the years. As the New Zealand public tends to express varying levels of confidence in vaccine safety (Lee et al., 2017), this raises the potential that there may be multiple subpopulations showing differing rates and directions of change in vaccine confidence over time. Using survey data across four waves of the NZAVS (2013 and 2015-17), we examine whether the New Zealand public collectively exhibits decreasing or steady vaccine confidence over time, or whether there are distinct subpopulations with diverging trajectories of confidence. In the occasion that multiple subpopulations are identified, we aim to assess key demographic differences between these distinct groups. Gender, age, ethnicity, education and deprivation are central variables of interest as they have frequently been linked with disparities in vaccine safety attitudes (e.g., Lee et al., 2017; Lee & Sibley, 2020; Shiu et al., 2006), as well as access to healthcare (MOH, 2019b), and susceptibility to misinformation (van Prooijen, 2017; van Prooijen et al., 2008). Our findings provide novel insight into the trajectory of New Zealanders' confidence in the safety of childhood vaccinations over time and help dictate interventions that aim to improve public vaccine confidence.

Method

Sampling procedure

The NZAVS is a longitudinal survey study of a national probability sample of New Zealand adults (See Appendix D for response and retention rates). This study is reviewed by the University of Auckland Human Participants Ethics Committee every three years and has most recently been approved from 5-September-2017 until 3-June-2021 (Reference Number: 014889). In Time 1 (2009), the NZAVS recruited participants from the entire country by randomly selecting samples from the New Zealand electoral roll (response rate: 16.6%; see Sibley [2019] for details on sampling procedures) A booster sample was later recruited at Time 3 (2011) through an unrelated survey posted on the website of a major New Zealand newspaper. Further booster samples were recruited from the 2012 and 2014 Electoral Roll in subsequent Time periods (See Sibley [2014] for comparisons to New Zealand Census) The current study uses Time 5 (2013), Time 7 (2015), Time 8 (2016) and Time 9 (2017) data, which included the item on vaccine confidence. Time 6 (2014) data was excluded as the Time 6 survey did not include this item.

Participants

Each sample included a large probability sample of New Zealand adults; Time 5 (N= 18,261), Time 7 (N=13,942), Time 8 (N= 21,937) and Time 9 (N= 17,072). Participants at each time point had a mean age of around 50 years (age range: 18–94, 19-96, 18-97, 18-98 respectively) and median household income of $90,000 (median household income was $63,800 in the 2013 New Zealand Census). Sixty three percent of each sample was female, with around 81% identifying as European, 12% as Māori, 3% as of Pacific and 4% as of Asian ethnicity (ethnic categories not mutually exclusive). Roughly 77% of participants from each time point were employed, and 74% were parents.

Measures

Vaccination items

At all four time points, vaccine confidence was assessed using the likert item (1 = Strongly Disagree, 7 = Strongly Agree; only 1 and 7 were labelled); "It is safe to vaccinate children following the standard NZ immunisation schedule." This item was developed for the NZAVS in consultation with medical professionals (see Lee et al., 2017). Vaccination status of participants' children was measured using the item; "If you have children under 18, are their vaccinations up-to-date, as per the recommendations of your doctor/GP?" There were four response options; (1) Yes-fully, (2) No-partially, (3) No-none, (4) Don't know. This item was developed for the NZAVS and included in Time 7, 8 and 9. We only report vaccination status data from Time 9 as vaccine confidence is the focus of our study.

Demographics

Participants were asked to report their gender, date of birth, ethnicity, region of residence and education level. Ethnicity was measured using the standard New Zealand Census item, in which participants could indicate each ethnic group they identified with. Education was coded into an eleven-level ordinal variable (0 = No qualification, 1=level 1 Certificate [basic knowledge/skills for work] to 10 = doctoral degree) based on the ten tertiary qualification levels in New Zealand. Deprivation was measured using the 2013 New Zealand Deprivation Index, which uses census information to assign a decile-rank index from 1 (least deprived) to 10 (most deprived) to each meshblock unit (i.e., small geographical area; Atkinson et al., 2014)

Analytic overview

Latent class growth models were conducted on Mplus version 8 to identify distinct latent classes (i.e., subpopulations) with similar trajectories of change in vaccine confidence over time. As some participants opted out while others opted in at different time points, we

were unable to follow the same group of individuals throughout 2013 to 2017. Thus, we used a linked model that allowed for missing data and identified links between respondent's responses over the four survey years. Those who were constant responders contributed more to the model. This was the most appropriate method of analysis given the algorithm of the model and provides novel insight into longitudinal changes in vaccine confidence at a population level.

Guided by Asparouhov and Muthen's (2014) three-step approach to mixture modelling, we identified (1) the number of subpopulations based on the growth curve of vaccine confidence, (2) then participants were assigned to the subpopulation they most likely belonged to and (3) the demographic covariates characterizing the subpopulations were examined. Gender, age, ethnicity (European/Other as reference category), education and deprivation level were included as covariates. Participants' reported education and deprivation level at Time 5 was prioritized and if missing, was overridden by that reported in Time 7, 8, and 9 consecutively (prioritizing Time 9 made trivial difference).

Osborne and Sibley (2017) note several model criteria including the Akaike information criteria (AIC), Bayesian Information Criteria (BIC), sample-sized adjusted BIC (aBIC), entropy and class proportion. These criteria assess the suitability of a model with *k* profiles relative to *k-1* profiles. Good fitting models have lower AIC, BIC and aBIC values, and higher entropy and likelihood of correct class membership (Osborne & Sibley, 2017). An entropy of 0.8 or above is generally regarded as a good fitting model. According to Kim (2014) and Tofighi and Enders (2008), aBIC is the most recommended fit criteria for growth mixture models. The sample-size adjusted consistent AIC (ADCAIC) also performed quite well (Kim, 2014). BIC, aBIC, ADCAIC and entropy values were used to our best fitting model. As a good model should be parsimonious (i.e. contain fewer classes as possible) and

avoid extremely small class proportions, model parsimony and class proportions were also taken into account.

STROBE Checklist

This manuscript adheres to the STROBE checklist where applicable.

Results

Main Analyses

A total of 12,826 participants were included in our final analysis. The number of responses included from Time 5, 7, 8 and 9 were 12,423, 11,912, 12,009 and 10,254 respectively. We assessed the growth curve of vaccine confidence using one to six latent class solutions. Each model was estimated using 500 initial stage starts, 40 initial stage iterations and 80 final stage optimizations to ensure we obtained a global solution. As seen in Table 1, model fit indices substantially improved after adding a second latent class to the single class model. The BIC, aBIC and ADCAIC showed a sharp decrease but the entropy value was still slightly low (0.57). Adding a third class further improved model fit, with the aBIC and ADCAIC decreasing by 2205 and 2220 respectively. The entropy value increased to 0.73, indicating a reasonably good model fit.

Due to the complexity of the model (i.e., latent class model with random effect on intercepts but not slopes), the model criteria continued to improve the more classes we added. However, considering model parsimony and class proportions, having more classes does not necessarily indicate a better model. In the four-class model, the fourth group was created by simply splitting the existing classes a little more and the class proportion of two groups were fairly small (6% and 7%; See Appendix D for four-class model results). The fifth and sixth-class model also extracted extremely small classes, with one class representing only 1% of

the sample. Caution needs to be applied when interpreting such small classes as they are based on a minor proportion of the sample. Overall, the three-class model had a reasonably good model fit and relatively large class sizes. The three-class model was judged to be the most parsimonious model and thus chosen as our final model.

Table 5.1. Model indices and class proportions for solutions ranging from one to six classes.

No. of Classes	BIC	aBIC	ADCAIC	Entropy	Class proportions
1	138955	138927	138895	-----	1.00
2	133194	133159	133120	0.57	0.57, 0.43
3	131001	130954	130901	0.73	0.60, 0.30, 0.10
4	129185	129124	129057	0.77	0.60, 0.26, 0.07, 0.06
5	128266	128192	128111	0.80	0.60, 0.22, 0.11, 0.06, 0.01
6	127374	127289	127193	0.80	0.56, 0.19, 0.10, 0.10, 0.03, 0.01

Subpopulations

Three subpopulations with distinct rates and directions of change in vaccine confidence were identified. These groups were labelled '*vaccine (safety) believers*', '*vaccine (safety) skeptics*' and '*former (safety) skeptics.*' The term 'safety' has been omitted from group labels hereafter for simplicity. Table 2 clarifies the definitions of key terms and groups labels used in this study. Table 3 reports the intercept (indicating group level of vaccine confidence in 2013) and slope (indicating the trend in confidence over time) for each group.

Vaccine believers

The largest subpopulation (*N*=7784, 60.7% of sample) was characterised by a high intercept (unstandardized mean intercept=6.52, p<0.001) and small positive slope (unstandardized mean slope=0.02, p<0.001). This subpopulation represents '*vaccine believers*' who exhibited consistently high and subtly increasing belief in vaccine safety over time.

Vaccine skeptics

The second subpopulation contained 29.5% of the sample (*N*=3792) and was characterised by a moderate intercept (unstandardized mean intercept=4.84, p<0.001) and negative slope (unstandardized mean slope=-0.14, p<0.001). This subpopulation represents '*vaccine skeptics*' who are becoming increasingly concerned about vaccine safety over time.

Former skeptics

The third subpopulation (*N*=1249, 9.7% of sample) was characterised by a low intercept (unstandardized mean intercept=3.43, p<0.001) and steep positive slope (unstandardized mean slope=.60, p<0.001). This subpopulation represents '*former skeptics*' who initially had low vaccine confidence in 2013 (3.47) but are becoming increasingly confident over time. By 2017, their confidence rating reached 5.88.

Table 5.2. Definition of key terms and group labels as per used in this study.

Key term	Definition
*Vaccine confidence**	Level of trust in the safety of childhood vaccinations measured by one's level of agreement to the statement that it is safe to vaccinate children following the NZ immunisation schedule. Having 'strong vaccine confidence' indicates that one has a high level of trust in and very minimal or no concerns about childhood vaccine safety.
Vaccine believers	Those that consistently expressed high levels of agreement to the statement that it is safe to vaccinate children following the NZ immunisation schedule during 2013 to 2017. Reasons for their 'strong vaccine confidence' may be diverse. This includes general trust in science or vaccinations specifically, better access to healthcare and/or positive perceptions of healthcare professionals or the government.
Vaccine skeptics	Those that showed decreasing levels of agreement to the statement that it is safe to vaccinate children following the NZ immunisation schedule from 2013 to 2017. Opposed to 'vaccine believers', reasons for decreasing 'vaccine confidence' may include increased exposure to anti-vaccine information, distrust in health professionals and/or limited access to healthcare or vaccine information. These individuals may be expressing diminishing belief in the safety of specific vaccines or vaccinations in general.
Former skeptics	Those that formerly showed the lowest level of agreement to the statement that it is safe to vaccinate children following the NZ immunisation schedule in 2013 but exhibited a steep increase in 'vaccine confidence' thereafter (until 2017). This increase could be due to multiple factors, including satisfactory follow-up vaccine conversations with doctors, corrected misconceptions about specific vaccines or vaccinations in general and/or improved access to healthcare.

* Note that 'vaccine confidence' is a term used to describe a key concept discussed in this study. The later three key terms are labels for the three subpopulations identified in this study.

Table 5.3. Model results for three latent class (subpopulation) solution.

Latent class	Proportion		Mean estimate	SE	t-value	P-value
1.Vaccine believers	.607	Intercept	6.516	0.017	394.273	<.000
		Slope	0.022	0.003	7.313	<.000
2. Vaccine skeptics	.295	Intercept	4.835	0.038	128.285	<.000
		Slope	-0.137	0.015	-9.223	<.000
3, Former skeptics	.097	Intercept	3.472	.074	47.112	<.000
		Slope	.601	.030	19.854	<.000

Differences between subpopulations

Vaccine believers persistently showed the highest level of vaccine confidence (see Figure 1). *Former skeptics* showed the steepest slope, with a particularly sharp increase in confidence between 2013 and 2015. *Vaccine skeptics* exhibited higher confidence than *former skeptics* in 2013, but their positions reversed across the years. In 2015, these two groups showed similar levels of confidence but in 2017, *former skeptics* showed notably higher confidence than *vaccine skeptics* (5.88 vs 4.29). With increasing confidence among *former skeptics* and decreasing confidence among *vaccine skeptics*, our findings indicate that vaccination attitudes are becoming increasingly polarized in New Zealand.

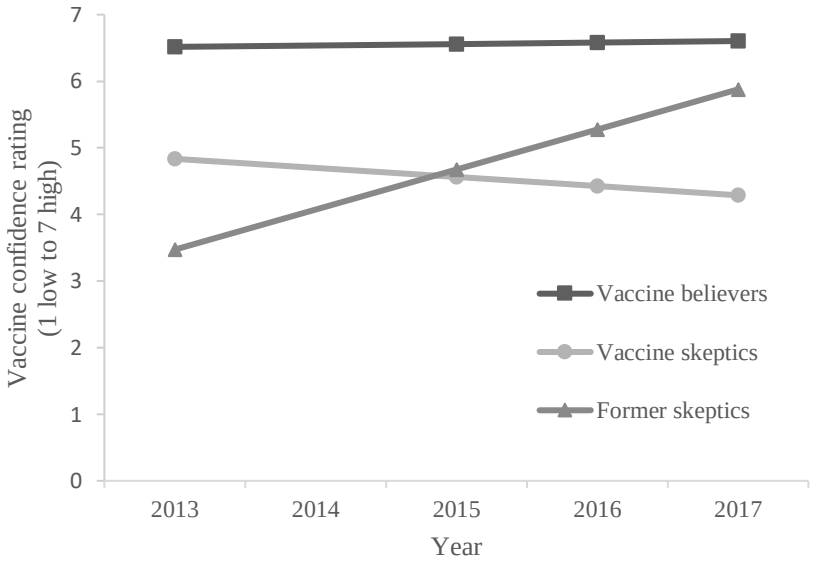

Figure 5.1. Differences in trajectories of vaccine confidence between subpopulations from 2013 to 2017.

Demographic profiles of subpopulations

To identify key demographic differences between subpopulations, gender (reference category: women), age, ethnicity (reference category: European/Other), education (0=no qualification to 10= doctoral degree) and deprivation (1=lowest to 10=highest deprivation) level were included as auxiliary covariates to predict subpopulation membership. Each subpopulation was consecutively treated as the reference category and compared to the other two subpopulations. Tables in Appendix D present the 95% confidence intervals of odds ratios and the demographic breakdown of subpopulations based on most likely group membership (Note: caution needs to be taken when interpreting demographic breakdown as our analyses were based on *probability* of classification).

