Vaccination in Aotearoa: the role of anticipated regret, temporal discounting and maternal mental health

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Table of Contents

Abstract

Background. Uptake of childhood vaccines in Aotearoa remains consistently lower than necessary for population immunity. Understanding drivers for vaccine hesitancy is a complex but essential exercise. New and expectant mothers are generally primary decision-makers about vaccination for their babies, yet the crucial timeframe for those decisions coincides with the highest risk period for perinatal anxiety and depression.

Study aims. This study was designed to test the hypothesis that anxiety and depression in pregnancy and postnatally have an effect on vaccination rates, given research support for a link between psychological distress and decision-making challenges. Decision theory guided the study, specifically temporal discounting, and anticipated regret. Participants' own perspectives about key influences on their decisions were also explored.

Methods. The study was a cross-sectional survey of new and expectant New Zealand mothers, recruited via social media – $N = 387$ (quantitative); $N = 411$ (content analysis). Survey items included existing measures (EPDS, GAD-7, MCQ) alongside purpose-built items and open-ended questions. Possible confounds, ethnicity and socio-economic status, were identified from a literature search and statistically controlled.

Results. Anticipated action regret (action and inaction) was strongly and significantly correlated with vaccination intention. However, the hypothesised relationships between temporal discounting and either perinatal depression or anxiety were not observed. Further, neither anticipated regret nor temporal discounting had the expected effects on vaccination intentions. The observed depression/intention relationship was negligible, and anxiety was moderately, statistically significantly, and (contrary to prediction) positively correlated with intention. The sixth hypothesis (partial mediation of the distress-intention relationship by temporal discounting and anticipated regret) was also unsupported. Content analysis of open-ended questions suggested six main categories of influence on vaccination intentions - beliefs

(safety/risk, effectiveness); knowledge/experience; health protection; formal sources (health officials/professionals); social (whānau/family, others); and pragmatic. Latent themes - fear and confidence, underpinned each category. Most participants reported no change, unless a strengthening of their position, due to the COVID-19 pandemic.

Conclusions. Overall, there was evidence of a strong relationship between anticipated regret and vaccination intentions. However, perinatal depression did not have an observable effect on intentions, and – contrary to predictions - perinatal anxiety increased, rather than decreased, intention to vaccinate. Although the hypotheses were not supported here, the findings nevertheless suggest that intention is impacted by predicted regret about the consequences of that decision. Furthermore, a role for anxiety or regret in vaccination decision-making was supported by analysis of participants' self-reported key influences on their decision-making. In this sample, limited variance in levels of elevated levels of either depression or anxiety (most experiencing no to low symptoms) or vaccination intentions (most being pro-vaccination), potentially affected the results obtained, Further investigation of the role of emotion and perinatal distress relationship is justified.

Preface

Part 1 of this thesis, chapters 1-5, provide an overview of vaccines, hesitancy and the link between psychological distress and decision-making challenges. The study itself was primarily quantitative, with a qualitative element introduced in recognition of the importance of asking participants for their perceptions and experiences to provide vital context for the study which otherwise would have been lacking. For ease of reading, the quantitative results and a discussion of these have been kept together (chapters 8 and 9), followed by the qualitative findings and discussion (chapters 10-11). Chapter 12 concludes the thesis, bringing together the findings and their practical implications.

The study was initially planned and designed before the start of the COVID-19 pandemic and required adjustment to reflect a changing landscape of vaccine availability and attitudes in response to the novel vaccines, which impacted views on routine immunisation. COVID vaccines were not yet available at the time data was collected, nor are they now part of the routine childhood schedule. Nevertheless, it was important to evaluate how the pandemic may have impacted decisions. Additional items were included to evaluate sources of stress or distress and participants' existing attitudes to vaccination. A chapter was also included outlining the impact of a health emergency on attitudes.

All information in this thesis is my own. Whilst guided by my three supervisors at each step of the research process, and grateful for the input of Dr Matt Shepherd (Massey) on important cultural considerations relating to study design and implementation, every stage - from design, through implementation, analysis and write up - was carried out by me alone. Ethical approval for the study was obtained from the Massey University Human Ethics Committee (Northern) Application 20/63. Interim findings of the study were presented at the conference of the Australasian Society of Behavioural Health and Medicine (February 2022).

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List of Tables

List of Figures

List of Abbreviations

APA	American Psychiatric Association
AMRF	Auckland Medical Research Foundation
AR	Anticipated regret
BCG	Tuberculosis vaccine
COVID-19	Coronavirus
CDC	Center for Disease Control
CFI	Comparative fit index
DAG	Directed acyclic graph
DTaP-IPV-HepB/Hib	Vaccine against diphtheria, pertussis (whooping cough), tetanus, polio and hepatitis B
DSM-5	American Psychiatric Association's Diagnostic and Statistical Manual, version 5
DWLS	Diagonally weighted least squares
EPDS	Edinburgh Postnatal Depression Scale
EVD	Ebola viral disease
GAD-7	Generalised Anxiety Disorder 7-item screening test
H1N1	Strain of influenza
HBM	Health belief model
HISO	Health Information Standards Organisation
HIV	Human Immunodeficiency Virus
HPV	Human papamillovirus vaccine
ICD-10/ICD-11	WHO's International Classification of Diseases, version 10/11
MCQ	Kirby's monetary choice questionnaire
MERS	Middle Eastern respiratory syndrome
MMR	Combined vaccine against measles, mumps and rubella
mRNA-CV	Pfizer/nBiotech vaccine against COVID-19
NZ	New Zealand
OSF	Open Science Framework
PADA NZ	Perinatal Anxiety and Depression Aotearoa
RMSEA	Root mean square error of approximation

SARS	Severe acute respiratory syndrome
SEM	Structural equation model(ling)
SES	Socio-economic status
TPB	Theory of planned behaviour
TD	Temporal discounting
UK	United Kingdom
UN	United Nations
USA	United States of America
WHO	World Health Organization

List of Appendices

PART I: LITERATURE REVIEW

Chapter 1: Introduction

Across the globe, vaccination has revolutionised human resistance to infectious disease (Andre et al., 2008). Yet despite its manifest benefits, vaccine uptake is not universal, with rates often well below required thresholds for population immunity (Lane et al., 2018; Ministry of Health, Manatū Hauora, 2020c). Although socio-economic, geographic, and medical barriers all play an important role in vaccine uptake, decisions whether to immunise or be immunised are also guided by individual perception and tolerance of risk. Fear of adverse reactions or side effects are commonly advanced to explain why vaccination is delayed or refused outright (Lee et al., 2017; Lee & Sibley, 2020a; Litmus, 2013). In general, there is a tendency to place more importance on potential adverse outcomes that might occur soon than on those which could occur in a more distant future (Green et al., 1996). *Temporal discounting* describes the phenomenon of an incremental decrease in the perceived value of a future outcome or reward as the time until its potential receipt increases. In the context of vaccination decision-making, a person must weigh competing spectres of possible adverse reaction to a vaccine in the present against potential future illness. This requires *prospection* - the present-moment contemplation of the future value (or consequences) of vaccinating. Unsurprisingly then, models of decision-making underpinning vaccination policy and intervention campaigns tend to be cognitive ones. Yet these are decisions also coloured by emotion, in particular the regret or guilt a person anticipates experiencing if the chosen path were to have an undesirable outcome (Chou & Budenz, 2020). In addition, both anxiety and depression can impact decision making, risk appraisal, the anticipation of regret, and the extent to which future outcomes may be discounted (Steinglass et al., 2017) . Despite this, the impact of psychological distress on cognitive models as applied to vaccination remains

under-researched. Given reported rates of pre- and postnatal depression and anxiety in Aotearoa/New Zealand, together with the timing for delivery of most vaccines in infancy and very early childhood, understanding the strength and direction of any relationship between maternal psychological distress and vaccination behaviours is particularly important.

Already crucial to population health, improved understanding in this area has become urgent in light of the global health crisis occasioned by the ongoing COVID-19 pandemic. Faced with the biggest threat to population health, and the largest mass vaccination campaigns of our time, researchers across the globe are redoubling efforts to understand and help address vaccine hesitancy (Robinson, Jones, et al., 2021; Sallam, 2021). Now, as during previous pandemics, behaviours in respect of both novel and existing vaccines fluctuate in line with threat perception, driven by numbers of people adversely affected and the nature and extent of media coverage (Aboelsaad et al., 2021; Bults et al., 2015; Cave, 2017; Determann et al., 2014; Feleszko et al., 2021; Henrich & Holmes, 2009; Rubinstein et al., 2015). Disruptions to routine healthcare due to lockdown or fears of contamination, long-term psychological sequelae of isolation and health worries, and the lengthy timeframe anticipated for the resolution of the present crisis, together render current evaluation of the influences on individuals' concerns about both disease and vaccine safety essential to safeguard both the mental and the physical wellbeing of our population (Kaufman et al., 2020; Poulton et al., 2020; Walker, 2020; World Health Organization, 2020b).

A focus on soon-to-be and new mothers in Aotearoa is crucial to evaluating vaccination behaviours. Mothers in this country carry primary responsibility for childcare, including child health and vaccinations, from infancy through adolescence (Litmus, 2013; McGuigan, 2012; Statistics New Zealand, 2013). Recent research in Aotearoa demonstrates that it is a mother's stance on vaccination and perception of risk that predicts uptake, not a father's (Lee et al., 2020). Health-related decisions continue to be made for a child until he or

she is deemed capable of consent. This includes those immunisations administered during early adolescence, yearly immunisations against the flu, and now the COVID vaccine for children. Yet, due to the necessary scheduling of administration of the majority of vaccines in very early childhood, vaccination decisions and uptake coincide with a period of heightened risk of psychological distress for mothers in the form of pre or postnatal anxiety or depression (Biaggi et al., 2016; Leach et al., 2017; Signal et al., 2017).

The central aim of this study was therefore to examine the case for the effect of perinatal psychological distress – pre- and postnatal depression or anxiety – on vaccination intentions and behaviours. Specifically, while controlling for plausible confounding variables, the strength and direction of any correlation between vaccination behaviours and depression and/or anxiety were evaluated. An additional, related aim was to qualitatively explore individuals' own understanding of the wider influences on their decisions and behaviours. The impetus for the study was to contribute evidence regarding any relationship between perinatal psychological distress and vaccination behaviour that might justify an intensive focus on and expenditure of resource to improve mental health for women in pregnancy and postnatally. Beyond intrinsic benefits to women and, consequently, for the child and family as a whole, it is hoped that these findings may also precipitate improvement in vaccination rates and population health overall. Already considered essential, this contribution to vaccination knowledge was rendered all the more urgent by the global health crisis that is the ongoing COVID-19 pandemic, timed to coincide with rising rates of endemic disease in the face of decreased confidence in or accessibility of vaccines. Conducting New Zealand-specific studies is crucial to population health in Aotearoa given evidence of the role of societal factors on vaccination, including culture, traditions, history, government campaigns or media coverage.

Vaccination – A Brief History

Although pathogens may quickly take hold of a host, human immune systems are capable of mounting powerful resistance against infection when the pathogen has previously been encountered by the body. Vaccines allow the exposure requirement to be sidestepped and public immunisation programmes have transformed human health and life-expectancy, dramatically reducing morbidity and mortality from infectious disease (Andre et al., 2008). The scientific process is sophisticated, but the mechanism by which a vaccine protects individuals and communities can be simply described. A vaccine is a substance introduced to a human body that stimulates immunity against a target disease or diseases through the production of antibodies to defend against the particular pathogen(s) in question. It may consist of either causative agents of the disease (whether live or inactive), its products (microbial fragments or particles), or a synthetic substitute. In response to the COVID-19 epidemic, a range of vaccine types were created at unprecedented speeds. New technology in development saw, alongside more traditional methods, the delivery of the "message" to human cells via adenovirus particles carrying a DNA version of the unique spike protein sequence (Ryan, 2021). The adenovirus itself, in this instance, is not the vaccine, merely the vehicle by which it is introduced to the body. Irrespective of vaccine technology or type, however, the ultimate aim remains the same - to create a "memory" for that pathogen within the cells of the human body, primarily the lymph nodes. When encountered again, the immune system recognises the pathogen, triggering a response that neutralises it before it can take hold (Ministry of Health, Manatū Hauora, 2018). This benefits the individual recipient of the vaccine, but also the wider community. The effect occurs because, when vaccine coverage is sufficiently high against any disease, fewer susceptible hosts are encountered, and widespread onward transmission is halted. Although some vaccines get very close to 100% effectiveness for all recipients (e.g., the MMR vaccine is reported to protect 99% of

recipients against measles and 88% against mumps), no vaccine yet made is entirely effective for every person. Furthermore, whether by choice or due to other factors such as accessibility or medical contraindications, not every person will be vaccinated. Population – or "herd" – immunity is therefore essential to keep disease from running rampant (Anderson & May, 1985; Andre et al., 2008). To achieve this, a certain minimum threshold number of individuals must become resistant to infection. The exact proportion varies by disease, in function of infectiousness (the rate of reproduction of the pathogen – *R number*), with measles and pertussis being highest, requiring 94-95% population coverage to prevent widespread transmission within the community (Cutts & Markowitz, 1994; World Health Organization, 2022b). Although frequently used interchangeably, the terms *immunisation* and *vaccination* in fact carry different meanings. Whereas vaccination is the act of administering a vaccine to a person, immunisation is the purpose and effect of the vaccine itself, namely becoming immune to the target disease. Government health schemes are referred to as immunisation programmes reflecting the aim and intent to achieve individual and population immunity.

Forerunners of modern vaccines are believed to have existed for at least several hundreds of years in China, Africa, and Turkey, and possibly as early as 1000 AC (Immunisation Advisory Centre, 2016a; College of Physicians of Philadelphia, 2022). It was in the 18th century, however, that Lady Mary Wortley Montague set in motion a chain of events that would eventually lead to the world's first – and only – successful eradication of an infectious disease in humans (Willett, 2021). Wortley Montague successfully inoculated first her daughter and, later, her son, by deliberate infection with a very small dose of smallpox. A survivor of the disease herself, Wortley Montague had learned about inoculation practices in Turkey and wanted her children to avoid the distress she had endured. Her ideas drew a small following but improper administration damaged not only Wortley Montague's own

credibility, but also of the process itself. Edward Jenner reignited interest in vaccination, lending credibility to the process in his capacity as an educated physician. He adopted a standardised approach to his experimentation and put medical safeguards in place for recipients. Thereafter, momentum for the practice began to grow in the West. Jenner had himself been vaccinated as child as a result of Wortley Montague's discoveries and he built on his knowledge of that process in creating his own vaccine using an animal pox (possibly cow or horse), demonstrating how this could produce immunity to smallpox in humans (Baxby, 1999; Plotkin, 2014). Although smallpox eradication was only achieved in 1979, long after Jenner's death, he is credited with saving some 530 million lives (Petousis-Harris, 2016). Nearly 100 years after Jenner's efforts, in 1885, Louis Pasteur developed a vaccine against rabies, and others soon followed through the 19th and 20th centuries. Immunity through vaccination became possible against diphtheria, tetanus, anthrax, cholera, plague, typhoid and tuberculosis, then measles, mumps and rubella, many developed by Maurice Hilleman (Plotkin, 2011).

The significance of the immunisation programme and ready availability of vaccines for human life and health in Aotearoa is evident from an examination of the chronology of the most lethal infectious diseases as they arrived on these shores (Te Ara, 2022). As an island nation, diseases were introduced by migrants or travellers, the worst public health crisis occurring when influenza swept New Zealand in 1918, claiming over 9000 lives (Rice, 2017). A new influenza variant and measles followed in 1935 and epidemic waves followed through the years, including pandemic swine flu (H1N1) in 2009. 2020 ushered in a new threat – COVID-19. With the benefit of observing what was unfolding overseas, everyday life in Aotearoa came to a standstill as unprecedented measures were implemented to avoid it taking hold and overwhelming the health and hospital system.

Each new communicable disease introduced to Aotearoa has seen repeated and often uncontrolled epidemics, until a specific vaccine could be developed and widely distributed (Petousis-Harris, 2016). Routine public vaccination was first offered in Aotearoa in 1941 against diphtheria, having initially been made available only to schools or orphanages in the 1920s to manage highest risk. This was followed in 1948 with the introduction of the BCG against tuberculosis. Other significant milestones were the polio vaccine in 1956; the combined diphtheria, tetanus and pertussis vaccine in 1960; then the measles and rubella vaccines in 1969 and 1970, respectively (later replaced by the combined MMR, which included mumps, in 1990). The national immunisation schedule in Aotearoa added protection against hepatitis B in 1988; haemophilus influenzae type B in 1994; meningococcal B in 2004; human papillomavirus in 2008; rotavirus in 2014. The most recent additions to routine vaccines were in 2017 against varicella (chickenpox) and 2018 for herpes zoster (shingles) (Dow & Mansoor, 1996; Ministry of Health, Manatū Hauora, 2018). Whilst the focus of this research is on those routine vaccinations administered in early childhood, the topic of vaccination is very much in the spotlight at present due to the pandemic. The vaccination campaign against COVID-19 is the largest seen to date, and the most complex, relying on the manufacture at speed in laboratories all located offshore, in countries initially hit much harder and earlier than our own (Office of the Auditor General, 2021).

Whilst no vaccine is entirely without risk of side effects, rates of serious adverse reactions are low (Gidengil et al., 2021; Spencer et al., 2017). Vaccine safety is the first priority through development, and through subsequent trials, from phases 1 (animal) to 3 (large-scale human). Vaccine safety and adverse reaction monitoring are continually conducted, reported on and shared globally (Immunisation Advisory Centre, 2016b; Plotkin et al., 2008; Reid, 2020), for all vaccines whether novel or longstanding. Any and all negative health events that occur after a vaccine has been administered are recorded and classified as

"adverse" (Shimabukuro et al., 2015). Of importance is that this is irrespective of whether a causal relationship with the vaccine or vaccination process is established. It also encompasses individual reactions related to the product itself, human error, anxiety-related responses, and purely coincidental events (Reid, 2020; Varricchio et al., 2004). While most experience a mild reaction only (e.g., elevated temperature, pain at the injection site), and others have no reaction at all, a very small minority of recipients will experience an adverse response as a direct result of the vaccine. Of these already rare cases, only a small proportion are serious or life threatening (World Health Organization, 2014a). For this reason, vaccines may only be administered by trained persons, capable of screening for possible contraindications, and in a setting capable of administering requisite care in the event it is required.

The World Health Organization also collects and publishes data on reactions reported by vaccine type (World Health Organization, 2020c), urging individuals and health providers to be mindful that the true risk is not from vaccination, but from the target disease, as well as the risks associated with treatment if that disease is contracted. Taking the example of measles, the WHO compares adverse events associated with vaccination against the adverse impact of illness itself. Inflammation of the central nervous system after vaccination occurs in 1 in 1 million MMR administrations, and anaphylaxis in 3.5 out of 10 million. This is in stark contrast to the 1-6 in 100 people with measles who contract pneumonia, the 1 in 2000 who develop an infection that leads to encephalomyelitis (swelling of the brain), and the 1 in 1000 who die as a direct result of measles itself (World Health Organization, 2016). Systematic reviews of the evidence of reported events and safety of routine childhood immunisation were conducted in the US published in 2014 and 2020, the authors of both studies reporting that serious outcomes for vaccine recipients are extremely rare events (Gidengil et al., 2021; Maglione et al., 2014). Echoing the WHO, they urge individuals to weigh the very low risk of

an adverse reaction against the significant risks of contracting an infectious disease and the adverse outcomes of the illness itself, or of its treatment in some cases.

Despite the scientific basis for vaccination, its acceptability and uptake by individuals, whether for themselves or on behalf of dependents in their care, is not universal. Vaccination is polarising, and on both sides of the debate, pro- and anti-vaccination positions are firmly entrenched, proponents at either extreme unlikely to alter their views or behaviours (Rossen et al., 2019; Smith, 2017). Between the poles, however, are the so-called "vaccine-hesitant", whose views, their determinants, and how readily they may be influenced, vary considerably. For example, a person might be opposed to vaccinations, but nevertheless accept vaccination for a child where other family members exert pressure. Another might be willing to consider each vaccine on a case-by-case basis, the child ultimately receiving some, all, or none. A further person might be accepting of vaccination in principle but be unable or unwilling to take the necessary steps or meet any costs required to see it implemented. A broad definition of *vaccine hesitancy* is adopted by the WHO, describing it as a "delay in acceptance or refusal of vaccines despite availability of vaccine services" (MacDonald et al., 2015; World Health Organization, 2014b), and it is considered one of the top ten threats to global health (World Health Organization, 2018c). As low uptake is associated with higher disease incidence and prevalence, in order to design and implement more effective public health interventions, it is the vaccination behaviours of the hesitant that have been a focus of extensive attention in the research and medical communities internationally. The phenomenon is complex, however - its influences and determinants are many and multi-faceted, combining in myriad ways, and varying by time, place, and by specific vaccine or target disease (Dubé & MacDonald, 2016; Lane et al., 2018; Larson et al., 2014).

Theoretical Framework: Decision Theory - Anticipated Regret and Temporal Discounting

One critical aspect of vaccination behaviour is decision making, and cognitive models, grounded in decision theory, have gained prominence in the field of vaccination research (Baron, 2000; Green et al., 1994, 1996; Loomes & Sugden, 1982). Decision theory, and specifically temporal discounting and anticipated regret, provide the theoretical framework underpinning this study. Although not the only lens through which researchers have sought to elucidate determinants of low vaccine uptake (Batista Ferrer et al., 2015; Williams, 2014), anticipated regret (the expected emotional impact of a decision's outcome) is a recurring theme (Gaube et al., 2019; Gorman et al., 2012; Rosso et al., 2020). Anticipated regret is also reported to be the strongest predictor of intention and behaviour, over and above other emotion, risk appraisal, or even knowledge about or attitudes towards vaccines (Abraham & Sheeran, 2003; Brewer et al., 2007; Chapman & Coups, 2006; Gaube et al., 2019; Hamama-Raz et al., 2016; Sandberg & Conner, 2008).

In the vaccination context, anticipated regret is linked to *prospection* - thinking about the future (Bulley et al., 2017; Bulley & Schacter, 2020; Moses-Payne et al., 2019; Worthy et al., 2014) and to temporal discounting - the increased devaluing over time of future reward or outcomes (Critchfield & Kollins, 2001; Vaidya & Fellows, 2017). The relevance of temporal discounting for vaccination decisions is clear – in the present-moment, decision-makers must weigh competing spectres of an unlikely but immediate adverse reaction against the much more realistic but temporally remote potential of becoming ill in the future. This balancing exercise will factor in the regret that a person expects will flow from the various possible consequences of the decision made. However, both anxiety and depression can impact decision-making (Blanchette & Richards, 2010; Paulus & Yu, 2012; Roese et al., 2009). Where nearly half the vaccines scheduled for delivery in childhood are due in the first six

months of life, the very time when women are at risk of postnatal depression and anxiety (O'Hara & Wisner, 2014), it is imperative to evaluate how the experience of perinatal anxiety or depression may impact vaccination decision-making.

Thesis Structure and Organisation

The chapters that follow provide an overview of the body of research in this field. Each respectively discusses: the literature on vaccination behaviours (Chapter 2); the theoretical framework for the study (chapter 3); previous pandemic outbreaks and the observed effect on vaccination (chapter 4); and what is known about the relationship between psychological distress - perinatal anxiety and depression in particular, and these behaviours (chapter 5). In Part 2 of this thesis, the research aims, rationale, and research questions are set out in Chapter 6, the method in Chapter 7. Part 3 contains the results and discussion chapters for the quantitative analyses (Chapters 8 and 9), the content analysis and discussion (Chapters 10 and 11), and an integrated discussion and conclusions section in Chapter 12.

Chapter 2: Vaccination and Vaccination Behaviours

Chapter Summary

The key constructs for this study are outlined in this chapter, in particular "vaccination behaviour" and "vaccine hesitancy", together with a summary of the relevant literature. This includes the role of vaccination and determinants of vaccination hesitancy, as well as outlining the rationale for a specific focus on maternal vaccination behaviours rather than parents or caregivers more broadly. The relevance and impact of the anti-vaccination movement is also briefly discussed. New Zealand-specific vaccination information and data are described to provide local context and justification for recruitment of a New Zealand-centric sample.

Definitions, Misconceptions and Usage: Understanding the Key Terms in this Study

For the purposes of this paper, *vaccination decision/decision-making* or *vaccination intention* refer to the idiosyncratic, internal process of vaccination decision making. This is the unique, personal contemplation about whether or not to vaccinate, taking into account perceived disadvantages and advantages on the basis of existing knowledge, information, or experiences.

Vaccination behaviour denotes the full range of actions taken by individuals relating to immunisation, including declaring and sharing both views on vaccination or intentions to vaccinate or refuse; vaccine uptake; delay in receiving a vaccine as scheduled in the national immunisation programme; deliberate and conscious refusal of vaccines; and pro- or anti-vaccination activism. Within this wide group of behaviours, it is important to distinguish between an intention or desire to vaccinate (*decision-making*) and action taken in practice (*action* or *behaviour*). For example, individuals concerned about vaccination may nevertheless accept the full programme for their child – often as a result of external pressure

from others (e.g., a spouse, other family or medical professionals) (Danchin et al., 2018; Grant et al., 2016; Wegwarth et al., 2014). Conversely, some or all vaccinations may be delayed or missed entirely by people who are not opposed to immunisation in principle. This can be due to pragmatic difficulties with access, a lack of motivation or limited knowledge about optimal timing or availability (Amour et al., 2015; Litmus, 2013). As this incongruity can lead to confusion, for clarity, lack of uptake will be referred to in this paper as *missed* vaccination, allowing for both active and passive non-administration, and only deliberate rejection of vaccination will be termed *refusal*.

Intention (as opposed to *intent*) is itself a key concept. Although these terms are often used interchangeably - in many circumstances, without distortion of meaning - there is an important distinction that is particularly relevant in studies of cognition. Whereas intent refers to the contemplation of a desired or planned action that already has or will take place (subject to barriers outside the decision-maker's control), intention conveys a slightly softer, less certain plan which may or may not be carried out (Ehrhardt, 2013). Intent is often used retrospectively, with the benefit of knowledge as to whether a person in fact took the action (or omitted to do so). Absent additional research steps that would allow the investigator to establish whether the theoretical intention was acted upon in reality (for example, a study with longitudinal follow-up), the true focus of inquiry is often intention, rather than intent. It is for this reason that in psychological theory such as the Theory of Planned Behaviour, intention is the target theoretical construct (Ajzen, 2020; Fishbein & Ajzen, 1977).

Vaccination hesitancy is a broad term, denoting attitudes as well as behaviours, which can be problematic when not clearly understood. Often mistakenly conflated with anti-vaccination, hesitancy (as defined by the WHO and used in this study) in fact refers to a continuum that spans deliberate or passive refusal, delayed uptake (for reasons other than purely practical barriers to access), and extends to selective acceptance of certain vaccines,

and reluctant or cautious acceptance (Larson et al., 2014). It also encompasses refusal due to needle phobias (McMurtry et al., 2015; Taddio et al., 2012). Moreover, hesitancy is frequently misunderstood to relate only to an intentional, conscious negative view of vaccines. This belies the many socio-economic determinants of vaccination behaviours such as practical or financial barriers to vaccine access (Bedford et al., 2018; MacDonald et al., 2015). In 2014, the WHO Strategic Advisory Group of Experts (SAGE) Working Group on vaccine hesitancy (SAGE Working Group) carefully considered the appropriateness of the term but opted to retain it. Of the less-used alternatives in the literature, the most common is *vaccine confidence*. However, this was rejected by the WHO in favour of hesitancy, as confidence semantically represents or is interpreted to apply to an even narrower construct, which is less helpful still than the existing terminology (World Health Organization, 2014b). Consistent with the bulk of published work in this field, vaccination hesitancy is therefore adopted for present purposes, but with the clear caveat that it be read inclusively, as intended by the WHO and described above.

There is a distinction between the terms *psychological distress* and *psychological disorder* that must also be noted, despite the frequency with which one is substituted for the other (Horwitz, 2007). Distress is a person's experience of emotional pain or cognitive disturbance, and the disruptive impact that this may have on day-to-day life (Clarke, 2012). Psychological disorders on the other hand, often used synonymously with *mental illness*, are diagnosable conditions, predicated on a match between particular clusters of symptoms and specific formalised criteria (Cockerham, 2021; Jencks, 1985). These criteria are set out in the internationally recognised psychiatric classification systems for disease or disorder published by the American Psychiatric Association (APA; DSM-5) and WHO (ICD-11) (American Psychiatric Association, 2013; World Health Organization, 2018b). The distinction between the two is important - a person may experience distress in the presence or in the absence of a

diagnosable disorder, and certainly in the absence of a formal diagnosis (Clarke, 2012). This matters where, irrespective of a label, affect and cognition are known to impact and influence each other and their respective effects on health behaviours (Kiviniemi et al., 2018). For these reasons, the focus of this research, and qualifying criteria for the study will not be a formal diagnosis, but rather the experience of relevant symptoms as reported by the individual participants recruited for this study, using well-validated screening instruments.

Finally, it is imperative to acknowledge the importance of gender inclusivity and the potential for the terms *woman* or *mother* to be perceived as exclusive or value-laden. Research should always be conducted in such a way to avoid further entrenching normative stereotypes and as such, conforming to mainstream constructs of *motherhood* or socially or self-determined gender risks perpetuating bias against a diverse group of transgender, gender fluid, or gender nonbinary individuals. For this reason, no questions were asked nor were assumptions made with respect to self-identified gender in this research. In this thesis, the terms *women/woman* are not used, unless quoting from prior sources. *Mother* was chosen to represent the birthing parent here, acknowledging that the term is neither universally adopted nor rejected by all groups or families. The intention was neither to exclude nor contribute to ongoing discrimination against any birthing parent. This research is preliminary in nature, seeking to understand whether and to what extent a relationship exists in broad terms. Subsequent, targeted research on the unique experiences of gender diverse birthing parents in Aotearoa, together with any particular implications this may have for their psychological and physical wellbeing, could include exploration of the impact on vaccination, extending this research.

Disease, the Role of Vaccination, and the Hesitancy Puzzle

Throughout history, the ever-present threat from uncontrolled infectious disease and human vulnerability have combined to hold families and communities hostage, poor

population immunity allowing illness to spread. The development of vaccines over the past two centuries ushered in a new era of resistance to disease, gradual at first, soon strengthened by increased accessibility through state-funded immunisation programmes (Andre et al., 2008; World Health Organization, 2018b). Only water sanitation has played a more pivotal role in the reduction of human morbidity, mortality, and illness-driven misery (Plotkin et al., 2008). In modern times, the consequences of low or lack of population immunity reach far beyond international borders. Globalisation and international travel have maximised the ease and rapidity of spread of disease where no vaccine exists, as was so catastrophically illustrated as the COVID-19 pandemic unfolded.

The revolutionary effects of vaccination in reducing human mortality and morbidity have failed to persuade all, however. Uptake of vaccines is not universal, rates often falling below thresholds required for population immunity (Lane et al., 2018; Ministry of Health, Manatū Hauora, 2020c). To date, smallpox remains the lone success story of eradication through immunisation (Centers for Disease Control and Prevention, 1999). Diseases such as polio or tuberculosis, largely controlled or eliminated in some parts of the world, retain their hold over others. This is particularly the case in low-income countries or areas where access to vaccination is compromised (World Health Organization, 2018a), and is compounded by population health inequities. Even in nations with robust public immunisation programmes, equity gaps impact vaccination rates, exacerbating health disparities along social, ethnic, and economic lines, as much in Aotearoa as elsewhere (Shingler et al., 2012; Turner et al., 2017). And where many nations saw a dramatic decrease in infection and disease in response to vaccination, this is only maintained where widespread immunisation becomes and remains routine. Low vaccination levels in any population pose a serious risk not only for the unimmunised themselves, but for society as a whole and the most vulnerable in particular - newborn infants, the immunocompromised, and others at too high a medical risk to tolerate

certain vaccines (Andre et al., 2008; Hayman, 2019; Hayman et al., 2017; Jarmolowicz et al., 2018). Resistance to immunisation has meant that many diseases expected to be confined to human history are instead on the rise. Clustered outbreaks of measles, diphtheria, pertussis, rubella, and bacterial influenza, among others, persist as a result of low vaccine acceptance (Andre et al., 2008; Falagas & Zarkadoulia, 2008; Gaube et al., 2019; Phadke et al., 2016).

However, accessibility is only one part of the story. Alongside pragmatic barriers to uptake, decision-makers' own perceptions of risk are influential. The greater puzzle for researchers and health professionals then is to predict and prevent low or incomplete vaccine uptake, even when they are readily available or to manage backlash where, in some countries, they are made mandatory (Holzmann & Wiedermann, 2019; Martin & Vanderslott, 2021; Salmon et al., 2006). Analysing data from the Wellcome Trust and the World Bank, The Economist (2020) describes vaccine hesitancy as a "first-world problem" where the proportion of a population reported to believe vaccines are safe is negatively correlated with the GDP of the country in which they live. This is particularly surprising in contrast to the positive correlation observed between GDP and trust in science and doctors. The Economist attributes this incongruity to the impact of anti-vaccination propaganda. The vaccination debate is convoluted and divisive, not uncommonly giving rise to protest action or violence (Kata, 2012; Tafuri et al., 2011, 2014; Wolfe & Sharp, 2002). Although firmly entrenched pro- and anti-vaccination views are diametrically opposed, all vaccination behaviours are complex and must be understood as more than dichotomous (Dubé et al., 2018; Gust et al., 2005; Thomson et al., 2016). Between the extremes, the attitudes, intentions, and behaviours of the vaccine-hesitant fall on a continuum (Jarrett et al., 2015; Larson et al., 2014; Wiley et al., 2020). Oversimplification is unhelpful - it is an in depth-appreciation of gradation of hesitancy types, as well as their possible causes, that are key to combating hesitancy.

Determinants of Hesitancy

For the medical and research communities seeking to uncover and address drivers of low vaccination uptake, the diverse array of attitudes, perceptions, fears, and unique circumstances of the vaccine-hesitant pose a complicated puzzle (Dubé et al., 2015; Jarrett et al., 2015). Motivated not only by the health implications of inadequate immunity but also their economic repercussions, researchers and public health officials have expended significant effort and resource in expanding knowledge about vaccination rates to improve public information campaigns and interventions (Brelsford et al., 2017). Despite a wealth of research evidence, however, the picture remains unclear, clouded by national, regional, and personal idiosyncrasies which variously influence vaccination decisions, complicating comparisons and making concrete conclusions difficult. On the basis of official population immunisation records, the prevailing sentiment in most societies – including in Aotearoa – is that vaccines are both necessary and safe (Dubé et al., 2015; World Health Organization, United Nations Children's Fund 2014).

Nevertheless, vaccine hesitancy is reported by nearly every country in the world and is the primary reason for low population immunity, presenting a significant threat to not only national but also global health (World Health Organization, 2014b). Attitudes span the full spectrum, from total acceptance to outright rejection. As to the underlying reasons for a person's stance on vaccines, a wide range of factors are observed, both at the individual and wider societal levels. At the more personal level, such factors variously include a person's level of belief in illness risk, their confidence in vaccine effectiveness, any concerns they may have about vaccine-specific risks, and the degree of trust they have in health providers or policy makers (Gilkey et al., 2016; Gust et al., 2005; Oladejo et al., 2016). Idiosyncratic factors such as a person's moral values, and how these values interact with personal perceptions or available knowledge and information about the role and importance of

vaccines are also in play (Amin et al., 2017). Such beliefs do not arise in a vacuum, however. Rather they are created and maintained in societies, perspectives of risk embedded and maintained socially, influenced by social interactions (Bandura & McClelland, 1977; Joffe, 2010). Drawing on the rich data from the Dunedin study (Dunedin Multidisciplinary Health and Development Research Unit, 2022), a longitudinal research project running for five decades, researchers have recently evaluated a link between hesitancy and adverse childhood experiences (Moffitt et al., 2022). They concluded that vaccine hesitancy often stems from deep-seated mistrust of authority that results from abuse, neglect, and deprivation. Whether such mistrust is pre-existing or a recent fear, in the Instagram age, the ready availability, dissemination and consumption of vaccine misinformation guarantees access to almost any confirmatory "evidence" that is sought. Online communities have been created and are easily accessible, their members united by suspicion and scepticism of authority and science, often exploited by extremist groups urging action or violence (Baker & Walsh, 2022; Kata, 2010; Koltai et al., 2022; Martin & Vanderslott, 2021; Pantucci & Ong, 2022). As if the picture were not sufficiently complex, attitudes towards vaccination and drivers of hesitancy do not necessarily remain fixed over time (Wiley et al., 2020). This fluidity of views, and how strongly they are held, compounds the dilemma facing researchers and analysts (Williams, 2014). How these internal factors combine and translate to uptake or refusal in practice also depends on a range of additional, external determinants, further complicating matters.

Various frameworks of vaccine hesitancy have been advanced in an attempt to bring some clarity. The *3Cs* of vaccination, developed by the SAGE Working Group, proposed that *Complacency, Convenience* and *Confidence* could describe and explain vaccination behaviours (World Health Organization, 2014b). In this context, *complacency* is a person's belief that vaccination is unnecessary, either due to a perception that the risk of disease is low, or that it is possible to rely on the numbers of others in the community who are vaccinated for

protection. *Convenience* refers to the availability, affordability, and accessibility (real or perceived) to vaccines and to services where they can be administered. The third C, *confidence*, is a person's degree of trust - whether in the health system, in medical professionals, in vaccines themselves, or in the policy makers, government officials or politicians who promote them. A fourth element, *calculation* was later added, and the original 3 became 4Cs, adding in a person's deliberative process as a core factor, that is the seeking of information and the weighing of pros and cons (Betsch et al., 2015). The Cs grew to five with the addition of *collective responsibility*, recognising the role of altruism where individuals are also motivated to be vaccinated themselves in order to protect the wider community. The 5Cs iteration of the relevant categories also reconceptualised convenience as *constraints,* to better describe the difficulties represented by this category (Betsch et al., 2018).

Alternative but similar conceptualisations of hesitancy exist, including the *5A* taxonomy which adopts a lexicon of access, affordability, awareness, and activation (Thomson et al., 2016), with clear parallels to the 5Cs. Broadly speaking, the determinants stressed in any of these frameworks can be viewed as an assortment of psychological and pragmatic impediments or barriers to access (Cox et al., 2012; Rainey et al., 2012). They may be physical or financial, can include knowledge about and attitudes towards vaccines (Hamama-Raz et al., 2016; Larson, 2018; Navin et al., 2019; Ozkaya et al., 2010), or may relate specifically to perceptions of safety and risk (Ahmed et al., 2018; Betsch, 2011; MacIntosh et al., 2017; Wheelock et al., 2017). Additional individualistic dynamics also contribute, such as personality, beliefs, bias, and trust in local medical or political systems (Bock et al., 2017). Lack of confidence or trust, either in vaccines, the health system, or both, compromises uptake (Lee et al., 2017; Sondagar et al., 2020). An individual's wider social context is therefore crucial, impacting these beliefs, corresponding social norms and expectations (Anello et al., 2017; Jung et al., 2013; Perez et al., 2017; Quinn et al., 2019;

Taylor, 2015). Vaccination attitudes or behaviours might also be fixed, applying to any and all vaccines, or may instead vary by target disease or vaccine type.

The breadth of influences leading to any one decision is clearly considerable (Rosso et al., 2020; Weston et al., 2017). Even subtle variations in the timing, content or tone of health promotion messages can influence decisions (Corben & Leask, 2018; Kim & Nan, 2019; O'Leary et al., 2018). For example, slight but definitive differences in uptake have been recorded in studies where choice about vaccination is presented as either *opt-out*, or *opt-in*, illustrating a general preference for the default option in this context as in many others (Chapman et al., 2010). The fragility of public attitudes and perceptions must also be accounted for - where emotions run high and people feel threatened, vulnerability to misinformation and incorrect appraisal of risk increases (Betsch et al., 2015; Chou & Budenz, 2020). Now infamous, the example of discredited physician Andrew Wakefield's paper on the MMR (measles, mumps, and rubella) vaccine is a chilling reminder of the damage that distorted or false information can cause, as well as its longevity in human memory, even where it has been comprehensively and unequivocally disproved (Larson, 2018; Pluviano et al., 2017). Reasons for poor uptake, whether psychological, behavioural, or structural, can therefore be conceptualised in several groupings, namely individual or social concerns (e.g., knowledge, beliefs or experiences), vaccine specific concerns (cost, schedule, mode of delivery etc.), or contextual factors (such as religious, political, historical or media influence).

Combatting Hesitancy: the Complexity of Targeted Intervention

Notwithstanding the manifest scale and complexity of the hesitancy puzzle, given the importance of vaccination to public health, officials expend significant effort and resource seeking to effectively promote and improve immunisation, guided by research evidence. In Aotearoa, Ministry of Health campaigns, devised with the assistance of the Immunisation Advisory Centre, are promoted through the Health Promotion Agency (Health Promotion

Agency, Te Hiringa Hauora, 2018). National and regionalised interventions are designed to enhance visibility and acceptability of vaccines, not only for routine immunisation but also one-off vaccine campaigns in response to specific outbreaks, such as the emergence of Meningitis W in Northland in 2019 (Northland District Health Board, 2019) and most recently in response to COVID-19. However, the success of vaccine-promoting initiatives varies in line with the nature and degree of vaccine hesitancy in a particular area, or within a specific target group (Jarrett et al., 2015; Lewandowsky et al., 2021; Rzymski et al., 2021). Evidence supports use of a clear framework, with a solid theoretical foundation, when designing and developing such interventions, drawing on empirical data that permits an accurate situational assessment for the target population (Dubé et al., 2014, 2015). The level of intricacy involved was exemplified in a comprehensive "review of reviews" by Dubé, Gagnon and MacDonald, working with the SAGE Working Group (2015). These authors concluded that no compelling evidence justified recommendation of any single intervention type or process alone but rather a combination of tactics, tailored for the audience(s) was preferable. One unexpected impact of the interventions in that study (including mandated vaccines, public campaigns, mass vaccine promotion or traditional education tools) was that, for some, existing anti-vaccination beliefs not only remained unchanged but became all the more entrenched. Variously adopting or drawing on one or more models of hesitancy determinants, including the Cs in their various guises, researchers have devised many ways to measure vaccine hesitancy, to gauge attitudes towards and confidence in vaccines, as well as levels of trust in professionals to advise and administer them (Larson, Jarrett, et al., 2015; Larson, Schulz, et al., 2015). The most reliable approaches not only probe confidence but also complacency, constraints (or convenience), calculation of risk, and sense of collective responsibility (Betsch et al., 2018).

Certainly, there is evidence that mandating vaccines alone does not necessarily improve uptake in those vehemently opposed and can in fact lead to considerable backlash (Smith, 2021). Coercive tactics – whether real (such as mandation) or perceived (such as positive vaccination stories used in campaigns) can be viewed cynically as advertising, intimidation, or bullying (Ashwell & Murray, 2020). Instead, careful, targeted messaging, from credible sources are critical to the success of campaigns intended to increase uptake. A recent study demonstrated the positive effects on vaccination intentions of exposure to brief, relevant explanations countering three major – but newly emerging – concerns relating to the new mRNA vaccine against COVID-19, controlling for the effects of pre-existing beliefs in conspiracy theories (Pummerer et al., 2022). The authors suggested that, if topics of uncertainty can be accessed and addressed early, it may be less difficult to shift these views that strong and long-held opinion may be. It is also important to consider the target audience in respect of message content and delivery method. For example, creative uses of social media have been proposed, including games or other decision-aids to encourage critical or strategic thinking (Abrams, 2021; Gianfredi et al., 2019; Walter et al., 2020). More general recommendations advanced include providing targeted, but limited, corrections only, ideally in conditions facilitating self-directed scrutiny of the arguments for both sides (Chan et al., 2017). There is also support for the effectiveness of emphasising collective benefits of immunising to protect the "herd" (Lazić et al., 2021). Where decisions on vaccination are considered by some to be inherently social, not a matter of individual rationality (Attwell & Smith, 2017), strategies promoting vaccination as a socially responsible and normative behaviour are argued to be more effective (Dubé et al., 2018). Overall, caution is urged, however, to ensure that messages are tailored to be consistent with the worldview of the target audience, that they are appropriately timed to maximise their effect, and that the

messenger also be selected with a view to considering who might be most persuasive given the intended recipient (Walter et al., 2020; Walter & Tukachinsky, 2020).

For any measures to be effective, they must also be relevant. As such, recommendations adopted from international sources must also be tailored to target the unique population and target groups in Aotearoa. In light of only limited evidence of effectiveness of strategies (Sadaf et al., 2013), it is therefore critical to commit dedicated resource to designing, conducting, and critically evaluating New Zealand-centric intervention studies.

Vaccination in Aotearoa

The national immunisation programme in Aotearoa/NZ is publicly funded and prescribes the standard administration of 21 vaccines and boosters across the lifespan, providing coverage against 15 diseases (Ministry of Health, Manatū Hauora, 2020c). Additional vaccines are also available, including additional funded protection for individuals at heightened risk (for example the annual influenza vaccine or the BCG against tuberculosis) and those that individuals elect to pay for privately to supplement immunity to disease (e.g., Bexero for meningitis B). Of 22 scheduled vaccines (including boosters), two are for women in pregnancy, and four more are available for all adults (at ages 45 and 65). The remaining 16 are due during childhood, of which seven should be given during a baby's first five months. A further two are due at 12 months, 3 more at 15 months and another at four years of age. The final two (three if administered after 15 years of age, requiring an additional booster) are delivered in early adolescence.

A child is considered fully covered if vaccines are up to date in accordance with age, whereas administration outside a 30-day window is generally considered to have been delayed. Vaccines are considered to have been refused where, deliberately or otherwise, they are never administered, and official New Zealand government data suggests that up to 5% of

parents refuse one or more of the scheduled vaccines (Ministry of Health, Manatū Hauora, 2021). Whilst refusal clearly has the greatest implications for a child's immunity to disease, delayed vaccination also poses an important threat. Uptake outside the recommended administration timeframe prolongs the period of vulnerability – for the individual but also their community – and also increases the likelihood that coverage will ultimately be incomplete (Grant et al., 2010, 2016; Litmus, 2013; Tull, 2019). Delay in Aotearoa has primarily been attributed to low trust in or limited understanding of the immunisation process and consequent high anxiety and emotion due to a fear of potential harm to baby (Litmus, 2013).

Official records for the 12-month period ending 30 June 2022 report the lowest proportion of fully immunised children in New Zealand at the 6-month milestone, when only 71% had full coverage (Ministry of Health, Manatū Hauora, 2022). This compares with 86% and 89%, for the 8- and 12-month age groups, respectively, falling again to 83% by 5 years. At each of these stages, significant variation by ethnicity is observed. For example, among babies in the six-month age bracket, 89.4% with a self-reported ethnicity of Asian were fully immunised, compared with 76.9% of NZ European/Pākehā, 63.2% Pacific, and 49.9% Māori. By five years of age, full coverage is reported for 88.9% of Asian babies, 86.1% Pākehā, 82.72% Pacific, and 73.5% Māori – a considerable improvement overall on the 6-month data, but still below the target threshold of 95% required for population immunity – overall or within any ethnic group (Ministry of Health, Manatū Hauora, 2022; Nowlan et al., 2019).

Trends in this latest data mirror those observed in earlier reporting periods and are consistent with research findings. Growing Up in New Zealand is another large-scale longitudinal study following over 6000 children since their birth in Aotearoa in 2009. Of these participants, 95% of infants were reported as fully immunised at six weeks, 94% at the three-month mark (Morton et al., 2012). This figure reduced to 92% by two years of age, with

only 85% fully immunised by four (Morton et al., 2017). These datasets also provide unique insight into differences between intentions to vaccinate antenatally and actual vaccination rates. Certain key variables were found to be particularly significant, including birth order across each vaccination phase, ethnicity and deprivation status, these latter findings consistent with other similar research (Lee et al., 2017). First-born children in the Growing Up in NZ cohort were more likely to be immunised at each phase, and least likely to have received no vaccines at all. Although mothers in the most deprived areas declared the highest intention to immunise, ultimately their children were those with the lowest overall rates of uptake. For all deprivation quintiles, immunisation numbers increasingly declined at each scheduled age of administration. Declared prenatal intentions were higher across all ethnic groups than rates of vaccines ultimately administered, with the highest uptake at each administration point seen in babies identified as Asian (Morton et al., 2012). Again, this aligns with national data on current trends from the Ministry of Health, where only 71% of babies aged 6 months in most deprived areas are fully immunised, compared to 85.1% of those in the least deprived areas (Ministry of Health, Manatū Hauora, 2020c). This is also consistent with reported findings of lower vaccine confidence in those living in more deprived areas (Lee et al., 2017). In terms of a mother's own vaccination status, a retrospective cohort study conducted in Aotearoa showed very low uptake of recommended vaccines against influenza and pertussis during pregnancy, with significant disparities observed by ethnicity and deprivation status (Pointon et al., 2022).

A recent global study evaluating levels of confidence in vaccine safety and effectiveness reported New Zealand attitudes as remaining relatively constant between 2015 and 2018 (Figueiredo et al., 2020). However, the findings (50-60% - vaccines are safe and effective; 60-70% - vaccines are important) also suggested that a considerable proportion of the population (30-50%) either have concerns about safety or effectiveness, or do not believe

that vaccination is important. New Zealand-specific research, however, reports an increasing polarisation of views on vaccination among New Zealanders (Lee & Sibley, 2020a), with 30% of those surveyed between 2013 to 2017 expressing a decrease in confidence. A clear relationship is consistently observed between trust in health professionals and positive vaccination behaviour (Freed et al., 2011; Gilkey et al., 2016; Glanz et al., 2013; Mahdawi, 2020), yet not all health professionals are pro-vaccine. Based on the New Zealand Values and Attitudes Survey, whilst 96.7% of those reporting their occupation as "doctor" or "GP" and 90.7% of pharmacists endorsed high trust in the safety of childhood vaccines, only 65.1% of midwives were similarly confident (Lee, Duck, et al., 2018). This is particularly concerning in Aotearoa where midwifery-centred care is mainstream and midwives are highly influential in guiding decisions of expectant or new mothers (Attwell et al., 2018; Grigg et al., 2015). Furthermore, high levels of vaccine confidence among most doctors is of limited benefit where trust in GPs is itself low. Certainly, trends observed in respect of the rates of confidence in GPs across disparate groups in this country align with patterns of reported confidence in vaccines expressed by these same groups (Lee & Sibley, 2020b). This highlights the importance not only of getting the right message, but ensuring it is delivered by the right messenger to enhance trust.

In a bid to elucidate core drivers of vaccination behaviours, an evidence-based, comprehensive literature review was carried out in Aotearoa/NZ. These researchers concluded that, although progress had been made, the 95% target threshold for public immunity remained unmet in this country, and consistently so (Nowlan et al., 2019). The study further highlighted significant gaps in coverage for Māori as well as for the socio-economically deprived. This research highlighted the key roles that a person's experience, education, as well as the nature of the relationship with pro-vaccination healthcare providers play in determining vaccine uptake. Health disparities in Aotearoa were again laid bare in

2019 when measles, previously largely eliminated, again took hold in some communities in Aotearoa, and in neighbouring Pacific Island nations (World Health Organization, 2019). Of more than 2000 people in New Zealand who contracted measles during that 2019 outbreak, the vast majority were in South Auckland. An official review concluded that a lack of resources and inconsistent, ineffective communication directly contributed to the extent of the spread (Quinn, 2020; Sonder & Ryan, 2020). This also shed light on other areas where anti-vaccination is strong, and immunity is consequently low (Turner, 2019). Although a sound evidence base suggests commonalities between the New Zealand experience and internationally, it is equally clear that targeted, population-specific research is imperative to effectively uncover specific factors that can be targeted to maximise success of interventions and reduce vulnerability to disease for all.

Vaccination and the Role of Mothers

Several factors influence a focus on mothers in this study, rather than parents or caregivers more broadly. In Aotearoa, mothers are usually the primary caregivers of children, particularly during the earliest years (Garfield & Isacco III, 2012; Patterson, n.d.; Peterson et al., 2018; Statistics New Zealand, 2013). Most mothers, working or otherwise, continue to shoulder responsibility for family health overall (Kahu & Morgan, 2007; Kushner, 2005; McGuigan, 2012). The same is true in many overseas societies. In a US study, 3 in 4 mothers had primary or exclusive responsibility for health-related decisions, in contrast to 1 in 5 fathers (Ranji & Salganicoff, 2014). Results of a New Zealand government survey estimated that only 10% of parenting unassisted by a partner was carried out by fathers, and that sole fathers spend less time than sole mothers engaged in parenting activities (Statistics New Zealand, 2013). The optimum time for immunisation against most vaccine-preventable diseases is during early childhood (World Health Organization, 2022b). In New Zealand, nearly half the vaccines scheduled for delivery in early childhood are due in the first five

months of life, with almost all of the remaining immunisation programme to follow before a child turns four (Ministry of Health, Manatū Hauora, 2020b). Unsurprisingly then, factors influencing parental vaccination behaviours –primarily those of mothers – have been a focus of study in this field (Angelillo et al., 1999; Dubé, Vivion, et al., 2016; Nowlan et al., 2019; Streefland et al., 1999). Recent findings by New Zealand researchers suggest that mothers', not fathers', attitudes towards and confidence in vaccines is crucial to eventual uptake or refusal (Lee & Sibley, 2020a). Furthermore, evidence suggests that most mothers begin their decision-making process on vaccination during pregnancy (Corben & Leask, 2018; Danchin et al., 2018; Grant et al., 2016). That women and mothers are reported to have lower levels of confidence in vaccines than men or fathers is therefore a cause for concern (Lee et al., 2017; Lee & Sibley, 2020a). So too are findings of suboptimal vaccine uptake among expectant mothers in Aotearoa, lower rates linked to ethnicity and deprivation status (Pointon et al., 2022). Not only does this deprive both mother and baby of protection antenatally and postpartum (Sebghati & Khalil, 2021), low personal uptake by a mother is correlated with higher vaccine refusal for baby (Danchin et al., 2018). It is clear that the role and experiences of expectant and new mothers are critical to understanding vaccination behaviours.

A mother's levels of vaccination-specific knowledge, and the accuracy of information received antenatally, has also been linked to vaccination behaviours (Larson Williams et al., 2018; Schuller & Probst, 2013). Information and the form and source of messaging available during this time is highly influential, and exposure to anti-vaccination campaigns in pregnancy has been associated with delays in vaccination, or the outright refusal of vaccines (Lee et al., 2017; Lee & Sibley, 2020a). Major influences also include social norms in a mother's immediate support system and wider community, as well as the interactions with and trust in health-care professionals (Leask et al., 2014). With certain variations by number of pregnancies – first-time mothers generally expressing higher levels of concern about

vaccines than those having a second or subsequent child (Corben & Leask, 2018), decisions on vaccination are said to be strongly influenced by perceptions of risk and anticipated regret (Rosso et al., 2020). A mother's own immunisation status is relevant as well, a high concordance found between personal childhood experiences and acceptance of vaccination as an adult, including vaccination during pregnancy (Hamlish et al., 2012; Nowlan et al., 2019; Robison & Osborn, 2017).

A mother's overall social context, including the extent of their decisional authority, must also be taken into consideration. In Aotearoa a mother's position on vaccination during pregnancy has been found to correlate highly with a child's immunisation status - and independently of the prospective father's views (Grant et al., 2016). For Māori and Pasifika mothers, it is also important to recognise the role of whānau in decision-making, and the influence of grandparents in particular (Petousis-Harris et al., 2002). The importance of understanding cultural variations is also evident when considering results of studies conducted in more traditionally patriarchal societies. Reported differences in authority and decision-making influence or power in studies carried out in Italy and in several East Asian nations, among others, provide a different perspective. These researchers highlight the importance of an awareness and appreciation of cultural variations in a woman's level of agency in individual households, as well as in communities generally (Anello et al., 2017; Jung, 2018; Thorpe et al., 2016). Nevertheless, in Aotearoa/NZ the weight of population-specific research to date supports a focus on vaccination behaviours of mothers as crucial in any evaluation of the determinants of vaccine behaviours and hesitancy in this country.

Vaccination and Ethnicity – a Misleading Relationship

The stark contrast in rates of vaccination by ethnicity so often reported, in official New Zealand government data as overseas, has led to considerable research attention to known health inequities and, in particular, the role of ethnicity in vaccination (Forster et al.,

2017; Hobbs et al., 2017; Ingleby, 2012; Ministry of Health, Manatū Hauora, 2020a). However, simply stating that ethnicity impacts vaccine uptake without closer examination as to why this may be is a crude and unhelpful oversimplification that cannot usefully contribute to a solution. To understand the relationship, it is necessary to examine the myriad underlying factors which contribute to health disparities for ethnic minority and indigenous groups the world over (Callister et al., 2007; Dressler et al., 2005; Ford & Harawa, 2010; Ingleby, 2012). In reality, where vaccines are readily accessible, uptake will be high where immunisation programmes are effectively implemented, ensuring their ready availability – it could be said then that it is not ethnicity per se, but rather the social context for and implications of ethnicity that are at play. Effective communication, delivered by a trusted or respected source, ensures that people are properly informed and trust in the message they receive. Widespread uptake leads to effective protection, irrespective of ethnic group membership (Médecins Sans Frontières, 2018; United Nations Children's Fund, 2004; Wong et al., 2019; World Health Organization, 2020b). Attributing uptake or immune response to ethnicity without attention to the socio-cultural context puts lives at risk (Ling et al., 2014).

It is undeniable that in so-called "developed" countries, including Aotearoa, there are significant variations in vaccine uptake by self-identified ethnic group (Lee et al., 2017; Lee & Sibley, 2020b; Ministry of Health, Manatū Hauora, 2021). In any country where such disparities are observed – and particularly where there is a widespread and entirely publicly funded vaccination programme, it is incumbent on public health officials and researchers to look behind these patterns to understand their socio-cultural determinants. Some studies have found, for example, that individuals from refugee or other migrant populations may not only arrive in Aotearoa unimmunised, but their general stance on vaccination will also have been heavily influenced by experiences predating their arrival, particularly if from a country where mistrust in government is high (Brown et al., 2012; Díaz Crescitelli et al., 2020; Jolley &

Douglas, 2014; Poland, 2010; Walter et al., 2012; Wood et al., 2019). Language barriers must also be considered to ensure that timely, accurate information is effectively imparted, enabling a fully informed decision to be made (Harmsen et al., 2015). It is also not uncommon for ethnic minority groups to have concerns about the safety and efficacy of vaccinations that were developed, tested and their efficacy evaluated primarily or exclusively with participants of other ethnicities – usually a majority group (Charania et al., 2018; Forster et al., 2016, 2017; Quinn et al., 2019).

Trust in the public health system and in practitioners themselves is another crucial factor impacting uptake. Healthcare practitioners play a key role in providing necessary information and advice about vaccination, providing the recipient considers them to be trustworthy (Benin et al., 2006; Leask et al., 2006; Tafuri et al., 2014; Wu et al., 2008). Increased trust or satisfaction with GP services has been found to be strongly correlated with vaccine confidence in Māori (Lee & Sibley, 2020b). The importance of this is evident when considering the subsequent findings in this same study, that the lowest confidence in GPs is observed among Māori participants - 59.4%, as compared to NZ European/Pākehā (74.7%), Asian (72.3%) or Pacific (65.8%) participants (Lee & Sibley, 2020b). Against the background of pandemic COVID-19 in particular, concerns have been raised about the impact of decades of diminished attention to or prioritisation of the health needs and concerns of women and many ethnic minority groups, which has further diminished trust in the health systems that will be promoting and administering vaccines (Mahdawi, 2020; Sacks, 2020). Early indication from research conducted during the pandemic suggested moderate to high correlation between support for routinely scheduled immunisations and the COVID-19 vaccine. Least willing to accept a novel vaccine were women and Māori, and authorities were concerned about the sizeable number of individuals who would otherwise be pro-vaccination who indicated they would not accept a newly developed one for COVID (Menon & Thaker,

2020; Thaker, 2021a, 2021b). Whilst official data in 2022 reports 91.5% of the whole population as at least partially vaccinated, and 73.2% boosted, for Māori these figures fell to 83.5% and 56.2%, respectively (Ministry of Health, Manatū Hauora, 2022a).

Where ethnicity is so often linked with socio-economic status in Aotearoa, cost can be a significant barrier to accessing routine medical care, leading to poor physical and mental health outcomes in this country (Jatrana & Crampton, 2020). This may be where certain vaccines outside those on the scheduled list are available only on payment of a fee (such as Bexero or the annual influenza vaccination) or due to associated travel or other expenses (Herliana & Douiri, 2017; Klem Thomsen, 2017; Quinn et al., 2017; Serpell & Green, 2006). Cultural and religious beliefs specific to some ethnic groups may also play a part, although this is moderated by other factors within the broader socio-cultural environment (Betsch et al., 2018; Dubé et al., 2018; Lane et al., 2018; McKee & Bohannon, 2016; Navin et al., 2019; Taylor, 2015). Understanding which factors influence the success or failure of interventions is vital to the elimination of health inequities related to vaccination (Gates et al., 2021). For example, given that low socio-economic status or geographic isolation does not equate to decreased belief in the value of vaccination, automated reminders, and resources as to the importance of vaccines is not sufficient to help parents in isolated, rural communities alone will not be sufficient (Wagner et al., 2021). Instead, multi-pronged approaches are indicated to support decision-making, but also improve access in tangible ways (Machado et al., 2021). Utilising available tools, including social media, to access groups across all ages and communities will be vital, not least given evidence of the importance of the normalisation of vaccination to influence uptake (Lazić et al., 2021).

Overall, whilst ethnicity is undeniably linked to patterns of vaccination rates, careful evaluation of the wider context is required to understand underlying reasons for these trends, as well as potentially influential factors that predict the success or otherwise of specific

interventions designed to increase uptake. Relevant, and ethical, research must enable inferences to be drawn and generalisations to be made to the entirety of a target population, and the diverse peoples within it. At the very least, it is important to conduct research domestically, rather than relying on international studies alone, to begin to identify other areas of particular relevance to the unique and diverse population of any given country.

Hesitancy and the Anti-Vaccination Movement

No discussion of vaccination or hesitancy can be complete without reference to the anti-vaccination movement. Almost as long as vaccines have existed, doubts about their necessity, efficacy, and safety have been forcefully voiced (Swingle, 2018; Wolfe & Sharp, 2002). Undeniably, all vaccines carry some degree of risk. In certain exceptional cases, vaccines may be medically contraindicated (Pronker et al., 2013). For example, some live vaccines may not be suitable for severely immunosuppressed individuals, or vaccines cultivated in egg yolk (such as yellow fever and some influenza) may be problematic for persons who have an anaphylactic response to eggs (Ministry of Health, Manatū Hauora, 2018). However, these are the rare examples and even for these individuals, assessment of risk from the vaccine against risk of the illness must be balanced, case by case. Ultimately, the science is unequivocal: for the overwhelming majority, vaccines are not only safe, but crucial for protection of individuals and entire communities against disease and death (Berezin & Eads, 2016; Larson, 2013, 2018; Maglione et al., 2014).

Yet the minority opposing vaccination is vocal, and its impact profound (Elkin et al., 2020; Jolley & Douglas, 2014; Martin & Petrie, 2017). Exposure to anti-vaccine conspiracy theories can increase hesitancy and shape vaccination behaviours (Jolley & Douglas, 2014). A significant negative relationship has been demonstrated between anti-vaccine conspiracy beliefs and intention to vaccinate, mediated by perceived risks from vaccines, sense of powerlessness or disillusionment, and level of mistrust in government authorities (Jolley &

Douglas, 2014). The consequences of conspiracy beliefs and their dissemination not only impact personal and public health, but political engagement, social cohesion, and inspire violence and extremism, mobilising the disillusioned in ways that are detrimental to democratic society (Jolley et al., 2022). Conclusions from similar research highlight the role of conspiracy theories in undermining trust in health authorities, with a consequent reduction in medical help-seeking overall (Marques & Natoli, 2019; Natoli & Marques, 2021). This is a worrying phenomenon given the dual implications of limiting necessary medical assistance as well as opportunities to obtain factual, evidence-based information from credible medical professionals.

An additional concern in Aotearoa is the overall low expression of confidence in vaccines by midwives (Lee et al., 2018), alongside a few, but vocal, doctors promoting vaccine misinformation (Broughton, 2021). For the most part, however, healthcare providers are the best and primary source of vaccine information and advice. They are also identified in successive studies as the most important source of vaccination advice by many parents (Dubé, 2017; Paterson et al., 2016; Williams, 2014). Yet a desire to do the best for one's child, coupled with worry or anxiety about potential consequences of their decision on vaccination, sees many mothers turning to a wide range of alternative sources to assist in their decision-making (Freed et al., 2011). In the internet era, ease of access to conflicting information and the speed of its dissemination enables misinformation to reach many more people than was possible by traditional means (Elkin et al., 2020; Stahl et al., 2016). Social media and the internet more generally ensure ready accessibility of the full continuum of views on vaccination. Although some researchers highlight the opportunities the internet presents to efficiently share information (Hilary & Dumebi, 2021), others stress the need to closely monitor information content, trends and perceptions given the amount of misinformation and the rapidity with which it is spread (Connolly & Reb, 2012; Elkin et al.,

2020; Rosselli et al., 2016). Unfortunately, rhetoric encountered online, in various guises, is highly persuasive (Kata, 2010), in particular when accessed on social media (Bradshaw et al., 2021; Bramadat et al., 2017; Stecula et al., 2020). In the face of the COVID-19 pandemic, some such platforms have pledged to take down posts promoting conspiracy theories or false scientific claims (Nunziato, 2020). In practice, this is no easy task and users can easily switch to an alternative provider (Beckett, 2021). With no filters restricting flow or quality of material, and no requirement for any demonstrated evidence base or peer review (Schmidt et al., 2018; Ward et al., 2015), anecdotes of adverse effects are shared, increasing fear and anxiety despite a paucity of evidence (Grant et al., 2015; Kata, 2012). Without effective (or any) regulation, individuals are profiled and deliberately targeted online, not only by advertisers, but by anyone with an opinion and a social media account (Mahdawi, 2019; Maréchal et al., 2020; Matthews, 2022). Mothers in particular are the strategic targets of anti-vaccine influencers on social media platforms, who exploit ideals of motherhood and what it means to be a "good" mother (Baker & Walsh, 2022).

A particular feature of anti-vaccine information sites and the extent of their persuasive power is the creation of communities of people, unified by fear or mistrust, who find support among others expressing similar concerns and experiences. The collegiality and validation this brings intensifies dangerous beliefs and their credibility (Martin & Vanderslott, 2021; Matthews, 2022). Not only are these sources generally unreliable, many deliberately push an alternative agenda. This ranges from the seemingly benign sharing and promotion of beliefs in the power of natural healing, to much more sinister ends. Extremist groups, including white supremacists and gangs, capitalise on anti-mainstream sentiment to mobilise action against the government and create political and social unrest (Pantucci & Ong, 2022). Shared aversions to mandated health measures is a potent unifier of even the most disparate groups

(Martin & Vanderslott, 2021), as became starkly evident during the 2022 anti-mandate protests in New Zealand and Canada (Dyer, 2022; Fildes, 2022; Walters & Fifield, 2022).