Vaccine believers

Compared to *vaccine believers*, *former skeptics* were more likely to be female relative to male (OR=0.83), of Māori (OR=1.70) or Pacific (OR=1.97) compared to European ethnicity, live in more deprived as opposed to affluent regions (OR=1.05) and have lower education (OR=0.93). Similarly, *vaccine skeptics* were more likely to be women (OR=0.66), of Māori (OR=1.99), Pacific (OR=1.58) or Asian (OR=1.41) ethnicity, live in more deprived regions (OR=1.06) and have lower education (OR=0.89).

Vaccine skeptics

Compared to *vaccine skeptics*, *former skeptics* were more likely to be male relative to female (OR=1.25), younger (OR=0.99; age range: 18-94) and have higher education (OR=1.05). *Vaccine believers* were less likely to be of Māori (OR=0.50), Pacific (OR=0.63) or Asian (OR=0.71) compared to European ethnicity, and more likely to be men (OR=1.51), live in more affluent regions (OR=0.95) and have higher education (OR=1.13).

Former skeptics

Compared to *former skeptics*, *vaccine skeptics* were more likely to be female relative to male (OR=0.80), older (OR=1.01) and have lower education (OR=0.96). *Vaccine believers* were less likely to be of Māori (OR=0.59) or Pacific (OR=0.51) compared to European ethnicity, and more likely to live in more affluent regions (OR=0.95) and have higher education (OR=1.08).

Vaccination status in Time 9

We only report data on vaccination status from Time 9 (most recent Time point) to reduce the density of our results and maintain our focus on vaccine confidence. As shown in Table 3, most participants reported that their children were 'fully vaccinated' (87.6%), followed by 'partially vaccinated' (6.1%) and 'unvaccinated' (2.9%). Asian peoples reported the highest percentage of fully vaccinated children (92.2%), whereas Pacific (6.9%) and Europeans (6.9%) reported the highest percentage of partially and Māori reported the highest percentage of unvaccinated children (4.0%).

Among those with 'no qualification to Level 2 certificate', 83.1% were fully vaccinated (see Table 4). This increased to 87.1%, 88.7%, and 89.3% for each higher education category respectively. The proportion of unvaccinated children slightly decreased as education level increased (3.5%, 3.3%, 2.7%, and 2.3% respectively). The rate of partially vaccinated children was similar across all education groups (5.9-6.4%). Compared to those with higher education, those with 'no qualification to Level 2 certificate' (2.9%) reported a higher rate of 'don't know' (1.3%, 0.5%, 0.6% respectively).

Table 5.4. Response to item; "If you have children under 18, are their vaccinations up-to-date, as per the recommendations of your doctor/GP?" across ethnic groups in Time 9.

	European (N=3232)		Māori (N=705)		Pacific (N=274)		Asian (N=599)		Total (N=4909)	
	%	N	%	N	%	N	%	N	%	N
Yes-Fully	87.3	2823	85.5	603	86.9	239	92.2	552	87.6	4302
No-partially	6.9	222	5.8	41	6.9	19	2.4	15	6.1	299
No-none	2.9	94	4.0	28	0.9	3	1.8	10	2.9	142
Don't know	1.2	37	2.0	14	0	0	0.5	3	1.1	55
Unreported	1.8	57	2.7	19	5.2	14	3.2	19	2.3	111

Note: Ethnic groups determined based on prioritized ethnicity (in order: Māori, Pacific, Asian, European). Sample weighting on gender, ethnicity and region of residence applied. Note the small cell sizes for Pacific and Asian peoples due to their low response rate.

Table 5.5. Response to item; "If you have children under 18, are their vaccinations up-to-date, as per the recommendations of your doctor/GP?" across education level groups in Time 9.

	No qualification to Level 2 Cert (N=712)		Level 3 to 5 Cert (N=1185)		Graduate cert/ Bachelor degree (N=1690)		Post-graduate degree (N=1239)	
	%	N	%	N	%	N	%	N
Yes-Fully	83.1	591	87.1	1032	88.7	1500	89.3	1107
No-partially	6.4	46	6.3	75	5.9	100	6.1	75
No-none	3.5	25	3.3	39	2.7	46	2.3	29
Don't know	2.9	20	1.3	15	0.5	8	0.6	7
Unreported	4.1	29	1.9	23	2.2	37	1.7	21

Note: Education was coded based on the ten tertiary qualification levels in New Zealand (e.g. Level 1 Cert: basic knowledge/skills for work, Level 2 Cert: introductory knowledge/skills for field of work). Group categorization: 'No qualification to Level 2 Cert' (No qualification, Level 1 and 2 Certificate), 'Level 3 to 5 Cert' (Level 3 to 5 diploma/Certificate), 'Graduate Cert/Bachelor degree' (Level 6 diploma/Certificate to Bachelor degree), 'Post-graduate degree' (Postgraduate diploma/Honours, Masters and Doctorate degree). Sample weighting on gender, ethnicity and region of residence applied.

Discussion

Our results indicate that confidence in the safety of childhood vaccinations are becoming increasingly polarized in New Zealand. Around 30% of the population show decreasing confidence over time (i.e., *vaccine skeptics*), 10% are becoming more confident (i.e., *former skeptics*) and the remaining 60% show consistent high vaccine confidence (i.e. *vaccine believers*). A wide range of factors are likely contributing to the maintenance of strong vaccine confidence among *vaccine believers*. Based on previous studies (Gust et al., 2005; Leask et al., 2006; Pal et al., 2014), *vaccine believers* may be those who have satisfactory access to vaccine information and strong trust in health professionals. Similar to Australian mothers with strong confidence (Leask et al., 2006), *vaccine believers* in New Zealand may also have better knowledge regarding the risk of vaccine-preventable diseases as well as the benefits and social responsibility associated with vaccinating. Oppositely, *vaccine skeptics* may represent those who lack access to adequate healthcare, have inaccurate or insufficient vaccine knowledge or negative perceptions of health professionals (Gust et al., 2005; Leask et al., 2006; Petousis-Harris et al., 2002). Due to limited access to trusted sources of vaccine information, their doubts about vaccine safety may not have been sufficiently addressed by health professionals and further exacerbated by exposure to anti-vaccine sentiments.

As health professionals have important influence on one's vaccination attitudes and uptake (Dubé, Vivion, & MacDonald, 2015; Freed et al., 2011; Leask et al., 2006; Petousis-Harris et al., 2002), they may have had a pivotal role in persuading and providing reassurance for *former skeptics.* Given their initially low confidence, parents who were *former skeptics* are more likely to have previously delayed or declined vaccinations. Among American parents who had previously declined the HPV vaccine, receiving higher quality recommendations from healthcare providers and greater satisfaction with provider

communication were associated with greater secondary vaccine acceptance (Kornides, McRee & Gilkey, 2018). Likewise, satisfactory follow-up vaccine conversations with doctors may have led *former skeptics* in New Zealand to reconsider and gradually change their views of vaccine safety. The 2014 measles outbreak (see The Institute of Environmental Science and Research Ltd., 2015) may have been a key event that encouraged these individuals to seek further vaccine information and consult health professionals. In contrast, *vaccine skeptics* may have limited knowledge about the risk of measles and lack the opportunities or capability to reassess their vaccine beliefs. Such discrepancies can be linked back to potential differences in healthcare access and trust in health professionals between subpopulations.

Disparities in healthcare access, perceptions of health professionals or vaccine knowledge are closely tied to one's demographic characteristics. Thus, examining demographic differences between the three subpopulations not only allowed us to identify those more likely to be *vaccine skeptics* but provided important insight into the reasons why certain groups may be exhibiting strong or decreasing vaccine confidence. Our results revealed similar differences between *vaccine believers* and those who were either *vaccine skeptics* or *former skeptics*. Men, those of European/Other ethnicity, with lower deprivation and higher education were more likely to be *vaccine believers*. Conversely, women, Māori and Pacific peoples, those living in more deprived regions and with lower education were more likely to have previously held or continue to show increasing vaccine safety concerns. Relative to *vaccine believers*, Asian peoples were more likely to be *vaccine skeptics* but not any more likely to be *former skeptics* than European/Others.

For those of Māori or Pacific ethnicity and from highly deprived regions, low healthcare access may be a key contributing factor to their higher likelihood of being a *vaccine skeptic* or *former skeptic*. These groups typically experience greater financial or transport related barriers to healthcare and difficulty communicating with health providers

due to language or cultural differences (Jansen et al., 2008; Ludeke et al., 2012; Litmus, 2013; MOH, 2019b). They are thus less likely to have sufficient access to vaccine information, feel well-informed or have high-quality vaccine conversations with doctors. Among these groups, those who were able to have their initial vaccine concerns addressed by culturally competent health professionals may be showing increasing confidence, while those who lacked this opportunity or do not trust their health professional persistently express growing concern. As for Asian peoples, contrary to their high vaccination rates (MOH, 2020b), they were more likely to be *vaccine skeptics* than *vaccine believers*. Perhaps Asian parents in New Zealand are more likely to be hesitant compliers—concerned but fully-vaccinating parents. Due to cultural or language barriers, Asian parents may find it difficult to communicate and/or health professionals may be unable to sufficiently address their vaccine concerns. Therefore, in addition to improving healthcare access for minority and low socio-economic groups, it is vital ensure that doctors acquire strong cultural competency and attend to the unique healthcare barriers of those with diverse backgrounds.

Interestingly, there were no significant differences in ethnicity or deprivation level between *vaccine skeptics* and *former skeptics*. Gender, age and education were key distinguishing factors between these two subpopulations. Compared to *vaccine skeptics*, *former skeptics* were more likely to be male, younger and have higher education. Women and those less educated were not only less likely to be *vaccine believers,* but more likely to exhibit decreasing as opposed to increasing confidence in vaccine safety over time. Age was only significant when comparing *vaccine skeptics* and *former skeptics.* Relative to older adults, younger adults with immunisation-age children may encounter more opportunities to re-evaluate their vaccine beliefs and strengthen their vaccine confidence. For instance, parents with young children may exhibit heightened fear for their child's health during measles outbreaks, leading them to seek further vaccine information from trusted sources of

vaccine information. Health professionals may also exert particular effort to convince and promote vaccinations to younger parents as opposed to older adults. With their misconceptions less likely to be corrected by health professionals, older adults may exhibit decreasing confience in vaccine safety amidst persistent vaccine controversies.

Many pregnant women and parents receive or seek information about childhood vaccinations through various sources such as health professionals, family and the internet (Charron et al., 2020; Freed et al., 2011; Veerasingam et al., 2017). With the abundance of anti-vaccine information online and on social media (Dubé, Vivion, & MacDonald, 2015), this increases the chances they are exposed to anti-vaccine sentiments. As women typically make all decisions regarding their child's vaccination (Litmus, 2015), they are more inclined to do additional vaccine research and feel anxious about making the right decision for their child. Consistent with findings from an American sample (Freed et al., 2011), perhaps New Zealand women are also more likely to trust non-professional sources of vaccine information than men. Given that health professionals are important sources of vaccine information that influence vaccination attitudes (Litmus, 2015; Pal et al., 2014; Petousis-Harris et al., 2002), they may have had a central role in alleviating safety concerns among women who are *former skeptics*. On the contrary, women who remain *skeptical* may be those that are swayed by anti-vaccine information and unsatisfied with their providers' ability to address their concerns. To effectively convince these women, health professionals need to go beyond simply providing pro-vaccine information (Healy & Pickering, 2011; Veerasingam et al., 2017). They need to take the time to understand the specific concerns and sources of misinformation among *skeptical* women and use easily understood language to communicate evidence-based data to correct any misconceptions they hold (Healy & Pickering, 2011).

Our findings suggest that low education is an important contributor to decreasing confidence among *vaccine skeptics.* Despite somewhat mixed findings (Larson et al., 2014), numerous studies suggest that low education is associated with poor vaccine knowledge, decreased access to vaccine information and lower trust in health professionals (D'Alessandro et al., 2018; Gust et al., 2003; Gust et al., 2005). Due to their reduced cognitive capability and increased feeling of powerlessness, people with low education are also more receptive to conspiracy theories (van Prooijen, 2017). Hence, *vaccine skeptics*, who tend to have lower education, are more likely to endorse anti-vaccine conspiracy theories but lack access to trusted sources of vaccine information that can correct their misconceptions. On the other hand, higher education may be a key factor helping maintain strong vaccine confidence among *vaccine believers.* Through better education, these individuals may possess the cognitive ability to accurately interpret vaccination information and differentiate between false and evidence-based studies on vaccinations. Those more educated may also be better able to understand and communicate with their doctor, and thus more likely to trust in health professionals and the safety of vaccinations they recommended. Parents with higher education were found more likely to have fully vaccinated children (see Table 4), further highlighting that parental education is a crucial contributor to both vaccine confidence and uptake among New Zealanders.

In contrast to studies that assess vaccination attitudes at one given (static) point in time, our analyses provide novel information forecasting how New Zealanders' perceptions of vaccine safety are changing over time, and how they are forecast to continue to change in the near future. Although the majority of New Zealanders consistently exhibit strong vaccine confidence, a considerable proportion show steadily decreasing confidence over time. Unless appropriate interventions are implemented in a timely manner, vaccine confidence among *vaccine skeptics* are likely to continue to decrease and lead to declines in vaccination uptake.

It is imperative to develop tailored interventions for groups at higher risk of low vaccine confidence. This includes improving healthcare access for low socio-economic groups and implementing educational campaigns on vaccine safety and interpreting vaccine information for those with low education. Moreover, health professionals need to be sufficiently trained to develop trusting relationships with and adequately address vaccine concerns among diverse groups, especially young mothers and ethnic minorities. To better identify specific strategies to effectively persuade *vaccine skeptics,* it is vital to further investigate the key facilitators of attitude change among *former skeptics.*

As there were limitations in the number and types of predictors we could include in our model, we were unable to assess how various other NZAVS items (e.g., satisfaction with healthcare access or family doctor, subjective health, personality traits) may influence subpopulation membership. We were also unable to assess non-linear trends or potential fluctuations in vaccine confidence among different subpopulations. Our study used a single 7-point likert item asking about safety perceptions of the New Zealand immunisation schedule to measure vaccine confidence. Although this item lends insight into general perceptions of childhood vaccine safety among the public, it could not accurately discern New Zealanders' specific vaccine concerns or the main contributors to the differential trends of the three subpopulations. Future studies should employ more comprehensive measures of vaccine confidence that tap into people's beliefs about vaccine harm and benefits, and trust in healthcare professionals or the government (see scale used by Gilkey, Reiter et al., 2016). The influence of disparate access to healthcare and vaccine information, and susceptibility to anti-vaccine conspiracy theories should also be investigated. Subsequent studies should use risk ratios for more readily interpretable results and examine the clinical significance of demographic differences in vaccine confidence.