Combatting misinformation is a complex exercise. Successive studies have consistently demonstrated the resistance of misinformation to correction - the *continued influence effect* (Ecker et al., 2010; Lewandowsky et al., 2012). This is the phenomenon whereby even after a person has received, understood, and can readily recall – and even believes – the correction, misinformation nevertheless persists in memory, having an ongoing influence on decisions and behaviours (Paynter et al., 2019). Notably, this effect has been specifically observed in relation to vaccination behaviours (Pluviano et al., 2017). The voices of those vehemently opposed to vaccines are generally emotive and highly descriptive, eclipsing pro-vaccine views (Dubé et al., 2015). In contrast, official, scientific, but impersonal repositories of pro-vaccination information, pale in their persuasive appeal. Not only is misinformation more persuasive when communicated or accessed online, it is also more enduring (Dubé et al., 2013; Larson et al., 2014). Unfounded, sensationalist claims, harnessing the power of fear and emotion, visually depicted on a person's own screens are readily embedded in memory. Once held, these beliefs are very difficult to change.

Further complicating the situation, communication of alternative, or even balanced information can be paradoxically problematic. Cognitive psychology researchers have extensively explored the difficulties in successfully correcting false information once encoded in memory (Larson, 2018; Pluviano et al., 2017). Some go so far as to contend that the very act of seeking to correct misinformation can have the opposite result. The *backfire* or *boomerang effect* proposes that the very act of correction will itself only increase and entrench belief in the very misconception that the correction was intended to change (Hart & Nisbet, 2012; Lewandowsky et al., 2012). Certainly, the potential for this to impact vaccination attitudes is something which should be borne in mind in designing campaigns.

However, whether this phenomenon exists at all is controversial, criticism having been levelled at the methodology employed in studies that purport to demonstrate it (Owen, 2019; Swire-Thompson et al., 2020). Generally speaking, individuals have been found to pay note to factual information, even if it challenges their ideology (Wood & Porter, 2019).

Nevertheless, sensitively outlining factual information about the relative risk profiles of vaccines versus disease, as well as prevention messaging, is a delicate exercise. The mental representation of future threats has a powerful impact on prospection and present-moment behaviour (Bulley et al., 2017). Drawing on prospect theory, Moukaddam (2019) found that risk-taking increases where major loss is expected but is uncertain. However, these authors also reported that, when the predicted outcome is framed as a gain, individuals are more risk averse. In the vaccination context, however, application of such conclusions are further complicated by whether individual perception of risk attaches more to the vaccine than to the disease it is designed to prevent. There is a potential that both withholding risk information or imparting it insensitively can increase a parent's reluctance to vaccinate (Ball et al., 1998; Clarke et al., 2015). Together, these findings illustrate the extent of the challenge for neutral and unemotional data to compete against moving, passionate personal accounts, irrespective of their accuracy (Kata, 2012; Krause et al., 2020). When giving information about relative risk, or seeking to correct misinformation, great care must therefore be taken with the content, tone and timing of corrective information, as well as the identity of the messenger (Ashwell & Murray, 2020; Dubé et al., 2015), to avoid inadvertent exacerbation of the very problem an intervention is intended to address.

Anti-vaccination messages are deliberately designed to provoke fear of potential consequences of vaccines, whether real or imagined (Bramadat et al., 2017; Jolley & Douglas, 2014; Swingle, 2018; Wolfe et al., 2002). Their relevance in the present context therefore is clear when considering evidence that exposure to such information heightens a

mother's decisional conflict, and particularly in the presence of underlying perinatal psychological distress (McHugh, 2016; Romijnders et al., 2019; Wallace et al., 2006). There is also evidence that likelihood of belief in conspiracies is correlated with experience of depression or anxiety (De Coninck et al., 2021). It is proposed here that perinatal anxiety and depression are one plausible cause for low vaccination, both potentially exacerbated by exposure to conflicting information, and a key part of the wider hesitancy puzzle demanding attention in a New Zealand-specific context.

Chapter 3: Decision Theory – Regret, Temporal Discounting, and Vaccination

Chapter Summary/Overview

In this chapter, the importance of theory, and a description and justification for the theoretical framework adopted for present purposes, are discussed. The theoretical lenses applied most often in vaccine-related research are summarised and key concepts - *anticipated regret* and *temporal discounting* - are introduced. The relevance of each in the present context is also outlined.

Why Theory?

Scientific theories seek to explain and describe phenomena, based on evidence available through observation and experimentation. A theory will also encompass factors that have not yet been, or cannot be, directly observed, such as processes, structures or organising principles (Price et al., 2015). Historically, psychology as a field valued the role of theory less than did other scientific disciplines. This contributed to the so-called *replication crisis* in psychology, casting doubt on the scientific credentials of the discipline as a whole (Pashler & Wagenmakers, 2012; Shrout & Rodgers, 2018; Świątkowski & Dompnier, 2017). Yet psychological theories, developed from a strong basis of existing knowledge, today play a key role in the development of and confidence in models applied to understand and predict human behaviour, thoughts, and emotions. Recent and increasing recognition of the centrality of scientific rigour to the advancement of knowledge and credibility of the discipline has seen a shift in approach. There is not only an increasing acceptance of the fundamental importance of theory, efforts have also been redoubled to ensure trust in and replicability of findings (Borghi & Fini, 2019).

Whereas a goal of exploratory research is the generation of new theories, in confirmatory research, hypotheses derived from evidence-based theories put existing

theories, both tentative and long-established, to the test. In this way, knowledge is challenged and extended, keeping respect for participants at the forefront. However, for research to be ethical, what is asked of individual participants in a study must be justifiable even in exploratory inquiry. A sound basis in theory for psychological study in any form can readily provide such justification (Emanuel et al., 2000). In seeking here to extend the existing knowledge base about vaccination and to probe the existence of a causal relationship between vaccination and perinatal anxiety/depression, it was important that the hypotheses specified in this study were grounded in established theory, and that they could be tested effectively (Wagenmakers et al., 2012). To the extent that this study also intended to explore qualitative themes to complement and provide context for the findings, it was equally important that the questions asked of participants for this part of the inquiry had a cogent basis and purpose. Without these safeguards, any imposition on individuals agreeing to take part, however minimal, would be unjustified and therefore unethical (Creswell & Creswell, 2017).

Accordingly, the quantitative hypotheses specified in this thesis, together with the exploratory and qualitative research questions, were derived from and devised to test temporal discounting and anticipated regret, both facets of decision theory. *Temporal discounting* refers to the incremental reduction of the importance or desirability of a reward as the delay until this reward is received increases (Critchfield & Kollins, 2001; Vaidya & Fellows, 2017). *Anticipated regret*, the expected or predicted negative emotional response that will arise as a consequence of a decision (Brewer et al., 2016), can also affect temporal discounting – a person's anticipated future value of that outcome (Morison et al., 2010; van der Swaluw et al., 2018; Weber & Chapman, 2005). Both are important concepts in theories of human decision-making and provide a salient perspective on the complexities of vaccination decisions.

Theory and Vaccination Behaviour – An Overview of the Approach to Date

Vaccination behaviours, and particularly negativity and ambivalence towards vaccines, have over time been examined through a variety of theoretical lenses (Batista Ferrer et al., 2015; Williams, 2014). Broadly speaking, the common aim in these studies has been to identify and understand the association between a person's attitudes or intentions towards vaccination and vaccine uptake in practice, as well as timeliness of uptake (if it occurs). It is a complex exercise, as a variety of individual attributes and the ways in which they interact all influence decisions. Behavioural change theory encompasses a range of psychological models, each of which seeks to demonstrate how relevant parameters relate to one another (Bandura, 1998). Well-known examples in the area of health psychology context include the Health Belief Model (HBM; Rosenstock, 1974; Rosenstock, Strecher, & Becker, 1988) and the Theory of Planned Behaviour (TPB; Ajzen, 1991; Ajzen & Kuhl, 1985), each applied extensively in the field of vaccination research. Broadly speaking, behavioural models predict that decisions and behaviours are driven by the consequences the decision-maker anticipates will result, as well as how this individual perceives the value or importance of any potential action that could be taken towards achieving that outcome. However, whereas behaviours according to the HBM are understood as a function of perceived severity of threat to health, the TPB focuses on intention (planning) to act – itself predicted by individual attitudes and evaluations as well as both subjective and social norms or expectations (Abhyankar et al., 2008; Brewer et al., 2007; Dubé, Gagnon, et al., 2016).

Assumptions that decisions are always underpinned by a high level of rationality and cognitive reasoning processes have led to criticism of these models, however, due to their failure to allow for the impact of affect, mood, emotion, or overall context on decision-making (Corrigan et al., 2014; Dubé & MacDonald, 2016). The implications of this are evident - affect and cognition have been shown to respectively mediate and moderate the

impact of the other on health behaviour, and both are impacted by an individual's experience, environment, and context (Kiviniemi et al., 2018). Various modifications or alternatives to the TPB have been advanced over time, such as the impact of emotion-laden messaging on attitudes (protection motivation theory; Rogers, 1975, 1983), or prospection and metacognition – thinking about the future, and thinking about thoughts themselves (Bulley et al., 2017; Bulley & Schacter, 2020; Moses-Payne et al., 2019; Worthy et al., 2014). Of the various alternatives, it is emotion, specifically regret, and temporal discounting (particularly as it is impacted by various forms of psychological distress) that stand out as crucial pathways to understanding and predicting vaccination as a specific type of health behaviour (Brewer et al., 2007).

Prospection, Emotion, and Decisions: Temporal Discounting and Anticipated Regret

Whilst neither temporal discounting nor anticipated regret are new concepts in decision-making theory and research (Baron, 2000; Green et al., 1994, 1996; Loomes & Sugden, 1982), increasing recognition of the salience of intertemporality and emotion has seen a change in focus in the field of research on vaccination decisions and behaviours. Often applied inconsistently, *emotion*, *affec*t and *mood* are separate constructs, albeit closely interlinked (Batson et al., 1992; Ketai, 1975). *Emotion* refers to the intense response a person may have to an event, their environment, or a thought – e.g., surprise, sadness, or anger. *Mood* is the subjective experience of that emotion, often longer lasting, and usually described as either positive or negative. *Affect* is its objective, observable manifestation – smiling, crying, frowning etc. (Alpert & Rosen, 1990). An emotion may lead to a mood, however, or a mood influence an emotional response and - together and separately - each can be a crucial influence on decisions (Clore & Huntsinger, 2007; Jung et al., 2014; Mellers et al., 2016; Worthy et al., 2014), and in motivating behaviour (Batson et al., 1992; Ekkekakis, 2013; Fernández-Dols & Russell, 2003).

Increasingly, regret, temporal discounting, and the role of emotion in decision making have been recognised as central to understanding and predicting vaccination behaviours (Brewer et al., 2007; Chapman & Coups, 2006; Chou & Budenz, 2020). Anticipated regret has been found across multiple studies to be the strongest predictor of vaccination behaviour, more so than risk perception, worry or perceived effectiveness of a vaccine (Gaube et al., 2019; Weinstein et al., 2007). The relationship between regret and decision-making has also been reported to vary by virtue of the length of delay between the making of a decision on the one hand and the outcome anticipated on the other (van der Swaluw et al., 2018). That is to say, the anticipated regret is also temporally discounted. In circumstances where vaccination involves a weighing of present and future outcomes, and decisions on vaccination are demonstrated to be strongly impacted by the regret the decision-maker anticipates as a consequence of the decision, it is easy to see why both temporal discounting and regret are key factors in any study of vaccination behaviours.

Temporal Discounting and Decision-Making

Intertemporal choice requires a mental trade-off between the different costs and benefits, real or perceived, of taking action and the consequences it might have across different timeframes. For example, a decision in the present to save for one's retirement can have immediate consequences (a smaller pool of available funds in the present) as well as future implications (more money on hand once the person stops working in later life). This mental trade-off has long been a focus for economists (Solow, 2000) but also for psychologists seeking to explain the cognitive determinants of these patterns of thoughts and behaviours (Rubinstein, 2003). *Discount utility* became the dominant economic model (Angner & Loewenstein, 2012). Underpinning this theory are assumptions that individuals make intertemporal choices based on careful scrutiny and evaluation of the utility of outcomes (i.e., their value to the individual). Those individuals are then believed to discount

the possible outcomes differently, depending on when in time each would be expected to occur. In essence, the model proposes that perceived value is not equal across time, rather the present is more important, and the future will be disregarded to a greater extent.

Although a phenomenon observed throughout the lifespan, from childhood to older adulthood, discounting of future reward has been found to be steeper in children (Green et al., 1994). This led to assumptions that a preference for immediate reward is due to impulsivity or underdeveloped restraint and control. Whilst this may be an accurate reflection in some circumstances, preference for reward in the present, irrespective of whether a greater reward might materialise in the future, is in many instances a highly adaptive response to uncertainty. Far from evidence of an impulsive failure of willpower, a decision to prioritise the present, based on foresight, experience, and need, will in certain circumstances be evidence of sound, rational long-term thinking, or prospection (Bulley, 2021). Taking a decision to favour immediate and certain reward over a delayed – or potentially less certain – reward (even if larger) may be particularly judicious in the face of a keen awareness of one's limited or diminished control over outcomes (Green et al., 1996). Discounting may occur for many reasons - including impulsivity and preference for instant gratification. Yet devaluing of a future reward may be rational where it is too remote, or less certain, particularly in the face of great need (Benzion et al., 1989; Stevenson, 1986).

A core assumption of discount utility theory was that the discounting of an outcome's value is exponential, and that the same steepness of discounting will apply at any point in time. This assumption did not withstand repeated testing, however (Angner & Loewenstein, 2012). Hyperbolic discounting was advanced as an alternative, proposing that human discounting is not constant, but inconsistent, value falling rapidly for short-term delays but more slowly for longer ones (Ainslie, 2001; Laibson, 1997; Rubinstein, 2003). This new conceptualisation of discounting was advanced as a means to explain why individuals who

intend to take health promoting decisions or actions do not ultimately follow through in practice (Ainslie, 2001; Laibson, 1997). However, inconsistent research findings began to emerge in testing this proposition also, highlighting the complexity of human decision-making in the health context in particular, where changes in motivation or environment interfere with prediction (Story et al., 2014).

Any discounting model based solely on economic utility that does not also account for individual differences in circumstances, preference, or need, will be faulty. It simply cannot be assumed that different people from different backgrounds and with vast differences in life experience, circumstances, and need will always attribute equal value to the same outcome, across various considerations and choice types (Frederick et al., 2002). Motives vary between individuals, or at different points in time, and may be evoked differently depending on the situation, personal beliefs and involuntary emotional or visceral responses. As Frederick and colleagues argued (2002), a model that allows for multiple motives may be more complex but will also be more valid.

Individuals' own metacognition – their knowledge about their own preference and decision-making patterns and behaviours – is also important. Temporal discounting is underpinned by higher-order capacities which permit prospection and metacognition (Bulley & Schacter, 2020b). Episodic and semantic memory interact in adaptive ways to help individuals in the present to understand, assess, evaluate, predict, and manage threat in their future (Bulley et al., 2017; Lempert & Pizzagalli, 2010). "Mental time travel" enables threat representation and evaluation across time, drawing on knowledge and experience to make balanced decisions that will best benefit the individual, curbing impulsivity as well as triggering immediate emotional reward (Boyer, 2008). Temporal discounting allows for human idiosyncrasies to be factored into the exploration of drivers for decisions. Individual differences – including personality, personal preference, culture, cognitive processes, past

experiences, state of mind, as well as the relevance of the overall situation, context or commodity may all impact the decision reached (Doyle, 2012; Iwaki, 2011). Undeniably a more complex approach, as compared with discount utility (Bleichrodt & Gafni, 1996; Frederick et al., 2002), temporal discounting is a more individualised approach and, as such avoids the pitfalls of a simplistic or reductive approach to understanding the human behaviour of decision-making. Adopting a perspective that accounts for temporal discounting is therefore critical when seeking to interpret any behaviours that are directed towards or driven by the prospect of delayed consequences over time (Critchfield & Kollins, 2001). Temporal discounting is therefore a natural fit for research seeking to elucidate drivers of unhealthy, dangerous, or risky choices (Chapman & Elstein, 1995).

Many factors have been explored in connection with temporal discounting (as well as psychological distress), for example, religion or a person's sense of power or control over their circumstances. Within broader cultural groupings, religious upbringing was found to modulate temporal discounting, patterns of delay tolerance (steeper discounting) and responses to large (versus small) rewards shown to be consistent across religions, and in various countries (Paglieri et al., 2013). Age and income are also said to be significant predictors of discounting, highest discounting linked to lowest socio-economic status, and *vice versa* (Green et al., 1996). Crucial for investigations of temporal discounting in indigenous peoples or minority ethnic groups are conclusions about the role that individual sense of power or self-determination, as well as frustration, optimism, and social status, have in determining likelihood and rate of temporal discounting (Duan et al., 2017; Ishii et al., 2017). Internationally recognised indicators of cultural dimensions (e.g., individualism versus collectivism; innovation and environmental protection; and long-term versus short-term orientation) all link a tendency toward individualism and greater importance of economic gain to reduced temporal discounting (Hofstede Insights, 2020; Wang et al., 2016). Like

Wang and colleagues (2016), Iwaki (2011) also concluded that individuals from more collectivist worldviews are more likely to consider themselves and their physical and social environments as a continuum, a theory of self being that is crucial to intertemporal decision-making and the evaluation of gain or loss. Further complicating such decisions are challenges in accessing relevant information – including linguistic challenges, perceived effectiveness of the contemplated health intervention, and the availability of and access to support (Knapp et al., 2014).

Temporal Discounting and Vaccination

With respect to vaccination, the relevance of time discounting is evident from the nature of the decision to be made itself - a mother must decide whether or not to act in the present (i.e., to permit or refuse permission for a vaccine to be administered to her child), but for a future purpose (potential prevention of disease). Protection against illness is a distant outcome of a decision to vaccinate, but an adverse reaction (or quite simply pain, or cost) is, if not immediate, less remote. As such, a mother may favour avoidance of negative impact in the short term over what appears to be less certain or necessary longer-term gain. A core aspect of the complexity arising in relation to health decisions is that a person may dread the health-promoting behaviour (vaccination), the illness (the target disease), or both. These competing influences will lead to different outcomes not only between individuals, but can also vary by virtue of the person's state of mind or other environmental factors at the time the decision is made (Chapman & Coups, 1999; Story et al., 2014).

The steepness of a person's discounting of future benefits of vaccination has been found to vary as a function of several factors. These include pre-existing beliefs about the benefits of immunisation and the level of anxiety that the decision may provoke, as well as the extent of decisional conflict experienced (Shourie et al., 2013). Decisional conflict here refers to the uncertainty an individual has about which course of action to select between

competing options. Risk perception, anticipated regret, and clashes with personal values will all be contributing factors (LeBlanc et al., 2009). In deciding on vaccination for a child, a mother weighs the risk of an adverse reaction (however minimal), against the risk of contracting the target disease. The decision must also be reconciled with personal values, for example strongly held views about introducing substances into the human body on the one hand, or the recognised importance of acting individually to contribute to protection of the wider community. Where a decision factors in immediate risk (whether of the vaccine, some other financial or emotional cost or a combination of these factors) and is weighed against future risk (of contracting and suffering consequences of disease), the rate and steepness of discounting could therefore be expected to vary. This variation would be anticipated as a function of an individual's unique perception of gain or loss, their level of knowledge or available information about the choices to be made and the person's unique social, cultural, and ethnic background, as well as any involuntary, instinctive, or unconscious responses to the contemplation of each of the options confronted, and their imagined outcomes.

Notwithstanding the importance of relevant information and the weighing of options to guide decisions, an individual's internal state is also engaged, not only driving but also fuelled by the decision and decision-making process (Sutton & Barto, 2018). Discounting is relevant for the first part of this process. Take the example of a person who decides to refuse a vaccine because any potential future illness seems too remote compared with perceived risk from the vaccine being given in the here and now. The perceived validity of that decision will be reinforced if, in the short-term, the intended recipient does not become unwell. A tendency to discount future outcomes more steeply can therefore also be problematic as a predictor of health behaviours – such as a mother's decision on later scheduled vaccines, or vaccination for a second or subsequent child – if prior learning or experience is not accounted for (Berns et al., 2006; Story et al., 2013). Personal experience or circumstance are powerful influences

on future decisions and can be difficult to counteract. Furthermore (and putting the adaptive nature of temporal discounting aside (Green et al., 1996; Kagel et al., 1986)), mental representation of future threat may arise in the absence of any signal of danger, but instead be a product of the individual's cognitive or affective state (MacKillop et al., 2011; Story et al., 2014; Worthy et al., 2014). Where a person responds emotively to a grossly exaggerated or imagined threat, in the absence of any real danger, this will generally be maladaptive (Steinglass et al., 2017; Worthy et al., 2014). In such circumstances, the perception of negative impact is amplified, and rumination and negative affective forecasting (the prediction of emotional states or mood in the future) follow (Pulcu et al., 2014). Avoidance and distress arise in turn, as seen in central components of anxiety or depressive presentations (Boyer, 2008; Bulley et al., 2017; Pulcu et al., 2014; Steinglass et al., 2017).

Nevertheless, discounting is a valuable tool to predict health behaviours. Successive studies strongly support a relationship between a high tendency to discount the future and unhealthy choices or behaviours (Story et al., 2014). To reliably and validly explore the discounting-health relationship though, the content and type of scenario presented in the measure must be right (Kim & Nan, 2019). For example, and somewhat counterintuitively, the balance of evidence suggests that health-specific discounting measures have only a weak relationship with health behaviour at best and are less sensitive a predictor than a monetary discounting example (Baker et al., 2003; Chapman & Coups, 2006; Petry, 2003; Story et al., 2014). One possible explanation is that monetary gains or losses present a concrete future outcome. This is in contrast to a broad range of idiosyncratic responses if forced to weigh undesirable preventive measures against often equally undesirable health consequences.

Importantly for the purposes of this study, predictive utility of the steepness of discounting using a range of measures has been repeatedly demonstrated in the context of a wide range of psychiatric disorders, not only in the context of addiction which was the initial

focus of much of this body of research, but also in respect of individuals with diagnosed anxiety or depressive disorders (among others) who consistently demonstrate steeper rates of discounting (Amlung et al., 2019; Cáceda, et al., 2014; Imhoff et al., 2014; Luhmann et al., 2011; Pulcu et al., 2014). This is not to say that temporal discounting is only observed in these populations. For example, in a vaccination-specific study, Chapman and Coups (1999) found evidence of a small relationship between vaccination behaviour and time preferences. However, mental health was not a variable of interest in that study and there is no information about its presence or absence among its 412 participants.

To illustrate, in their 2014 systematic review, Story et al. conclude that, of the studies considered, monetary discounting was predictive of health behaviours, but significantly higher in presence of addictive and disordered eating behaviours. This finding was reflected in a meta-analysis of temporal discounting and addiction research by MacKillop and colleagues (2011). These authors reported significantly larger effect sizes for studies using clinical samples compared with those that did not, and overall that the results supported greater discounting in presence of addictive behaviours, highest where criteria were met for addictive disorder. Extending beyond addiction, In 2011, Luhmann and colleagues found that individuals with generalised anxiety and high intolerance of uncertainty were more likely to prefer immediate over delayed reward, concluding that their findings had implications for delay discounting in presence of anxiety. Similarly, Worthy et al. (2014) reported a positive correlation between high discounting and high level of worry. In a 2019 meta-analysis of 57 effect sizes from 43 studies across 8 diagnostic categories, Amlung et al. (2019) reported robust differences in delay discounting between participants with a diagnosed psychiatric disorder and non-clinical controls. Most individuals with disorders (including depression, bipolar disorder, borderline personality disorder, bulimia nervosa, and binge-eating disorder) exhibited steeper discounting compared with controls (with the exception of anorexia nervosa

and schizophrenia). Cáceda and colleagues (2014) considered the literature on decision-making in presence of diagnosed psychiatric illness reporting significantly higher temporal discounting in clinical populations in each of the studies reviewed. In a study of depression, smoking, and discounting Imhoff and colleagues (2014) considered discounting tendencies in adolescents, to form four groups (non-depressed non-smokers; depressed non-smokers; non-depressed smokers; depressed smokers). Delay discounting was significantly correlated with depression, lowest discounting observed in the non-smoking, non-depressed group, reflecting previous findings on the effects of addictive behaviours and affect on discounting tendencies. In presence of major depressive disorder, Pulcu et al. (2013) also reported higher discounting in individuals with a diagnosis of depressive disorder whose symptoms were most severe. Where symptoms were in remission, discounting rates were similar to those of non-clinical controls. Collectively, these studies suggest that both presence and severity of a diagnosable disorder is highly correlated with steeper tendency to discount future reward.

Anticipating Regret: The Effect of Emotion on Discounting and Decisions

In decision theory, *anticipated regret* refers to the negative emotional response a person expects they will experience as a direct consequence of a decision they take if a particular outcome were to result (Diecidue & Somasundaram, 2017; Loomes & Sugden, 1982). There is a fundamental distinction to be drawn between emotion experienced *in the moment* (relating directly to an action or decision); *anticipatory* emotion (worry in the present about a future event); and *anticipated* emotion (expectation in the present of adverse emotional consequences occurring in the future) (Worthy et al., 2014). Thus *anticipated regret* can be understood to refer to the expected, undesirable but future psychological effects, such as from loss that may result from a decision, well before that loss has eventuated (Janis & Mann, 1977).

The nature and determinants of regret, and how these may be individually conceptualised and regulated, is a topic of importance in cognitive psychology, but has gained particular prominence in the field of health behaviour research (Koch, 2014). Anticipated regret has been found to have a strong, stable association with health behaviours across a range of studies (Brewer et al., 2016). It also successfully predicts engagement in protective behaviours – including vaccination - particularly when its impact is evaluated alongside associated affective states (Moss et al., 2015; Stevens et al., 2019; Zajac et al., 2017). It has been suggested that the intensity of the regret anticipated may be due to the type of regret in question – *action regret* (regret as a consequence of deciding to take a particular action), or *inaction regret* (regret about a decision not to act). Whilst anticipation is largely a forward-looking cognitive process involving prospection and mental time travel, the act of envisioning the future also involves experiencing of emotion in the present (Kiviniemi et al., 2018). Some researchers have contended that the intensity of inaction or action regret depends on whether it is felt in the shorter or the longer term (Gilovich et al., 1998; Gilovich & Medvec, 1994, 1995). More recently, however, studies conclude that action regret is more intensely experienced overall (Towers et al., 2016), and may therefore be a more powerful motivator, particularly in relation to health behaviours.

Particularly for those already familiar with anticipated regret theory, it is helpful to clarify the nature of expectations or predictions made in the context of vaccination hesitancy, and therefore in this study. Typically, both action and inaction regret would be expected to be correlated positively with unfavourable outcomes, and negatively with favourable outcomes. For example, taking the case of a study of regret about marriage: a person might have action regret for acting to marry the wrong person, and/or inaction regret about not acting – not marrying the right person. Both would be expected to have the same directional relationship: higher regret would see more negative emotion in response. However, in respect of

vaccination, the direction of the relationship between intention and either inaction or action regret could be expected to point in opposite directions – increased inaction regret should correspond to increased vaccination intentions, whereas increased action regret is expected to correspond with lower intention to vaccinate. Simply put, although both relate to undesirable consequences, action regret in this study relates to regretting a bad outcome of a vaccination, and so is expected to predict higher intention to vaccinate, whereas inaction regret relates to a bad outcome of not vaccinating (i.e., getting sick) but is expected to predict lower vaccination intention.

Applied in the context of vaccination, therefore, these cognitive models suggest that a mother will, firstly, consider the risk perceived to attach to the act of vaccination, and will contemplate the (action) regret that it is anticipated might result if administration leads to an adverse reaction. The mother will then weigh this all against the risk posed by contracting a vaccine-preventable disease, together with the (inaction) regret that would be expected to be experienced as a direct consequence of the omission/failure to act to permit vaccine administration. Manifestly, the nature and severity of risk as perceived by a given individual is key. For the most part, mothers who refuse or are hesitant about vaccinating their child are, like their pro-vaccination counterparts, motivated to act in the best interests of their children, constructing risk with reference to a combination of social and expert advice or opinion, lifestyle choices, and individual perception of what constitutes best parenting practices (Díaz Crescitelli et al., 2020; Ward et al., 2017).

Cognitive processing is generally congruent with a person's current affect, and judgments are regulated by the thoughts and emotion a person experiences at the time they are made (Clore & Huntsinger, 2007). Affect and cognition are fused in anticipated regret, interacting to influence perceptions and experiences of the emotion believed will be the result of a decision made (Kiviniemi et al., 2018). Successive studies consistently find anticipated

regret to be the strongest predictor of intention and behaviour, over and above other anticipated emotion, risk appraisal, and even attitudes towards or knowledge of vaccines (Abraham & Sheeran, 2003; Brewer et al., 2007; Chapman & Coups, 2006; Gaube et al., 2019; Hamama-Raz et al., 2016; Sandberg & Conner, 2008). Furthermore, anticipated regret fully mediates the link between risk perception and vaccination intention (Lagoe & Farrar, 2015), even after controlling for cognitive constructs such as behavioural, normative and control beliefs and risk perception (Magnan et al., 2017). This motivated an exploration of the nature and drivers of a mother's concerns in the present study. It was expected that the hypothesised effects of perinatal distress on vaccination intention or behaviour would be mediated by the regret anticipated to result from the decision, considering which outcome - adverse reaction to a vaccine, or future illness from a preventable disease – was most feared.

Although anticipated regret is undeniably an important component of risk evaluation, enabling sound decisions for the future to be made in the present, these adaptive benefits of emotion and prospection may be lost in the face of acute levels of worry or anxiety. Where *worry* (conceptualised as primarily cognitive) and *anxiety* (a more global construct, encompassing cognitive, behavioural, and somatic elements) are extreme, either may result in reduced emphasis on future outcomes, and an enhanced preference for immediate reward (Worthy et al., 2014). High anxiety has been linked to reduced tolerance of uncertainty and, consequently, the importance of future risk avoidance is minimised in favour of maximising immediate reward (Bulley et al., 2017). Anxiety's relationship with regret, demonstrated across multiple studies, has also been demonstrated for depression (Roese et al., 2009). Prior experience of depression influences the anticipation of a negative emotional response to the outcome of a decision (Rae & Haw, 2005). Together or separately, anxiety and depression impact decision-making processes. Taking the case of vaccination decisions then, individuals might be expected to be most influenced by their primary cause of concern (vaccination or

disease). However, where either scenario may lead to apprehension, a preference for avoiding uncertainty in the *present* (i.e., uncertainty about a potential adverse reaction to the vaccine in the here and now) is expected to be more powerful than uncertainty about the *future* risk (that is the more temporally remote potential for baby to fall ill from a vaccine-preventable disease at some point in the future), therefore leading to a higher likelihood of delayed vaccine uptake or outright refusal.

Despite a predominant focus in the literature on the respective or combined effects of emotion and affect on decision-making, the very act of decision-making itself is reported to either lead to or exacerbate existing distress (Pittig et al., 2020; Treffers et al., 2017). Decisions impacting a child's health are weighty, with lifelong consequences. As such, they are likely to be highly emotionally charged and particularly in the face of interpersonal or internal decisional conflict (Ferrer & Mendes, 2018; Shourie et al., 2013). During pregnancy as well as postnatally, an expectant or new mother's risk of psychological distress is amplified - the potential for perinatal anxiety or depression added to significant adjustments to daily routine, role responsibility, in addition to hormonal changes and sleep deprivation. Against this background the need to take a decision on vaccination that will have long-term implications for baby may not only seem a daunting or impossibly difficult task, but the process itself may also intensify or otherwise impact underlying emotional and affective states (Biaggi et al., 2016; Leach et al., 2017). For example, where a mother's anxiety is highest for disease, the act of vaccinating may itself provide instrumental and emotional means to control threat and consequent anxiety (Wang et al., 2017). Distress may also be heightened where a decision, action or omission is incongruent with personal values (Chrystal et al., 2019) - for example, if the decision to vaccinate was the result of external pressure, or the failure or delay in vaccinating was due to an inability to access appropriate services.

The suitability of cognitive models that assume rational decision-making to exclusively explain and predict vaccination behaviours must therefore be approached critically by researchers in this field and public health officials, not least given their importance to the development of effective public campaigns or interventions. As multiple theorists and researchers contend, rational cognitive decisions require "emotional processing" but it is often the unintended or even unconscious emotive responses to actual or contemplated outcomes – somatic or physiological responses, our "gut instincts" - that are the most powerful influences of decisions (Bechara et al., 1994; Damasio, 2008). In the vaccination context in particular, neither dispassionate nor highly evidence-driven decision-making should be assumed (Corrigan et al., 2014). The *somatic marker hypothesis* advanced by Damasio (2008), which postulates that reasoned decisions are biased by physiological signals resulting from emotion, is not without its critics. There is support for a strong role of prior knowledge in overriding emotive responses (Maia & McClelland, 2004). Certainly, emotion as a driver for decisions does not render a decision irrational per se. Negative affective states and emotion have been demonstrated in many studies to impact the accessibility of beliefs and threat perception, particularly in the heat of the moment (Ajzen, 2011). Whether aiding or clouding decisions, the effect of emotion on decisions is undeniable. Human decision-making is not a completely cold-blooded process, objectively and dispassionately weighing objective evidence – even presuming the objectivity of knowledge to hand. The assertion made here, therefore, is that to fully understand vaccination decision-making (taken, for the most part, by mothers for their children), assessing for the potential effects of perinatal psychological distress is essential. The rationale for this contention is due to the combined effects of the highly influential role of expectant and new mothers in vaccination decisions for a child, and the prevalence of perinatal anxiety and

depression at the material time for vaccine decision-making and administration, given the necessary timing of childhood vaccinations.

Chapter 4: Pandemic Illness and Vaccination Behaviour

Chapter Summary/Overview

Research conducted during and in the wake of earlier pandemics this century has provided valuable insight into effects of these global health emergencies on health behaviours, including vaccination. This research is summarised in this chapter, alongside the emerging findings of studies carried out since the COVID-19 pandemic began. The implications for this study, and for vaccination behaviours more broadly, are also discussed.