The present study did not examine the number of participants who had immunisation-age children nor potential differences in vaccination confidence between parents with different age groups of children. There may have been important differences in the way with those with young (<5 years) or school-aged children interpreted the vaccination item and viewed the safety of specific vaccinations (e.g., MMR or Human papillomavirus vaccine). Nevertheless, the aim of this study was to assess population level changes in general perceptions of vaccine safety in New Zealand and our findings still provide a valuable framework for future research on the key determinants of New Zealanders' vaccine confidence. Examining the relationship between vaccine confidence and actual vaccination uptake is another important direction for future research. As the Time 7 to 9 NZAVS surveys ask about child vaccination status, our data will enable us to investigate the degree to which vaccine confidence and characteristics associated with the three subpopulations may influence vaccination uptake across time.

Survey response rates have been declining over the years. Telephone survey response rates at the Pew Research Centre have decreased from 36% to 15% between 1997 to 2009 and stabilized at 9% in 2012 (Pew Research Center, 2012). Similarly, the NZAVS obtained a relatively low initial response rate of 16.6% in 2009 and the average response rate for booster samples remains at 9% (excluding Time 3 booster; See Appendix). As participants opted in and out of our study throughout the years, we were unable to follow the same group of individuals consistently over time. However, collecting booster samples helped us increase the national representativeness of our sample and maintain a large sample. Given that certain groups are more likely to respond to our surveys (Satherley et al., 2015), booster samples purposely oversampled specific areas (e.g., areas with high deprivation, greater ethnically diversity) to compensate for this (see Sibley, 2020). After applying sample weighting on gender, ethnicity and region, the NZAVS was able to accurately track changes in New

Zealanders' political attitudes over time (Sibley, 2017). Although this weighting procedure could not be used in our main analysis, our sample is still a reasonable reflection of the New Zealand adult population and provides scarce longitudinal data on population level changes in vaccine confidence.

In summary, our findings indicate that 30% of the New Zealand population are becoming more concerned about vaccine safety over time, 10% are becoming more confident, while the remaining 60% show consistent high vaccine confidence. Men, those of European/Other ethnicity, those living in more affluent regions and more educated were more likely to be *vaccine believers*. Compared to *former skeptics*, women, older individuals and those with lower education were more likely to be *vaccine skeptics.* Better healthcare access, stronger trust in health professionals and higher education may be key factors that help maintain high vaccine confidence among *vaccine believers*. Health professionals are likely to have had a pivotal role in alleviating vaccine safety concerns and boosting confidence among *former skeptics*. In contrast, *vaccine skeptics* may be those who lack access to trusted sources of vaccine information and are more susceptible to anti-vaccine theories. It is essential to further investigate the specific concerns and reasons for declining confidence among *vaccine skeptics* and implement target interventions accordingly.

CHAPTER SIX

General Discussion

General Discussion

Vaccine hesitancy was recently declared one of the top 10 global health threats that urgently need to be addressed (World Health Organization, 2019c). As vaccine safety concerns are key contributors to vaccine hesitancy (Giambi et al., 2018; Gidengil et al., 2019; Lane et al., 2018), it is essential to better understand the level and predictors of confidence in vaccine safety among the population. However, there is currently a dearth of research on New Zealanders' attitudes towards the safety of standard childhood vaccinations. Vaccine safety perceptions are influenced by many contextual factors, including political or social events, trust in the government and ethnic composition of the population (see Dubé, Vivion, & MacDonald, 2015). Hence, it is crucial to expand research on public perceptions of vaccine safety and identify groups with greater vaccine safety concerns within the specific context of New Zealand. The present thesis provides insight into this understudied area by (1) identifying differences in vaccine safety perceptions between distinct groups of health professionals and ethnic groups, (2) assessing the extent to which maternal and paternal confidence in vaccine safety predict child full vaccination status, and (3) examining changes in New Zealanders' vaccine safety perceptions over time.

This final chapter will first review the aims and novelty of the four studies presented in this thesis and briefly summarize the results from each study. It will then discuss the implications of findings from these studies, including how they advance our understanding of group differences in vaccine safety perceptions and inform the development of target interventions. Lastly, it will consider the caveats of the current thesis and explain how our results provide a useful framework for future research on New Zealanders' vaccination attitudes.

Summary of results

Confidence in vaccine safety among health professionals

Many parents regard health professionals as a primary and trusted source of vaccine information (Chow et al., 2017; Freed et al., 2011; Giambi et al., 2018). Thus, it is vital to ensure they have strong confidence in vaccine safety to encourage parental compliance with vaccinations. In line with findings from international studies (European Centre for Disease Prevention and Control, 2015; Dube et al., 2018), a survey in Rotorua (N=188) identified disparities in vaccine safety perceptions across different groups of New Zealand health professionals (Jelleyman & Ure, 2004). Midwives, who are chosen by most New Zealand women to be their lead maternity carer (Ministry of Health [MOH], 2017c), showed greater concern about vaccine safety relative to nurses and doctors. Although this study was conducted back in 2004 and only focused on one region of New Zealand, there have been no subsequent follow-up studies that assess disparities in vaccine safety perceptions among health professionals across the country. Study one addressed this research gap by investigating the level of confidence in childhood vaccine safety among 11 groups of health professionals across New Zealand.[8] This included General Practitioners (GPs), pharmacists, dentists, nurses, radiographers, midwives, and practitioners of alternative medicine.

Study one is the first study to assess general vaccine safety perceptions among a broad range of health professionals across the entire country. Our findings indicate that disparities in perceptions of vaccinations continue to exist between distinct health professional groups. Consistent with the study in Rotorua (Jelleyman & Ure, 2004), GPs and nurses showed

[8] Confidence in vaccine safety was measured using one's level of agreement to the statement that "It is safe to vaccinate children following the NZ Immunisation Schedule" in all four studies. In studies one, three and four, this concept was referred to as 'vaccine confidence'. In study two, this concept was described as 'vaccine safety agreement.' To report our findings more accurately and use consistent terminology, this concept is referred to as 'confidence in vaccine safety' or 'vaccine safety perception' when describing results from the four studies in this chapter (i.e., General Discussion).

greater confidence in vaccine safety relative to midwives. However, nurses (83.6%) showed a lower proportion of 'strong confidence' (rating of 6 or 7 on vaccination item) in vaccine safety compared to GPs (96.7%). GPs (96.7%) and pharmacists (90.7%) showed the highest proportion of strong confidence across all health professional groups. In contrast, only 65.1% of midwives and 13.6% of practitioners of alternative medicine were strongly confident in childhood vaccine safety. Our results indicate that there is still a considerable degree of uncertainty about vaccine safety among some health professional groups. Low confidence among midwives and practitioners of alternative medicine is particularly concerning. Their attitudes are likely to be negatively impacting parental views and decisions about childhood vaccinations.

Ethnic disparities in perceptions of GPs and vaccine safety

Although most GPs are strongly confident in vaccine safety, previous studies have yet examined the extent to which GPs influence vaccine safety perceptions of distinct ethnic groups. Each ethnic group in New Zealand has a unique history, cultural values, health beliefs, and experience of healthcare (see Harris et al., 2012, 2019; Jansen et al., 2008; Wong, 2015). Therefore, they are not likely to have the same level of satisfaction with or expectations from GPs and uniform views of vaccinations. Accordingly, Study two assessed disparities in perceptions of GPs and childhood vaccine safety among European, Māori, Pacific and Asian New Zealanders. Results revealed that Europeans report a higher level of satisfaction with healthcare access and GP services, and higher perceived GP cultural similarity and respect relative to other ethnic groups. Europeans also showed the largest proportion of high confidence in vaccine safety (74.4%) followed by Asian peoples, (72.3%) Pacific peoples (59.4%) and Māori (59.4%).

Study two also provided novel insight into the differential correlates of vaccine safety perceptions among the four main ethnic groups in New Zealand. It examined whether one's

GP perceptions, healthcare access and demographic factors were significantly associated with their level of confidence in vaccine safety. Among Europeans, higher ratings on all three GP perception variables, greater healthcare access and a broad range of demographic factors (e.g., being male, younger, non-religious, having high education, low deprivation) were associated with higher confidence in vaccine safety. A similar but smaller range of variables were significant among Māori. This included higher GP satisfaction, greater healthcare access, being male, non-religious, not a parent, having higher education, lower deprivation and living in an urban area. Compared to Europeans, Māori education level showed a weaker association and religiosity showed a stronger association with confidence in vaccine safety.

In contrast to European and Māori samples, only three variables were significant correlates of higher confidence among the Pacific sample – being non-religious, born overseas and having a partner. Interestingly, GP perceptions and healthcare access were non-significant, and religiosity showed a particularly strong association with lower confidence in vaccine safety. As for Asian peoples, being male, younger, more educated and perceiving greater GP cultural respect showed significant relationships with higher confidence. Contrary to other ethnic groups, religiosity was not significant among this ethnic group. These findings illustrate how each ethnic group has disparate perceptions of GPs and key predictors of vaccine safety perceptions. Whereas GP perceptions showed little influence in the Pacific sample, GP satisfaction was a significant correlate of greater confidence among Europeans and Māori, and GP respect was a significant correlate among Asian peoples.

Parental confidence in vaccine safety and child vaccination status

In the 2013 New Zealand Attitudes and Values Study (NZAVS), New Zealand women showed lower confidence in vaccine safety than men (Lee et al., 2017). Women also exhibited lower confidence among the European, Māori and Asian sample in Study two which used 2017 NZAVS data. These are concerning findings given that mothers are

generally more engaged in childcare than fathers (Statistics New Zealand, 2013b) and take the lead in making childhood vaccination decisions (Litmus, 2013). However, little is known about the extent to which mothers' and fathers' vaccine safety perceptions predict their children's vaccination status. To bridge this gap in knowledge, Study three used a sample of 68 New Zealand couples to investigate the differential influence of mothers' and fathers' level of confidence in vaccine safety on whether their children are fully vaccinated.

Results from this study indicated that mothers', but not fathers', vaccine safety perception significantly predicted their children's full vaccination status. Higher maternal confidence in vaccine safety increased the likelihood that their children are fully vaccinated, whereas paternal confidence level did not have a significant effect. Despite having greater confidence in vaccine safety than mothers, fathers do not appear to have a major role in deciding whether their children receive all vaccinations recommended by the National Immunisation Schedule. Perhaps due to lower perceived knowledge or confidence in engaging with childcare issues (see Garfield & Isacco, 2012), fathers may largely rely on their partners to make childhood vaccination decisions. This study provides a novel contribution to the literature by uncovering the distinct impact that New Zealand mothers' and fathers' view of vaccine safety have on decisions regarding their children's vaccination uptake.

Trajectory of vaccine safety perceptions over time

Population attitudes towards vaccinations are not static and can change over time in response to various time-related factors such as exposure to anti-vaccine information, political and social events, or outbreaks of diseases (see Dube et al., 2015). Therefore, it is vital to constantly monitor and track changes in perceptions of vaccinations across time. Currently, there is a substantial lack of international studies on vaccination attitudes in the international literature, and no previous longitudinal research has been conducted in New

Zealand. Study four advances the literature by assessing New Zealanders' level of confidence in vaccine safety over a period of 5 years (2013 to 2017). This represents a period of heightened vaccine controversies and rise in vaccine hesitancy that led to the outbreak of vaccine-preventable diseases. Using a novel method of analysis, Study four identified three distinct subgroups within the population that show differing trajectories of confidence in vaccine safety. The demographic profiles of these subgroups were also examined.

Findings from Study four revealed that vaccination attitudes are becoming increasingly polarized in New Zealand. Most of the population (60%) showed consistently high confidence in vaccine safety (i.e. *vaccine believers*), but around 30% showed decreasing confidence (i.e. *vaccine skeptics*) and 10% showed increasing confidence over time (i.e. *former skeptics*). *Former skeptics* initially showed the lowest level of confidence in 2013, but their confidence level rapidly increased in subsequent years. It surpassed the confidence level of *vaccine skeptics* in 2016 and approached the high confidence range by 2017. Health professionals may have had a pivotal role in initiating attitude change and correcting misconceptions among *former skeptics.* On the other hand, *vaccine skeptics* may represent those who lack access to adequate healthcare, have inaccurate or insufficient vaccine knowledge or negative perceptions of health professionals.

Relative to *vaccine believers*, women, Māori and Pacific peoples, those living in more deprived regions, and those with lower education were more likely to be *former skeptics* or *vaccine skeptics*. Compared to *former skeptics, vaccine skeptics* were more likely to be female, older and have lower education. These three characteristics are particularly important risk factors of having unaddressed concerns and showing decreasing confidence in vaccine safety. As women are typically more involved in making children's vaccination decisions (Litmus, 2013), they may be more inclined to do additional vaccine research and be exposed to negative information about vaccinations. In contrast, older individuals who do not have

young children may be less likely to consult health professionals about vaccinations and have their misconceptions corrected. Lastly, those less educated may express greater vaccine safety concerns due to their lack of vaccine knowledge and ability to interpret vaccine information.

Implications of research

Group disparities in vaccine safety perceptions

The studies in this thesis revealed important group differences in vaccine safety perceptions. Study one and Study two indicated disparities in vaccine safety perceptions between health professionals and ethnic groups. Study three identified disparities in the influence that mothers' and fathers' level of confidence in vaccine safety have on their children's full vaccination status. Lastly, Study four identified distinct subpopulations with different demographic profiles and trajectories of confidence in vaccine safety over time. These findings shed light on the importance of recognising and understanding group differences in vaccine safety attitudes, rather than treating the whole population as one large homogenous group. Increased insight into these group disparities will help develop target interventions that effectively improve vaccination perceptions and enhance vaccination uptake among specific groups.

Confidence in vaccine safety among midwives and GPs

Findings from Study one indicated that midwives and practitioners of alternative medicine exhibit low levels of 'strong confidence' in vaccine safety and require focused education or additional resources about vaccine safety. Of particular concern was the low level of confidence among midwives. Previous studies have indicated that midwives exhibit a wide spectrum of beliefs about vaccinations (Jelleyman & Ure, 2004; Litmus, 2015). Whereas some confidently recommend vaccinations to parents, others are uncertain, desire

more vaccination information or believe it is up to parents to make vaccination decisions. As midwives are the most involved in and frequently interact with mothers throughout their pregnancy (MOH, 2017c), they are likely to have a crucial influence on mothers' perception of and decisions regarding vaccinations. Low confidence in vaccine safety among midwives may be contributing to why women exhibit greater safety concerns than men. Although midwives have a key role in referring mothers and infants to primary health practitioners for immunisation (Midwivery Council, 2017), many appear to lack accurate vaccine knowledge and confidence in communicating the importance of childhood vaccines to expectant mothers. It is vital to review the vaccination education process for midwives and ensure they are provided sufficient resources and training to alleviate their concerns about vaccine safety. Stronger confidence in and knowledge about vaccine safety among midwives will most likely translate to increased maternal confidence in and greater compliance with childhood vaccinations over time.

Contrary to midwives, there was a consensus of high confidence in childhood vaccine safety among GPs. Explicitly stating that "96.7% of GPs are strongly confident in vaccine safety" may help alleviate concerns and encourage vaccination uptake among some parents. However, GPs also need to be able to effectively communicate their strong confidence in vaccine safety to parents during vaccination discussions. The way GPs initiate discussions and recommend vaccinations will impact the degree to which they can encourage parental vaccine acceptance (see Leask et al., 2012; Opel et al., 2013). Some important facilitators of vaccine acceptance include building rapport and a trusting relationship with parents and attending to their specific concerns and questions (Leask et al., 2012). For hesitant parents, the use of motivational interviewing strategies (i.e. guiding parents to increase their own motivations to vaccinate) rather than direct or excessive persuasion would be a more appropriate strategy (Leask et al., 2012). To optimize GPs' influence on parental vaccination

decisions, GPs must have sufficient knowledge to identify the most adequate methods to promote vaccinations to parents with varying levels of readiness to vaccinate.

GPs and target interventions for ethnic groups

Study two found that GP perceptions were not uniform and had a differential impact on level of confidence in vaccine safety across ethnic groups. Interventions involving GPs should thus consider how to adequately promote vaccinations to parents of diverse cultural backgrounds. Among Europeans and Māori, general satisfaction with GP services was a key contributor to higher confidence in vaccine safety. Accordingly, ensuring that GPs develop strong rapport and consistently deliver high-quality health services would help improve vaccine safety perceptions among these ethnic groups. Increasing GP satisfaction and healthcare access among Māori is particularly important as Māori exhibit lower levels of GP satisfaction, confidence in vaccine safety and vaccination coverage (Lee et al., 2017; Mueller et al., 2011; MOH, 2020b). Some Māori express negative perceptions of European doctors due to experiences of racism and discrimination in the health setting (Harris et al., 2012; Jansen et al., 2008). GPs should be aware of the unique barriers to healthcare and vaccination uptake experienced by Māori and be sufficiently trained to communicate with and provide vaccination information to Māori parents effectively.

Contrary to Māori and Europeans, the degree to which GPs respect their cultural values and demonstrate cultural competency was a more important correlate of vaccine safety perceptions among Asian peoples. Cultural competency refers to having awareness and knowledge about diverse worldviews and the skills to provide culturally appropriate services to those who require such treatment (Medical Council of New Zealand, 2017). Although cultural competency should be practiced when engaging with all patients, demonstrating cultural respect and recommending vaccinations in a culturally appropriate manner may be particularly essential to improve vaccination perceptions among Asian peoples. As GP

perceptions were not significant among the Pacific sample, it suggests that GPs have the least influence on Pacific peoples' view of vaccine safety. Demographic factors appear to have greater impact on their vaccine safety perceptions than healthcare experiences. Nevertheless, understanding the key factors that drive Pacific peoples' vaccination attitudes can help GPs identify the most appropriate ways to recommend vaccinations to Pacific parents.

Previous studies indicated that ethnic minorities tend to report higher rates of racism in healthcare, which can have a detrimental impact on their future healthcare use and health outcomes (Harris et al., 2019; Paine et al., 2018). Extending on these studies, our findings indicate an additional area (i.e. vaccination uptake) in which negative GP interactions can have adverse health implications for ethnic minorities. Additionally, it should be noted that perceived GP cultural similarity was not significantly associated with vaccine safety perceptions among Māori, Pacific and Asian peoples. The fact that most New Zealand doctors are European (NZCGP, 2019) and do not share a similar cultural background does not appear to be a significant barrier to improving vaccine safety perceptions among ethnic minorities. The type of GP service they receive and whether the GP is culturally competent are more important determinants of whether one expresses greater confidence in vaccinations. Hence, mainstream doctors who provide satisfactory GP services and vaccination discussions can positively influence vaccine safety perceptions of those with diverse cultural backgrounds.

Currently, there are a range of cultural diversity training available for doctors but participation in these courses is relatively low (around 30%) and largely driven by self-motivation (Simmonds et al., 2020). Due to pressures to focus on identifying and treating physical health symptoms, many doctors have limited time to reflect on their cultural competency and some do not recognize the importance of culturally oriented healthcare. To increase GP satisfaction and perceived cultural respect among ethnic minorities, it is vital to

more strongly promote and further develop cultural diversity courses and resources for doctors. Cultural diversity courses should be extended to include content on ethnic differences in perceptions of vaccine safety, and the best communication strategies to adopt during vaccination conversations with people from specific ethnic groups. It is essential to ensure that doctors engage in continuous cultural training throughout their career and persistently develop their ability to provide higher-quality and satisfactory services for diverse ethnic groups. This will not only help increase public confidence in vaccine safety but have a broader positive impact on the health outcomes of marginalized ethnic groups in New Zealand.

The role of demographic factors

Ethnic differences in demographic correlates of vaccine safety perception further highlight the need to implement target interventions for specific groups. Compared to the Europeans and Māori, a smaller number of variables showed significant associations with vaccine safety perceptions among Pacific and Asian peoples. However, the strength of these associations was stronger among the latter two groups. The regression model for Pacific and Asian peoples also explained a greater amount of variance in their vaccine safety perception relative to the European and Māori sample. This finding suggests that target interventions for high-risk groups may be more appropriate and effective among Pacific and Asian peoples. For Pacific peoples, these high-risk groups include those who are religious, single, and born in New Zealand. For Asian peoples, high-risk groups include women, those younger and who report lower perceived GP respect. As mentioned above, it would be beneficial for health professionals to be aware of these risk factors and be able to recognize and alleviate common vaccine safety concerns held by people from distinct ethnic groups.

Interestingly, deprivation was only significantly associated with lower confidence among Europeans and Māori. Although Māori and Pacific peoples are more likely to

experience negative social and health consequences due to high deprivation (MOH, 2020), deprivation was not significant in the Pacific sample and a relatively weak predictor in the Māori sample. While deprivation level may influence vaccine safety perception to a certain extent, its significance appears to have been overridden by the inclusion of other, more important, predictors of vaccine safety perception in our model. Among Māori, GP satisfaction and healthcare access showed a much stronger relationship with vaccine safety perception than deprivation. Religion was the strongest predictor of vaccine safety perception among Pacific peoples, suggesting that belief systems rather than socio-economic deprivation are central factors to consider for this group. It should be noted that higher deprivation was previously found to be significantly associated with lower confidence when assessing the population as a whole (Lee et al., 2017). Hence, while deprivation is a significant predictor of lower confidence at a population level, this effect only held for Europeans and Māori when assessing attitudes for each ethnic group separately. This finding again emphasizes the importance of assessing vaccination attitudes of specific groups to understand disparities in key contributors and the types of interventions most crucial for each group.

Higher educational attainment showed a stronger relationship with increased confidence in vaccine safety among European and Asian peoples relative to Māori. This variable was not significant among Pacific peoples. Hence, interventions for European and Asian peoples should target those with lower education, focusing on enhancing understanding and knowledge about vaccinations. They could also help people develop skills to identify trusted sources of vaccine information, interpret vaccine information and distinguish between false and accurate information about vaccinations. Given the high amount of anti-vaccine information online (Dubé, Vivion, & MacDonald, 2015), it is essential to increase parents' ability to recognize misinformation and reduce their susceptibility to conspiracy theories. Among Māori and Pacific peoples, religiosity showed a stronger relationship with lower

confidence in vaccine safety than education. Interventions for these groups need to consider the role of religious beliefs in shaping their perceptions of vaccine safety. It is essential to first increase insight into why vaccinations may be perceived as incompatible with their religion and identify strategies to promote vaccinations in a way that does conflict with their religious beliefs.

Health officials and researchers need to work more closely with Māori and Pacific religious groups, cultural leaders and community organizations to gain accurate insight into the association between religion and vaccine safety perception. Some examples of organizations include Mahi Tahi Trust (2021), a Kaupapa Māori organization, and Vaka Tautua Trust (2021), a charitable organization for Pacific peoples, that promotes the health and wellbeing of minority ethnic groups. In partnership with these organizations, research needs to be undertaken at community settings and religious groups to identify the most common barriers to positive vaccination attitudes, and best methods to interact with and promote vaccinations to these groups. This may be through the development of workshops specifically oriented towards people's cultural and religious values that are provided at a familiar setting such as their local community centre. These workshops should aim to foster a safe and supportive environment where people can comfortably discuss their concerns about vaccinations and are willing to accept new or alternative information.

In terms of gender differences, women showed lower confidence in vaccine safety than men in both the 2013 (Lee et al., 2017) and 2017 NZAVS (see Study two). Gender showed a particularly strong association with lower confidence among Asian peoples. Concerningly, Study three found that mothers', but not fathers', level of confidence in vaccine safety is a significant predictor of their children's full vaccination status. Hence, mothers and their views of vaccine safety have a more central role in determining their children's full vaccination status. This finding accentuates the urgency of implementing

target interventions for mothers to improve their confidence in and compliance with standard childhood vaccinations. Moreover, it is important to promote fathers' involvement in the vaccination decision-making process. Interventions for fathers should focus on improving their confidence in and knowledge about childcare issues (see Garfield & Isacco, 2012). Through increased engagement in vaccination decisions, fathers may be able to positively influence maternal perceptions of vaccine safety and promote full vaccination uptake.

There are various fully funded antenatal and pregnancy courses available for the public in New Zealand (e.g., Auckland District Health Board, 2021; Plunket, 2021). However, the content of these courses mainly targets mothers and there is a lack of focus on understanding the safety and necessity of vaccinations or the vital supporting role of fathers. By taking a more 'couple' and 'family' oriented approach, these programmes could encourage the involvement of fathers and be used to provide focused education about vaccinations to both parents. As being a parent was associated with lower confidence among Māori and Europeans, the antenatal period is an especially important time to strengthen confidence in vaccine safety and encourage vaccination uptake for these groups. On the other hand, having a partner was significant among Pacific and European peoples, suggesting that encouraging parents to work together and support each other through the vaccination process will be particularly effective in improving vaccine safety perceptions for these groups. Moreover, further developing and increasing the number of culturally-oriented antenatal courses (e.g., Whānau Mai – Antenatal education for Māori [Te Puawaitanga ki Otautahi Trust, 2021]) is likely to be most effective in increasing engagement and improve trust in Western health practices among ethnic minorities.

In addition to educating and persuading parents, improvements in vaccination training and resources for health professionals should be made. This includes increasing confidence in vaccine safety among midwives, the lead maternity carer for most New Zealand mothers, and

educating GPs about the reasons for concerns among mothers and effective communication strategies to alleviate vaccine safety concerns among mothers as well as specific ethnic groups. As midwives work most closely with mothers throughout their pregnancy, it is essential to ensure they are educated about the specific concerns and best methods to encourage vaccinations among mothers. Similar to GPs, midwives should be provided continuous cultural diversity training to build on their knowledge about cultural differences in vaccine safety attitudes and their ability to provide culturally appropriate healthcare. In addition to supporting mothers, midwives should further encourage fathers' involvement in child healthcare and enable couples to support each other as they make decision about their child's vaccinations. Being mindful of gender and ethnic differences in vaccination attitudes will help health professionals and authorities provide appropriate and targeted support for both mothers and fathers.

Group differences in vaccine safety perceptions over time

Using longitudinal data, Study four identified three subpopulations with divergent directions and rates of change in level of confidence in vaccine safety. Building on Studies one, two and three, this finding indicates that distinct groups not only differ in vaccine safety perceptions at one given point in time but also across time. Our findings also reinforce that compliance with vaccinations does not necessarily indicate strong confidence in vaccine safety. Although 60% of New Zealanders consistently exhibited strong confidence in vaccine safety during our study period (2013-2017), vaccination coverage has generally remained at around 80 to 90% during these years (Statistics New Zealand, 2017). Many parents who vaccinate their children still hold some degree of concern about vaccine safety. To prevent future declines in vaccination coverage, there is an urgent need to identify and alleviate concerns among parents with lingering concerns.

Worryingly, 30% of the population (i.e., *vaccine skeptics*) exhibited decreasing confidence in vaccine safety. If appropriate interventions are not implemented in a timely manner, confidence in vaccine safety may further decrease among this group and lead to decreases in vaccination uptake. This poses a serious threat to the maintenance of high vaccination coverage and herd immunity in New Zealand. On a more positive note, the rapid increase in confidence level among *former skeptics* suggests that it is possible to persuade those who currently hold vaccine safety doubts. Health professionals are likely to have a pivotal role in correcting misconceptions and addressing vaccine safety concerns for previously skeptical individuals (see Kornides et al., 2018; Leask et al., 2012). Hence, interventions involving health professionals may be most effective in increasing confidence in vaccine safety among *vaccine skeptics*. Identifying the specific factors that facilitated the increase in confidence among *former skeptics* and maintain strong confidence among *vaccine believers* will further help inform the development of target interventions.

Study four also examined the demographic profiles of the three identified subpopulations. Māori and Pacific peoples, those living in deprived regions and less educated were found less likely to be *vaccine believers*. Given that ethnic minorities also exhibited lower confidence in vaccine safety in Study two, this finding stresses the importance of increasing research on the reasons for persistent concerns among Māori and Pacific peoples. Interestingly, deprivation nor ethnicity were key distinguishing factors between *vaccine skeptics* and *former skeptics.* Women, older individuals, and those with lower education were more likely to be *vaccine skeptics*. This finding indicates that gender, age, and education level have a significant influence on whether one is becoming increasingly supportive or skeptical of vaccine safety over time. Contrary to findings that younger people exhibit lower confidence among European and Asian peoples in Study two, older people were found more likely to exhibit decreasing confidence in vaccine safety at a population level. Perhaps

women, older and less educated people are less likely to have their concerns adequately addressed by health professionals or have lower access to trusted vaccine information sources. There is an urgent need to understand the nature of vaccine safety concerns and implement target interventions for these high-risk groups.