Pandemic Effects: Learning from the Past

A *pandemic* describes the worldwide spread of a disease. Although often used interchangeably with *epidemic* or *outbreak*, each carries a different and specific meaning. Whereas an *epidemic* refers to a disease that reaches many people in a defined area, an *outbreak* is an increase in incidence of a disease that already exists but that exceeds usual or expected patterns. Pandemics have played an important role in the shaping of human history and health behaviours, from the Antonine plague that devastated the Roman empire between 161-180, to the "Black Death" in the 1300s which took 200 million lives, to the so called "Spanish flu" of 1918-1920 – the deadliest in modern times, estimated to claim in the region of 500 million people worldwide. All are grim illustrations of human vulnerability in the face of disease for which a population has no immunity or effective medical treatment (Hays, 2005; Huremović, 2019; LePan, 2020). Accelerated by ever increasing globalisation, pandemic SARS (sudden acute respiratory syndrome), H1N1 influenza, Ebola Viral Disease (EVD), MERS (Middle Eastern respiratory syndrome) and HIV (Human Immunodeficiency Virus) have seen infection spread through communities, nations and then across international borders with alarming speed (LePan, 2020). Each wave of disease resulting in extreme loss of life, with severe costs for livelihoods and wellbeing.

Despite warnings to prepare (Henig, 2020; Morse, 1996), the virulence and rapidity of the spread of novel coronavirus disease - SARS-Cov-2 (COVID-19) took all but epidemiologists and virologists by surprise when it so rapidly fanned out across the world after its initial discovery in China in late 2019. Human collective cultural memory for events not personally experienced is alarmingly short lived (Curtis & Van Besouw, 2020; Swift, 2020). Individuals' own sense of vulnerability, personally, or as a member of a social group, will inform their emotional and behavioural response to an event. This was illustrated in a study of Australian university students who were largely unconcerned or disinterested during pandemic H1N1, continuing to attend classes and socialise when unwell (Van et al., 2010). The exception to this pattern of behaviour was observed among the Asian-born participants in that study, whose home nations had been singularly impacted by SARS and by MERS. In other similar studies, those experiencing high health anxiety or affective responses specific to the risk from the outbreak (to themselves or to loved ones) increased their compensatory and protective behaviours (Liao et al., 2014; Peng et al., 2010; Wheaton et al., 2012). Temporal effects are also reported, the perception of relative seriousness and motivation to adopt protective measures paradoxically reducing during the course of a pandemic (Huremović, 2019; Jones & Salathé, 2009; Wong & Sam, 2010). This is generally attributed to the level and nature of media attention rather than epidemiological data, as media – and therefore public – attention and interest often declines before peak infection is reached (Bults, Beaujean, de Zwart, et al., 2011; Reintjes et al., 2016).

A clear correlation has also been found between information content or availability and the perception of personal or community risk (Zanetti et al., 2012). Perceptions are often based on misinformation or misconceptions, promulgated by unreliable sources and fuelled by open-access public commentary (Lynch et al., 2012). This can be problematic where personal risk or severity assessments are based on poor quality information (Liao et al.,

2014). Where such trends are observed, adoption of protective behaviours, including vaccination, is generally suboptimal. Another factor influencing risk perception is a person's level of trust in the local public health system and government. Trust in officials is correlated with willingness to believe in and comply with official communications about the danger posed and the need for preventive measures (Bults et al., 2010, 2015; Determann et al., 2016; Poland, 2010; Rubin et al., 2009).

Of relevance for this study is the clear and consistent evidence that health behaviours – including vaccination – change both during and after a pandemic (Amour et al., 2015; Bish et al., 2011; Brandt et al., 2011; Bults, Beaujean, Richardus, et al., 2011; Cave, 2017, 2017; Determann et al., 2014; Moukaddam, 2019; Wong & Sam, 2010). Distinctive patterns observed have related to the acceptability of novel vaccines and willingness to have these administered, as well as attitudes or access to routine immunisation. These findings from earlier pandemics, together with emerging patterns in research since 2020, provide researchers with a valuable basis from which to examine the present-day context and plan for both the near and distant future. Humankind would do well to take heed of history. With each pandemic, a severe psychological toll accompanies the often devastating physical one.

Psychological Implications of a Pandemic

Evidence from research carried out during and in the wake of earlier pandemics supports a strong positive relationship between pandemics and mental health challenges. This is observed whether a person has had direct and personal experience of the illness or has simply lived through a time where the disease was uncontrolled in the environment (Brooks et al., 2020; Huremović, 2019; Lee, Kang, et al., 2018; Maunder et al., 2003; Ornell et al., 2020; Shah et al., 2020; Wu et al., 2009). Beyond those who become ill, the psychological impact of pandemic illness extends to their families, healthcare workers, and the wider

community. For some, existing distress is exacerbated, and for others it is the catalyst (Huremović, 2019; Moukaddam, 2019; Santomauro et al., 2021; Tucci et al., 2017).

The mental health implications of pandemic illness are also mediated by a person's appraisal of risk, their level of anxiety or their intolerance of uncertainty, alongside any existing coping strategies (Taha et al., 2014). Adverse and enduring effects on mental health are highest for those directly personally affected, including healthcare workers, victims of illness and their family members (Jalloh et al., 2018; Maunder et al., 2003; Mohammed et al., 2015). Health professionals and hospital employees working in high-risk units during SARS and MERS, for example, were most likely to exhibit post-traumatic stress symptomology, even after the passage of time (Lee, Kang, et al., 2018; Wu et al., 2009). Such conclusions were mirrored across every pandemic of the modern era. Survivors and relations of EVD victims experienced extensive psychological distress during and in the aftermath of the Ebola outbreak (Kamara et al., 2017; Reardon, 2015; Tucci et al., 2017). Mak et al. (2009) described the consequences of SARS for survivors in their sample recruited from a large hospital in Hong Kong as a "mental health catastrophe". Concerned with a reported peak in suicide observed in older adults in Hong Kong in 2003, Cheung et al. conducted a study to understand any underlying reasons (2008). They concluded there was evidence that the disease and social distancing had led to an increase in loneliness, disconnection, and an inability to manage fear and anxiety in densely populated communities in the absence of social support. Despite a manifest imperative to focus on physical health and infection control during any outbreak, it is equally clear that mental health and wellbeing must not be ignored.

COVID-19

Emerging in Wuhan, China in late 2019, COVID-19 spread across the globe with unexpected speed and efficiency in the first months of 2020. By September 2022, the WHO reported over 600 million officially recorded cases worldwide, and nearly 6.5 million deaths,

with only one country still to report a case (Turkmenistan) (World Health Organization, 2022b). Bearing in mind the differences in detecting and reporting causes of illness or death, it is inevitable that these figures are a gross underestimation of the true scale of the pandemic . Although slow to officially designate the initial outbreak as a pandemic, the WHO eventually recognised and declared the pandemic a crisis, stressing the importance of a concurrent focus on mental and psychological wellbeing (World Health Organization, 2020a). Extreme measures were implemented in almost every country to slow the spread of disease and ease the burden on overstretched health systems. An unprecedented event in living memory in its rapidity, severity and the extent of its reach, the COVID-19 pandemic was predicted (and supported by studies in the initial two years after it began) to have serious long-term implications for the psychological wellbeing of the world's population (Almeida et al., 2022; Boden et al., 2021; Dawson & Golijani-Moghaddam, 2020; Samji et al., 2022).

To build on and extend understanding from earlier related research, studies were rapidly devised and conducted in an attempt to identify and describe the relationship between COVID-19 and psychological distress. The well-established neuropsychological effects of past viral pandemics made this an important focus in this new pandemic (Troyer et al., 2020). Many researchers cautioned against attending only to biological or physiological risk to the exclusion of psychological sequelae, fuelled by high and widespread levels of fear (Ornell et al., 2020; Shah et al., 2020; Shalev & Shapiro, 2020; Torales et al., 2020). A critical concern was the differential impact of disease on already marginalised populations, now suffering fear, loss and isolation, augmenting significant existing health inequalities (Druss, 2020; Yao et al., 2020). Whilst necessary to reduce unacceptable risk to life, the consequences of extreme protective measures, such as the closing of schools and workplaces, social distancing, managed isolation, and quarantine, are many (Brooks et al., 2020; Dawson & Golijani-Moghaddam, 2020). Particular attention was also directed to the consequences for

the mental health of children and adolescents arising from extended periods of isolation and restricted interactions with peers, as well elevated risk for those living in unsafe homes during lockdowns (Fegert et al., 2020; Officer et al., 2022; Panda et al., 2021). A particularly high psychological toll was reported among health care workers (Khajuria, 2020), exacerbating distress that was already a problem for many in stretched health systems (British Medical Association, 2019). As COVID-19 and its variants continue to extend their hold, they bring a constant need to change and adapt health measures and consequent uncertainty for health and livelihoods. Concern for psychological wellbeing has only increased, demanding urgent and population-wide public mental health interventions (del-Valle et al., 2022; Reizer et al., 2021; Satici et al., 2020; Smith et al., 2022; Zolopa et al., 2022).

Despite some suggestion of a return to pre-pandemic levels of psychological disorders after an initial rise (Robinson et al., 2021), other studies paint a different picture. A systematic review of available global data, published in late 2021, also reported dramatic impact on global prevalence and disease burden of depressive and anxiety disorders directly attributable to the pandemic, respectively said to have increased by 27.6% and 25.6% by January 2021 (Santomauro et al., 2021). Adverse psychological outcomes are consistently reported, study after study (Bueno-Notivol et al., 2021; del-Valle et al., 2022; Li et al., 2022, 2021; Necho et al., 2021; Raymond et al., 2022; Reizer et al., 2021; Richaud et al., 2022; Sahebi et al., 2021; Santabárbara et al., 2021; Satici et al., 2020; Weinberger-Litman et al., 2022). As the pandemic lingers, the need to concentrate efforts to reduce risk to psychological wellbeing is manifest, and comes at a time when access to assessment, intervention and treatment via usual channels is singularly compromised (Campion et al., 2020).

Gendered Effects of COVID-19

The wide-reaching effects of the pandemic are also reported to have disproportionately affected the general, physical, psychological, and economic wellbeing of

women specifically. Being female was identified as a risk factor for poor mental health, in contrast to comparatively stable reported rates of psychological distress in males (Stroud & Gutman, 2021). Adverse effects on general and psychological wellbeing were reported in particular for pregnant and postpartum mothers (Adrianto et al., 2022; Ahmad & Vismara, 2021; Farrell et al., 2020; Iyengar et al., 2021; Naurin et al., 2021; Pascal et al., 2022; Patabendige et al., 2022). In one New Zealand study, eight mothers who gave birth during the first year of the pandemic and experienced postnatal depression or anxiety were interviewed to understand their experiences, together with three healthcare providers (Ryan & Barber, 2022). The authors concluded that the pandemic lockdown had limited reasonable accessibility to necessary treatment. Women across the workforce reported difficulties they attributed to the additional burdens of lockdowns, domestic as well as professional responsibilities, managing educational requirements for children, or being forced to take leave (Dean et al., 2022; Jiwnani et al., 2021; Ranasinghe & Zhou, 2023; Sharma & Vaish, 2020). The European Parliament reports the effects of the COVID-19 pandemic, and in contrast to previous crises, as having had a particularly detrimental effect in those sectors of the economy that employ more women than men, as well as increasing the number of hours of unpaid care and housework, and higher reported levels of violence against women, in the home and online (Lopez & Schonard, 2022).

Pandemic Implications for Aotearoa

In Aotearoa, loneliness itself, as well as its link to other factors prejudicing wellbeing, poses a public policy challenge. This pre-dated the pandemic, 3.5% of New Zealanders reporting feeling lonely most of the time in 2018 but rose to 10.6% of survey respondents during the most restrictive Alert Level 4 lockdown (Walker, 2020). Daily lives, livelihoods, education and family and social contact ground to a halt, implications being particularly severe for older people, those living alone, individuals with existing health problems and

those in compromised or unsafe home situations (Fiorillo & Gorwood, 2020; Kaufman et al., 2020; Topalidou et al., 2020; Usher et al., 2020). A report commissioned by the Mental Health Foundation in Aotearoa found that, nearly a year after the pandemic began, a quarter of New Zealanders and 1 in 3 women had low levels of mental and physical wellbeing (Dudding, 2021a). This was most often observed in those with the lowest recorded household income. A meta-analysis of available evidence on maternal mental health, antenatally and postpartum, highlighted the particular risk to expectant and new mothers to depression and anxiety during this period (Hessami et al., 2020).

Such findings are chilling, yet unsurprising. Faced with a real and present threat of contagion during a pandemic, heightened worry – particularly health-related – must be expected. To a degree, such concerns and worries may be protective, increasing adherence to public health measures and adoption of adaptive health behaviours such as handwashing (Harper et al., 2020). However, when excessive, the experience of health anxiety likely meets criteria for a psychiatric disorder (as defined in the DSM-5 or ICD-10), giving rise to a combination of distressing thoughts and emotions, physiological arousal, and physical sensations. Bodily sensations are interpreted as illness, leading to defensive, sometimes extreme, behaviours and decisions (Taylor & Asmundson, 2004, 2017). Particularly concerning behaviours with physiological and psychological implications include reduced essential routine visits to general practitioners (such as for well-baby checks and vaccinations), panic buying, and extreme social withdrawal or the adoption of obsessive or compulsive levels of hygiene or safety behaviours, well beyond what is indicated for personal or public protection (Asmundson & Taylor, 2020).

In user-pays healthcare systems, as in the US, a dramatic downturn in visits to a GP or other health professionals, including emergency rooms across the country, has been observed. This is reported to be due to two primary factors: a fear of contagion, and an inability to

afford care given the economic effects of the pandemic (Abelson, 2020; Hamel et al., 2020). The same trend has been reported by public sector district health boards in Aotearoa, with routine health encounters in primary care and in hospitals reducing, alongside a rise in vaccine hesitancy (Clent, 2020; Ministry of Health, Manatū Hauora 2020a). Although there is some evidence to suggest that a spike in adverse psychological sequelae may resolve with the passage of time, this appears primarily to be in terms of returns to pre-pandemic symptom severity for those already experiencing psychological distress before the pandemic began, rather than a reduction or disappearance of distress in individuals first diagnosed during or as a consequence of pandemic (Robinson, Sutin, et al., 2021). Certainly, it is still too early to truly gauge the long-term implications.

The pandemic brought a toxic mix of physical health threat, isolation – from the world and each other, alongside personal and national economic hardship, and challenges not only to social cohesion but the sense of personal or collective safety. Researchers and health professionals in Aotearoa have expressed grave concern about the long-term psychological implications of COVID-19 for this country, underscoring the need for careful and ongoing attention to impacts for Māori and Pasifika in particular, as well as for all children and young people (Broodryk & Robinson, 2022; Houkamau et al., 2021; Officer et al., 2022; Poulton et al., 2020). New Zealand-centric research urges attention to the risks arising from a combination of existing and disproportionate disadvantage and high rates of employment of Māori in those areas affected by tourism and export downturn, such as forestry. The lack of trust in or relevance of general and mental health services, already failing to effectively address need for Māori, amplifies this imperative (Graham & Masters-Awatere, 2020). To design and implement a truly effective mental health strategy for the COVID-impacted future, it is critical to recognise and engage with the broad range of cultural perspectives on mental wellbeing in our society. Meaningful and effective engagement rests on genuine

participation and empowerment of communities, harnessing the wealth of existing knowledge and expertise of social norms and protective frameworks to reach the people (Ratuva et al., 2021). It is hoped that the findings of this particular study will lead to further exploration of the mental health-vaccination relationship, and that this will be beneficial to the development of an effective, respectful, and enduring approach to understand and support vaccination behaviours across the country. Where both maternal mental health and immunity may be improved, side by side, it is hoped this may contribute to an urgent reduction in current disparities in health outcomes for minority groups in Aotearoa.

Vaccination Behaviours: The Pandemic Effect

Health behaviours, including willingness to immunise, are vital to disease control but require individual compliance. Anxiety has been found to increase the likelihood of vaccine uptake, primarily due to heightened fear of circulating illness (Chan et al., 2015; Scherr et al., 2017; van der Weerd et al., 2011). Paradoxically, pandemic-related worry has also been shown to entrench anti-vaccination views, particularly relating to novel vaccine safety (Bish et al., 2011; Henrich & Holmes, 2009; Savas & Tanriverdi, 2010). This is particularly sobering when considering research evidence of both the global prevalence of susceptibility to conspiracy theories (Roozenbeek et al., 2020) and the effects of misinformation to prevent the suppression of epidemics (Sontag et al., 2022).

For this study, the relevance of attitudes to COVID vaccines is due in part to the implications of increased, mixed, publicity about vaccination, but also the broader impact of the pandemic on availability and accessibility of vaccines in general. Early on, Heidi Larson, director of the Vaccine Confidence Project, predicted COVID-19 would lead to a shift in individual attitude or behaviours, but that overall numbers of acceptance or rejection would remain the same (Ganarich, 2020; Reynolds, 2020). She cautioned that a more significant impact of COVID-19 would ultimately be on those routine immunisations that were

cancelled, delayed, or missed altogether. Certainly, initial data on immunisation were troubling. Disruptions in routine healthcare, including routine immunisation, were observed in all countries, with middle- and lower-income countries the hardest hit (Nelson, 2020; Santoli, 2020). Fears of a resulting spike in other life-threatening illnesses– particularly as restrictions ease and international travel resumes - are credible (Durrheim et al., 2021; Khatiwada et al., 2021; Roberts, 2021). Such concerns were already fuelled by a downturn in vaccine uptake, rates well below the 95% required to avert community outbreak for many preventable diseases (Lane et al., 2018). Before COVID, in 2018, the UN had already estimated that an approximate 20 million people were unvaccinated (Lane et al., 2018; World Health Organization, 2018a). By April 2020, the MMR campaign had been delayed in 24 countries, and cancelled entirely in 13 others (Ryeng, 2020). By the November of that year, the WHO reported a 20-year high of measles cases, as a direct result of disruptions to vaccination due to the pandemic, with a 50% increase in mortality since 2016 (Patel, 2020). Two years later, 57 preventable disease campaigns across 43 countries were still postponed, 73 million children at risk of measles as planned catch-up campaigns were hindered both by changes and increases in health risk, as well as significant global conflict in various regions, (UNICEF, 2022). The numbers of measles cases continued to grow, increasing by 79% in the first two months of 2022, compared to the same timeframe the previous year.

Looking at New Zealand, at the start of the pandemic, only 51% of those surveyed in a 2020 study indicated an intention to be vaccinated (Dudding, 2021b). However, once a vaccine was available, the figure rose in many parts of the country, 96% of the population having at least one dose, and 95% double vaccinated, but the numbers for boosters declined, only 72.7% of the country being fully protected by mid 2022 (Ministry of Health, Manatū Hauora, 2022). Nevertheless, uptake remained below the required level to protect the wider population, based on modelling suggesting at least 97% coverage was required to protect the

population against the more infectious variants of this virus (Steyn, Plank, et al., 2021). Further, there were marked discrepancies in these figures by DHB and ethnicity. Against a background of longstanding health inequality, fuelled by a healthcare system inadequately serving the health interests of minorities - Māori in particular, the implications of suboptimal vaccine uptake are particularly chilling. Vaccine uptake by Māori not only fell behind, but Māori and Pasifika in Aotearoa were reported to be substantially more at risk of hospitalisation from COVID-19 (Steyn, Binny, et al., 2021). Māori were also reported 50% less likely to survive COVID-19 if infected (Steyn et al., 2020).

Attitudes and willingness to be vaccinated changed over time and as pandemic fatigue set in. A series of longitudinal studies in Aotearoa canvassing attitudes towards and monitoring uptake of the COVID-19 vaccine showed a slow but steady upward trend in acceptance and acceptability to New Zealanders across all gender, age, education, and ethnic groups (Thaker, 2021b). By May 2021, 67% said they would “definitely” accept the vaccine, and among Māori surveyed, there had been a 10% increase by May to 54%, compared to 44% in March 2021. However, this figure is contrasted to a 68% “definite” intention in NZ European/Pākehā, and 72% in Asian respondents to this survey. In practice, this translated to reports in 2022 of 91.5% of the whole population of Aotearoa at least partially vaccinated, and 73.2% boosted (Ministry of Health, Manatū Hauora, 2022a). Whilst the numbers were a vast improvement on prediction, they remain below the 97% needed to protect against the more virulent variants of the virus. Further, taking a closer look at the figures, it was evident that vulnerable communities remained the least protected – reported figures for Māori fell to 83.5% at least partially vaccinated and 56.2% boosted (Ministry of Health, Manatū Hauora, 2022a).

This matched reports in other countries. As the pandemic progressed, a welcome shift in attitudes was observed (YouGov, 2021). In one poll a downturn in hesitancy relating to the

COVID vaccine in particular was reported from 45% to 20% between January and late June 2021, in every country other than Australia. This was attributed primarily to two factors: the pace of vaccination, and gravity of the pandemic as measured by number of deaths (The Economist, 2021). But still uptake remained below required levels for population immunity. Well in to 2022, inequitable supply, inadequate infrastructure (e.g., cold chain storage) and continuing disruptions to routine immunisation programmes still drive low rates of uptake of all vaccines – including against COVID-19 – in many nations (Guarascio & Rigby, 2022; Healy, 2022; United Nations Children's Fund, UNICEF, n.d.).

Clearly vaccine hesitancy in the context of a pandemic has serious implications. Quite simply, to be effective in preventing widespread illness, vaccines need to be adopted on a large scale (Larson, 2018). Some were optimistic that a modern-day experience of pandemic illness and high mortality would cure complacency about uncontrolled disease, hopeful this would reduce the credibility of conspiracy theorists and increase critical thinking (Gammon, 2020). However, the stance of the anti-vaccination lobby also hardened (Henley, 2020). As the attention of the world turned to vaccines, and whether they might pave the way back to a more normal life, negative publicity and mistrust also grew (Mahase, 2021; Pace, 2021; Vogel & Kupferschmidt, 2021; Wise, 2021). Scepticism about the vaccine was widespread, in particular as related to the speed of its development and a perceived lack of adequate testing (Dawson & Golijani-Moghaddam, 2020; Detoc et al., 2020; Henrich & Holmes, 2009; Kessels et al., 2021; Mahmud et al., 2021; McCarthy, 2020; Mooney, 2020; Reynolds, 2020; Tomkins, 2020). Social media provided an insidious platform for the proliferation of unfounded claims (Rosenberg et al., 2020). Political parties and religious groups capitalised on the pandemic to promote an anti-vaccination or anti-government agenda (Macdonald, 2021; Spaggiari, 2020). Where mistrust in government or in healthcare in particular was highest, hesitancy about the COVID-19 vaccine followed. In some social groups, the

pandemic saw extreme resistance to government-promoted or mandated health measures, with flow-on effects for vaccination more generally.

Mandatory policies in particular have united anti-vaccine and anti-COVID-19 groups, but also provided a fertile ground for groups with a broader anti-government agenda to rally support. In 2022, anti-mandate protests in Ottawa and Wellington descended into riots and violence. Unlikely allies included rival gang members, church leaders, white supremacists, and convicted criminals on home detention (Atkins, 2022; Daalder, 2022; Godfery, 2022; Ling, 2022; Walters & Fifield, 2022). Surveys and studies of healthcare workers also revealed a lack of trust in the research and in the advice to vaccinate (Grabowski, 2021; Sabahelzain et al., 2021). Particular themes in studies of hesitancy in nurses included a lack of long-term data, frontline staff burnout and disenfranchisement (Choi, 2021). In a 2022 study of online bulletin board interviews, the pervasiveness of misinformation online and the difficulty in shifting those ideas was clear, particularly among those inclined to individualistic reasoning and highest where there was low trust in government health institutions (Gorman et al., 2022). Of relevance to the current research are the implications of combined findings of rising anti-vaccine sentiment and prevalence of conspiracy theories, heightened levels of psychological distress, and an increased likelihood to believe in conspiracies in the face of depression and anxiety (De Coninck et al., 2021).

As with psychological sequelae, it is still too early to know the full impact that the COVID-19 pandemic may have on vaccination behaviours in the longer term (Motta et al., 2021). However, these earlier studies provided important context and a useful starting point. As was foreshadowed by such research, the two key issues facing health officials and researchers are wide public acceptance of novel vaccines against COVID-19, alongside reputational implications of vaccination more broadly (Chou & Budenz, 2020; Danchin et al., 2020; Harrison & Wu, 2020; Sabahelzain et al., 2021; Verger & Dubé, 2020). Early results of

popular polling on preparedness to accept a vaccine against COVID-19 were disquieting, hesitancy generally higher than for routine immunisations (Kessels et al., 2021; McCarthy, 2020; Mooney, 2020; Tomkins, 2020). There can be no question that the COVID-19 pandemic has both amplified the urgency for current, relevant vaccine hesitancy research, and provided a rich basis of knowledge on which to draw to continue to improve vaccine uptake. Recommended approaches to increasing uptake of the COVID-19 vaccine may prove relevant for other immunisation programmes. For example, the acceleration of pro-vaccination normalisation through communication campaigns leveraging evidenced-based argumentation tools with expert spokespeople has been proposed, as well as leaning on behavioural insights to increase accessibility, and encouragement of communication by early adopters of their decision to increase visibility and acceptability (Chevallier et al., 2021; Motta et al., 2021).

Chapter 5: Perinatal Anxiety, Depression, and Vaccination

Chapter Summary: Focus and Scope

The influential role of mothers and the prevalence of perinatal anxiety and depression underscore the importance of evaluating their impact on vaccination in Aotearoa. This chapter brings together knowledge from the research literature on the role of mothers in vaccination and the impact of psychological distress on decisions generally and makes the case for the hypothesised effects of perinatal anxiety and depression on vaccination intentions.

Psychological Distress: Pre- and Postnatal Depression and Anxiety

Psychological distress affects millions of people across the world, including mothers in the perinatal period. To help understand the scale of the problem, in 2015 and 2016, the WHO (World Health Organization, 2017) estimated the global *prevalence* - the proportion of cases in the population, of diagnosed depressive disorders at 322 million people (4.4%). Estimated prevalence of anxiety disorders was 264 million (3.6%). Females were recorded in higher numbers in both cases – 5.1% (vs 3.6% of males) for depression, and 4.6% (vs 2.6% males) in relation to anxiety. In a large-scale analysis of available international data, James et al. (2018) reported *incidence* (new diagnoses) of depression and anxiety in 2017 as approaching 260 million and 425 million, respectively (James et al., 2018). This study also found mental disorders to have consistently comprised more than 14% of the total number of years lived with disability, over three decades to 2017, its authors urging increased attention to and funding for treatment. These figures make it unsurprising that diagnosed psychological disorders comprise 10% of the total global disease burden, and 30% of the non-fatal disease burden (World Health Organization, 2017, 2018b), poor mental health therefore a lead cause of morbidity and disability.

Anxiety and Depression in the Perinatal Period

Despite similar rates of psychological disorders reported for both men and women overall, women are overrepresented in depressive and anxiety-related conditions, unipolar depression in particular being twice as common in women (World Health Organization, 2020d, 2017). During pregnancy and during the postnatal period specifically, estimated global averages of psychological disorders range between 10% to 20% (Fisher et al., 2012; World Health Organization, 2020d). However, these figures likely underrepresent the full scale of the problem. Missed or misdiagnoses are commonplace (Misri et al., 2015; Muzik & Borovska, 2010), and many women do not seek help, either due to reluctance (e.g., fearing custodial implications), to a lack of knowledge, or limited access to services (Bina, 2020; Button et al., 2017). Even without attempting to account for underreporting, depression is already the primary source of disability in women of childbearing age, in particular for indigenous mothers and those in lower income brackets (Bowen et al., 2014; Fisher et al., 2012; Ghaedrahmati et al., 2017). Of the broader anxiety category, GAD is not only the most prevalent form of perinatal anxiety, it is also reported to be experienced at higher rates than for the general population (Fisher et al., 2012; Meades & Ayers, 2011; Wenzel et al., 2005).

Particularly poor outcomes in terms of length and severity of postnatal distress are observed where anxiety or depression manifest antenatally, highlighting the importance of screening and monitoring during pregnancy (McDaid et al., 2019; Underwood et al., 2016, 2017). Despite serious implications for women, as well for the development of the child (Meintjes et al., 2010; Misri et al., 2015; Muzik & Borovska, 2010; World Health Organization, 2022a), psychological distress during the perinatal period is understudied, poorly understood, and detection remains low (Bowen et al., 2014). Given the broad and indiscriminate impact of psychological distress or disorders in pregnancy and postpartum and

the risk this poses to public health, increased and ongoing attention to maternal mental health is critical.

Recognising the unique nature of psychological distress that has its onset or is exacerbated during this period, the APA included "with peripartum onset" as a specifier for several disorder categories in the DSM-5 (American Psychiatric Association, 2013). It is applicable to conditions only within the depressive, bipolar and related, and schizophrenia spectrum categories, however, and is not available for any in the anxiety category. In addition, where it is available, strictly applied postpartum symptom onset (as opposed to during pregnancy) must be during the first four weeks only. This restrictive criterion is controversial. Many clinicians and researchers oppose the very brief postpartum timeframe, but also the limited application of the specifier – particularly the exclusion of anxiety – many arguing for a standalone category, as opposed to a specifier at all (Abramowitz et al., 2003; Harp, 2021; Koukopoulos et al., 2020; Park & Kim, 2018; Segre & Davis, 2013; Sharma & Mazmanian, 2014, 2021). Debate also centres on the appropriateness of an overarching "perinatal" category itself, some suggesting that prenatal distress, triggered by rapid but time-limited hormonal change, should be classified distinctly from postnatal manifestations (Batt et al., 2020; Ogasawara et al., 2018; Sharma & Mazmanian, 2014). In practice, there is also considerable variation as to how clinicians and researchers define the postpartum period. Consistently, however, the 4-week timescale is not adhered to. Some academics and clinicians limit it to the first six months after birth, the other extreme extending it to 2.5 years, but most consider onset during the first 12 months after birth to qualify (Dominguez et al., 2020; Goodman, 2004; Moraes et al., 2017; Romano et al., 2010; Seth et al., 2016).

However they are defined, depression and anxiety are highly comorbid perinatally (Coelho et al., 2011; Grigoriadis et al., 2011; Schmied et al., 2013), and risk of either or both rises during both the antenatal and postpartum periods (Dennis et al., 2017; O'Hara &

Wisner, 2014; Woody et al., 2017). It is also clear that, if anxiety or depression are experienced prenatally, the likelihood increases of either – or both – occurring postnatally (Fairbrother et al., 2016; Lancaster et al., 2010; O'Hara & Wisner, 2014). This risk is higher still in the presence of factors such as domestic violence or a history of abuse, prior mental illness, deprivation, lack of support or other adverse life events including pregnancy-related (Biaggi et al., 2016).

Adding weight to the voices calling for formal recognition of perinatal distress (be this by extension of the specifier or as a separate category) is a wealth of evidence relating to the onset or intensification of anxiety perinatally (Harp, 2021; Sharma, 2021). Although not now formally part of the anxiety disorder category (American Psychiatric Association, 2013), the evidence is particularly persuasive in relation to obsessive compulsive symptomology (Buchholz et al., 2020; Fairbrother et al., 2021). OCD-specific research also supports the call for distinguishing pre- and postnatal manifestations of OCD (Sharma, 2021; Speisman et al., 2011; Starcevic et al., 2020). Poor recognition and underdiagnosis of OCD perinatally poses a serious threat to mothers and their new babies (Brandes et al., 2004; Buchholz et al., 2020; Williams & Koran, 1997). Intrusive obsessions in particular elevate risk where they take an aggressive form, such as thoughts or images of harm to baby, or that baby would be better off without mum around (Zambaldi et al., 2009). Lack of routine screening and diagnosis results in limited data on which to base research, further hindering assessment and treatment, making this a crucial focus for future studies, and supporting a call for further amendments to diagnostic criteria (Fairbrother et al., 2021; Speisman et al., 2011).

Anxiety and Depression – More Alike Than Not?

Internationally reported rates of diagnosed anxiety and depression at these levels are clearly a cause for concern. Whilst it is important to understand each of these forms of distress individually, their similarities in aetiology, presentation and implications for day-to-

day function is equally important. In 1991, Clark and Watson proposed a Tripartite Model of Anxiety and Depression, highlighting symptom commonalities between these highly comorbid disorder categories. However, primarily intended to improve diagnostic accuracy, their focus was on how anxiety and depression are distinct, rather than variant presentations of what has later been proposed may be the same underlying condition. The rationale for the tripartite model was that distinguishing between disorders is important, if complex, and necessary to provide insight into the sources of a person's distress, its impact on mood and behaviour, the trajectory of the disorder, as well as which treatment modalities may be most successful (Beuke et al., 2003; Bryant, 2010; Conway et al., 2017; Kendall & Clarkin, 1992; Wetzler & Katz, 1989). However, research consistently supports the contention that shared, core difficulties underlying both anxiety and depression explain the high comorbidity between these two conditions (Brown & Barlow, 2005; Campbell-Sills & Barlow, 2007; Etkin & Wager, 2007; Roemer et al., 2005). These commonalities include a predisposition to strong emotion, and the adoption of avoidance strategies to cope with aversive emotional experiences (Barlow et al., 2016; Unified Protocol Institute, 2019). A conceptualisation of depression and anxiety as a broader category of "emotional disorders" followed, with a focus on parallels in emotional regulation or dysregulation, and, ultimately, led to the development of the Unified Protocol for the Transdiagnostic Treatment of Emotional Disorders (Barlow et al., 2017; Cassiello-Robbins et al., 2020; Ehrenreich et al., 2009; Farchione et al., 2009; Moses & Barlow, 2006).

The approach underlying the Unified Protocol is important to an appreciation of perinatal anxiety and depression as a broader distress category, with overlapping experiences and impacts. Studies attribute particular features and risk factors to the category of perinatal disorder(s) experienced, such as mood, behaviours, ability to care for the infant, and possible neurodevelopmental implications for the child (Misri et al., 2015; Murphey et al., 2017;

Muzik & Borovska, 2010). Although in one meta-analysis, larger effect sizes were found for anxiety-specific interventions than for others that were either transdiagnostic or depression-specific, the authors cautioned against overinterpretation of this finding given the extent of other research indicating that differential and transdiagnostic approaches result in equivalent outcomes (Maguire et al., 2018). The success of the Unified Protocol in treating many different emotional disorders (Cassiello-Robbins et al., 2020), including perinatal depression and anxiety (Bentley et al., 2020; Crespo-Delgado et al., 2020), also supports a focus on commonalities between the two. It is on this basis that a broader approach has been adopted in this research study, centred on the experience of symptoms of perinatal anxiety or depression on vaccination behaviours in Aotearoa, and irrespective of whether a diagnosis has been or would be made.