Although Study two revealed ethnic disparities in the role of education level, education is a pivotal contributor to decreasing confidence in vaccine safety at a population level. This finding can be linked to the vast amount of anti-vaccine information and conspiracy theories easily accessible online and on social media (Kata 2012). Without accurate knowledge about or strong confidence in vaccinations, people are prone to developing doubts and concerns about vaccine safety when exposed to such information (Downs et al., 2018). Those who are less educated are especially more likely to lack the cognitive ability and knowledge to distinguish between fraudulent and evidence-based vaccination information. They may thus be more receptive to anti-vaccine conspiracy theories (see van Prooijen, 2017). In addition to increasing public knowledge about vaccinations on a broader scale, it is essential to develop target interventions for those with low education to reduce their likelihood of being influenced by fraudulent and informal sources of vaccine information.

Vaccination interventions need to be developed and implemented in a way most appropriate for a specific target group to achieve the best results. Health promoters and public health officials need to recognize group disparities in vaccination perceptions and develop interventions that adequately attend to these differences. As many parents cite health professionals as their primary source of vaccine information (Chow et al., 2017; Freed et al., 2011; Stefanoff et al., 2010), improving vaccine safety perceptions among health professionals and ensuring they are sufficiently trained to effectively communicate vaccine information is of utter importance. Moreover, alternative approaches could be considered for

different groups based on their level of healthcare access and perceptions of health professionals. For instance, public health authorities could work in partnership with ethnic community leaders or groups to communicate information about vaccinations to specific groups. As stated above, cooperating with religious leaders may be a valuable strategy to connect with Māori and Pacific peoples and promote vaccinations in a way that is compatible with their religious or cultural beliefs.

Novel method of investigating population vaccination attitudes

Study four used a novel method to investigate population level changes in vaccine safety perceptions over time. Previously, there has been a lack of sophisticated longitudinal studies on population vaccination attitudes and the population of each country has generally been treated as one homogenous group (e.g., Lane et al., 2018). Extending on past studies, Study four used a latent class analysis to identify distinct subpopulations within a country that show differing trajectories of attitude change over time. Moreover, it subsequently estimated the demographic factors predicting membership in these distinct subpopulations. Our model revealed three subpopulations with diverging trajectories of confidence in vaccine safety and indicated that attitudes towards vaccine safety are becoming increasingly polarized in New Zealand. This finding accentuates the importance of identifying groups that show differing levels and trends of confidence in vaccine safety across time.

The analysis method used in Study four provides an essential framework for future longitudinal research on population level health attitudes globally. It is likely to be of interest to those assessing vaccination attitudes in other countries as well as those conducting research in other fields of health. Our analysis can be used to investigate whether there are distinct subpopulations that show differing trajectories of attitudes over time. If so, it can further assess the specific number of subpopulations, the attitude trajectory and demographic profile of each subpopulation. This method enables the identification of risk factors that

predict persistent or increasingly negative health outcomes or attitudes that may not have been initially hypothesized. Such findings would help determine which subpopulations or demographic groups are most in need of targeted support or focused interventions. Study four not only adds to the literature on longitudinal trends in vaccination attitudes but informs the design of study approaches and analysis that provide more accurate insight into population health attitudes.

Taken together, findings from this thesis highlight that vaccine safety attitudes are not static and differ across groups. Presently, there is a lack of longitudinal research on vaccination attitudes not only in New Zealand, but globally. It is essential that all countries frequently collect information on vaccine safety attitudes and tailor communications to the specific needs of different groups based on these findings. Although cross-sectional studies can be insightful, it is crucial to promptly be aware of changes in attitudes at both a population and group level. Interventions should be refined according to changes in attitudes or contextual factors relevant to that specific point in time. In addition to surges in previously eradicated diseases (e.g., MMR), novel disease outbreaks such as COVID-19 can occur at unpredictable times. Hence, it is crucial to remain vigilant and constantly monitor population attitudes to maintain high public confidence in vaccinations in general. Following vaccination attitudes of distinct groups over time will also reveal whether communication strategies currently being adopted have been effective in improving confidence levels and vaccination uptake over time. These findings will be useful in improving the development and implementation of future vaccination strategies.

Caveats and future research directions

The studies in this thesis advance the literature in multiple ways and inform the development of target vaccination interventions. However, they also have several limitations and raise a number of unanswered questions. These questions lay the foundation for future research on New Zealanders' vaccine safety perceptions: a vital research topic that will be beneficial for public health authorities and policy makers. The remainder of this chapter will consider the caveats of the four studies in this thesis and discuss important directions for future research on public confidence in childhood vaccine safety. This includes issues regarding the measurement of 'vaccine confidence' and need for further research on group differences and longitudinal changes in vaccine safety perceptions.

Measuring 'vaccine confidence'

All four studies used people's level of agreement to the single 7-point Likert item: "It is safe to vaccinate children following the standard NZ Immunisation Schedule" to measure vaccine safety perception. Study one, three and four referred to this concept as 'vaccine confidence.' However, one's sense of 'vaccine confidence' is not solely determined by their vaccine safety perceptions but a diverse range of multiple factors. This includes their level of trust in science, health professionals, the government and pharmaceutical companies, beliefs about vaccine efficacy or necessity and exposure to anti-vaccine information (Badur et al., 2020; Larson et al., 2011). Among certain groups, lack of knowledge about or belief in vaccine necessity may be a more significant barrier to vaccination uptake than vaccine safety concerns. It is essential to examine the role of these additional factors to gain a more accurate understanding of population vaccine confidence and identify groups more likely to exhibit low vaccine confidence.

Future New Zealand studies should assess 'vaccine confidence' using more comprehensive measures with multiple items. A good example would be the Vaccination

Confidence Scale, which has a total of 8 items assessing parental perceptions on (1) the benefits, (2) harms and (3) trust in healthcare providers (Gilkey, Reiter et al., 2016). The 'benefits' section comprises of items asking about belief in vaccine safety, necessity and efficacy. This scale has been validated as a promising tool to identify parents at greater risk of refusing adolescent vaccines (Gilkey, Reiter et al., 2016). The items in this scale would also help discern group differences in level of trust in vaccine benefits, vaccine harms and health professionals. Increased insight into the multiple dimensions of vaccine confidence and group differences in vaccine-related beliefs will aid the development of interventions for the general population as well as target groups.

Vaccine safety concerns among distinct groups

The studies in this thesis revealed that distinct groups have different perceptions of vaccine safety, with certain groups exhibiting greater concern than others. However, our single-item measure that asked about people's level of confidence in standard childhood vaccinations provided limited insight into the specific reasons or concerns that lead to low confidence among different groups. There is a broad range of concerns one may hold and diverse reasons why people express differing concerns. Some people may hold fears about a specific vaccine (e.g. MMR vaccine), whereas others may be skeptical about the total number of vaccinations given or the age at which children receive vaccinations (Kennedy et al., 2011; Smith et al. 2007). The extent to which one is exposed to anti-vaccine information online or through social groups may also impact their view of vaccine safety (Kata, 2010). The following section provides an overview of how findings from this thesis provide a framework for further research on group disparities in vaccine safety perceptions.

Health professionals

Study one assessed health professionals' general level of confidence in vaccine safety but did not examine the reasons why they showed differing levels of confidence. Clarifying

the meaning of ‘vaccine safety’ held among health professional groups may be the first step in understanding why certain groups show lower confidence than others. Distinct groups of health professionals may have interpreted the term ‘safety’ in our item differently due to the nature of their work. As midwives work closely with mothers throughout their entire pregnancy, even minor vaccine-related side effects or distress to the child or mother may be considered a safety concern for midwives. On the other hand, doctors are frequently exposed to more serious health issues such as terminal illnesses, heart attacks or broken bones. Thus, they may be less likely to consider minor side effects a significant issue of concern and rather focus on the benefits of vaccinations that outweigh minor side effects or stressors. Consequently, doctors may have reported higher, and midwives reported lower, confidence in vaccine safety.

Further investigation is warranted on the specific concerns held by different groups of health professionals. Some groups may lack vaccine knowledge and require more education or resources, while others are more likely to hold strong anti-vaccine beliefs. Better understanding the concerns and attitudes of different groups will reveal what specific interventions they require. This is particularly important for midwives and practitioners of alternative medicine, as they show substantially lower confidence levels than other health professionals. Qualitative research on experiences and views of vaccinations among midwives and practitioners of alternative medicine will provide deeper insight into the concerns they hold and how they provide vaccination information to parents. These studies would inform the development of resources or training procedures to ensure that all health professionals have adequate vaccine knowledge, confidence, and relevant communication skills to positively influence parental vaccination decisions.

Ethnic groups and demographic factors

Study two provides a useful foundation for future research on ethnic disparities in vaccine safety perceptions. As key correlates of vaccine safety perceptions for each ethnic group were identified, we need to further investigate why these factors lead to greater or lower confidence in vaccine safety. Some questions that arise include: Why might Pacific peoples and Māori perceive that vaccinations are incompatible with their religious beliefs? How does low education impact European, Māori and Asian New Zealanders' perception of vaccine safety? What other ethnicity specific factors should be considered when assessing vaccine safety perceptions?

Religiosity showed a particularly strong association with lower confidence in vaccine safety among Pacific peoples. Although to a lesser extent, this variable was also a key correlate of low confidence among Māori. To better understand the role of religion, future studies need to investigate why one's religious values or beliefs may be perceived as incompatible with vaccinations. This includes examining whether religious people's vaccine safety concerns are based on specific religious teaching or a general rejection of science. Grabenstien (2013) suggests that the refusal of vaccines among religious groups generally reflects social traditions (e.g., rejection of modernity or science) or genuine concern about vaccine safety rather than theological objections. However, as there are diverse beliefs held by different religious groups, we need to investigate the nature of vaccine safety concerns among specific religious groups. It is important to identify potential disparities in vaccine-related concerns between Pacific peoples and Māori, as well as different religious groups. Further insight into the reason for concerns will help identify the best and most appropriate method to communicate the necessity and safety of vaccinations to specific religious groups.

Study two identified risk factors of low confidence in vaccine safety among Asian peoples. This study treated the Asian population in New Zealand as one broad ethnic group.

Yet, it is important to recognize that there are numerous subgroups within the Asian population. These subgroups have differing histories of settlement, socio-economic status, cultural values, health beliefs and healthcare experiences (see Mehta 2012; MOH, 2006; Wong, 2015). For instance, homeopathy and ayurvedic therapies are common alternative health therapies used among Indians, whereas Chinese people tend to prefer Traditional Chinese Medicine. Indians also exhibit higher English language competence than Chinese people in New Zealand (MOH, 2006). Limited English abilities act as a major barrier to healthcare access and knowledge among Chinese (DeSouza & Garrett, 2005). Differences in characteristics between ethnic groups influence their level of health literacy, access to healthcare and vaccination information, and perceptions of GPs. These factors all contribute to their vaccination perceptions. Future studies should differentiate between specific Asian subgroups to gain a more accurate understanding of vaccine safety perceptions among each Asian subgroup.

Some international studies have identified ethnic differences in health information-seeking behavior and preferred sources of health information (Ball-Rokeach & Wilkin, 2009; Moran et al., 2016). Similarly, there may be ethnic disparities in the degree to which one regards GPs, the internet, and religious or social groups as trusted sources of vaccine information in New Zealand. For those who do not trust or encounter cultural barriers to healthcare, ethnic communities or the internet may be regarded as a primary or preferred source of vaccine information. Based on findings from Study two, religious groups or leaders are an important information source for Pacific peoples. Vaccination issues within one's home country may also influence their perception of vaccinations. For example, Chinese people in New Zealand may have been influenced by the major vaccine scandal in China about a vaccine manufacturer that fabricated the production process of human rabies vaccines (Han et al., 2019). Those who are aware of this issue may have become more skeptical about

vaccine manufacturers in general, reducing their belief in vaccine safety. Further investigating the role of diverse sources and origins of people's vaccine safety concerns will help recognize and address misconceptions among each ethnic group.

Study four found that being younger, female and having low education were demographic risk factors of exhibiting decreasing confidence in vaccine safety over time. Education and gender also showed similar effects among European, Māori and Asian peoples in Study two. Further research is required to determine the specific reasons for low or decreasing vaccine confidence among these groups. There may be notable differences in the information sources used by men and women, those less and more educated, and younger and older people. Regarding the effect of education, it is yet unclear whether New Zealanders with low education simply have less vaccine knowledge or whether they are more likely to hold anti-vaccine beliefs. These individuals could be more susceptible to anti-vaccine conspiracy theories due to their reduced ability to understand and interpret vaccine information. Disparities in the role of education across different demographic groups should also be explored. For instance, limited English abilities may be a major barrier to accessing vaccine information among ethnic minorities with lower education. In contrast, health literacy may be a significant contributor among low socioeconomic status groups, and strong anti-vaccine beliefs may be more prevalent among high socioeconomic status groups.

Conspiracy beliefs and vaccination attitudes

With increased coverage of anti-vaccine content online and on social media, exposure to misinformation has become a significant contributor to the rise and persistence of public concern in vaccine safety (see Dubé, Vivion, & MacDonald, 2015; Tustin et al., 2018). Therefore, it is crucial to investigate the degree to which vaccine misinformation is impacting on New Zealanders' perceptions of vaccinations and whether this is a key determinant of low confidence among certain groups. The NZAVS surveys used in this thesis did not ask about

people's source of vaccination information or anti-vaccine beliefs. It was thus unable to investigate group differences in likelihood of sourcing the internet or degree of exposure to anti-vaccine conspiracy theories. Understanding group differences in exposure and susceptibility to vaccine misinformation in New Zealand is crucial to ensure that high-risk groups are promptly identified, provided educational interventions and directed to trusted vaccination sources.

The 2020/21 NZAVS survey included items on general trust in science and belief in conspiracy theories. Specifically, these items asked about one's degree of (1) "confidence in the scientific community", and belief that (2) "society places too much emphasis on science" and (3) "the official version of major world events given by authorities often hides the truth." Using these items, future NZAVS studies will be able to identify groups that show lower trust in science and higher conspiracy mindsets, and investigate the extent to which these factors impact one's confidence in vaccine safety and actual child vaccination status. Perhaps low trust in science is a key driver of low confidence among those less educated, while higher conspiracy beliefs are a stronger predictor among ethnic minorities who lack trust in government and health authorities. Increased insight into this novel area will further our understanding of the psychological contributors to vaccine safety perceptions and help tailor vaccination communications to the needs of specific groups. As these new items will continue to be included in future surveys, we will soon have longitudinal data to examine whether trust in science and conspiracy beliefs are key determinants of changes in New Zealanders' vaccine safety perceptions over time.

Child vaccination status

Study three examined the differential influence of maternal and paternal confidence on whether their children are fully vaccinated. However, it did not differentiate between children who are fully or partially vaccinated and not vaccinated at all. Future studies should

use a multi-category measure of vaccination status to distinguish between selective vaccinators who have safety concerns about certain vaccines and those who refuse all vaccinations due to general disbelief in vaccine safety. They should also differentiate between parents with children of different age-groups. As our vaccination item asks about the safety of vaccinations "following the New Zealand Immunisation Schedule," the number of or specific vaccines recommended in this Schedule at their children's milestone age may have impacted the way parents responded. Parents with young children may be particularly concerned about the MMR vaccine, receiving "too many" vaccinations at a young age, or the stress and pain that vaccines may cause for their child. In comparison, parents with adolescent children may hold concerns about the Human papillomavirus vaccine due to their lack of knowledge about the vaccine (see Kornides et al., 2018).

As most studies in the current literature focus on maternal vaccination attitudes (e.g., Dube et al., 2019a; Henrikson et al., 2017; Petousis-Harris et al., 2002), there is a lack of understanding about paternal attitudes. Qualitative research on fathers' vaccination perceptions is needed to increase insight into key drivers of their higher confidence in vaccine safety. Perhaps due to their limited involvement in child healthcare decisions, they are less likely to seek or receive additional vaccine information and be exposed to anti-vaccine sentiments. Additionally, it should be investigated whether the role of fathers in the vaccination decision-making process differs depending on the child's age or changes as the child grows. Using an American sample, Moore and Kotelchuck (2002) found that younger age of a child was associated with increased father involvement in child healthcare. Similarly, New Zealand fathers may become less engaged with childcare duties as the child grows. Hence, the influence of fathers' vaccine safety perception on children's vaccination status may diminish over time.

Due to the small sample size, Study three did not include any additional control variables and solely focused on assessing the role of maternal and paternal confidence in vaccine safety. Future studies should control for key demographic factors, such as employment, age, ethnicity, and socio-economic status, which can influence how childcare is shared within couples. Given that fathers spend more time with their children if the mother is employed (Statistics New Zealand, 2013b), fathers may be more involved in making vaccination decisions if both parents have paid work commitments. Moreover, women from East Asian cultures that strongly promote traditional gender roles are more likely to bear excessive childcare responsibilities, even if they have work commitments (Hori, 2017). The extent to which mothers' and fathers' attitudes predict child vaccination status may thus depend on work commitments or cultural backgrounds of a couple. The role of these additional factors should be explored in a larger and ethnically diverse sample of couples in New Zealand.

Longitudinal research on vaccine safety perceptions

A limitation of the first three studies in this thesis is the use of cross-sectional data. As Study one only assessed vaccine safety perception in 2013, it was unable to discern whether confidence in vaccine safety among various health professionals have been increasing or decreasing over time. Building on findings from Study one, future studies should continue to assess longitudinal changes in vaccine safety perceptions among health professionals. Constant monitoring of their confidence levels over time is essential to determine whether the implementation of new interventions is effective in increasing confidence among groups that previously showed low confidence (i.e., midwives, practitioners of alternative medicine). In Study two and three, we were unable to infer causality from our results due to the cross-sectional nature of our data. Nevertheless, it is reasonable to assume that demographic factors precede vaccine safety perceptions and vaccination decisions. That is, one's demographic

characteristics (e.g., ethnicity, education) is likely to impact on one's level of confidence in vaccine safety, and maternal perceptions of vaccine safety is likely to influence child vaccination status, rather than the other way round.

The use of longitudinal data is a major strength of Study four. However, due to the complexity of the model used, there were limitations in the number and types of predictors we could include in our model. We were unable to assess how various other factors (e.g., healthcare access, GP perceptions, anti-vaccine beliefs, information sources) may affect peoples' trajectory of confidence level over time and the reasons for differing trends in confidence across the three subpopulations. *Vaccine skeptics* may represent those who have limited healthcare access and low GP satisfaction, and are more exposed to negative vaccine information via informal sources. On the other hand, *former skeptics* may have had their previous vaccine safety concerns addressed by health professionals and exhibit increasing satisfaction with GPs or healthcare access over time. High satisfaction with GP services and better healthcare access may be critical factors helping maintain strong confidence among *vaccine believers*. Exploring the specific reasons for disparities in confidence levels between these subpopulations will further inform interventions aiming to improve and maintain strong public confidence in vaccine safety. As the influence of GPs on vaccine safety perceptions depends on the patients' ethnic or cultural background, it is also vital to investigate the main facilitators of increasing confidence among distinct ethnic groups.

Another limitation of Study four is that it was unable to assess non-linear trends or potential fluctuations in level of confidence in vaccine safety over time. Rather than a simple linear trend, changes in confidence level may have decreased or increased at different rates during distinct time periods. For instance, the increase in confidence among *former skeptics* may not be best represented by a linear trend as confidence levels may have stabilised or increased at a less (or more) steep rate over certain years. Similarly, the slope of decreasing

confidence among *vaccine skeptics* may have been steeper during certain years compared to others. In addition to identifying non-linear trends, future longitudinal studies should assess the reasons for changes or fluctuations in confidence level over time. This may include the impact of immunisation campaigns, disease outbreaks or media coverage of anti-vaccine information. Children's vaccination status could also be examined along with vaccine safety perceptions to better understand the extent to which safety perceptions predict actual vaccination uptake over time. Such findings will help understand the immediate and long-term threat of decreasing confidence in vaccine safety on childhood vaccination rates in New Zealand and anticipate future changes in vaccination coverage.

Conclusion

Public concern about vaccine safety threatens the maintenance of high vaccination coverage and prevention of infectious disease outbreaks. It is thus crucial to investigate and monitor population attitudes towards vaccinations. The current thesis provides novel insight into New Zealanders' level of confidence in childhood vaccine safety and identifies important group differences in vaccine safety perceptions. Midwives, ethnic minorities, and women showed lower confidence in vaccine safety, and key correlates of high confidence in vaccine safety were found to differ across ethnic groups. Additionally, mothers and fathers were found to have differential influence on the likelihood of their children's full vaccinations status. Only mothers' level of confidence in vaccine safety significantly predicted their children's full vaccination status. Analysis of longitudinal data indicated that there are three distinct subpopulations with differing trajectories of confidence in vaccine safety. Around 30% of New Zealanders showed decreasing confidence over time. These individuals were more likely to be women, younger and have lower education compared to those who showed increasing confidence over time. Findings from this thesis reveal risk factors of low or

declining confidence in vaccine safety and shed light on the importance of implementing tailored interventions for target groups. Attending to group differences in key contributors to vaccine safety perceptions will inform the development of more effective and culturally appropriate vaccination interventions. This thesis provides a promising springboard for future research on group disparities and longitudinal changes in New Zealanders' vaccine safety perceptions.

Appendices

Appendix A

Appendix A presents the appendix for Study one (Chapter Two).

Table A1. Partial Eta Squared value for covariates and occupation in ANCOVA.

Variable	Partial Eta Squared
Occupation	.149
Age	.004
Gender	.000
Māori	.002
Pacific	.003
Asian	.002
Religion	.000
Parent	.004
Partner	.001
Urban	.002

Appendix B

Appendix B presents the appendix for Study two (Chapter Three).

Table B1. New Zealand National Immunisation Schedule in 2014 (MOH, 2020a).[9]

Age	Diseases covered and vaccines
6 weeks	Rotavirus 1 oral vaccine
	Diphtheria/Tetanus/Pertussis/Polio/Hepatitis B/Haemophilus influenzae type b 1 injection
	Pneumococcal 1 injection
3 months	Rotavirus (second dose) 1 oral vaccine
	Diphtheria/Tetanus/Pertussis/Polio/Hepatitis B/Haemophilus influenzae type b 1 injection
	Pneumococcal 1 injection
5 months	Rotavirus (third dose) 1 oral vaccine
	Diphtheria/Tetanus/Pertussis/Polio/Hepatitis B/Haemophilus influenzae type b 1 injection
	Pneumococcal 1 injection
15 months	Haemophilus influenzae type b 1 injection
	Measles/Mumps/Rubella 1 injection
	Pneumococcal 1 injection
4 years	Diphtheria/Tetanus/Pertussis/Polio 1 injection
	Measles/Mumps/Rubella 1 injection
11 years	Tetanus/Diphtheria/Pertussis 1 injection
12 years (girls only)	Human Papillomavirus (HPV) x 3 doses
45 years	Diphtheria/Tetanus 1 injection
65 years	Diphtheria/Tetanus 1 injection
	Influenza 1 Injection annually

[9] Childhood immunisation schedule changes made in 2017 (varicella vaccine at 15 months and HPV vaccine for boys) and 2020 (new event created at 12 months, MMR vaccine given at 12 and 15 months). Previous schedule used during study period reported here.

Table B2. Socio-demographic characteristics of each ethnic group and total sample.

	Gender (N)		Mean age (Age range, SD)	Proportion of parents (N)	Proportion of religious people (N)	Mean education level (SD)	Mean deprivation level (SD)
	Female	Male					
European (N=11724)	53.7% (6277)	46.3% (5406)	52.37 (17-98, 13.74)	75.2% (8811)	34.1% (3988)	5.52 (2.68)	4.38 (2.64)
Māori (N=2123)	49.5% (1048)	50.5% (1068)	50.29 (17-90, 12.98)	77.5% (1645)	40.2% (850)	4.52 (2.79)	5.97 (2.95)
Pacific peoples (N=792)	49% (385)	51% (400)	47.07 (19-77, 13.22)	66.1% (524)	68.2% (537)	5.07 (2.67)	6.56 (2.83)
Asian peoples (N=2166)	62.7% (1354)	37.3% (804)	43.38 (18-81, 14.25)	57.2% (1237)	53.4% (1147)	6.83 (2.14)	4.65 (2.62)
Total sample (N=17072)	54.3% (9234)	45.7% (7773)	50.69 (17-98, 14)	72.8% (12423)	38.9% (6612)	5.54 (2.70)	4.72 (2.76)

Note: Standard NZAVS sample weighting on gender, ethnicity and region of residence applied (numbers may slightly differ to that reported in 'participants' section due to sample weighting). Number of participants included in each variable may differ due to missing data. Religiosity was measured using the item: "Do you identify with a religion and/or spiritual group?" (yes/no response). Education was coded using an 11-level ordinal variable (0 = No qualification to 10 = doctoral degree). Deprivation level was measured using the 2013 New Zealand Deprivation Index, which assigns a decile-rank score between 1 (least deprived) to 10 (most deprived) to each small geographical area in New Zealand based on census information (e.g. home ownership, income, employment rate).

Table B3. Correlates of vaccine safety perception among Europeans in New Zealand.

	B	Lower 95% CI	Upper 95% CI	SE	β	P-value
GP satisfaction	.082**	.059	.106	.012	.076	.000
GP similarity	.016*	.001	.031	.008	.019	.043
GP respect	.068**	.044	.093	.013	.056	.000
Healthcare access	.054**	.041	.067	.007	.080	.000
Gender [C]	.182**	.130	.233	.026	.062	.000
Age	-.004**	-.007	-.002	.001	-.042	.000
Born in NZ [C]	-.018	-.079	.043	.031	-.005	.566
Religion [C]	-.151**	-.202	-.099	.026	-.051	.000
Parent [C]	-.095**	-.160	-.031	.033	-.029	.004
Partner [C]	.131**	.068	.194	.032	.039	.000
Employed [C]	-.080*	-.142	-.018	.032	-.024	.011
Education	.060**	.050	.069	.005	.117	.000
Deprivation	-.015**	-.024	-.005	.005	-.027	.003
Urban [C]	.268**	.204	.332	.033	.074	.000

Note: p<.05*, p<.01**, 'Vaccine safety perception' measured using level of agreement to statement that "it is safe to vaccinate children following the standard NZ Immunisation Schedule" (1=strongly disagree, 7=strongly agree). Scale of measurement: Healthcare access (0-10), Education (0-10), Deprivation (1-10), GP-related variables (1-7), [C] denotes categorical variable (0=women, 1=men for gender; 0=no, 1=yes for all else), R-squared = .067, Average *N*= 12008.

Table B4. Correlates of vaccine safety perception among Māori in New Zealand

	B	Lower 95% CI	Upper 95% CI	SE	β	P-value
GP satisfaction	.155**	.084	.227	.036	.135	.000
GP similarity	.036	-.005	.077	.021	.044	.086
GP respect	.024	-.043	.092	.034	.021	.477
Healthcare access	.060**	.022	.098	.019	.081	.002
Gender [C]	.221*	.049	.393	.088	.061	.012
Age	.001	-.006	.008	.004	.006	.828
Born in NZ [C]	-.290	-.789	.209	.255	-.027	.255
Religion [C]	-.296**	-.461	-.130	.085	-.085	.000
Parent [C]	-.286**	-.501	-.071	.110	-.069	.009
Partner [C]	.093	-.090	.275	.093	.025	.320
Employed [C]	.171	-.029	.371	.102	.042	.095
Education	.032*	.002	.062	.015	.053	.037
Deprivation	-.031*	-.060	-.001	.015	-.053	.041
Urban [C]	.287**	.085	.490	.103	.067	.005

Note: p<.05*, p<.001**, R-squared = .086, Average *N*= 1658.

Table B5. Correlates of vaccine safety perception among Pacific peoples in New Zealand.

	B	Lower 95% CI	Upper 95% CI	SE	β	P-value
GP satisfaction	-.025	-.194	.144	.086	-.022	.775
GP similarity	-.006	-.095	.084	.046	-.008	.903
GP respect	.048	-.102	.199	.077	.048	.528
Healthcare access	-.023	-.117	.071	.048	-.032	.626
Gender [C]	.201	-.192	.594	.201	.064	.315
Age	-.005	-.023	.013	.009	-.042	.585
Born in NZ [C]	-.607**	-.997	-.217	.199	-.189	.002
Religion [C]	-.700**	-1.111	-.289	.210	-.216	.001
Parent [C]	-.039	-.497	.419	.234	-.012	.869
Partner [C]	.625**	.201	1.049	.216	.191	.004
Employed [C]	.021	-.420	.461	.225	.006	.927
Education	.051	-.020	.121	.036	.091	.157
Deprivation	.021	-.044	.085	.033	.039	.533
Urban [C]	-.597	-1.333	.138	.375	-.097	.111

Note: p<.05*, p<.001**, 'Vaccine safety perception' measured using level of agreement to statement that "it is safe to vaccinate children following the standard NZ Immunisation Schedule" (1=strongly disagree, 7=strongly agree). Scale of measurement: Healthcare access (0-10), Education (0-10), Deprivation (1-10), GP-related variables (1-7), [C] denotes categorical variable (0=women, 1=men for gender; 0=no, 1=yes for all else), R-squared = .122, Average *N*= 258.