Perinatal Psychological Distress in Aotearoa

New Zealand-centric research provides insight into the situation for expectant and new mothers in Aotearoa. In their study of pregnant New Zealanders, carried out over several years, Signal and colleagues (2017) asked over 1000 participants to complete various self-report measures of depression, anxiety, and life stress, relating variously to the periods of their pregnancy and postnatally. These researchers assessed presence and severity of participants' symptoms using the Edinburgh Postnatal Depression scale (Cox et al., 1987). Cut-offs of 13 for depression (across the whole measure) and 6 for anxiety (across the three items strongly correlated with anxiety) were used to identify participants with high levels of symptoms. Fifteen to twenty-two percent of participants scored above this threshold for depression, rising to 20-25% for anxiety, with the higher of these figures in both categories representing the experience of Māori participants (Signal et al., 2017). Fewer than 50% of the individuals who were experiencing elevated distress levels had sought help. In addition, emotional distress is not always readily detected by midwives in Aotearoa. In one study of 68

women on antenatal unit, and 33 in community maternity care, high levels of distress were poorly detected in the hospital setting, and depression was not well recognised in the community (Barber et al., 2017).

Significant disparities are consistently reported along ethnic and socio-economic lines in Aotearoa, with Māori, Pasifika and Asian mothers experiencing disproportionately higher rates of perinatal anxiety and depression compared with their New Zealand European counterparts (Latham, 2020; McDaid et al., 2019; Waldie et al., 2015). In one study, postnatal depression was reported in 1 in 7 Māori participants at the four-week postpartum mark, in contrast to 1 in 16 for non-Māori (Deverick & Guiney, 2016). Tragically, suicide is the lead cause of maternal death in Aotearoa, a rate seven times higher than in the United Kingdom (Perinatal and Maternal Mortality Review Committee, 2018). Of these mothers, 57% in the ten years to 2016 were Māori. This sobering local data mirrors the experience of indigenous and ethnic minority mothers elsewhere (Kirby et al., 2019; Liu & Tronick, 2013; Mukherjee et al., 2016). As in Aotearoa, studies in Australia and Canada repeatedly find indigenous mothers to experience higher rates of psychological difficulties (Bowen et al., 2014). Echoing earlier findings, a recent report called for more services, delivered in a culturally appropriate way emphasising the importance of trust in the service and the providers, and the essential role of community-led and kaupapa Māori services (Walker, 2022).

Anxiety, Depression and Decision-Making

The relevance of anxiety and depression for this study, specifically as it manifests perinatally, relates to the reported impact of psychological distress on cognition and decisions. Distressing symptoms of depression or anxiety – whether or not in the context of a psychiatric diagnosis – may impact cognitive function, decision-making in particular (Blanchette & Richards, 2010; Paulus & Yu, 2012; Roese et al., 2009). For a time, depressive realism was a popular theory that sought to explain this phenomenon. The main concept was

depression might in fact render people more realistic than others who were not depressed (Alloy & Abramson, 1988). It is important to acknowledge this here, as the theory generated a sizeable body of research. However, the balance of studies supports the conclusion that depressive realism, if it exists at all, would manifest only in very select circumstances (Ackermann & DeRubeis, 1991; Carson et al., 2010; Moore & Fresco, 2012; Moses-Payne et al., 2019). To the contrary, most research results support a link between psychological distress and compromised decision-making, aligning with severity and frequency of symptoms, believed to relate to the ability or motivation to weigh risk against value (Clore & Huntsinger, 2007; Corrigan et al., 2014; Grupe, 2017; Hartley & Phelps, 2012; Jung et al., 2014; Maner et al., 2007; Park et al., 2016; Paulus & Yu, 2012; White, Geraci, et al., 2016; Worthy et al., 2014). Autobiographical memory and the prediction of future events are also reported to be adversely impacted by anxiety and depression (Gadassi Polack et al., 2020). In their 2014 study, Cáceda and colleagues reviewed the literature on decision making in presence of major psychiatric disorder, including panic disorder, depression, and other disorders of thought, affect or impulse control. In that study, variations were reported in function of disorder category, for example, unrealistically negative judgement of future outcomes was linked to anxiety. In another study decision-making in individuals diagnosed with a psychiatric disorder was assessed by comparing performance on a decision-making task, the Cambridge Gambling Task (Murphy et al., 2001). Participants were either psychiatric inpatients or day patients, admitted due to experiences of mania or depression and non-clinical controls, Steep temporal discounting was found to be correlated with both mania and depression in bipolar disorder. Anhedonia was also linked to a lack of motivation, preventing any decision or action being taken and individual differences were also observed. These researchers also reported that anxiety, paradoxically, was found to either increase protective action against risk or prevent the individual from taking any action at all.

Emotion and mood are also important to decisions. A person's judgement has generally been found to be mood-congruent and to impact reasoning style in the moment (Blanchette & Richards, 2010). The particular type of distress experienced also affects a person's assessment of outcomes of an event, and consequently their behaviours or decisions. For example, a person experiencing anxiety may anticipate agitation and experience a strong drive to reduce uncertainty. This is contrasted to a person with depression who might expect to feel dejected, and either negatively appraise events or expects an absence of positive events (Leone et al., 2005). It is suggested that distinctive decision-making patterns in both anxiety and depression are due in part to attentional biases specific to each, as well as individual differences in risk tolerance. In the presence of anxiety, high levels of risk aversion or risk-avoidant decision-making have been observed (Giorgetta et al., 2012; Maner et al., 2007), disruptions in value-based decision attributed to various factors, including neurobiological factors such as modulation of somatic signals (Grupe, 2017; Miu, Heilman, et al., 2008; Miu, Miclea, et al., 2008). Altered belief systems, intolerance of uncertainty and threat-related content experienced in the context of heightened anxious arousal all impact decision-making (Paulus & Yu, 2012). In the context of depression, anhedonia especially, a person will often view the future negatively, or cannot imagine it at all; and both temporal discounting of reward and unwillingness to expend effort in reward-related decisions are frequently observed (Lempert & Pizzagalli, 2010; Paulus & Yu, 2012; Yang et al., 2014). Negative expectations are fuelled by past negative experiences (or experiences recalled with a negative filter), fuelling beliefs about the likelihood of further unwanted outcomes of future events (Gadassi Polack et al., 2020). Evidence of the negative impact of psychological distress on decisions has led to criticism of models of decision-making that are based on an underlying assumption of rationality. Corrigan et al. (2014), for example, argue that many decisions are made outside a person's awareness, without careful planning and impacted by

emotional factors, in the health context, and that highly cognitive models that do not account for such factors cannot reliably explain or predict intentions or behaviours.

Regret, a negative or painful emotional experience in any context, is associated with anhedonia and heightened anxious arousal in the context of either depression or anxiety (Roese et al., 2009). Yet it does not follow that emotion-based decision-making will always equate with irrationality (Cáceda, Nemeroff, et al., 2014; Frederick et al., 2002). Careful evaluation of the emotion anticipated to flow from a decision's outcome is neither unreasonable nor irrational. In this evaluative process, the decision-maker considers whether the expected emotional impact is desired and, if not, is nevertheless tolerable on balance. Temporal discounting, for its part, can also be taken as evidence of a highly reasoned response. It does not follow that favouring an outcome in the present in preference to a remote future eventuality is always the product of impulsivity. This said, difficulty will arise where discounting is so universal or extreme that very little value is ever placed on temporally distant outcomes, for example due to a lack of interest in or an inability to conceive of a future (Loewenstein & Lerner, 2003; Paulus & Yu, 2012). Prospection is often reduced in presence of high levels of worry or anxious arousal, and emotions or mood strongly affect error prediction and the appraisal of temporal outcomes, greater importance given to immediate than remote reward (White, Geraci, et al., 2016; Worthy et al., 2014).

Depression and Anxiety and Vaccines in the Perinatal Period

The relevance of regret and temporal discounting to vaccination decision-making can then be readily understood. By definition, vaccination behaviours require present-moment decisions and action to protect against potential future threat. Uncertainty about either the necessity for or the effectiveness of a vaccine, as well as the indeterminate level risk of illness in the future, produces a level of ambiguity which then moderates the relationship between anxiety and risk-taking. In these circumstances, high anxiety predicts both greater perception

of risk and a lower likelihood of risk-taking (Smith, 2017). Yet the distress-decision-making relationship has been given comparatively limited attention. Of those studies conducted, a correlation has been observed between mental illness or distress and protective health behaviours in the general and elderly populations. In one 2010 study by Lord and colleagues a comparative analysis was conducted of 26 research papers looking at differences in preventive health care between psychiatric and non-psychiatric populations (including but not limited to anxiety and depression). Of the studies specifically considering vaccination, none reported a positive association between vaccine uptake and mental illness, three were declared "neutral" – any association was not statistically significant, and further three reported a statistically significant negative relationship.

In terms of the potential effects on vaccination of perinatal psychological distress specifically, the results of the small number of cases identified paint a mixed picture. A negative relationship was reported in five instances. In 2003, researchers examined the relationship between post-partum maternal health (including mental health) and patterns of vaccination seeking for their infant (Turner et al., 2003). Of the 159 mothers in that study, those experiencing anxiety and depression were between 3 and 5 times more likely to have begun scheduled vaccinations late, or not at all. Six years later, Zajicek-Farber's 2009 research reported similar results. In her sample of 134 mothers, women with symptoms of depression were less likely to engage in either positive or preventive health behaviours, including vaccination. Ozkaya, Eker, Aycan, and Samanci also investigated the anxiety-uptake relationship in their 2010 study of 195 infants and mothers at a teaching hospital in Turkey, reporting a significant association between high anxiety levels on the State-Trait Anxiety Inventory (STAI) and incomplete vaccination status. Osam and colleagues conducted a retrospective cohort study of 479,949 mother-baby pairs in the United Kingdom between 1993 and 2015 (2020). In addition to depression and anxiety, maternal mental illness was

defined in that study to include psychosis, eating disorders, personality disorders, and alcohol and substance use disorders. These authors concluded that children exposed to maternal mental illness were significantly less likely to be vaccinated by ages 2 and 5, the strongest effects observed in presence of maternal alcohol or substance abuse. However, a sixth piece of research, conducted approximately the same time as this one, failed to find any relationship between postnatal anxiety and low vaccine uptake (Zaikin et al., 2022). Another retrospective cohort study (2006-2019), the focus was on maternal postpartum depression and immunisation rates of 681 children. The results did not support a significant association between these variables of interest, however the authors identified several limitations to the research design which may have prevented detection of an effect.

Distress and Decision-Making: Which Comes First?

Despite a predominant research focus on the impact emotion and affect have on decision-making, the relationship may in fact be bi-directional (Pittig et al., 2020; Treffers et al., 2017). Already an emotive decision (Ferrer & Mendes, 2018; Shourie et al., 2013), timed to coincide with a heightened risk of psychological distress can make the decision on vaccination all the more difficult. The decision-making process itself may both exacerbate and be exacerbated by underlying emotional and affective states (Biaggi et al., 2016; Leach et al., 2017). Different outcomes can result, varying by social or environmental context, individual beliefs and value systems, the influence of conflicting messages from multiple sources, and personal coping strategies. Where a mother's anxiety is highest for disease for example, the act of vaccinating may itself provide instrumental and emotional means to control threat and consequent anxiety (Wang et al., 2017). Conversely, anxiety may instinctively lead to extreme avoidance, whether of a perceived immediate risk from a vaccine in the present, or of making any decision at all (Giorgetta et al., 2012; Liao et al., 2014). Further complexity arises where worries about a vaccine exist alongside fears about

disease, and the two must be balanced, amplifying decisional conflict. This contextualises the importance of an individualised approach to understand decisions and behaviours. Each vaccination decision is underpinned by idiosyncratic concerns based on existing knowledge, past experiences, and external influences, together with the individual's own emotional or affective state and personal coping style.

Vaccination, Decision Theory, Psychological Distress (and a Pandemic)

In the first part of this thesis, the key concepts in this study were outlined. First, vaccination and vaccination rates were described, together with their drivers and the complexities involved in addressing hesitancy. Secondly, the role of temporal discounting and anticipated regret in decision theory was explained, and how these are important aspects of vaccination decision-making in particular. Next the nature and extent of psychological distress, and perinatal anxiety and depression in particular, were set out, together with the evidence of their relevance for decision-making. The fourth important factor concerned the focus on mothers in this study, due to the significance of their role in childhood vaccination at a time of heightened risk for psychological distress, in the form of perinatal anxiety or depression. Finally, given the present and ongoing threat to population health from pandemic illness, taken together with the known psychological sequelae of the illness and of necessary preventive health measure, the importance of current, relevant research on population health was highlighted. These factors together resulted in designing this study to permit examination of the utility of the theories of anticipated regret and temporal discounting to explain vaccination behaviour of New Zealand mothers, and to evaluate a causal role for perinatal anxiety and/or depression in these decisions and behaviours.

PART II. THE STUDY – EVALUATING THE VACCINE-DISTRESS RELATIONSHIP

Chapter 6: Study Aims, Rationale, and Research Questions

Chapter Summary

This research was designed to extend current understanding of vaccination behaviours, in Aotearoa and internationally, specifically in terms of the role of perinatal anxiety and/or perinatal depression in suboptimal vaccine uptake. The study relates to routine childhood immunisations on the national schedule, not the COVID-19 vaccine, and data collection took place whilst vaccines were in development, but not yet available for either adults or children. The findings outlined are intended to contribute to the body of domestic and international literature that helps inform the planning and delivery of interventions. This chapter briefly outlines the aims, rationale and intended outcomes for the study. Next, the specific, preregistered hypotheses for the quantitative part of the study are set out, with inferential criteria and models depicting the relationships tested. The overarching qualitative research question is also described.

Study Aims

The central aim was to examine the case for a causal[1] effect of perinatal psychological distress – namely pre- and postnatal depression and/or anxiety – on expectant and new mothers' vaccination intentions and behaviours. Specifically, the strength and direction of any correlation between vaccination behaviours and depression and/or anxiety was evaluated. An additional, related aim was to qualitatively explore individuals' own understanding of the wider influences on their decisions and behaviours as well as the effect that decision-making may have had on them personally. Finally, participants were also asked about their perception

[1] See Quantitative Strategy – Causal Inference, in the Methods section, for a discussion on the approrpriateness of testing causal hypotheses using an observational design.

of the effects that living through the pandemic may have had on their vaccination intentions or behaviours to explore the potential impact of the COVID-19 pandemic on vaccination intentions.

Research Rationale and Justification

Research that enhances knowledge to improve population immunity, whilst always important, has never been more pressing than now, during the global health crisis that is the COVID-19 pandemic. Despite the revolutionary effects of vaccines for human mortality and morbidity, uptake remains consistently lower than required for population health (Lane et al., 2018; Ministry of Health, Manatū Hauora, 2021; Nowlan et al., 2019). A dual crisis faces public health officials across the globe, not only in terms of ensuring sufficient uptake of the various vaccines against COVID-19, but also as relates to low availability and increased hesitancy in respect of routine immunisations (Aboelsaad et al., 2021; Boyon, 2020; Harrison & Wu, 2020; Ryeng, 2020). It is hypothesised here that one plausible cause of low uptake is anxiety and depression in pregnant women and new mothers. Certainly, and as outlined in the literature review (see Anxiety, Distress, and Decision-Making, above) a strong link is consistently reported between psychological distress and decision-making challenges, for example: indecisiveness; rigidity or impulsivity; altered estimation of value or probability of outcomes; among others (Clore & Huntsinger, 2007; Corrigan et al., 2014; Grupe, 2017; Hartley & Phelps, 2012; Jung et al., 2014; Maner et al., 2007; Park et al., 2016; Paulus & Yu, 2012; White, Geraci, et al., 2016; Worthy et al., 2014). Yet it is during the very period when 10-20% of pregnant and new mothers experience anxiety or depression that vaccine decisions are made, and half the childhood vaccines fall due (Fisher et al., 2012; Ministry of Health, Manatū Hauora, 2020b; World Health Organization, 2020d). At the time this study was devised, some limited emerging international findings consistently supported this hypothesised relationship. Lower vaccination uptake – among other preventive health

behaviours – was observed in presence of psychological distress generally (Lord et al,, 2010; Thorpe et al., 2006), and specifically reported in the context of perinatal wellbeing (Osam et al., 2020; Ozkaya et al., 2010; Turner et al., 2003; Zajicek-Farber, 2008). However, a more recent publication, underway at a similar time to this one, failed to find any relationship between postnatal anxiety and low vaccine uptake (Zaikin et al., 2022). Overall, these studies represent a very limited focus on this potential relationship in the otherwise extensive field of hesitancy research (see Depression, Anxiety, and Vaccines in the Perinatal Period, above, for further detail), and further exploration and replication studies are needed, not least given inconsistencies between conclusions reached. Furthermore, of the studies that have been carried out, none have sought to establish a causal link between distress and vaccination uptake. This project, informed by decision theory – specifically temporal discounting and anticipated regret – has been designed to permit inference of causation from observational data using specific statistical methods (structural equation modelling, informed by a directed acyclic graph) described further under Methods, below (Pearl, 2009; Rohrer, 2018).

It is also notable that, based on a comprehensive search of the available literature available at date of writing, of the few correlational studies conducted examining the relationship between vaccination and maternal mental health, none was preregistered with a repository such as the Open Science Foundation, nor has open data available, nor yet been tested through close replication. Credibility of findings is vital, particularly if results indicate a need for change in public policy and expenditure is to be justified (Field et al., 2020; Gonzales & Cunningham, 2015; Nosek et al., 2018). High priority has been given to open science in this project to increase confidence in the conclusions. Furthermore, given the role of societal factors in influencing vaccination behaviours, including culture, traditions, history, and government campaigns or media coverage (World Health Organization, 2021), the New Zealand-specific context is crucial, recognising the importance of this to target population

health in Aotearoa. The study design - preregistered, and New Zealand-centric - will therefore provide valuable insight, relevant to effective campaigns to improve health of our unique population.

Key Outcomes Intended

The main impetus for this study was to further knowledge about vaccination behaviours, in Aotearoa and internationally. The findings will also add to the existing body of literature that informs intervention planning and delivery to improve vaccination rates through elucidating potential effects of distress on decision-making and gaining insight into important contributing underlying factors that influence these decisions. A key intended outcome was to understand the ways in which an intensive focus on maternal mental health, in pregnancy and postnatally, might benefit not only mothers (and, consequently, the child and wider family) but have the potential to precipitate improvement in vaccination rates and population health overall. An essential contribution to vaccination knowledge already, these outcomes were rendered all the more urgent by the threat posed by the ongoing COVID-19 pandemic – from the coronavirus itself, together with growing rates of endemic disease due to decreased confidence in or availability of vaccines.

Validity – Internal and External Validity of the Research

Two key issues may potentially impact the validity of the study and credibility of the results obtained. The first concerns inferences about cause and effect (internal validity). The second relates to the credibility of generalisations beyond the study sample (external validity).

The nature of the research variables are such that random assignment to conditions is not feasible – it would be unethical to assign participants to experimentally manipulated conditions of higher or lower anxiety and then examine the resulting effect on their

vaccination decisions for their child. However, although causal inference in the absence of experimental manipulation is complex, it is not by any means impossible. Statistically controlling for confounds identified through a careful analysis of the available research literature, will permit credible inferences to be drawn as to cause and effect (Greenland & Morgenstern, 2001; McNamee, 2003; Pearl, 2009; Rohrer, 2018). Certainly, appropriate causal inferences from a cross-sectional study can only be tentative in nature. However, where confounding variables have been identified by careful and thorough examination of the literature, the credibility of these inferences is greatly enhanced (in contrast, for example, to a purely correlational study) (Grosz et al., 2020). By statistically controlling for truly plausible confounding variables (see Controlling for Confounds in the Method section, below, for a description of this process as applicable to this study) and sharing a detailed preregistration (as in this study - https://osf.io/hzunr/) (Lakens, 2019), hypotheses are subjected to a rigorous, severe test, and face a genuine risk of falsification (Popper, 2002). By openly and transparently declaring an interest in drawing causal inferences and providing careful detail as to the planned means by which this might be achieved, a reader may critically evaluate the rationale for identification (and exclusion) of variables selected for control, the methods adopted, and – consequently – the credibility of claims and conclusions (Wysocki et al., 2022). There is a strong argument that this approach is preferable to the often-adopted observational research practice of avoiding explicit conclusions about causality, but nevertheless suggesting recommendations or outlining clinical implications that ought to rest on the establishment of causal effects (Grosz et al., 2020; Haber et al., 2022).

To maximise external validity, participants must be representative of the population about which inferences are sought. This typically requires recruitment from a wide range of socio-economic, cultural, and ethnic backgrounds. Nevertheless, and although every effort was made to maximise diversity in recruitment, the scale of this research, together with time

and resource constraints made the ideal recruitment of a truly random sample unrealistic. This said, although caution has been exercised in interpretation of the results here, a non-random sample is not automatically fatal to external validity (Berkowitz & Donnerstein, 1982; Mitchell, 2012). Furthermore, collection of demographic data ensures that the applicability of the study beyond the sample is understood, avoiding inappropriate generalisations (Calder et al., 1982). Clarity as to the sample makeup also permits highlighting of important avenues for future exploration. That there is open access to the data allowing replicability is all the more important in this context. In this way, these exploratory findings can readily and meaningfully be extended in future research with a specific focus on particular groups, including Māori, Pasifika and other ethnic minority groups or gender diverse parents, among others.

Quantitative Research Hypotheses

Based on the theories of temporal discounting and anticipated regret, the following relationships were expected to be observed:

1. Mothers who anticipate greater *inaction regret* (i.e., regret they expect to experience if they choose not to vaccinate, and their child later contracts a vaccine-preventable disease), will be more likely to intend to vaccinate their child; This will be demonstrated by a positive, statistically significant relationship between inaction regret and vaccination intention.[2]
2. Mothers who anticipate greater *action regret* (i.e., regret that they expect to experience if they choose to vaccinate, and their child has an adverse reaction to a vaccine) will be less likely to intend to vaccinate their child. This will be demonstrated by a negative, statistically significant relationship between action regret and vaccination intention.

[2] An error was made in the preregistered statement of hypotheses 1 and 2. Both hypothesised relationships were said to be "positive", where this could only realistically be expected to apply to one: anticipated action regret and and anticipated inaction regret are opposing constructs. A footnote has been included in the preregistered materials, and flagged in the code to avoid confusion in any future replication.

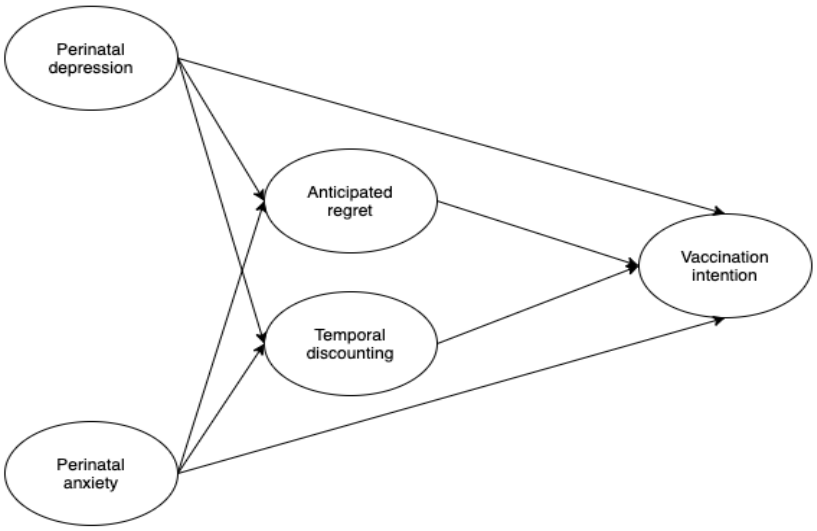
3. Experience of depression and anxiety will result in a bias toward discounting the future. This will be demonstrated by a positive, statistically significant relationship between temporal discounting (scores on the MCQ; Kirby et al., 1999) and:
    a. perinatal depression (scores on the EDPS); and
    b. perinatal anxiety (scores on the GAD-7) (Lempert & Pizzagalli, 2010; Paulus & Yu, 2012).
4. Higher levels of depression and anxiety (as measured by scores on the EPDS and GAD-7) will predict greater anticipated regret (Giorgetta et al., 2012; Jung et al., 2014; Maner et al., 2007; Paulus & Yu, 2012; Worthy et al., 2014). This will be demonstrated by positive and statistically significant relationships between each of:
    a. perinatal depression and action regret;
    b. perinatal depression and inaction regret;
    c. perinatal anxiety and action regret; and
    d. perinatal anxiety and inaction regret.
5. Results will support a causal effect of both perinatal anxiety and depression on a mother's vaccination intentions. Controlling for plausible confounding variables, identified via a systematic literature search, this will be demonstrated by a statistically significant negative relationship between presence and severity of symptoms of perinatal anxiety and depression as predictors, and vaccine intentions as the outcome variable.

The relationship between anxiety and depression as predictors and vaccination intentions as an outcome variable will be partially mediated by temporal discounting and anticipated regret (see

6. Figure 1).

Figure 1

Causal Effects of Perinatal Distress on Vaccination Intentions – Mediating Pathways



Additional Research Question

Whilst a quantitative approach permits testing of specific, explicit hypotheses, in any study of human decision-making, it is also important to consider what individuals themselves perceive as important to those decisions. As such, open-ended questions were posed for content analysis purposes (see Method section, below, for further detail). This was to allow exploration of the question: What do soon-to-be and new mothers themselves perceive as important factors influencing their intentions towards vaccination for baby? To answer this question, participants were asked to outline what they considered important, as well as whether the pandemic affected those intentions. An additional query related to whether participants felt they had been (positively, negatively, or at all) affected by the decision-making process itself.

Chapter 7: Method

Chapter Orientation: Focus and Scope

This chapter describes the detailed methods of this study, including the design, participant eligibility requirements and recruitment process, materials, and data collection procedure, together with the analytic strategies adopted.

Theoretical Perspective

Critical realism was the approach adopted in conducting this research. Clarity regarding theoretical perspective is important as researchers should give careful consideration to their own research methods, examining and critiquing all aspects of their research methods – including the most basic underlying assumptions. It is equally important that those assumptions be transparently disclosed to enable readers of research to understand and critique the alignment of *ontological* (the researcher's perspective on the nature of reality or being) and *epistemological* (the theory of knowledge and how it is gathered) stances with data gathering method and interpretation (Gray, 2014). In this way, both researchers and readers can more readily reflect on the knowledge derived from a study, and how it may be extended (Bracken, 2010; Gray, 2014).

Critical realism is an approach that lends itself well to both quantitative and qualitative research. Arising as a scientific alternative to either positivism or constructivism (Denzin & Lincoln, 2011), this is an analytical process driven by not only by theory but also by researcher, and to a greater extent than other approaches. In critical realism, the world may be considered theory-laden, but not theory-determined. This is not a denial of a reality, but rather acknowledges that some knowledge may be closer to that reality than other knowledge (Fletcher, 2017). Theory is considered useful to help approach that reality, identifying causal mechanism for social phenomena. As Fletcher (2017) explains, "the ability to engage in

explanation and causal analysis (rather than engaging in thick empirical description of a given context) makes [critical realism] useful for analyzing social problems and suggesting solutions for social change", including preventive health issues. Although pertaining to thematic, rather than content, analysis, Braun and Clarke's (2006, p.81) description is apt – critical realism "acknowledge[s] the ways individuals make meaning of their experience, and, in turn, the ways the broader social context impinges on those meanings, while retaining focus on the material and other limits of 'reality'. Therefore, thematic analysis can be a method that works both to reflect reality and to unpick or unravel the surface of 'reality'".

Critical realism is a useful philosophical framework, but is not associated with a defined set of methods, providing a degree of flexibility for the individual researcher to design research that aligns with its broader principles. Importantly for present purposes, "reality" in critical realism is stratified into three levels – the empirical, the actual, and the real. These distinguish human experience of events, true occurrences – whether experienced or not, and inherent properties that cause an event (Archer et al., 1998). Critical realism aims to explain social, or human, behaviour with reference to causal mechanisms, of importance given the overarching goals of this research.

Research Design

The design of this study is cross-sectional, observational research, conducted by electronic survey (Qualtrics, 2019). Although primarily quantitative in approach, a qualitative element was introduced through inclusion of open-ended questions that enabled content analysis of information provided by participants about their experiences and perceptions. This added context for the results overall, as well as providing helpful markers for potential future research.

Participants

Final sample sizes for the quantitative and qualitative analyses differed slightly. Whereas the sample for the content analysis section included 411 participants, the stricter requirements for the quantitative analyses meant that data from only 387 participants were retained. Further explanation, together with a detailed description of the demographic characteristics of the participants, is set out in the respective results chapters.

Sampling Plan: Eligibility and Recruitment

In this study, *perinatal* was more broadly defined than it is for the restrictive DSM-5 *with peripartum onset* specifier. As discussed above in the literature review, the limitations of the specifier make it highly controversial (Koukopoulos et al., 2020; Park & Kim, 2018; Segre & Davis, 2013; Sharma & Mazmanian, 2014). In clinical practice, a much more generous timeframe after baby's birth is adopted to ensure adequate recognition, diagnosis, and support (Goodman, 2004; Romano et al., 2010; Seth et al., 2016). Accordingly, a prospective participant was eligible for this study if they were either in the second or third trimester of pregnancy or having had a baby no more than 12 months prior to survey completion.

Eligible participants were either pregnant (in their second or third trimester) or had a baby aged 12 months or younger at time of survey completion. This is a broader conceptualisation of perinatal than the restrictive timeframe in the DSM-5 *with peripartum onset* specifier, limited to up to 4 weeks postpartum. The eligibility window in this study was based on broader criteria for designation of ante- or postnatal depression or anxiety widely applied by clinicians in practice (Goodman, 2004; Romano et al., 2010; Seth et al., 2016). Participants were also required to be over 18, the age at which adults are ordinarily assumed to be capable of giving fully informed consent (New Zealand Psychologists Board, 2017). In addition, they needed to be physically present in Aotearoa at time of survey completion or, if

overseas, be New Zealand citizens. This was to ensure domestic relevance of this study for Aotearoa.

Advertising and recruitment were carried out entirely online, the study advertised on social media both informally (personal Facebook and LinkedIn pages, and university social media pages – postgraduate research groups, including Psychology-specific, Massey at distance, with a shareable ad that individuals could repost on their own pages) as well as formally (paid Facebook advertisement and promotion on the LinkedIn and Facebook pages of the Auckland Medical Research Foundation, PADA NZ, and Plunket). The Bays North Harbour parents centre also included information about the study in their monthly newsletter.

Sample Size, Rationale and Stopping Rule

To ensure sufficient power for all of the specified quantitative analyses, a power analysis was performed for the SEM, using the pwrSEM app created by Wang and Rhemtulla (2020). This tool enables computation of the necessary power for parameter estimation in structural equation modelling, suggesting a minimum necessary sample of 230 participants for this study. The preregistered code for hypothesis 5, representing the primary focus of this study, was entered into the app. The variances of latent variables were fixed, specified as follows: regression coefficients: 0.2; factor loadings: 0.7; covariances: 0. All residual variances were set by the app. The next step was to set the alpha level (0.05) and seed (42) and test the estimated power with the intended target sample size. After an initial test with 100 simulations, 2100 simulations were run to increase confidence in the output obtained. With the assumptions set as described here, a sample size of 230 suggested power of 0.93 to detect the target effects (i.e., regression parameters for the effects of depression and anxiety on vaccination intentions).

Estimation by this method rests on input of auxiliary assumptions, however. Therefore, to avoid a risk of underestimation of required power, and to enhance robustness of

the study, this final estimated necessary target sample size was increased by 50%, to 345 participants. Although a seemingly arbitrary figure, the 50% increase was considered necessary (25%, for example, may not have made enough of a difference) but also sufficient (75% was likely more than required) to mitigate this risk, balancing the desire to avoid underestimation of power, against oversampling without good justification for doing so. To allow for any necessary data exclusion due to factors such as incomplete responses or ineligibility, recruitment continued until the number of responses meeting minimum quota requirements set in Qualtrics reached at least 390. The quota would only be incremented where a survey was determined "finished" by Qualtrics and four minimum requirements for participation were also met: consent given; being 18 or over; living in Aotearoa or otherwise a NZ citizen; and being either pregnant or having a new baby.

Costs – Study Budget and Expenditure

Costs for this project related to advertising and participant incentivisation. No other expenses were incurred, the research being conducted remotely, by electronic survey. A maximum budget for paid advertisements on Facebook (or other sites including Twitter, if required) was set to $11 per day per site. The maximum anticipated recruitment period was 40 days.

Participant incentivisation took two forms. Firstly, commitment was made to a charitable donation of $2 per completed survey payable to both Plunket and to PADA. Participants were advised of this in the information sheet. The second incentive was the option for participants a chance to enter the prize draw for one of two $100 "prezzy cards", on provision of email details via a separate, external survey reached from the final item of the main questionnaire. Responses to the second survey were not linked to response forms for reasons of confidentiality, nor included in the open data uploaded to Open Science Framework. Both incentives were deemed necessary. Whilst evidence suggests that charitable

donations are an effective recruitment method for female participants (particularly individuals who consider themselves to be pro-social), this tactic alone may be insufficient for individuals who are less altruistic, suggesting that a dual incentivisation approach can be more effective (Gendall & Healey, 2010).