Table B6. Correlates of vaccine safety perception among Asian peoples in New Zealand.

	B	Lower 95% CI	Upper 95% CI	SE	β	P-value
GP satisfaction	.011	-.079	.101	.046	.012	.808
GP similarity	-.009	-.063	.045	.027	-.015	.747
GP respect	.092*	.007	.177	.043	.105	.033
Healthcare access	.023	-.031	.078	.028	.039	.399
Gender [C]	.330**	.108	.551	.113	.123	.004
Age	-.021**	-.031	-.012	.005	-.233	.000
Born in NZ [C]	-.201	-.452	.049	.128	-.071	.115
Religion [C]	-.191	-.405	.024	.110	-.077	.082
Parent [C]	-.094	-.369	.181	.140	-.037	.501
Partner [C]	.028	-.227	.283	.130	.010	.830
Employed [C]	-.198	-.457	.061	.132	-.065	.134
Education	.061*	.015	.107	.024	.111	.010
Deprivation	-.006	-.048	.036	.022	-.013	.772
Urban [C]	.415	-.005	.836	.215	.086	.053

Note: p<.05*, p<.001**, R-squared = .115, Average *N*= 526.

Appendix C

Appendix C presents the appendix for Study three (Chapter Four).

Table C1. Sample sizes, retention rates and response rates at each Time point of the New Zealand Attitudes and Values Study.

	Time 1 (2009)	Time 2 (2010)	Time 3 (2011)	Time 3.5 (2012)	Time 4 (2012)	Time 5 (2013)	Time 6 (2014)	Time 7 (2015)	Time 8 (2016)	Time 9 (2017)
Sample size (N)	6,518	4,441	6,884	4,514	12,179	18,261	15,820	13,942	21,936	17,072
N retained from at least one previous Time point	-----	4,423	3,918	4,090	6,807	10,502	15,740	13,941	13,779	16,931
N retained from previous Time point only	-----	4,423	3,530	-----	5,762	9,844	14,878	12,550	11,933	15,784
Wave-to-Wave retention [Mortality Adjusted]	-----	68.15%	79.88%	-----	84.13%	81.00%	81.65%	79.58%	85.99%	72.05%
Time 1 Retention [Mortality Adjusted]	-----	68.15%	60.74%	-----	63.26%	61.84%	58.96%	53.32%	54.24%	44.95%
Number of Booster Samples	-----	-----	1	-----	5	2	-----	-----	1	-----
Additional N (including booster, occasional opt-in partners)	-----	16	2,966	424	5,374	7,759	82	2	8,157	141
Response rate (average rate if more than 1 booster sample)	16·6%	----	92·4%	-----	9·8%	8·55%	-----	-----	9·7%	-----

Note: Response rates for Time 2, 3.5, 6, 7 and 9 are not reported as these time points did not include booster samples (these samples included participants from previous time points and occasional opt-ins). Time 3 included a non-random booster recruited from unrelated online newspaper website. In Time 3.5, 424 Pacific participants were recruited informally via Pacific networks. Time 4 included 5 booster samples from the NZ electoral roll (one was a random sample of all registered voters, three sampled people from a certain region or ethnic group, and one sampled people with moderate to high socio-economic deprivation levels). Time 5 included one random electoral roll booster and one booster of those with Māori ancestry. Time 8 included a random electoral roll booster. See technical document for further details (Sibley, 2020).

Table C2. Vaccine confidence, child vaccination status and demographics of full sample (68 couples).

Couple Number	W[a] Vacc Con	M[b] Vacc Con	W[c] Child Vacc	M[d] Child Vacc	W[e] Age	M[f] Age	W[g] Eth	M[h] Eth	W[i] Edu	M[j] Edu	Deprivation[k]
1	7	7	full	full	33	35	NZ Euro	NZ Euro	10	10	-
2	3	6	full	full	39	50	Māori	NZ Euro	7	1	6
3	5	5	full	full	38	37	NZ Euro	NZ Euro	8	7	2
4	7	4	full	full	43	46	NZ Euro	NZ Euro	7	9	9
5	5	6	full	full	40	46	NZ Euro	NZ Euro	7	9	3
6	6	4	full	full	46	49	NZ Euro	NZ Euro	7	1	3
7	7	7	full	full	27	28	NZ Euro	NZ Euro	7	8	3
8	5	6	full	full	48	48	NZ Euro	NZ Euro	4	7	2
9	7	7	full	full	52	51	NZ Euro	NZ Euro	8	10	5
10	6	7	full	full	54	54	NZ Euro	NZ Euro	10	9	4
11	7	6	full	full	46	45	NZ Euro	NZ Euro	8	5	8
12	7	7	unreported	full	51	50	NZ Euro	NZ Euro	8	9	4
13	2	2	none	none	37	37	NZ Euro	NZ Euro	7	8	1
14	2	3	none	partial	39	46	NZ Euro	NZ Euro	0	8	5
15	7	5	full	full	48	47	Māori	Māori	8	3	8
16	6	7	full	full	46	45	NZ Euro	NZ Euro	7	7	1
17	6	7	full	full	40	42	NZ Euro	NZ Euro	7	7	4
18	7	6	full	full	43	38	NZ Euro	NZ Euro	7	5	3
19	7	7	full	full	35	42	NZ Euro	-	7	8	1
20	5	6	full	partial	40	43	NZ Euro	NZ Euro	9	7	2
21	7	7	full	full	41	50	NZ Euro	NZ Euro	1	1	7
22	3	6	none	none	43	42	NZ Euro	NZ Euro	2	6	10
23	7	7	full	full	36	38	NZ Euro	NZ Euro	8	5	5
24	5	1	full	full	44	48	Māori	Māori	8	9	8
25	6	7	full	full	33	32	NZ Euro	NZ Euro	7	7	8
26	6	5	full	full	44	54	NZ Euro	NZ Euro	8	2	5
27	7	7	full	full	41	40	NZ Euro	NZ Euro	9	5	9
28	6	6	full	full	48	51	NZ Euro	Māori	3	3	2

Couple Number	W[a] Vacc Con	M[b] Vacc Con	W[c] Child Vacc	M[d] Child Vacc	W[e] Age	M[f] Age	W[g] Eth	M[h] Eth	W[i] Edu	M[j] Edu	Deprivation[k]
29	6	7	full	full	39	36	NZ Euro	NZ Euro	7	6	9
30	7	6	full	full	39	39	NZ Euro	NZ Euro	7	7	1
31	5	6	full	full	22	25	NZ Euro	Māori	7	7	2
32	4	6	full	full	42	43	NZ Euro	NZ Euro	7	1	9
33	4	7	full	full	33	34	NZ Euro	NZ Euro	7	5	2
34	3	4	don't know	unreported	56	58	NZ Euro	NZ Euro	10	6	3
35	7	5	full	full	42	42	Asian	Asian	3	7	7
36	2	3	partial	partial	52	56	NZ Euro	NZ Euro	5	3	2
37	5	6	full	full	43	43	NZ Euro	NZ Euro	7	7	3
38	6	7	full	full	42	43	Māori	NZ Euro	9	7	3
39	4	5	full	full	29	28	NZ Euro	NZ Euro	9	1	8
40	7	7	full	full	44	44	Māori	NZ Euro	3	5	8
41	7	7	full	full	39	39	NZ Euro	NZ Euro	9	9	8
42	7	6	full	full	53	52	NZ Euro	NZ Euro	6	8	3
43	7	6	full	full	41	43	NZ Euro	NZ Euro	9	7	8
44	5	6	full	unreported	50	55	NZ Euro	NZ Euro	8	9	3
45	4	4	partial	partial	46	50	NZ Euro	NZ Euro	7	10	2
46	6	7	full	full	41	42	NZ Euro	NZ Euro	5	1	2
47	7	6	full	full	40	42	NZ Euro	Pacific	3	3	8
48	7	5	full	full	47	48	-	NZ Euro	0	5	3
49	7	7	full	full	34	38	NZ Euro	NZ Euro	3	3	8
50	7	7	full	unreported	36	34	NZ Euro	NZ Euro	10	7	10
51	6	7	full	full	38	39	NZ Euro	NZ Euro	7	10	1
52	7	4	partial	partial	40	40	NZ Euro	NZ Euro	3	8	1
53	5	7	full	full	46	46	NZ Euro	NZ Euro	8	7	4
54	7	7	full	full	27	29	NZ Euro	NZ Euro	3	4	9
55	7	7	full	full	42	42	NZ Euro	Pacific	3	4	1
56	5	6	full	full	45	51	Māori	NZ Euro	4	4	8

Couple Number	W[a] Vacc Con	M[b] Vacc Con	W[c] Child Vacc	M[d] Child Vacc	W[e] Age	M[f] Age	W[g] Eth	M[h] Eth	W[i] Edu	M[j] Edu	Deprivation[k]
57	7	7	full	full	40	40	NZ Euro	NZ Euro	7	4	7
58	4	7	unreported	full	41	40	NZ Euro	NZ Euro	3	3	4
59	5	7	don't know	full	41	41	Pacific	Pacific	9	7	4
60	7	5	full	full	41	42	NZ Euro	NZ Euro	3	2	1
61	1	3	partial	partial	35	41	NZ Euro	NZ Euro	1	4	6
62	3	4	none	none	33	35	NZ Euro	NZ Euro	7	7	3
63	6	7	full	full	50	45	NZ Euro	NZ Euro	1	8	7
64	7	7	full	full	47	50	NZ Euro	NZ Euro	7	7	4
65	7	7	full	full	50	46	NZ Euro	NZ Euro	10	7	5
66	7	7	full	unreported	33	35	NZ Euro	NZ Euro	7	7	4
67	6	7	full	full	41	42	NZ Euro	NZ Euro	7	7	10
68	7	7	full	full	37	30	NZ Euro	NZ Euro	8	2	8

Note: [a] Women's vaccine confidence, [b] Men's vaccine confidence, [c] Women's reported child vaccination status, [d] Men's reported child vaccination status, [e] Women's age, [f] Men's age, [g] Women's prioritized ethnicity, [h] Men's prioritized ethnicity, [i] Women's education level (0 = No qualification to 10=doctoral degree), [j] Men's education level, [k] Couples' deprivation level. Deprivation level measured using the 2013 New Zealand Deprivation Index, which assigns a decile-rank score between 1 (least deprived) to 10 (most deprived) to each small geographical area in New Zealand based on census information (e.g. home ownership, income, employment rate). '-'indicates missing data.

Appendix D

Appendix D presents the appendix and supplementary material for Study four (Chapter five).

Table D1. New Zealand Immunisation Schedule in 2017 (MOH, 2020a)[10]

Age	Diseases covered and vaccines
Pregnant women	Influenza 1 Injection annually, at any stage of pregnancy
	Tetanus/Diphtheria/Pertussis (who oping cough) 1 injection, during the second or third trimester of pregnancy
6 weeks	Rotavirus (start first dose before 15 weeks) 1 oral vaccine
	Diphtheria/Tetanus/Pertussis/Polio/Hepatitis B/Haemophilus influenzae type b 1 injection
	Pneumococcal 1 injection
3 months	Rotavirus (second dose must be given before 25 weeks) 1 oral vaccine
	Diphtheria/Tetanus/Pertussis/Polio/Hepatitis B/Haemophilus influenzae type b 1 injection
	Pneumococcal 1 injection
5 months	Diphtheria/Tetanus/Pertussis/Polio/Hepatitis B/Haemophilus influenzae type b 1 injection
	Pneumococcal 1 injection
15 months	Haemophilus influenzae type b 1 injection
	Measles/Mumps/Rubella 1 injection
	Pneumococcal 1 injection
	Varicella (Chickenpox) 1 injection
4 years	Diphtheria/Tetanus/Pertussis/Polio 1 injection
	Measles/Mumps/Rubella 1 injection
11 or 12 years	Tetanus/Diphtheria/Pertussis 1 injection
	Human Papillomavirus (HPV) 2 injections given at least 6 months apart for those aged 14 and under 3 injections given over 6 months for those aged 15 and older
45 years	Diphtheria/Tetanus 1 injection
65 years	Diphtheria/Tetanus 1 injection
	Influenza 1 Injection annually

[10] Childhood immunisation schedule changes made in October 2020 (new event created at 12 months, MMR vaccine given at 12 and 15 months). Previous schedule used during study period reported here.

Table D2. Sample sizes, retention rates and response rates at each Time point of the New Zealand Attitudes and Values Study.

	Time 1 (2009)	Time 2 (2010)	Time 3 (2011)	Time 3.5 (2012)	Time 4 (2012)	Time 5 (2013)	Time 6 (2014)	Time 7 (2015)	Time 8 (2016)	Time 9 (2017)
Sample size (N)	6,518	4,441	6,884	4,514	12,179	18,261	15,820	13,942	21,936	17,072
N retained from at least one previous Time point	-----	4,423	3,918	4,090	6,807	10,502	15,740	13,941	13,779	16,931
N retained from previous Time point only	-----	4,423	3,530	-----	5,762	9,844	14,878	12,550	11,933	15,784
Wave-to-Wave retention [Mortality Adjusted]	-----	68.15%	79.88%	-----	84.13%	81.00%	81.65%	79.58%	85.99%	72.05%
Time 1 Retention [Mortality Adjusted]	-----	68.15%	60.74%	-----	63.26%	61.84%	58.96%	53.32%	54.24%	44.95%
Number of Booster Samples	-----	-----	1	-----	5	2	-----	-----	1	-----
Additional N (including booster, occasional opt-in partners)	-----	16	2,966	424	5,374	7,759	82	2	8,157	141
Response rate (average rate if more than 1 booster sample)	16.6%	----	92.4%	-----	9.8%	8.55%	-----	-----	9.7%	-----

Note: Response rates for Time 2, 3.5, 6, 7 and 9 are not reported as these time points did not include booster samples (these samples included participants from previous time points and occasional opt-ins). Time 3 included non-random booster recruited from unrelated online newspaper website. Time 4 included one weighted deprivation booster and four electoral boosters (one random and other three oversampling based on region of residence or ethnicity). Time 5 included a random electoral and Māori electoral booster. Time 8 included a random electoral booster. Around 400-450 Pacific participants were recruited informally via Pacific networks in Time 3.5

Table D3. Odds rations for multinomial logistic regression with *vaccine believers*, *vaccine skeptics* and *former skeptics* as reference groups respectively.

		Former skeptics					*Vaccine skeptics*				
Reference Category: *Vaccine believers*		OR	Lower CI	Upper CI	SE	P-value	OR	Lower CI	Upper CI	SE	P-value
	Gender	0.827*	0.704	0.972	0.068	0.011	0.660**	0.591	0.738	0.037	<0.001
	Māori	1.699**	1.372	2.104	0.185	<0.001	1.988**	1.707	2.315	0.155	<0.001
	Pacific	1.968**	1.386	2.795	0.352	0.006	1.576*	1.183	2.100	0.231	0.013
	Asian	1.066	0.724	1.569	0.210	0.753	1.406*	1.089	1.814	0.183	0.026
	Age	0.996	0.991	1.002	0.003	0.195	1.003	0.999	1.007	0.002	0.115
	Deprivation	1.054**	1.025	1.083	0.015	<0.001	1.056**	1.035	1.077	0.011	<0.001
	Education	0.929**	0.904	0.956	0.013	<0.001	0.887	0.871	0.904	0.009	<0.001

Note: *p<0.05, **p<0.01, numbers in tables are rounded to 3 decimal points for greater accuracy.

		Former skeptics					*Vaccine believers*				
Reference Category: *Vaccine skeptics*		OR	Lower CI	Upper CI	SE	P-value	OR	Lower CI	Upper CI	SE	P-value
	Gender	1.252*	1.039	1.509	0.119	0.035	1.514**	1.355	1.692	0.086	<0.001
	Māori	0.855	0.679	1.076	0.101	0.148	0.503**	0.432	0.586	0.039	<0.001
	Pacific	1.249	0.856	1.821	0.240	0.301	0.634**	0.476	0.845	0.093	<0.001
	Asian	0.758	0.493	1.167	0.167	0.148	0.711**	0.551	0.918	0.093	0.002
	Age	0.993*	0.987	0.999	0.003	0.031	0.997	0.993	1.001	0.002	0.114
	Deprivation	0.998	0.967	1.030	0.016	0.902	0.947**	0.929	0.966	0.009	<0.001
	Education	1.047**	1.014	1.081	0.017	0.005	1.127**	1.106	1.148	0.011	<0.001

Note: *p<0.05, **p<0.01, numbers in tables are rounded to 3 decimal points for greater accuracy.

Table D3 continued.

		Vaccine skeptics					*Vaccine believers*				
Reference Category: *Former skeptics*		OR	Lower CI	Upper CI	SE	P-value	OR	Lower CI	Upper CI	SE	P-value
	Gender	0.799**	0.663	0.963	0.076	0.008	1.210*	1.029	1.421	0.100	0.035
	Māori	1.170	0.929	1.473	0.138	0.216	.589**	0.475	0.729	0.064	<-0.001
	Pacific	0.801	0.549	1.168	0.154	0.197	.508**	0.358	0.722	0.091	<0.001
	Asian	1.318	0.857	2.029	0.290	0.272	0.938	0.637	1.381	0.185	0.737
	Age	1.007*	1.001	1.013	0.003	0.032	1.004	0.998	1.009	0.003	0.197
	Deprivation	1.002	0.971	1.034	0.016	0.902	0.949**	0.923	0.976	0.014	<0.001
	Education	0.955**	0.925	0.986	0.016	0.004	1.076**	1.046	1.107	0.016	<0.001

Note: *p<0.05, **p<0.01, numbers in tables are rounded to 3 decimal points for greater accuracy.

Table D4. Average latent class probabilities for most likely latent class membership (row) by latent class (column).

	1	*2*	*3*
1. Former skeptics	0.843	0.101	0.056
2. Vaccine skeptics	0.057	0.878	0.065
3. Vaccine believers	0.014	0.085	0.901

Table D5. Demographic characteristics of subpopulations based on most likely group membership.

	Gender		Ethnicity			Age (Time 5)		Deprivation	Education
	Female	Male	Maori	Pacific	Asian	Age range	Mean age (SD)	Mean level (SD)	Mean level (SD)
Vaccine believers (N=12826)	60.81%	39.19%	10.55%	2.69%	4.30%	17-94	49.72 (14.30)	4.45 (2.70)	5.36 (2.78)
Vaccine skeptics (N=3388)	67.89%	32.11%	19.45%	4.90%	4.78%	18-94	50.03 (12.09)	5.02 (2.78)	4.53 (2.73)
Former skeptics (N=1117)	64.87%	35.13%	17.46%	5.55%	4.48%	18-82	48.90 (13.66)	4.96 (2.80)	4.83 (2.82)

Note: The current study initially aimed to make inferences about and look at population level trends in vaccine attitudes rather than identify the specific demographic breakdown of subpopulations. This is because our analyses were based on the *probability* of classification (not simple categorization) and thus, we need to be cautious about categorizing people into groups. Nevertheless, this data may inform the development of target vaccination interventions by helping identify groups of individuals most likely to fall into each subpopulation.

Ethnicity is not mutually exclusive (participants indicated all ethnic groups they identified with at each time point); Proportion for European is not included as it was used as reference category in the regression analysis that was used to obtain most likely class membership. Scale for deprivation (1=lowest, 10=highest) and education level (0=no qualification, 10=doctoral degree).

Supplementary Material

Results for four class model using latent class analysis

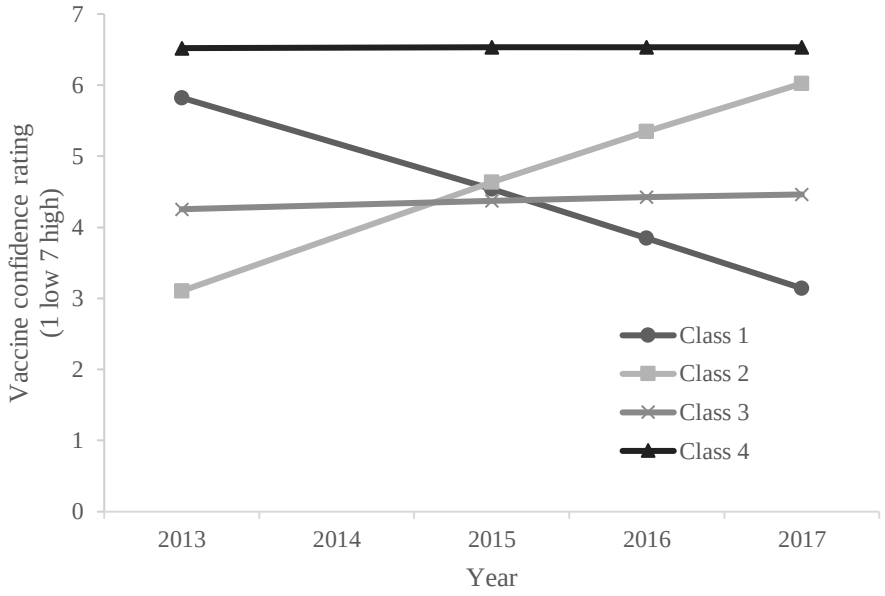

Figure D1. Trajectory of vaccine confidence over time in four-class solution.

Table D6. Class proportions, mean intercept and slope values for each class.

	Class proportion	Mean intercept	P-value	Mean slope	P-value
Class 1	0.060 (N=765)	5.948**	<0.001	-0.630**	<0.001
Class 2	0.074 (N=947)	3.287**	<0.001	0.724**	<0.001
Class 3	0.260 (N=3343)	4.449**	<0.001	0.038**	0.009
Class 4	0.605 (N=7770)	6.559**	<0.001	0.005	0.165

Note: *p<0.05, **p<0.01

Table D7. Odds rations for logistic regression predicting class membership; Class 1 as reference category.

Reference Category		Class 2				
Class 1		OR	Lower CI	Upper CI	SE	P-value
	Gender	1.457*	1.134	1.872	0.186	0.014
	Maori	0.635**	0.473	0.851	0.095	<0.001
	Pacific	0.891	0.557	1.424	0.213	0.609
	Asian	0.495**	0.289	0.847	0.136	<0.001
	Age	0.996	0 .989	1.004	0.004	0.370
	Deprivation	0.981	0.940	1.023	0.021	0.367
	Education	1.068**	1.024	1.114	0.023	0.003
Reference Category		Class 3				
Class 1		OR	Lower CI	Upper CI	SE	P-value
	Gender	1.139	0.907	1.431	0.133	0.294
	Maori	0.791*	0.619	1.011	0.099	0.035
	Pacific	0.731	0.482	1.107	0.155	0.082
	Asian	0.688*	0.443	1.068	0.154	0.043
	Age	1.009**	1.003	1.016	0.003	0.005
	Deprivation	0.975	0.939	1.012	0.019	0.174
	Education	1.029	0.992	1.067	0.019	0.132
Reference Category		Class 4				
Class 1		OR	Lower CI	Upper CI	SE	P-value
	Gender	1.678**	1.370	2.056	0.174	<0.001
	Maori	0.414**	0.331	0.518	0.047	<0.001
	Pacific	0.506**	0.348	0.737	0.097	<0.001
	Asian	0.542**	0.368	0.798	0.107	<0.001
	Age	1.005	0.999	1.011	0.003	0.096
	Deprivation	0.929**	0.898	0.961	0.016	.<0.001
	Education	1.147**	1.110	1.186	0.019	<0.001

Note: *p<0.05, **p<0.01, numbers in tables are rounded to 3 decimal points for greater accuracy.

Table D8. Odds rations for logistic regression predicting class membership; Class 2 as reference category.

Reference Category		Class 1				
Class 2		OR	Lower CI	Upper CI	SE	P-value
	Gender	0.686**	0.534	0.882	0.088	<0.001
	Maori	1.576*	1.176	2.112	0.236	0.014
	Pacific	1.122	0.702	1.794	0.269	0.649
	Asian	2.021	1.180	3.460	0.554	0.066
	Age	1.004	0.996	1.012	0.004	0.371
	Deprivation	1.020	0.977	1.064	0.022	0.376
	Education	1.323**	0.898	0.977	0.020	0.002
Reference Category		Class 3				
Class 2		OR	Lower CI	Upper CI	SE	P-value
	Gender	0.782**	0.640	0.956	0.080	0.006
	Maori	1.247	0.962	1.616	0.165	0.134
	Pacific	0.820	0.533	1.262	0.180	0.318
	Asian	1.390	0.849	2.276	0.350	0.265
	Age	1.013**	1.006	1.020	0.003	<0.001
	Deprivation	0.994	0.960	1.029	0.018	0.721
	Education	0.964*	0.931	0.997	0.017	0.032
Reference Category		Class 4				
Class 2		OR	Lower CI	Upper CI	SE	P-value
	Gender	1.152	0.972	1.365	0.100	0.128
	Maori	0.652**	0.517	0.823	0.077	<0.001
	Pacific	0.568**	0.388	0.832	0.111	<0.001
	Asian	1.095	0.715	1.679	0.239	0.690
	Age	1.009**	1.003	1.015	0.003	0.005
	Deprivation	0.947**	0.919	0.976	0.014	<0.001
	Education	1.075**	1.043	1.107	0.016	<0.001

Note: *p<0.05, **p<0.01

Table D9. Odds rations for logistic regression predicting class membership; Class 3 as reference category.

Reference Category		Class 1				
Class 3		OR	Lower CI	Upper CI	SE	P-value
	Gender	0.878	0.699	1.103	0.102	0.232
	Maori	1.264	0.989	1.615	0.158	0.096
	Pacific	1.369	0.904	2.074	0.290	0.203
	Asian	1.454	0.936	2.258	0.326	0.165
	Age	0.991**	0.984	0.997	0.003	0.005
	Deprivation	1.026	0.988	1.065	0.020	0.185
	Education	0.972	0.937	1.008	0.018	0.121
Reference Category		Class 2				
Class 3		OR	Lower CI	Upper CI	SE	P-value
	Gender	1.279*	1.046	1.563	0.131	0.033
	Maori	0.802	0.619	1.039	0.106	0.062
	Pacific	1.220	0.792	1.878	0.268	0.413
	Asian	0.719	0.439	1.178	0.181	0.121
	Age	0.987**	0.981	0.994	0.003	<0.001
	Deprivation	1.006	0.972	1.042	0.018	0.723
	Education	1.038*	1.003	1.074	0.018	0.039
Reference Category		Class 4				
Class 3		OR	Lower CI	Upper CI	SE	P-value
	Gender	1.473**	1.306	1.662	0.091	<0.001
	Maori	0.523**	0.443	0.618	0.045	<0.001
	Pacific	0.693**	0.506	0.949	0.111	0.006
	Asian	0.788	0.592	1.048	0.115	0.064
	Age	0.996*	0.992	1.000	0.002	0.038
	Deprivation	0.953**	0.933	0.973	0.010	<0.001
	Education	1.115**	1.093	1.138	0.012	<0.001

Note: *p<0.05, **p<0.01

Table D10. Odds rations for logistic regression predicting class membership; Class 4 as reference category.

Reference Category		Class 1				
Class 4		OR	Lower CI	Upper CI	SE	P-value
	Gender	0.596**	0.486	0.730	0.062	<0.001
	Maori	2.416**	1.930	3.025	0.277	<0.001
	Pacific	1.975*	1.358	2.875	0.378	0.010
	Asian	1.845*	1.253	2.718	0.365	0.020
	Age	0.995	0.989	1.001	0.003	0.094
	Deprivation	1.077**	1.041	1.114	0.018	<0.001
	Education	0.871**	0.843	0.901	0.015	<0.001
Reference Category		Class 2				
Class 4		OR	Lower CI	Upper CI	SE	P-value
	Gender	0.868	0.732	1.029	0.075	0.079
	Maori	1.533**	1.215	1.936	0.182	0.003
	Pacific	1.760*	1.202	2.578	0.343	0.027
	Asian	0.913	0.596	1.399	0.199	0.662
	Age	0.991**	0.985	0.997	0.003	0.005
	Deprivation	1.056**	1.025	1.088	0.016	0.001
	Education	0.931**	0.903	0.959	0.014	<0.001
Reference Category		Class 3				
Class 4		OR	Lower CI	Upper CI	SE	P-value
	Gender	0.679**	0.602	0.766	0.042	<0.001
	Maori	1.912**	1.618	2.259	0.163	<0.001
	Pacific	1.443	1.054	1.976	0.231	0.056
	Asian	1.269	0.954	1.688	0.185	0.145
	Age	1.004*	1.000	1.008	0.002	0.039
	Deprivation	1.049**	1.028	1.072	0.011	<0.001
	Education	0.897**	0.879	0.915	0.009	<0.001

Note: *p<0.05, **p<0.01

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