The advertising campaign ran on Facebook for 29 days, with a total cost of $274.84. On completion of recruitment, $790.00 each was paid to Plunket and to PADA reflecting the 395 surveys deemed complete according to the Qualtrics quota requirements. Email addresses of participants who chose to enter the prize draw email addresses were each assigned a number, and then two numbers were generated using a randomiser to select the two participants to receive the $100 prize. The two successful candidates were approached by email for a contact address to have the prize mailed to them directly. Final costs for the project therefore totalled $2,054.84. These expenses were paid from the Massey School of Psychology postgraduate research fund (PGRF).

Procedure

All participants completed the same survey, answering a range of questions, including items drawn from existing measures of anxiety and depression as well as for-purpose created questions about vaccination intentions. In the case of postnatal participants, the child's current vaccination status was also sought. Additional items collected relevant demographic data to permit control of confounds, as well as open-ended questions to collect qualitative data from participants for content analysis. The survey was administered electronically via Qualtrics (2019), and available on desktop and mobile platforms. A detailed information sheet preceded the survey (see Appendix A), concluding with the informed consent item. Endorsement of consent was necessary to launch the survey.

Data Exclusions

For the quantitative analyses, survey responses were considered invalid and excluded in their entirety if one or more of the following was true (in addition to any failure to meet eligibility criteria outlined above):

- the response to an attention check question ("This is an attention check question, please select 'smaller reward today'"), embedded in the block of items drawn from the MCQ was anything other than "Smaller reward today" (including a failure to respond to this item at all), suggesting the participant was not attending to item content;
- responses assigned a status by Qualtrics of 1 (preview), 2 (test), 8, 9, or 12 (possible spam or duplicate responses).

Excepting a missed response to the required vaccination intention item, a missed answer or answers to a small number of questions would not automatically exclude an entire survey. However, across the whole survey, a minimum of 55% of the substantive items required a response. These included the items from the EPDS, the GAD-7 and the temporal discounting and anticipated regret questions. Failure to meet this threshold meant the dataset for that survey respondent would be excluded from the quantitative sample. 525 individuals interacted with and completed at least one field of the survey, although only 519 reached an end point (deliberately exiting or completing the survey), all of whom had consented. 466 survey respondents remained after excluding those who did not meet either citizenship/residence or pregnant/new mother eligibility criteria. Further exclusions were made based on an incorrect or non-response to the attention check item embedded in the MCQ block of items, leaving a total, final sample size of 387 participants for this part of the survey.

For the content analysis, slightly less restrictive criteria were applied. Responses were only considered ineligible where one or more of the following was true:

- consent was declined or the item was left blank;
- "no" answers were provided to both items about living in/citizenship of New Zealand;
- there was no response to the age item (no participants having indicated they were under 18);
- the item requiring indication that the prospective participant was either pregnant or had a baby aged 12 months or younger was either left blank, or "neither of the above" was selected.

In this way, participants who had generously given their time to the survey and had provided valuable qualitative data, responding to the open-ended questions posed within the survey, had not done so unnecessarily. Additional criteria relating to percentage of completion of or attention to items that had no bearing on the content analysis was considered unnecessarily restrictive rendering exclusion of data, in view of the imposition on participants, ethically questionable. This resulted in a total sample size of 411 for content analysis.

Measures

The sole data collection mechanism for this study was the online, anonymous survey completed by participants, made up of a combination of purpose-built items and blocks of items from existing measures. Measured variables for the quantitative analyses were perinatal depression; perinatal anxiety; anticipated regret; temporal discounting; and intention to vaccinate; as well as the plausible confounding variables – socioeconomic status; and ethnicity (see below, *Controlling for confounds*). The substantive elements of the questionnaire (at Appendix 1) were designed to capture the information necessary to measure

these variables and alongside contextual information for the purposes of the study, including participant demographics and qualitative material. This first part of the survey consisted of a detailed information sheet and informed consent item, endorsement of which launched the main part of the survey. The final item directed interested participants to a separate, external survey (for preservation of anonymity) where they could elect to enter an email address to either be included in the prize draw and/or to receive a summary of the study findings, once available.

Measuring Perinatal Depression: the EPDS

The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 2014, 1987) provides a well-validated and ready means to gauge perinatal depression. A participant's depression score was the total score across the ten self-report items of the EPDS, whereas their total anxiety score was the total score on the GAD-7. As the aim of the study was not to diagnose, but to identify and understand the strength and direction of the hypothesised causal relationship between perinatal psychological distress and vaccination decisions, cut scores were not used to assign participants to a specific category (i.e., anxious/depressed; not anxious/depressed). Dichotomising the variables here would not only have been artificial and unnecessary, but potentially damage the validity of conclusions reached. This can occur for example, due to a loss of statistical power to detect an effect or a false positive or possible masking of non-linearity between groups (Altman & Royston, 2006). In addition, where the research question relates to a relationship between variables, a continuous score provides a more precise indicator of that relationship than is possible using a dichotomous classification such as presence or absence of disorder.

As a screening tool, rather than formal diagnostic measure, the EPDS does not purport to be a conclusive indicator of presence or absence of a disorder. Nevertheless, where screening tools are evidence-based, with strong psychometric properties justifying their use

with the population of interest, these are invaluable resources for clinicians and researchers alike (Beidas et al., 2015). In a research context in particular, it is important to balance thoroughness and diagnostic rigour against unreasonable imposition on participants. This is not only important ethically (Emanuel et al., 2000), but helps to minimise attrition by keeping the survey relatively brief. Where a demonstrably reliable and valid measure is widely used in research, there is also a clear advantage to adopting such a popular tool for transparency, replicability, and comparability purposes. Developed in 1987 by Cox and Holden, the EPDS is a ten-item self-report screening tool, originally designed to target postnatal depression. It is used more broadly to assess perinatal depression and anxiety, in pregnancy and up to 12 months postpartum. The items target core symptoms of depression, including anhedonia (e.g., "I have looked forward with enjoyment to things"), guilt ("I have blamed myself unnecessarily when things went wrong") and suicidal ideation ("the thought of harming myself has occurred to me") as well as sleep and energy levels ("I have been so unhappy that I have had difficulty sleeping"). Each single-item statement is accompanied by four response options – different for each statement – along a dichotomously anchored semantic differential scale (e.g., *As much as I always could; Not quite so much now; Definitely not so much now; Not at all*). Test-takers are asked to select the option best reflecting themselves over the preceding seven-days. Items are scored from 0 to 3, six of which are reverse scored, for a possible score range between 0-30. The higher the score on the measure overall, the greater the likely severity of symptoms. A variety of cut-off scores have been proposed and used in research, including scores of 10, as in the original validation study (Cox & Holden, 1987), 12 or more (Rowe et al., 2008), or 13 and above (Flynn et al., 2011; Matthey, 2008; Simpson et al., 2014). Other researchers propose a more stepped approach to interpretation, proposing the following severity ranges as more clinically useful indicators: none or minimal depression

(0–6), mild depression (7–13), moderate depression (14–19), and severe depression (19–30) (McCabe-Beane et al., 2016).

Strong psychometric evidence suggests the EPDS is reliable and valid as screening tool for postnatal depression (split half reliability 0.88, $\alpha = 0.87$, ICC = 0.92, $\kappa = 0.61$, sensitivity 86%, specificity 78%, PPV 73%; Cox et al., 1987). Subsequent studies consistently support the validity and reliability of the EDPS to detect both pre and postnatal depression (Cox, 2019; Cox et al., 2014; Ekeroma et al., 2012). In development, its items were selected based on diagnostic criteria, drawing on existing measures of anxiety and depression. These were then refined to exclude common physiological experiences after childbirth that could be confused for somatic symptoms of depression (Cox, 2019). The EPDS is widely used in Aotearoa, various studies concluding it to be an effective screen for depression for New Zealand women postnatally (Underwood et al., 2016, 2017; Waldie et al., 2015). Notably, one study concluded it to be both valid and reliable to identify anxiety and depression in Samoan and Tongan women living in Aotearoa (Ekeroma et al., 2012). Nevertheless, despite its extensive clinical use with Māori women as well as in Māori-centred research, there has to date been no similar validation study conducted for Māori. Any purported conclusions must take this into account, in this study as in others.

Perinatal Anxiety: the GAD-7

Operationalising perinatal anxiety for the purpose of this study was an important consideration given the breadth of anxiety disorders. Comprehensive assessment to capture all anxiety subtypes raised a serious risk of introducing attrition bias. To balance the competing priorities of completeness and brevity, perinatal anxiety was operationalised for the purpose of this research as symptoms of generalised anxiety disorder (GAD). This was primarily due to GAD being the most prevalent form of anxiety experienced perinatally (Fisher et al., 2012; Meades & Ayers, 2011; Wenzel et al., 2005). Furthermore, GAD is highly

comorbid with most other anxiety disorders, suggesting that a brief, reliable measure of GAD would be the best approach (Goldstein-Piekarski et al., 2016; Grant et al., 2005; Misri et al., 2015; Nutt et al., 2002).

The seven-item GAD-7 (Spitzer et al., 2006) was selected to measure presence and severity of participants' generalised anxiety. The GAD-7 is a brief but reliable screening tool, specifically validated for use with perinatal populations (Barthel et al., 2014; Essiben et al., 2018; Loughnan et al., 2019; Misri et al., 2015; Simpson et al., 2014; Sinesi et al., 2019). Total scores on the GAD-7 were used as an operational definition of anxiety level. Each of the seven items is linked to diagnostic criteria for generalised anxiety disorder, all introduced by the question "Over the last 2 weeks, how often have you been bothered by the following problems". Test-takers rate their experience on a four-point scale, by selecting one of four response options - *Not at all; Several days; Over half the days;* or *Nearly every day.* The seven scenarios themselves are "Feeling nervous, anxious, or on edge"; "Not being able to stop or control worrying"; "Worrying too much about different things"; "Trouble relaxing"; "Being so restless that it's hard to sit still"; "Becoming easily annoyed or irritable"; and "Feeling afraid as if something awful might happen". Level of anxiety is then gauged based on the resulting score, where 5-9 is considered indicative of mild anxiety, 10-14 suggesting moderate anxiety, and 15 or over, severe anxiety. Items are scored 0-3, for a total score range between 0-21.

The GAD-7 is widely used in research and in clinical practice. Like the EPDS, its developers reported strong psychometric properties in the original validation study (Spitzer et al., 2006).[3] Although the GAD-7 has yet to be normed for Aotearoa, it is recommended by

[3] Good convergent validity between the GAD-7 and similar measures (Beck Anxiety Inventory, r = 0.72; Symptom Checklist-90 anxiety subscale r = 0.72); high sensitivity and specificity for GAD - 87% and 82%, respectively; good sensitivity also for other anxiety related syndromes - panic disorder: 74% sensitivity, 81% specificity; social anxiety disorder: 72% sensitivity, 80% specificity. Positive and negative predictive values (with a cut-off score of 10) were also reported as 29% and 99%.

the Royal Australian and New Zealand College of Psychiatrists in their clinical practice guidelines as a quick, easily administered, and accurate tool for use in detection of panic disorder, social anxiety disorder and generalised anxiety disorder (Andrews et al., 2018). Whilst the GAD-7 was not designed for use with a perinatal population specifically, there is considerable, consistent support for its use in this context (Barthel et al., 2014; Essiben et al., 2018; Loughnan et al., 2019; Misri et al., 2015; Simpson et al., 2014).

Consideration was given to whether the EPDS would in fact suffice to measure both forms of perinatal distress. Ultimately, however, it was deemed necessary to use both in order to accurately understand and distinguish perinatal anxiety and depression. Whilst various studies support use of the EPDS to detect presence and severity of anxiety as well as depression, it does not perform as well to distinguish between the two (Brouwers et al., 2001; Rowe et al., 2008). The GAD-7 has also been found to detect perinatal anxiety more accurately than the EPDS used alone (Simpson et al., 2014). As screening tools, rather than formal diagnostic measures, neither purport to be a conclusive indicator of presence or absence of a disorder. A participant's perinatal anxiety score was their total score on the GAD-7. The same rationale applied to not use cut-scores in this study as outlined above for perinatal depression.

Anticipated Regret

To define and measure anticipated regret, it was first was broken down into its two main forms – anticipated *action* regret (i.e., about the act of vaccinating), and anticipated *inaction* regret (regret about omission, i.e., not vaccinating). These were measured with two separate purpose-built items, each describing possible outcomes of a decision to accept or refuse a vaccine ("If I decided not to vaccinate my child and s/he later got sick from an illness that a vaccine could have prevented against, I would expect to feel…"). Item responses were

recorded using a slider on a 0-100 visual analogue scale, anchored by dichotomous statements: *absolutely no regret* to *the most regret I could possibly feel*.

These items were created with reference those used in previous, similar studies which measured regret with items tailored to the particular issues of interest (Abraham & Sheeran, 2003; Chapman & Coups, 2006; Morison et al., 2010). Most studies explicitly use the word "regret" in the item and so this was deliberately included in the scale to highlight this as the target construct (Brewer et al., 2016). The items were tested with colleagues in the research lab of the primary supervisor, Dr Matt Williams, and with the benefit of his research expertise on anticipated regret (Towers et al., 2016).

Temporal Discounting

Somewhat counterintuitively, the balance of evidence suggests that health-specific discounting measures have only a weak relationship with health behaviour and are a less sensitive predictor (at best) than a monetary discounting example, irrespective of the broader topic or context of the research (Baker et al., 2003; Chapman & Coups, 2006; Kim & Nan, 2019; Petry, 2003; Story et al., 2014). As such Kirby's Monetary Choice Questionnaire (1999) was used to measure temporal discounting. This 27-item measure, initially developed to assess impulsivity and steepness of discounting in the presence of addiction, has since been used more broadly in many research contexts. Participants were asked to select either *Smaller reward today* or *Larger reward in the specified number of days* in response to questions taking the format "Would you prefer $54 today, or $55 in 117 days", the monetary value and delay to receipt changing for each item. Although no monetary rewards were offered to participants (as was made clear to participants was the case within the survey item), research that has assessed whether the presence or absence of tangible rewards alter response choice suggests that it does not (Johnson & Bickel, 2002; Madden et al., 2003).

Kirby et al. (1999) designed the MCQ to permit computation of a discounting rate parameter (*k)* based on a participant's pattern of responses to each of the 27 items. Each response is assigned a value of 0 (for selection of the smaller, immediate reward (SIR)) or 1 (selection of larger, delayed reward (LDR)). However, as every item is also weighted (to account for variation between the 27 scenarios presented), the overall discounting rate parameter (*k)* is based on a participant's overall pattern of SIR and LDR responses (Kirby et al., 1999). This estimates a participant's overall discounting tendency, based on where the total responses fall on reference discounting curves (steeper curves indicating higher tendency to discount future outcomes). Scores can be calculated by hand (as outlined by Kirby et al. (1999)), by fitting a logistic regression as described by Wileyto et al. (2004)[4], or by using an automatic scorer. One such tool, developed at the Centre for Applied Neuroeconomics at the University of Kansas to facilitate calculation of *k* and reduce error, was used in this study (Kaplan et al., 2014). This method several versions of *k* (overall *k*, adopted here, as well as composite (geometric mean) *k,* log *k* or natural log transformation *k*). Although the authors of some studies opt to use the natural log transformed discount rates due to the positive skew of discounting, there was no reason to do this here. The developers do not recommend one method over the other, but simply caution that researchers specifying which *k* is reported to avoid spurious comparisons between studies.

Each participant's *k* value therefore represents their rate of temporal discounting derived from the pattern of their answers to all 27 items. Although ranging from a possible of 0-1, the *k* value generally will fall between 0 and 0.5, smaller values indicating less discounting and tendency to prefer delayed over immediate reward. To illustrate, for a person whose *k* value is 0.1, the subjective value of $10 in 10 days' time could be understood as

[4] The relevant function is $V = A/(1+kD)$, where V is the present value of the delayed reward, A is the delayed reward itself, D is the delay.

equivalent to $5 (10/(1+ 0.1 x 10)), but for a person whose *k* is 0.01, the subjective value of that reward would be equivalent to $9.09 (10/(1 + 0.01 x 10)).

The MCQ has been used in other, similar research contexts. For example, in connection with exploring factors relating to uptake of the COVID-19 vaccine, Strickland et al. (2022) concluded that vaccine demand predicted vaccine uptake, when controlling for other predictors (including temporal discounting measured with the MCQ – although unfortunately this data was not included in the resulting article). Garcia (2019) also used the MCQ in the context of research on health protective behaviours (hearing protection use) and noted a correlation between low use, high discounting, and addictive behaviours. He concluded that discounting is a fair predictor of positive health behaviours.

Vaccination Intentions

The vaccines of interest in this study were those on the routine schedule for children in Aotearoa and did not include the COVID-19 vaccine which, moreover, was not yet available for adults, much less children or infants, at the time of data collection. Intention, rather than behaviour in practice was the focus in this study. Where research evidence suggests that decision-making on childhood vaccines begins in pregnancy (Corben & Leask, 2018; Danchin et al., 2018; Grant et al., 2016), the potential influence of anxiety or depression throughout this period was of interest. Vaccines can, of course, only be administered to baby after birth, and at specific times in the early weeks and months. Exploring uptake would have required waiting until after all the mothers had at least had the opportunity to vaccinate, and then attempt to look back to understand distress, limiting the ability to measure anxiety and depression which were key variables in this study.

Intention to vaccinate was assessed by asking participants to select the response option most true for them from a list of four to indicate if they would either fully or partially

vaccinate; refuse all vaccinations; or that they were still undecided (e.g., "I intend to fully vaccinate my baby"). New mothers were also asked about the child's current vaccination status as a means by which to gauge whether there had been a delay, irrespective of intention. Mothers were asked to select one of: "my baby has received all vaccinations due by age"; "my baby has received some but not all vaccinations due by age"; "my baby has not received any vaccinations due by age". Mothers who indicated they would partially vaccinate were asked to list the vaccines they would not accept.

Intention scores were the numeric value assigned to the selected response option (1 = *refuse all*; 2 = *undecided*; 3 = *partial*; 4 = *accept all*). Baby's vaccination status was scored similarly (1 = *none by age*; 2 = *partial* – some by age; 3 = *full by age*).

Undecided – A Methodological and Analytic Dilemma

Where vaccination intention is a key variable for the study, the possible response options for this scale required careful consideration. Whether to include a neutral, midpoint or non-response option such as *undecided* or *I don't know* is always an important question in survey design given the inevitable impact on analyses and conclusions drawn from the data (Chyung et al., 2017). On the one hand, inclusion of such an option avoids participants falsely selecting a response that does not apply to them or avoiding giving any answer altogether, but on the other, it can provide an easy way out for participants reluctant to take a stance, even in an anonymous survey (Friedman & Amoo, 1999; Robbins, 2017). When it comes time to analyse the data, there is then also a question as to whether and where in a rank order scale a neutral response should sit, given this will impact analysis and output (DeCastellarnau, 2018; Durand & Lambert, 1988; Montagni et al., 2019; Robbins, 2017). Sometimes it may be appropriate to drop all middle or neutral responses altogether (Denman et al., 2018; Durand & Lambert, 1988). In some surveys, a neutral response may find a natural fit between two extremes (for example where it signifies a strength of belief or

preference). In others, such as in this study, how it should be ranked to permit statistical analysis is less clear. The decision then was whether, on a scale from *refuse all* to *accept all*, should *undecided* be ranked above or below *partial acceptance.* Consideration was given to whether a person undecided about vaccinations is more alike to someone who will refuse all, or another who will accept all. It was also necessary to decide how to treat a person's *undecided* response that might apply only to certain vaccines - is it more equivalent to partial acceptance, or closer overall to an intention to refuse or to accept? The meaning and implications of including or omitting such an item for analysis must always be very carefully balanced, taking into consideration what a researcher wants to know, how the question has been asked, and how it can be analysed to safeguard the validity of responses and their analysis (Chyung et al., 2017; Groothuis & Whitehead, 2002).

On balance, it was considered more important to include *undecided* in this survey, despite associated analytic complexities. Several reasons guided this decision. First, individuals who are genuinely undecided about whether to vaccinate baby have an important role in vaccine hesitancy research. The views of such individuals may be less entrenched, and perhaps more readily influenced, depending on timing, content and source of information accessed. Secondly, in any study of decisions or intentions, some participants may not yet have reached any firm conclusion. Forcing a yes or no response, where in truth neither applies may bias the survey. Alternatively, the participant would ignore the item, and here would have resulted in their exclusion from the survey, as intention was a core variable.

The more complex issue of where to fit *undecided* in the rank order was resolved by its placement between *partial* and *refuse all.* This was in recognition that, until a decision to vaccinate is definitively made and also acted on, baby would only be partially vaccinated at best, and potentially receive no vaccines at all. The resulting rank order for the scale was therefore 1 = *refuse all*; 2 = *undecided;* 3 = *partial*; 4 = *accept all*. As it transpired, only 10

participants out of the 387 in the final sample selected *undecided*. Nevertheless, supplementary analyses were carried out, firstly reversing the order of *undecided* and *partial* and secondly aggregating the *partial* and *undecided* responses to verify whether and to what extent this might affect the outcome and interpretation. The process and results obtained are detailed in the Supplementary Analyses section of the chapter, below.

Ethnicity and Socio-Economic Status (SES) – Defining and Measuring the Confounds

In the demographic information block, data were collected relating to participants' self-identified ethnic group or groups and their self-perceived socio-economic status, relative to others in Aotearoa. Beyond their descriptive value, these data were to enable statistical controls to be applied to plausible confounding effects (see below, Controlling for Confounds, in the analytic strategy section).

Ethnicity

Ethnicity data were collected using the categories adopted for official purposes by the New Zealand Government, such as the Census (Statistics New Zealand, 2018). Participants were able to select as many ethnicities as they wished. This information was used to describe the sample in both parts of the study. For analytic purposes, however, where multiple ethnicities were selected, prioritised ethnicity was adopted. This methodology, outlined in the Health Information Standards Organisation (HISO) Protocols (Ministry of Health, Manatū Hauora, 2017), is the most used output in the health and disability sector in Aotearoa. Respondents are allocated to a single ethnic group using specified "prioritisation tables", the aim being to ensure that "ethnic groups of policy importance or small size are not swamped by the New Zealand European ethnic group". It does not equate to an assumption that the respondent identifies more strongly with the prioritised group.

To permit comparisons with other studies, particularly official government reports, participants could select from nine of the most frequently endorsed ethnic groups in Aotearoa

(NZ Māori, NZ European/Pākehā, Samoan, Tongan, Cook Islands Māori, Niuean, Chinese, Korean, or Indian). Participants could also select *other* instead, or as well, and were asked to describe the other ethnicity or ethnicities identified with. Where multiple ethnicities were listed, for purposes of statistical control, level 1 prioritisation was applied, as follows (where 1 takes first priority etc.):

- Māori – priority 1
- Pacific peoples – priority 2
- Asian – priority 3
- Middle Eastern/Latin-American/African – Priority 4
- Other Ethnicity – Priority 5
- European – Priority 6
- Residual – Lowest priority level

New Zealand European/Pākehā falls within *European*, lowest priority with the exception of *residual categories* (encompassing *don't know*/*prefer not to answer* etc.).

As a nominal variable, it was necessary to transform this categorical variable to *dummy* variables to permit logistic regression. This is because, where a continuous scale cannot be artificially adopted, levels must nevertheless be assigned to permit estimation of the effect that the various groupings may have on the response (Hardy, 1993; Suits, 1957). A dummy variable is binary, indicating either that a variable does or does not have a particular characteristic, the values of 0 or 1 enabling incorporation of nominal variables in regression analyses. Based on responses in the survey, participants' ethnicities were classified into one of six of a possible six level 1 categories according to the HISO protocols (Ministry of Health, Manatū Hauora, 2017). The categorical ethnicity variable here then can take on six different values - *Māori; Pacific peoples; Asian; Middle Eastern/Latin-American/African; European*; and *Residual categories* (no participant's response was classified *other ethnicity*).

Effectively, dummy ethnicity variables divide the wider ethnicity categorical variable into all of its values, minus one (European), left out deliberately as a reference category. All the parameters of the dummy variables included denote the difference/deviation from this reference category. The fastDummies package in R was used here (Kaplan & Schlegel, 2020).

Socio-Economic Status

Socio-economic status is a challenging variable to measure as raw income data does not necessarily reflect relative wealth or deprivation without further information. Calculation of deprivation status is an intricate process, requiring the availability and detailed analysis of multiple factors such as the overall financial demands on household or wider family group (University of Otago, 2022). Accordingly, rather than asking about income bands, for example, the MacArthur Ladder of Subjective Social Status was adopted (Adler et al., 2000), with some minor adaptations. The MacArthur Ladder is a single-item measure of self-perceived relative status, with a focus on wealth and economic position. This more accurately taps socio-economic status as a potential confound where the impact of a person or household's financial position may contribute to both psychological distress and to pragmatic barriers to accessing vaccines. Psychometric evidence from research conducted across a wide range of peoples and ages, in diverse settings, provides strong support for use of this scale (Amir et al., 2019; Cundiff et al., 2013; Giatti et al., 2012; Goodman et al., 2001; Hoebel et al., 2015).

Participants viewed an image of a ladder and were asked to **"**[t]hink of this ladder as representing where people stand financially in Aotearoa/New Zealand. At the top of the ladder are the people who are the best-off financially. At the bottom are the people who are the worst-off financially". Participants were then asked: "Where would you place yourself on this ladder?" and to "[p]lease click on the rung to place a dot where you think you stand at this time in your life, relative to other people in Aotearoa/New Zealand". The item wording

was slightly modified from the original for the purposes of this research to refer to Aotearoa, and to tap self-perceived relative economic wealth more specifically, as opposed to education or employment status.

An SES score was therefore the number assigned to the rung the participant selected as best representing their perceived economic position, relative to the rest of the country, from 1, at the bottom (lowest perceived wealth), to 10 (highest perceived wealth).

Indices – Summary

In summary, indices for each variable are as follows:

- Perinatal depression score: A participant's total score across the EPDS items (0-30).
- Perinatal anxiety: Total score on the GAD-7 items (0-21).
- Anticipated regret: Value out of 100, assigned by the participant to each of the two anticipated regret items (0-100) (one action regret, one inaction regret).
- Temporal discounting: overall *k* value, derived from responses to 27 items, generally falling between 0 and 0.5 (smaller values = less discounting, i.e., a tendency to prefer delayed over immediate reward),
- Intention to vaccinate: Intention scores were the numeric value assigned to the selected response option (1 = refuse all; 2 = undecided; 3 = partial; 4 = accept all)
- Baby's vaccination status (new mothers only): Baby's vaccination status was scored similarly (1 = none by age; 2 = partial – some by age; 3 = full by age)
- Socio-economic status: SES is represented by the number each participant chose to correspond with their perceived economic position, relative to the rest of the country. The range was between 1 a the lowest and 10 at the highest.
- Ethnicity/Prioritised ethnicity: Nominal variable

Participant Perspectives

To permit exploration of individual perception as described above, all participants were invited to provide their perspectives on the influences on (and impact) of the decision made. Three items (none of which were character-limited) asked:

- "How did you make your decision about vaccination for your baby – what were the things that influenced your decision?";
- "How did making the decision about vaccination impact you (if at all)?"; and
- "How did the COVID-19 pandemic affect you and/or your decision about vaccinating your baby?".

Participants indicating either uncertainty or intention to partially refuse were also asked to list the specific vaccines of concern to them.

Analytic Strategy

Although primarily quantitative, this study was designed to answer certain research questions requiring collection and analysis of some limited qualitative data. The detailed analysis plan was devised and preregistered on OSF (see https://osf.io/hzunr/, and Appendix 3). The data collection and analytic strategies for both types of data in this research are set out below.

Quantitative Strategy – Causal Inference

Establishing causality outside a controlled experimental context is of course complex and experimental manipulation is not feasible where participants can or must not be randomly assigned to levels of an experiment. Here it would have been unethical to manipulate and randomly assign participants to experience a particular level or type of perinatal distress. However, statistical methods that permit for control of plausible confounding variables are available to permit tentative conclusions about causation from cross-sectional or

observational data (Pearl, 2009; Rohrer, 2018). Structural equation modelling (SEM) is one good way to achieve this.

The first crucial step to ensure that causal conclusions could be drawn was to identify any potential confounding variables that could bias the results or their interpretation. This required careful evaluation of the existing literature (Greenland & Morgenstern, 2001; McNamee, 2003), assisted by graphical causal modelling -a conceptual tool to isolate variables requiring statistical control (Rohrer, 2018). Ethnicity and socio-economic status emerged as plausible confounds that would therefore need to be controlled in this study (as discussed further below – see Plausible confounds). In a bid to maximise relevance of the study for Aotearoa, the sample recruited was limited to expectant and new mothers either living in New Zealand, or who were NZ citizens residing overseas. All variables, research questions and survey items were derived from decision theory, in particular anticipated regret and temporal discounting. Correlation sizes are described using Cohen's standards (i.e. small .10, moderate .30, large .50) (Cohen, 1992).

The overall quantitative analytic strategy can therefore be broken down into three key stages: firstly, identifying potential confounds, next identifying which of these would plausibly result in bias, and finally using structural equation modelling (SEM) to analyse the data, statistically controlling for identified confounds.

Controlling for Confounds

Cause and effect, the goal of much scientific research, is the central aim in this study which asks whether perinatal anxiety and depression have a causal effect on vaccination uptake. There are three requirements to establish causation: temporal precedence (cause comes before effect); covariation of cause and effect (when the cause is present, the effect occurs); and elimination of alternative explanations (Cozby & Bates, 2020). These alternative explanations are confounding variables, or confounds, i.e., other independent variables that

could plausibly be causing or contributing to the effect of interest (American Psychological Association, 2020). Confounds are correlated with the independent variable of focus in a study, but are not affected by it (McNamee, 2003). Confounds introduce bias and render the results meaningless because they erroneously suggest that a relationship exists where it does not (Fisher, 1936).

Through randomisation, the experimental method allows relatively unambiguous interpretation of results. However, true experimental conditions are often not possible or ethical in many studies, as was ultimately the case here. Whilst mood induction is not unheard of (Westermann et al., 1996), for example having participants sing a song in front of others to induce stress (Brouwer & Hogervorst, 2014), such methods are generally only acceptable where the effects are mild and temporary. In this case, experimental manipulation would have required random assignment to experience distress of different types, and varying severity to see how this impacts intentions about health-related decision for their baby with potential long-term consequences. Fortunately, it is possible to rely on statistical methods – for example logistic regression or structural equation modelling (SEM), to draw conclusions about causation from cross-sectional or observational data (McNamee, 2003; Pearl, 2009).

Graphical Causal Modelling and Directed Acyclic Graphs

Understanding which variables are in fact confounds (and which are not) is the essential first step. Graphical causal modelling using a directed acyclic graph (DAG) helps isolate which variables do (and, equally important for avoiding bias, do not) require statistical control (Elwert, 2013; Rohrer, 2018). In a DAG, the variables (*nodes*) are represented in boxes, and the relationships between them by unidirectional arrows (*directed edges*). The assumption is that, were it possible to experimentally manipulate the variable where a directed edge starts from, it would cause a change in the variable at the other end of that edge, providing the other variables in the diagram were held constant. This allows visualisation of

the multiple pathways (through single or multiple nodes) that the independent variable of interest may have the hypothesised effect on the dependent variable. It also ensures that data collection is complete, but also ethical, as what is asked of participants will be necessary and sufficient, justifying the imposition on their time, but going no further than necessary (Emanuel et al., 2000).

As Rohrer (2018) describes, there are several types of pathway that can be depicted in a DAG – chains, forks, and inverted forks. A chain is the simplest of these, transmitting a causal association from the first to the final node, often via others (e.g., A => B => C). A fork also shows an association, but not a causal one. This is the most important type of association to recognise in detecting confounds. A fork shows a correlation between one variable and a given outcome that exists only because there is a common cause for both. For example, in A <= B => C, A and C are associated – there is a common cause (B), but they do not have causal effects on one another. The third structure type, an inverted fork, shows variables that are not related causally and help to distinguish variables that contribute to an outcome, but do not affect the variable of interest (A => B <= C).

Creating a DAG is conceptually simple. First, graph the independent and dependent variables then, on the basis of existing research findings, map other potential causal influences for the outcome (identified from a literature search). Important variables are those that affect the target independent variable *and* another variable or variables in the DAG. In the final DAG, only those variables which causally affect two or more others (whether directly or indirectly) will be included. In doing so, "back-door paths" – those variables which affect both the independent variable *and* the dependent variable (B => A => C, *and* B => C) – can readily be identified. (Rohrer, 2018).

If confounding variables (those which combine with the independent variable of interest to produce the effect observed) are not identified and controlled statistically,

conclusions about the existence, strength and direction of the relationship will be invalid. Statistical control effectively blocks the transmission chain and allows only the target relationship to be evaluated. Undeniably, identifying and controlling for confounds is crucial to the validity of results and conclusions. However, statistically controlling variables which are not confounds may be unnecessary, and in some cases, may undermine conclusions. Two categories of variable not requiring control are *colliders* - variables causally affected by two other, but unrelated variables – as seen in an inverted fork, and *mediators* – intermediate variables that account for the relationship between two other variables, whether fully, or partially (Rohrer, 2018). Colliders and mediators are visually depicted in a DAG as nodes on the pathway between the variables of interest. Controlling for colliders is not just unnecessary but can result in biased estimates, whereas controlling for mediators can block the causal pathway or lead to an underestimate of the strength of the relationship between the two target variables. Statistical control of variables is a powerful tool and there may be other reasons for controlling variables – where a variable's only role in the DAG is that it impacts the outcome (an *extraneous* variable), and that variable is neither a collider nor a mediator, then controlling for it will cause no harm, and may increase statistical power (Senn, 1994). A DAG allows relevant variables, their relationships, and their possible roles and significance to be identified to enable important, considered decisions to be made in terms of the analysis plan.

A DAG for Perinatal Depression/Anxiety and Vaccination

In this study, the independent variables of interest are perinatal anxiety and/or depression. The dependent variable is vaccination intention (intention to vaccinate, fully, partially, to refuse, or to delay). Although factors contributing to vaccine hesitancy are many and varied, of interest here are only those which confound the estimated presence, magnitude, and direction of the relationship between these forms of psychological distress and the decision reached on vaccinating. The hypothesis here is of course not that perinatal anxiety

and/or depression *alone* causes missed or delayed vaccination, rather that it is *a* cause, and one which – if properly understood – can be better addressed to good effect. Identification of any potential confounds from careful evaluation of the existing research literature was crucial to this process (Greenland & Morgenstern, 2001; McNamee, 2003).

Plausible Confounds: Ethnicity and Socio-Economic Status

Several consistent themes were identified in the literature review process as to contributing causal factors for low vaccine uptake. As described above (see Determinants of Hesitancy), a broad range of factors contribute to one or more of each of the five categories of hesitancy identified by Betsch et al. (2018) - confidence, complacency, calculation, collective responsibility, and constraint. This necessitated careful evaluation of the variables in each category and whether and how they might contribute to both perinatal anxiety and depression, as well as low vaccine uptake. Crucially, a potential contribution to vaccination intentions could not be sufficient to require statistical control unless that variable was *also* causally linked to perinatal anxiety or depression.

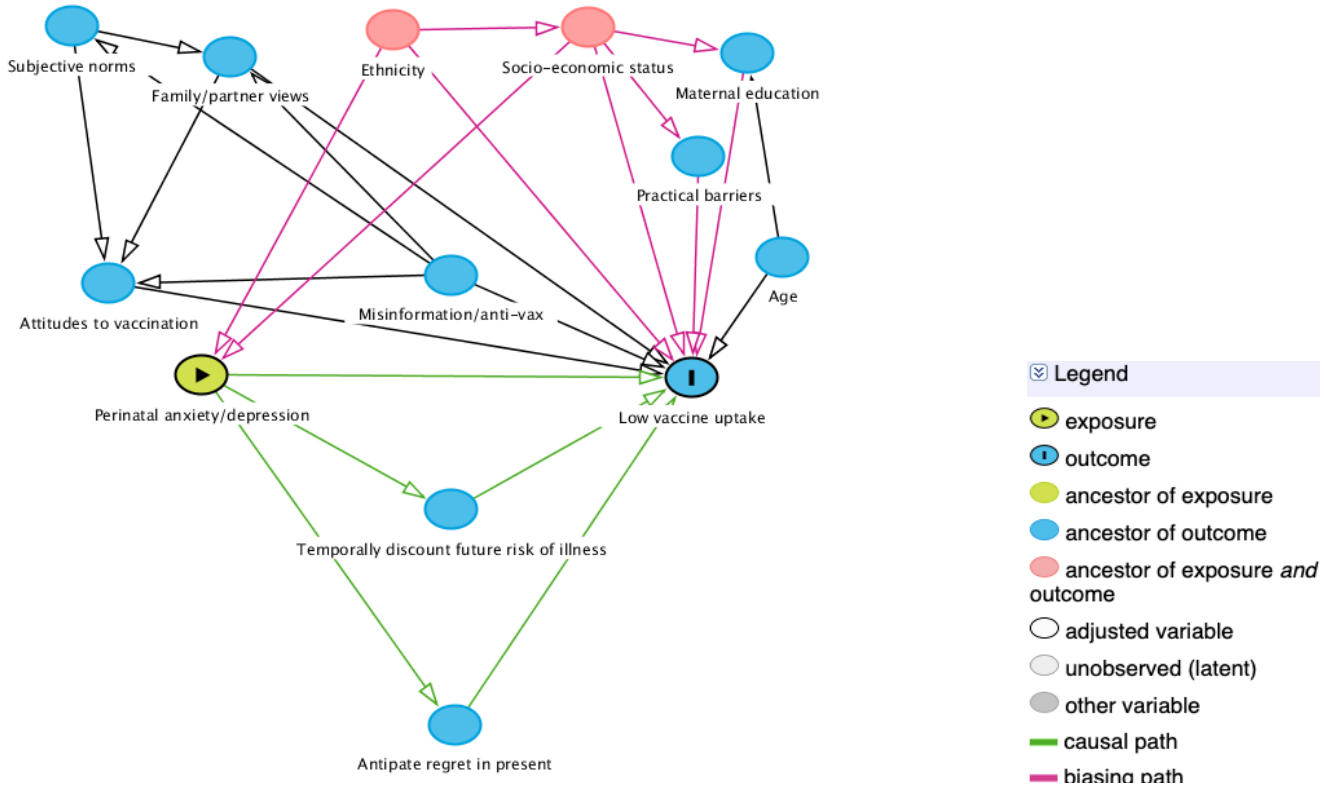
After an extensive search, and with the assistance of graphical causal modelling (see Figure 2 and Figure 3), of the many potential contributing factors two were identified as plausible confounds that could realistically have a directional association with both perinatal anxiety and/or depression and vaccination intention:

- socio-economic status (Coelho et al., 2011; Grant et al., 2011; Hayman et al., 2017; Leach et al., 2017; Osam et al., 2020; Schuller & Probst, 2013); and
- ethnicity (Coelho et al., 2011; Deverick et al., 2016; Forster et al., 2017; Freed et al., 2011; Hayman et al., 2017; Lee et al., 2017; Lee & Sibley, 2020b; Liu & Tronick, 2013; Mukherjee et al., 2016; Osam et al., 2020; Underwood et al., 2017; Waldie et al., 2015; Wilson et al., 2015).

The hypothetical relationships were visually mapped in DAGitty (Textor et al., 2016). Figure 2, depicts all possible relevant variables identified, whereas Figure 3, is the simplified DAG retaining only the plausible biasing and causal pathways.

Figure 2

Complete DAG Depicting Causal Pathway and Variables Identified as Impacting the Independent variable, the Dependent Variable, or Both.[5]



An additional advantage of the DAGitty programme is the identification of sufficient adjustment sets (Textor et al., 2016). These are groups of covariates that need to be controlled to minimise bias in estimating the relationship between the independent and dependent variables of interest (Textor, 2020). The DAG graphically depicts an adjustment set as an open causal path (here, the path between perinatal anxiety/depression and low vaccination

[5] Legend as created in DAGitty programme. "Exposure" equates to "predictor" in this study, "ancestor of exposure and outcome" are the confounding variables – evidenced by the biasing pathways, and "ancestor of outcome" are the mediating variables.

uptake) and closed biasing paths, whether as the total effect, or the direct effect. Based on the information in the diagram, DAGitty specifies which covariates should be controlled for in estimating either the total effect or the direct effect between the variables of interest. In this instance, the minimal sufficient adjustment sets for estimating the total effect between perinatal anxiety/distress on low vaccine uptake are ethnicity, socio-economic status, and misinformation/anti-vaccination messaging.

Although one New Zealand-based study did not strongly support SES as a confound (Underwood et al., 2017), SES was retained here given the balance of the evidence consistently does suggest a strong relationship with both perinatal anxiety or depression and vaccination intentions. Other New Zealand-specific evidence also supports this approach – in the 2015 New Mothers Mental Health Survey (Deverick et al., 2016) the authors concluded that, with regards to postnatal depression specifically, only ethnicity and socioeconomic status had predictive value.

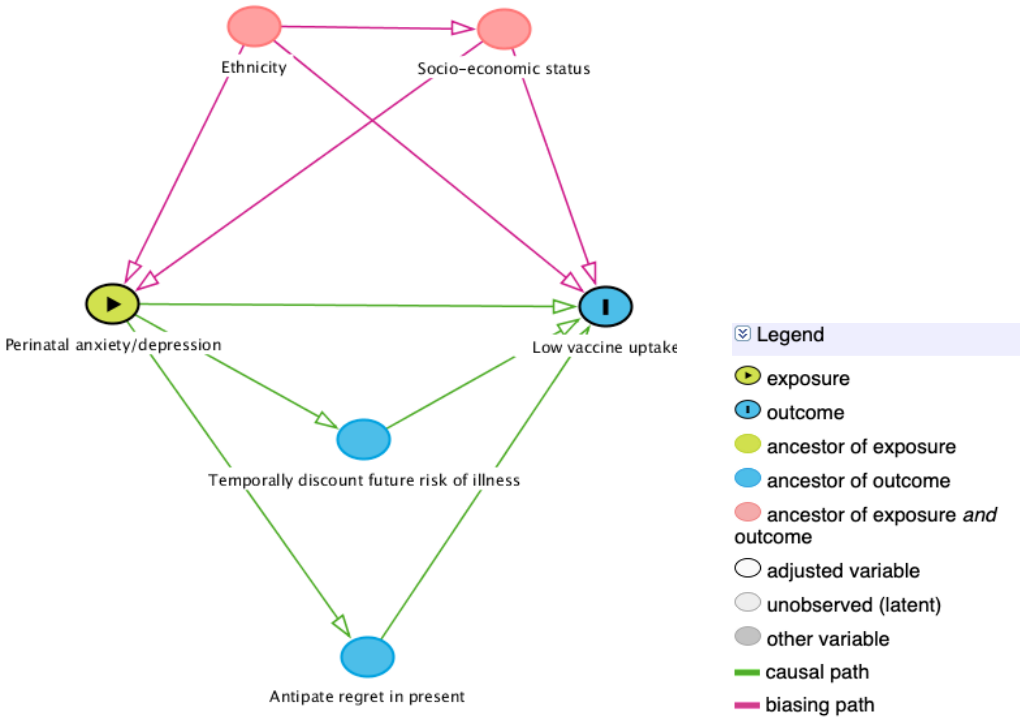
Potential confounding effects of vaccine misinformation and the effect of the anti-vaccine lobby were carefully considered. However, the evidence of impact on perinatal psychological distress is inconclusive (British Medical Association, 2019; Deverick et al., 2016; Ju et al., 2015; Khajuria, 2020; Kim, 2019). Surprising though this may seem at first glance, it is more likely that exposure to this type of information acts as a mediator of the effect of anxiety or depression on vaccination intentions. This will be due to an aversion to perceived vaccination risks, created by anxiety, that prompts searching for confirmatory evidence (Tafuri et al., 2014; Tomljenovic et al., 2019; Wolfe et al., 2002). As such, misinformation would not be a true confound and therefore controlling for exposure to misinformation would lead to a biased estimate of the distress/intention relationship. On balance, controlling for misinformation was not considered necessary or appropriate here.

However, it remains a significant issue for hesitancy more broadly, and the relationship between anti-vaccination and distress in Aotearoa merits further exploration.

Other factors often deemed important in studying both depression and vaccination, for example trust, maternal age, infant sex, marital status, maternal education, and parity were also discounted. This was due also to inconsistent evidence of any association with either perinatal psychological distress or vaccination status, or both (Underwood et al., 2016, 2017), or where controlling for the variable was not only unnecessary, but could result in biased estimates (as described above under Controlling for Confounds).

Figure 3

Simplified DAG – Causal Path and Closed Biasing Paths Depicting Minimal Sufficient Adjustment Sets.[6]



[6] As for Figure 2, legend as created in DAGitty programme. "Exposure" equates to "predictor" in this study, "ancestor of exposure and outcome" are the confounding variables – evidenced by the biasing pathways, and "ancestor of outcome" are the mediating variables.

Data Analyses: Method and Inferential Criteria

All analyses were performed using R (R Core Team, 2013). Data were first "cleaned" to identify and quantify missing data points, enabling responses to be removed in accordance with specified exclusion criteria outlined above. Where participants missed items (but fewer than the specified criteria for exclusion described above), responses to those items were imputed using single expectation-maximisation imputation, as implemented in missForest (Stekhoven & Buehlmann, 2012). Only 19 data points were missing, amounting to 0.1% of the total possible values and were imputed as described.

Hypotheses 1 and 2: Relationship Between Anticipated Inaction Regret (H1) or Anticipated Action Regret (H2) and Intention to Vaccinate

A Spearman's rho[7] correlation was computed to assess the magnitude and direction of the relationship between declared vaccination intentions and the subjectively reported expectations of either inaction regret (expected regret about not vaccinating and the child later becoming ill: H1); or action regret (regret if baby was immunised but reacted badly to the vaccine: H2).

These hypotheses were to be considered supported where the correlation between scores was statistically significant and either positive (in respect of inaction regret) or negative (in respect of action regret) ($p < .05$, 2-tailed). [8] For H1 (inaction regret), it was expected that as a mother's intention tends more towards full vaccination, so too will her anticipated regret of inaction be higher, whereas for H2 (action regret) – as mothers report increased reluctance towards vaccination (so *lower* on the uptake scale), their action regret was expected to be higher.

[7] As a nonparametric measure of rank correlation, Spearman's rho was used, as the intention variable is ordinal.

[8] See correction note at footnote 2, above.

Hypotheses 3-6: Structural Equation Modelling - Perinatal Distress and Discounting (H3); Perinatal Distress and Regret (H4); Perinatal Distress and Intentions (H5); Mediating Effects of Discounting and Regret on the Distress-Intentions Relationship (H6)

The proposed relationships in hypotheses 3-6 were estimated by structural equation modelling (SEM), using the lavaan package (Rosseel, 2012). SEM permits control of the plausible confounding variables, thereby increasing confidence in causal inference (Pearl, 2009). It also enables effects of measurement error to be accounted for (Westfall & Yarkoni, 2016). Fit of the proposed models was also assessed and reported for each hypothesis. Model fit effectively takes all observed relationships between every variable in a proposed model – in essence, a correlation matrix – and then compares this to the covariance matrix that is implied by the model. Model fit permits conclusions as to whether the covariance matrix proposed is a good match to what has actually been observed in the dataset.

The estimation method for hypothesis three was Maximum Likelihood (ML). This permits an examination of how likely the observed sample is, as a function of the possible parameter values (it determines the parameters most likely to produce the observed data). ML assumes that the observed indicators follow a continuous and multivariate normal distribution (not appropriate for ordinal observed variables). The estimation method for the remaining hypotheses (4-6) was Diagonally Weighted Least Squares (DWLS). DWLS is calculated by fitting a regression line to the points from the data set with the minimal sum of the deviations squared (or the least square error). DWLS is specifically designed for ordinal data.

Importantly, fit was computed and reported to provide additional information, namely the capability of the model to estimate the relationships proposed, based on accuracy of measurement assumptions. Fit neither supports nor refutes any hypothesis in this study. This is not to say there is no connection between fit and conclusions about whether a hypothesis is

supported – if the model does not fit well, this is potentially indicative of measurement error that has not been adequately captured in the proposed model and could potentially bias the relationships observed.

Interpretation of fit was in accordance with guidance outlined by Hu and Bentler (1999). Whilst chi square was computed to understand the difference between the expected and observed statistics, and a statistically significant chi square suggests poor fit, it is affected by sample size. Model fit was assessed by examination of the following statistics in the output:

- root mean square error of approximation (RMSEA; the residual – i.e., the error in the model);
- comparative fit index (CFI; the discrepancy between the data and the model, adjusted for sample size); and
- chi square (the difference between the expected and observed statistics).

Fit would be considered supported only if the robust RMSEA was less than 0.06, *and* the robust CFI greater than 0.95 (Hu & Bentler, 1999), both "sample-corrected". The lavaan package in fact provides several versions of these indices. This is to allow for the impact of nonnormality in the data. One is the unadjusted value, another is scaled using the Satorra-Bentler correction (applied to the estimated population value) and a third - restricted to output of more complex SEM computation (hypotheses 5 and 6) – modifies the *sample* estimate, leaving the population value unaffected.[9]

[9] When preregistered, it was specified that a Satorra-Bentler correction would be applied. At that time the availability of a third option in the output was not anticipated and, as such, no specific statement was made as to which of the specific indices would be reported. These "sample-corrected robust RMSEA" (and CFI) have been found to be more accurate than the other versions (Brosseau-Liard et al., 2012; Brosseau-Liard & Savalei, 2014). This is to say that, in conducting a study to [compare] performance of these methods, on close examination of the various statistical corrections for non-normality, the "sample-corrected" method produced less variability in the fit indices, and were closer to the population values they were designed to estimate. As these corrections do not change the population value estimate, the resulting findings can be interpreted in the same way.

Specific inferential criteria for each of hypotheses 3-6 were as follows:

Hypothesis 3: impact of perinatal depression/anxiety on temporal discounting: The relationship between temporal discounting scores and perinatal depression scores (H3(a)) or perinatal anxiety scores (H3(b)) was to be assessed by computation of a correlation statistic, as derived from the SEM output in R. The hypothesis would be considered supported if the correlation between scores was positive and statistically significant ($p < .05$, 2-tailed).

Hypothesis 4: greater severity of perinatal depression and anxiety will predict greater anticipated regret: Higher levels of depression and anxiety (as measured by scores on the EDPS and GAD-7) would predict greater anticipated regret (Jung et al., 2014; Worthy et al., 2014), demonstrated by statistically significant relationships between:

- perinatal depression and anticipated action regret;
- perinatal depression and anticipated inaction regret;
- perinatal anxiety and anticipated action regret; and
- perinatal anxiety scores and anticipated inaction regret.

Each of these hypotheses was to be considered supported where the standardised regression path derived from the SEM output in R was positive, and statistically significant ($p < .05$, 2-tailed).

Hypothesis 5: causal effect of perinatal anxiety and depression on vaccination intention: To conclude that the data supports hypothesis five, statistically significant ($p < .05$, 2-tailed) regression paths from perinatal anxiety and depression to intention to vaccinate were required.

Hypothesis 6: temporal discounting and anticipated regret will mediate the relationship between anxiety/depression and vaccination intention: For hypothesis six to be considered supported in its entirety, significant (negative) total effects of both anxiety and

depression on vaccination intentions were to be observed. In addition, significant (negative) indirect effects via each of six indirect pathways also needed to be observed:

i. perinatal anxiety on intention via temporal discounting;
ii. perinatal anxiety on intention via anticipated action regret;
iii. perinatal anxiety on intention via anticipated inaction regret;
iv. perinatal depression on intention via temporal discounting;
v. perinatal depression on intention via anticipated action regret; and
vi. perinatal depression on intention via anticipated inaction regret.

If none of the six indirect effects was negative and statistically significant, hypothesis six would be falsified (irrespective of the total effects). However, if one or more of the six indirect effects and the two total effects were significant, hypothesis six would be partially supported (and, therefore, also partially contradicted).

Content Analysis: Participant Perspectives and Experiences

Although primarily quantitative in nature, certain research questions in this study required collection and analysis of some limited qualitative data. This is in recognition that, whilst a purely quantitative approach permits robust testing of specific, explicit hypotheses, individuals' own unique perceptions and experiences are best probed by inviting expression in their own words. Qualitative research is valuable to answer a wide variety of research questions, particularly as regards individual experiences, views, and opinions, or how people make sense of their own decisions and behaviours (Braun & Clarke, 2006; 2021a). Over the past two decades, a growing recognition of the value of both quantitative and qualitative research elements in a single study has seen increasing acceptance, a proliferation of mixed methods designs, and the launch of several journals dedicated to this approach (Bryman, 2006; Creswell & Creswell, 2017; Creswell & Tashakkori, 2007; Johnson et al., 2007; O'Cathain et al., 2007; Tashakkori & Teddlie, 2010). How and when the different research

methodologies are combined, using which techniques, are many and varied. For example, data collection may be concurrent or sequential; analytic strategies may seek to transform all data to single dataset (so-called "quantitising" the qualitative or "qualitising" the quantitative) or instead the data will be treated separately within the same study (Creswell & Tashakkori, 2007; Driscoll et al., 2007). Whichever approach is ultimately adopted, it must always be guided and justified by the research question ensuring collection and analysis techniques are necessary, relevant, and appropriate for the particular element(s) of the study (Gray, 2014; Punch, 2014; Shank, 2006).

In this study, the aim in gathering qualitative information was to provide context for the quantitative findings, as well as to help inform potential future avenues for research. Content analysis enabled examination of these data in a way that was complementary to the quantitative approach of the rest of the study. Participants were asked about the underlying drivers for their vaccination decisions, as well as the impact they felt the decision-making process itself had on them. This permitted an exploration of underlying phenomena associated with decisions made, and for common themes important to mothers in Aotearoa to be identified. It is important to distinguish the approach adopted here from others that also seek to develop patterns or themes across cases. The most well-known of these, reflexive thematic analysis shares many features with content analysis and the two are often conflated (Braun & Clarke, 2021a). Differences are subtle, one of the key aspects relating to the alleged atheoretical nature of content analysis, as well as its being regarded as a method for producing descriptive analyses from qualitative data. Certainly, content analysis has been described as a bridge between positivist and interpretive research paradigms (Braun & Clarke, 2021b). The features of content analysis align with the critical realist approach adopted in this study, and are a good complement to quantitative findings, which was the central focus of this research. As Braun and Clarke (2021a) also explain, where the focus in

thematic analysis is the themes themselves – the aim of the analysis, for content analysis it is the "what", the content itself which is a different approach to looking at where "truth" may lie and how it is discovered.

Content analysis was used in this study to explore underlying phenomena associated with participants' intentions, decisions, and actions. With regards to vaccination decisions in particular, understanding perspectives and experiences underlying decisions made enables insight to guide the development of targeted, effective campaigns of action. Content analysis is a flexible approach, permitting researchers to identify and examine patterns from text (Neuendorf & Kumar, 2015; White & Marsh, 2006). These patterns are coded, usually by assignment of a label. Depending on the research aims of the particular study, the content analysis process may be deductive, inductive, or a mixture of both (Grbich, 2012; Krippendorff, 2018). Whilst a deductive approach involves the identification within the data of known themes and patterns to test an existing theory, inductive content analysis organises and analyses the text to discover and describe latent meanings.

This latter approach was adopted to answer the research question in this study about what New Zealand mothers consider are the important influences on their decisions about vaccinating baby. Individual perspectives and understandings were elucidated by generating semantic and latent themes from responses to three open-ended questions in the survey (see Measures, in Method section, above). Whilst qualitative researchers often consider deep, cross-cutting themes across responses to multiple questions, in this case, responses to each item were considered separately, reflecting the approach to this section of the research as information to complement and contextualise the quantitative part of the study which was its primary focus.

The first step was for the researcher to become familiar with the data, by carefully reading through all participant responses three times, before beginning to think about patterns

or codes. The next step, still involving repeated examination of text generated by participants, was to begin to identify patterns and similarities within the text, as well as starting to assign tentative codes. This was done using NVivo 12 software (*NVivo*, 2018), by assignment of labels to permit organisation of these patterns and generation of themes. The powerful "crosstab" function also permitted evaluation of the relative importance of themes, based on numbers of participants endorsing each one, and comparisons to be drawn for example based on particular characteristics (e.g., pregnant, or new mother; intention to fully or partially vaccinate, or to refuse all vaccines). The preliminary codebook was discussed with supervisors, text chunks re-read, and codes reviewed and updated. The decision was made to allow for double coding, in that is one chunk of text could lend itself to more than one code label. However, this did not mean that multiple codes were applied to the same idea. Instead, where a full chunk of text was required for context, but contained more than one idea, it would be used in its entirety to enable it to be understood. Individual ideas within the text were only coded once.

Researcher Reflexivity

Methodological rigour is important in all scientific research, to give confidence in the reliability or credibility of findings. There is often a tension between the scientific endeavour of evidence-based research, with attention to detail of design, administration and analysis, and the crucial importance of remaining curious and open to genuine discovery, welcoming unexpected findings (Levitt et al., 2017; Shank, 2006). Qualitative research in particular has been the subject of critique – or outright criticism, often due to a misunderstanding of methodology (Hennink et al., 2020; Sofaer, 2002). Yet the value of employing qualitative methodology in any exploration of human behaviour is undeniable. In any qualitative research, a researcher's reflexivity – their acceptance of a lack of objective neutrality, and open recognition of the impact that they themselves have on every step of the study – is

crucial (Atkinson, 2007; Berger, 2015; Gergen et al., 1991). A researcher's own perspectives and life experiences, their gender, education, and age, will impact and influence a study's design and outcomes (Adkins et al., 2002). For example, reflexivity was important here, acknowledging that the research team – principal researcher and supervisors - were all parents. To mitigate this influence, careful reflection, at every stage of the process is essential to maximise methodological rigour. Consequently, confidence in and credibility of the findings and conclusions are increased (Bishop & Holmes, 2013; Darawsheh, 2014).

Even before the pandemic, vaccination was an emotive, polarising topic. So too can opinions on parenting decisions be divisive. A key aspect of the study design was to ensure its construction to ensure open and transparent consideration of the effect of the researcher's personal views and life experience on the relative importance or risk of vaccines, or the "right" thing for a mother to do, vis a vis her child, and to mitigate risk of bias. Reflexivity was important to understand how personal values and opinions, together with age, gender, life and educational experiences, and the broader social context could potentially skew the design, interpretation, and conclusions of this study. For example, careful consideration was given to recruitment criteria and methods to avoid unconsciously targeting mothers of a particular mindset to the exclusion of others. Questions were also designed and examined to ensure they were not value-laden. By far the biggest challenge was in making decisions around coding and organisation of themes within the responses. It was necessary to repeatedly reflect, during coding and thematic organisation, then analysis and discussion on the impact of personal perspectives and experience. To maximise rigour, ongoing self-reflection, challenging decisions taken on the study design, item content and analysis plan, in discussion with supervisors, were key. The most meaningful step was to treat each participant and their responses as unique and valid, irrespective of whether they mirrored the researcher's, accepting that all views and experiences are unique and valid, in a bid to ensure

each person's voice was respected and reflected in the results. Further reflections are outlined in the Case Study, at Appendix 8.

Ethics

Various ethical issues were considered and addressed: potential discomfort or harm to participants; cultural appropriateness and upholding of the principles of te Tiriti o Waitangi; and confidentiality and data protection, as described further below. Approval was obtained from the Massey University Human Ethics Committee (Northern) (approval number NOR 20/63). The project was carried out in accordance with University and NZ Psychological Society ethical codes (Massey University, 2017; New Zealand Psychological Society, 2012).

Avoidance of Harm

Any questioning about psychological distress may cause discomfort. Item content relating to anxiety or depression has the potential to be upsetting, and it was also possible that some participants might have an emotive response to questions about their vaccination. These risks were considered to be small, however, given steps taken to mitigate this risk, including a high level of detail in the information sheet, reiterated in the informed consent item, explicitly warning about the nature of questioning. In addition, efforts were made to ensure well-validated measures were used wherever possible to make up the survey item content. No deception was necessary, and the detailed information about the project itself and participation requirements was designed to maximise free, fully informed choice to participate. Participants were also clearly advised that they could pause or stop at any time, for any reason, with no penalty for doing so. A recent study was conducted in response to increasing concern from ethical review boards about the potential for harm or undue distress from investigation of sensitive research topics (McMurtrie, 2022). Whilst a small minority of participants undeniably experienced some level of distress, the authors also observed that

these individuals also report feeling that their role was an important one, and a sense that they wished to continue and to contribute.

Harm minimisation steps notwithstanding, to ensure support would be available if contact details were provided for relevant organisations who can help in the event that any experienced distress, or otherwise desired assistance, support, or further information. These included PADA and Plunket, as well as general mental health helpline contact information and links to a list of Māori health providers. These details were in the information sheet and all concluding messages for the survey, irrespective of whether a potential participant was screened out early or completed it in full.

Cultural Appropriateness and Relevance of Study and Survey Materials

Māori have a vested interest in any matters relating to health in Aotearoa and this project relates to health issues impacting wāhine, children, whānau and communities. Māori are not a specific or separate focus of this research but, as the sample is of the wider population in Aotearoa, it was of course expected that a number of participants would be Māori, and ethnicity data were collected for analytic purposes. Recognising the centrality of te Tiriti o Waitangi to all research conducted in Aotearoa, the project was designed with regard to the core principles of te Tiriti - partnership, participation, and protection. Careful consideration was also given to te Ara Tika (Pūtaiora Writing Group, 2010) and the Massey University Code of Ethical Conduct for Research, Teaching and Evaluations Involving Human Participants (MUHEC; Massey University, 2017). The study design and survey content were all specifically devised to safeguard the four principles of te Ara Tika, each closely aligned to one or more of those in te Tiriti: whakapapa, tika, manākitanga, and mana.

Having regard to whakapapa (relationships) and manākitanga (cultural and social responsibility), te reo was used in greetings, alongside other languages in the information sheet, to maximise inclusivity. Links to national support services included specific Māori

health providers by region. In selecting measures for this study, attention was paid to evidence of cultural relevance and appropriateness. In terms of the principles of Tika (purposefulness) and Mana (justice and equity), the viability of the project and whether the aims could reasonably be expected to be achieved were carefully assessed.

Depression is the primary source of disability in women of childbearing age, highest for indigenous women and those in lower income brackets (Bowen et al., 2014; Fisher et al., 2012; Ghaedrahmati et al., 2017). In Aotearoa, significant disparities are observed along ethnic and socio-economic lines, with wāhine Māori at highest risk perinatally, alongside those identifying as Pacific and Asian (McDaid et al., 2019; Waldie et al., 2015). Given the disproportionate rates at which wāhine Māori are impacted by perinatal psychological distress (Signal et al., 2017), and the lower rates of vaccine uptake for pēpi and tamariki Māori, it is expected that this research will be beneficial in itself, but also in terms of informing and justifying funding for future Māori-centred research.

A core part of this process was consultation with Dr Matt Shepherd, a Māori Psychologist at Massey University. Dr Shepherd was satisfied with the cultural appropriateness of the proposed approach overall, as well as the content of the survey.

Confidentiality

Materials (in Qualtrics) and data analyses (conducted in R) were saved and backed up on the Massey OneDrive cloud system. Once analysed, the data and analysis code were uploaded to an online repository, to be stored indefinitely to ensure availability to other researchers and the public. To safeguard confidentiality, only the minimum demographic data required for the purposes of ensuring compliance with eligibility requirements and necessary for analyses were collected. This included participants' age, in bands, to balance the need to establish the minimum age of 18 and the importance of being able to describe the against the importance of minimising the potential for identification of any particular individual. Month

due or baby's birth month was also sought, alongside NZ citizen or resident status; ethnicity; and subjective socioeconomic status. No contact information was requested within the survey. Although interested individuals could choose to provide an email address to permit notification of the research findings and/or entry to the prize draw, this information was entered in a separate survey, accessed via a link in the final item of the main questionnaire. As such, contact information was not linked to or stored alongside any given survey response. This information will be destroyed after interested participants are notified of the prize draw outcome and have been provided with a summary of the study's findings.

Preregistration

Preregistration enhances accountability and transparency in science, enabling replication (Flake & Fried, 2019). Increased confidence in the conclusions reached is vital in an area where changes in public policy and expenditure may be indicated. This study was preregistered on the Open Science Framework (OSF) on 7 April 2021 (see https://osf.io/hzunr). The study was embargoed to prevent wider public access until after data analysis, interpretation, and production of a written report of the findings. The de-identified raw quantitative data and analysis code were uploaded and shared openly as a project file on OSF, ensuring full transparency and replication. In accordance with preregistration requirements, no data were collected, created, or realised prior to uploading the preregistration setting out the detailed plan for design and analysis of the study. Preregistration is also an important means by which research can comply with ethical standards of adequacy, as required in the Massey University ethics code (2017).

PART III. STUDY RESULTS, DISCUSSION AND CONCLUSIONS

In this section of the thesis, the quantitative results are outlined (chapter 8), then discussed (chapter 9), followed by a description and discussion of the qualitative findings (chapters 10 and 11). Careful consideration was given to the structure of the thesis and whether to present the results and discussions of the statistical and content analysis separately. There being merits and detractors to both options, these sections were ultimately kept separate to avoid disruption to the flow and enhance readability. To ensure a cohesive overview of the study as a whole and its implications, Chapter 12 brings the separate parts of the study together in a combined discussion and conclusions section, summarising the important limitations and outlining clinical implications and directions for future research.

Chapter 8: Quantitative Results – Hypothesis Testing

Chapter Orientation: Focus and Scope

This chapter sets out the results of the quantitative hypothesis testing, together with an explanation of the analyses carried out.

Participants

The final sample size for the quantitative analyses after applying preregistered exclusion criteria was 387. Demographic characteristics of this sample are described in Table 1 to Table 3.

Table 1
Descriptive Characteristics of Participants for Quantitative Exploration

	N	% of sample (Tot = 387)
Age		
18-25	30	7.75
26-35	282	72.87
36+	75	19.38
Parent status		
Pregnant	137	35.4
New mother	250	64.6
New Zealand status		
Living in NZ	385	99.48
NZ citizen living overseas	2	0.52
Prioritised ethnicity		
NZ Māori	38	9.82
Other Pacific	5	1.29
Asian	8	2.07
Middle ELAA	2	0.52
European	333	86.05
Other (not specified etc)	1	0.26

Note. MELAA – Middle Eastern, Latin American and African priority code, of which here 2 participants identified as Latin American

Table 2
Self-Identified Socio-Economic Status of Participants (confound 1)

Socio-economic status (*M* 5.99, *SD* 1.6)	*N*	*% of sample*
1	2	0.52
2	6	1.55
3	24	6.20
4	37	9.56
5	60	15.50
5.5	*2*	0.52
6	86	22.22
7	95	24.55
7.5	*3*	0.77
8	46	11.89
9	11	2.84
10	2	0.52
Not answered	*13*	3.36

Note. SES – socio-economic status, self-perceived rank (0 – lowest, 10 highest), relative to others in Aotearoa.

Table 3

Detailed Ethnicity Data of Participants – As Identified and Prioritised (Confound 2)

	N	% of sample	Corresponding prioritised ethnicity
All ethnicities endorsed			
NZ Māori	38	9.82	NZ Māori
Fijian	1	0.26	Pacific
Cook Islands Māori	1	0.26	Pacific
Tongan	1	0.26	Pacific
Samoan	5	1.29	Pacific
Tokelauan	1	0.26	Pacific
Tahitian	1	0.26	Pacific
Vietnamese	1	0.26	Asian
Filipino	3	0.77	Asian
Chinese	3	0.77	Asian
Indian	2	0.52	Asian
Pakistani	1	0.26	Asian
Sri Lankan	1	0.26	Asian
Latin American	2	0.52	MELAA
French	2	0.52	European
Dutch	3	0.77	European
Swedish	1	0.26	European
German	1	0.26	European
Danish	1	0.26	European
American	4	1.03	European
Canadian	3	0.77	European
Irish	1	0.26	European
British/English	12	3.1	European
Scottish	2	0.52	European
Australian	6	1.55	European
South African/South African-European	8	2.07	European
Other European, not specified	4	1.03	European
NZ European/Pākehā	319	82.43	European
Residual categories (“human”)	1	0.26	Residual

Note. Total numbers of all ethnicities endorsed exceeds sample size, reflecting selection of multiple categories.
MELAA – Middle Eastern, Latin American and African priority code

Scores on the EPDS, GAD-7, MCQ and AR Items

Table 4 describes participant scores, overall and by subsample group, on each measure. The violin plots at Figure 4 to Figure 8 illustrate the full distribution of the data (in contrast to more limited summary data represented in a box and whisker plot), as a function of the eligibility status of participants (expectant or new mother). A violin plot is a hybrid of a box plot and a kernel density plot, designed to show peaks in the data. The thicker sections of the "violin" demonstrate the higher frequency of the values in that section, where the thinner parts indicate lower frequency.[10] As violin plots are created using kernel density smoothing (compared to a rolling average), the area of the plots do not correspond to exact numbers of data points. This means that some of the areas of these plots fall outside the possible range. Each violin plot contains a box plot for readability indicating the median, interquartile range, and length of rest of the distribution of data. Additional frequency distribution graphs are also set out at Appendix 4.

[10] The table and plots describe frequencies in the sample overall and by subgroup (ie expectant or new mother). Whilst this was not a key focus of preregistered analyses, observing whether there were key differences between mothers still pregnant and mothers already faced with acting on their decision provides some additional context for the findings in discussion of the results. It also more readily lent itself to the supplementary analyses which include exploratory consideration of the distress-uptake relationship, only possible in respect of new mothers. Finally it was considered of potential relevance for future researchers interested in further exploration in this area.

Table 4

Descriptive Statistics: Scores Across EPDS, GAD-7, MCQ, and AR Items

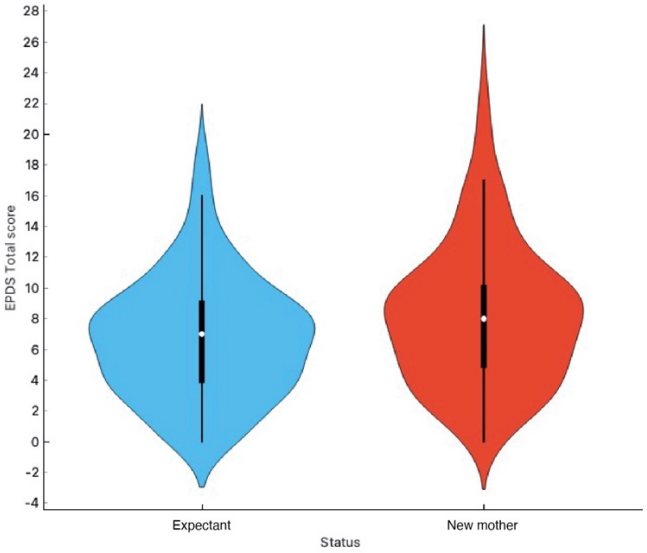
	Full sample				Expectant		New mother	
Measure	*M*	*SD*	*Min*	*Max*	*M*	*SD*	*M*	*SD*
EPDS	7.65	4.48	0	24	6.69	3.94	8.17	4.68
GAD-7	4.63	4.01	0	21	3.95	3.27	5.00	4.33
MCQ	0.02	0.04	0.00	0.25	0.02	0.04	0.02	0.03
AR - action	53.07	33.01	0	100	55.71	32.24	51.62	33.41
AR - inaction	85.88	27.97	0	100	88.8	32.76	88.67	24.58

Note. Score ranges: EPDS: 0-30; GAD-7: 0-21; MCQ: 0-0.5; AR items: 0-100. *M* and *SD* represent mean and standard deviation, respectively. *Min* and *Max* are the highest and lowest scores on each measure across all responses.

Scores on the EPDS ranged from 0 (no evidence of depression symptoms, to 24 in the severe range, but below the maximum of 30. The average score was 7.65 (mild), with a standard deviation of 4.48. The mean score and standard deviation was higher for new mothers (M = 8.17, SD 4.68) than for expectant mothers (M = 6.69, SD 3.94).

Figure 4

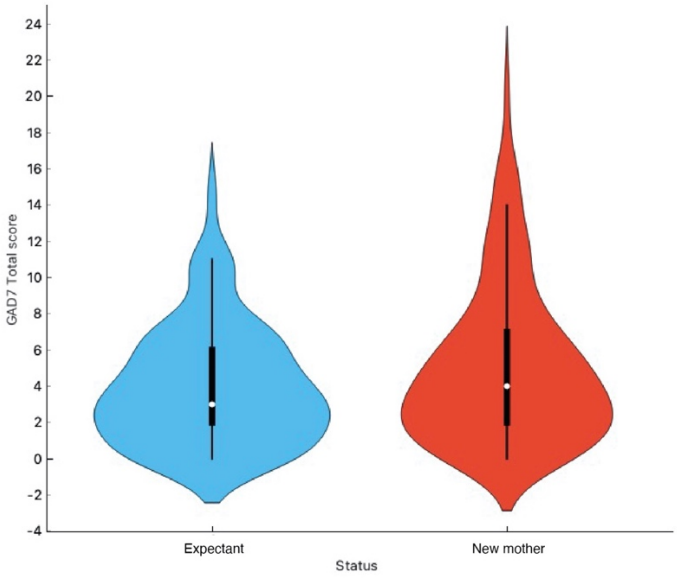
Distribution of Total Scores on the EPDS for Expectant and New Mothers



Scores on the GAD-7 fell between the endpoints of the total possible range (0 to 21), the average score overall being 4.63 (*SD* = 4.01). Again, new mothers' mean scores were higher, however (*M* =5.00, *SD* = 4.33) than for expectant mothers (*M* = 3.95, *SD* = 3.27).

Figure 5

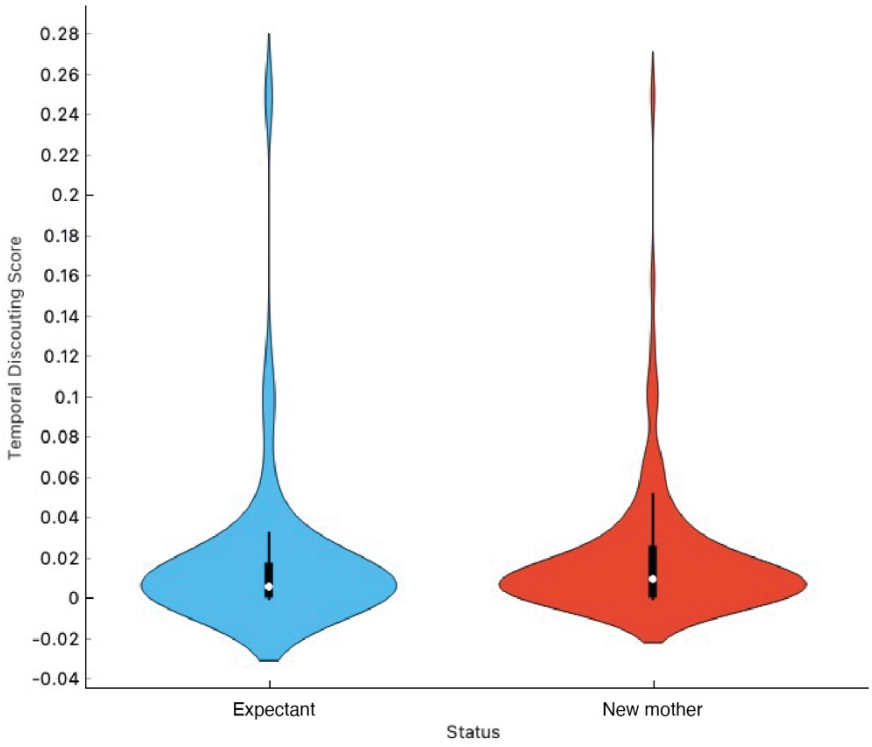
Distribution of GAD7 Total Scores for Pregnant and New Mothers in the Sample



On the MCQ, the overall discounting rate, or *k*, ranged between 0 and 0.25, out of a possible 0-1. The mean for the full sample was 0.02 (*SD* = 0.04). Consistency scores were high – only 5 of the 387 participants' scores fell below 85%, and the lowest of which suggested 70% consistency in item selection. There was only mild variation between the rates for expectant and new mothers (see Figure 6 and Table 4). These scores are broadly consistent with trends observed in the general population, as represented by experimental research control groups, and in contrast to target populations in many such studies which often focus on addiction (Kirby & Petry, 2004; Story et al., 2014).

Figure 6

Distribution of Expectant and New Mothers' Temporal Discounting Scores



Patterns of self-rated anticipated regret differed considerably between action regret (about vaccinating), which was more evenly spread, and anticipated inaction regret (about not vaccinating) score where higher regret was more consistently endorsed, as depicted at Figure

7 and Figure 8. Scores for both regret types ranged from 0 to 100, but whilst the mean action regret score across the full sample was 53.07 (*SD* = 33.01), the mean inaction regret score was 85.88 (*SD* = 27.97). There was little difference between pregnant and new mothers' scores however (see Table 4, above).

Figure 7

Distribution of Anticipated Action Regret (Regret about Vaccinating) Self-Rating by Expectant and New Mothers in the Sample

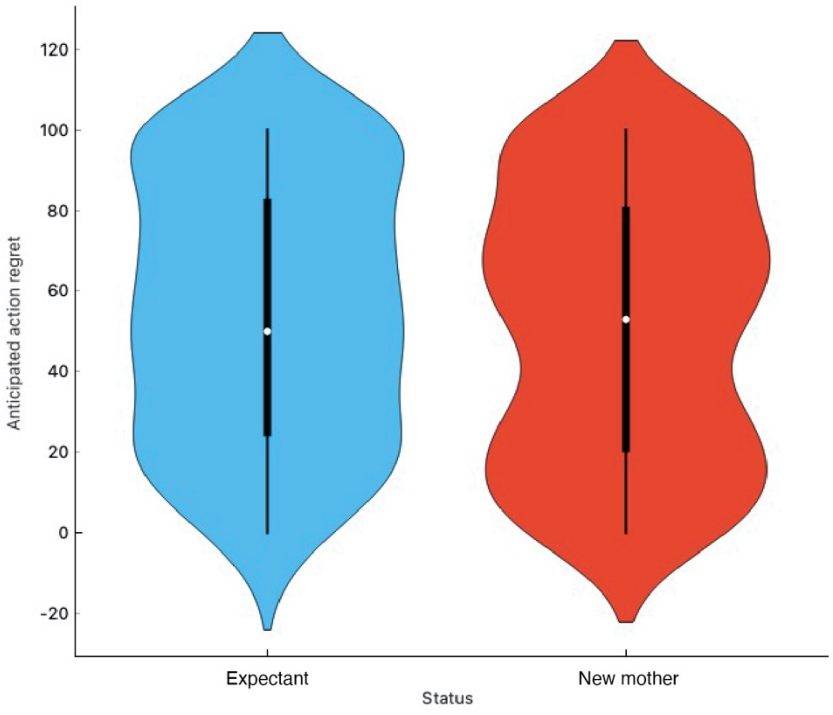


Figure 8

Distribution of Self-Rated Anticipated Inaction Regret (Regret About Not Vaccinating) Among Pregnant and New Mothers

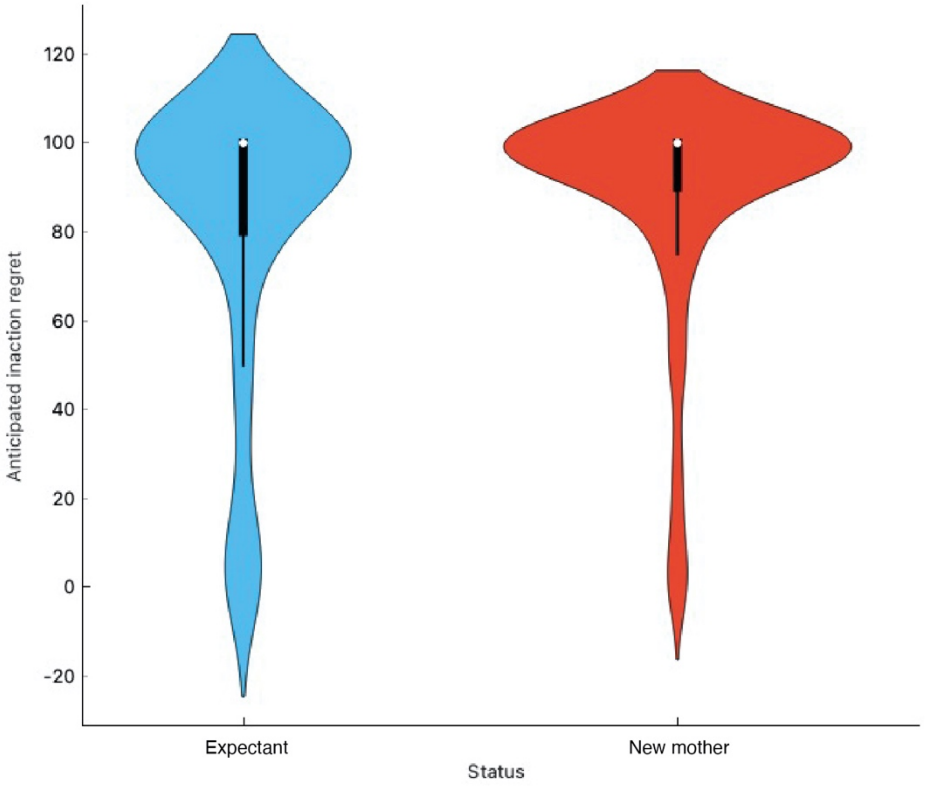


Table 5 describes the intention patterns in the sample, and as observed in expectant and new mothers, the distribution of declared intentions across all participants in the quantitative sample depicted at Figure 9.

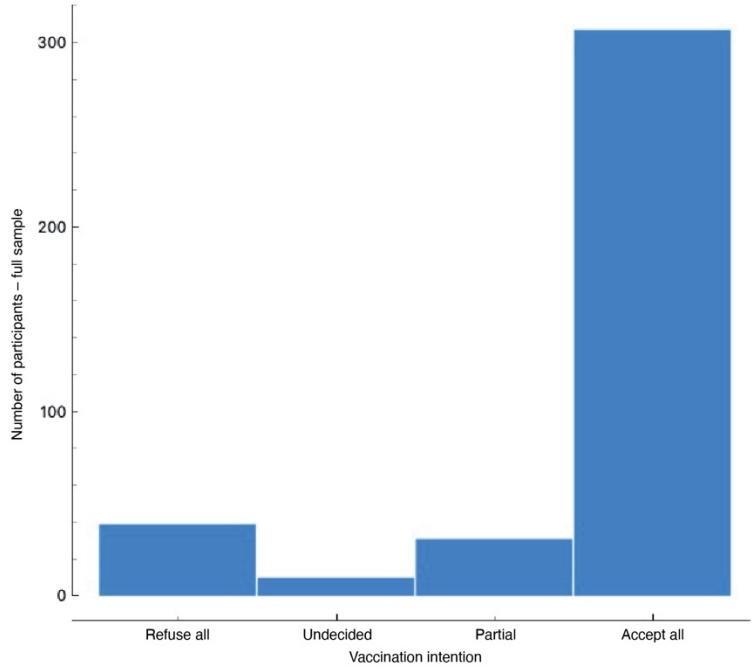
Table 5

Vaccination Intentions of Full Sample, and of Expectant and New Mothers

	Full Sample		Pregnant		New mother	
Vaccination intention	N = 387	% of total	N = 137	% of preg	N = 250	% of new
Accept all	307	79.32	105	76.64	202	80.8
Partial	31	8.01	9	6.57	22	8.8
Refuse all	39	10.08	21	15.33	18	7.2
Undecided	10	2.58	2	1.46	8	3.2

Figure 9

Distribution of Declared Vaccination Intentions of Participants



Hypothesis Testing: Results of Preregistered Data Analyses

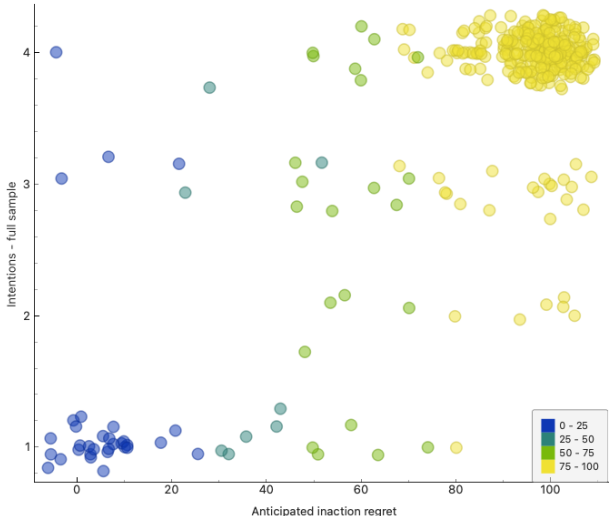
The six quantitative research hypotheses were tested using a range of statistical analyses, all carried out in R (R Core Team, 2013), and tested using the full sample. For ease of interpretation and comparison, description and interpretation of correlation sizes adopt the widely used and recognised Cohen's standards (i.e. small .10, moderate .30, large .50) (Cohen, 1992).

Hypotheses 1 and 2: Relationship Between Anticipated Inaction Regret (H1) or Anticipated Action Regret (H2) and Intention to Vaccinate

A strong, positive, and statistically significant correlation was observed between participants' self-assessed anticipated inaction regret (about not vaccinating) and their intention to vaccinate ($r(385) = .64$, $p < .001$, 95% CI [.57, .69]). Hypothesis 1 was therefore supported. See scatterplot at Figure 10.

Figure 10

Relationship of Anticipated Inaction Regret to Participants' Vaccination Intentions



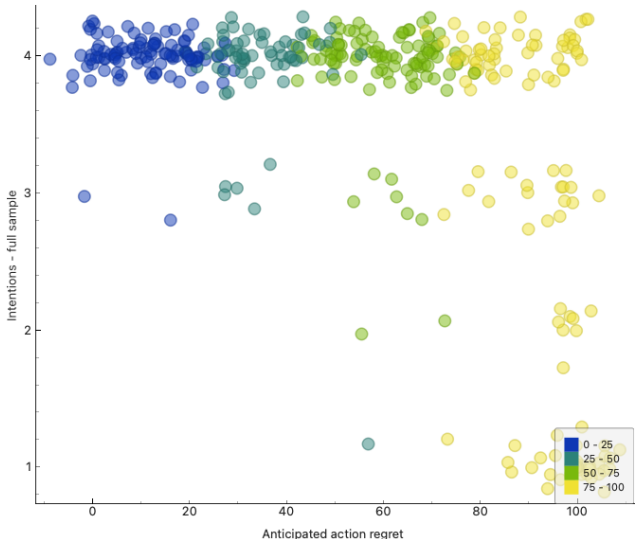
Note: colours denote range of anticipated regret

The observed relationship was stronger for expectant mothers ($r(135) = .75$, $p < .001$, 95% CI [.67, .82]) than for new mothers ($r(248) = .56$, $p < .001$, 95% CI [.46, .64].

The relationship between vaccination intention and anticipated action regret scores (regret about vaccinating), depicted at Figure 11, was also large, statistically significant and negative ($r(385) = -.53$, $p < .001$, 95% CI [-.60, -.46]). Hypothesis 2 was therefore supported.

Figure 11

Effect of Anticipated Action Regret on Participants' Vaccination Intentions



Note: colours denote range of anticipated regret

Again, the relationship was stronger for expectant mothers ($r(135) = -.63$, $p < .001$, 95% CI [-.72, -.51]) than for new mothers ($r(248) = -.48$, $p < .001$, 95% CI [.-.57, -.37]).

Hypothesis 3: Perinatal Depression or Anxiety and Temporal Discounting

The relationship between temporal discounting scores and perinatal depression scores (H3(a)) or perinatal anxiety scores (H3(b)), was assessed by computation of a correlation statistic, derived from the SEM output from the lavaan package (Rosseel, 2012) in R (R Core Team, 2013). As per the preregistration, the hypothesis would be considered supported if the observed correlation between depression or anxiety and discounting scores was positive and statistically significant ($p < .05$, 2-tailed).

To test this hypothesis, a structural equation model was estimated, coded in lavaan syntax (depicted at Figure 12).

Firstly, the relationship between perinatal depression and temporal discounting (H3(a)) was evaluated and, secondly, the relationship between perinatal anxiety and temporal discounting (H3(b)). In both cases, maximum likelihood (ML) was used, the default estimator in lavaan.

Both observed relationships were statistically insignificant, negative and so small as to be negligible: [11]

- temporal discounting scores and perinatal depression: $\beta = -.06$, $p = .592$; and
- temporal discounting scores and perinatal anxiety: $\beta = -.01$, $p = .902$.

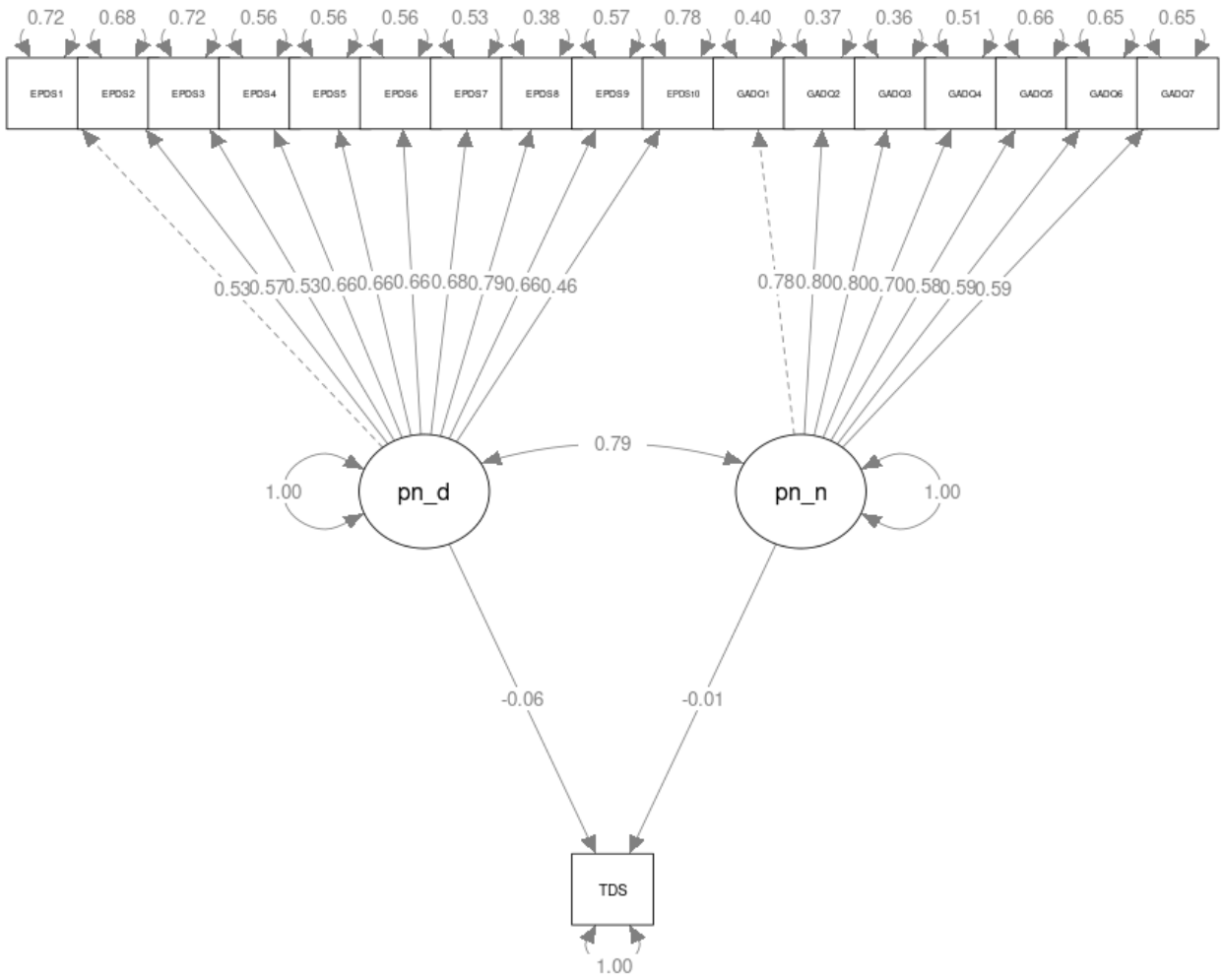
Hypothesis three was therefore not supported.

In addition, the fit statistics showed poor fit of the data to the model: $\chi^2 (133) = 538.41$, $p < .001$; comparative fit index (CFI) = .86; and root mean square error of approximation (RMSEA) = .09, $p < .001$, 90% CI [.08, .1]. See Figure 12.

[11] Fully standardised – in lavaan output "std.all" column.

Figure 12

Model of Observed Relationships Between Perinatal Distress and Temporal Discounting (H3)



Note: pn_d: perinatal depression; pn_n: perinatal anxiety; TDS: temporal discounting score

Hypothesis 4: Severity of Perinatal Depression and Anxiety will Predict Severity of Anticipated Regret

Hypothesis four posited that higher levels of depression and anxiety (as measured by scores on the EPDS and GAD-7) would predict greater anticipated regret (Jung et al., 2014; Worthy et al., 2014), demonstrated by positive relationships between:

a) perinatal depression and anticipated action regret;

b) perinatal depression and anticipated inaction regret;

c) perinatal anxiety and anticipated action regret; and

d) perinatal anxiety scores and anticipated inaction regret.

Each of the hypotheses 4(a)-(d) would be considered supported where the standardised regression path derived from the SEM output R was positive and statistically significant ($p < .05$, 2-tailed).

None of these relationships were statistically significant (see path diagram at Figure 13) :

a) A negligible, negative relationship was observed between perinatal depression and anticipated action regret ($\beta = -.03$, $p = .836$);

b) The relationship between perinatal depression and anticipated inaction regret was small and positive ($\beta = .14$, $p = .160$);

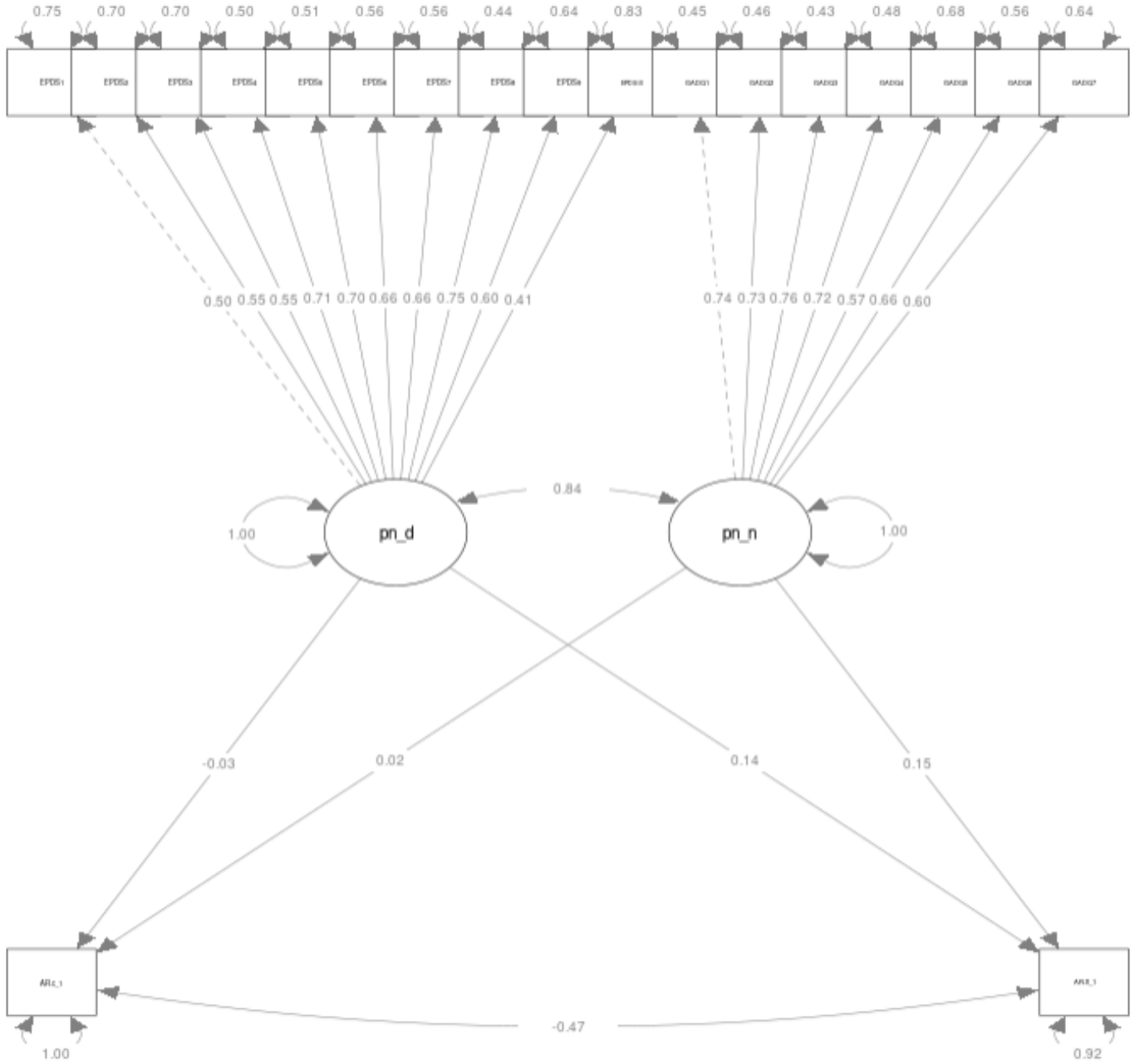
c) A negligible positive relationship was observed between anticipated action regret and perinatal anxiety ($\beta = .02$, $p = .889$);

d) The relationship between anticipated inaction regret and perinatal anxiety was small and positive also ($\beta = .15$, $p = .096$).

Accordingly, in accordance with preregistered inferential criteria, hypothesis four is not supported. Although the chi square obtained was significant (χ^2 (148) = 549.04, $p <$ .001), on the inferential criteria overall, the data appeared to suggest a good fit to the model, comparative fit index (CFI) = .97, root mean square error of approximation (RMSEA) = .05, $p < .01$, 90% CI [.04, .05]).

Figure 13

Diagram of Observed Relationships Between Perinatal Distress and Anticipated Regret (H4)



Note. pn_d: perinatal depression; pn_n: perinatal anxiety; ARc_1: anticipated action regret; ARn_1: anticipated inaction regret

Hypothesis 5: Causal Effect of Perinatal Anxiety and Depression on Vaccination Intention

Hypothesis five was tested by specifying an SEM in which intention to vaccinate was the observed (ordinal) dependent variable, and anxiety and depression were latent

independent (continuous) variables – see Figure 14.[12] Diagonally weighted least squares (DWLS) was used to estimate this relationship.

In this model, it was important to control for the confounding effects of SES and ethnicity (represented here as dummy variables created using fastDummies (Kaplan & Schlegel, 2020), as described in the Method section, above). The process as preregistered stated that *"at the time of final data analysis, the predictor variable "ethnicity" in the code above will be replaced by dummy variables "ethN-1", where ethN is the number of observed ethnicity categories in the sample"*. The intention had been to take the largest grouping as the reference level (European in this sample, encompassing New Zealand European/Pākehā), with the remaining "dummy" variables in the SEM code being the other prioritised ethnicity categories selected. Unfortunately, however, this intended process was statistically problematic, due to the considerable discrepancies in the subgroup sizes in the sample (1, in Residual, 2 for MELAA, 5 for Pacific, 8 for Asian). This prevented lavaan from running effectively, resulting in a warning message[13], suggesting care be taken in relying on this output.

It would appear that the problem was one of multi-collinearity, where the algorithm within lavaan does not permit for perfect prediction of participants' values on one independent variable based on the other independent variables – at least one of those variables appears then to provide no independent information. In essence, some of the ethnicity dummy variables corresponded to categories with very small numbers of cases, leading to computational difficulties for the estimation algorithm. Whilst it was important to

[12] The code specified in the preregistration in lavaan syntax contained an error – the variables anticipated action regret, anticipated inaction regret and temporal discounting, whilst not described in the text explanation of the analyses to be conducted, were included in the preregistered code as controls. This was unintended and the preregistration on OSF has been footnoted to explain the oversight in reviewing the document before uploading.

[13] "The variance-covariance matrix of the estimated parameters (vcov) does not appear to be positive d efinite! The smallest eigenvalue (= -9.601461e-17) is smaller than zero. This may be a symptom that the model i s not identified."

take note of this warning (and, for this reason, the supplementary analyses were performed and are reported, below), it is important to note that it was triggered automatically as the size of the smallest eigenvalue[14] was smaller than zero. However, the obtained value (-9.601461e-17) was only very slightly below zero. As such, evidence against identification of the model as preregistered is in fact weak.

When running the code as preregistered, listing each of the dummy variables created, and only European standing as reference, the following results were obtained:

- The relationship between perinatal depression and intention was negligible, negative, and statistically insignificant ($\beta = -.007$, $p = .951$);
- The relationship between perinatal anxiety and intention was small to medium, positive, and statistically significant ($\beta = .22$, $p = .035$).

The fit statistics suggested good fit of data to the model, despite the significant chi square: $\chi^2 (218) = 501.51$ $p < .001$; CFI = .97, RMSEA = .04, $p = .062$, 90% CI [.04, .05]).[15]

To permit a conclusion that the data supported hypothesis five, negative, statistically significant ($p < .05$, 2-tailed) regression paths from perinatal anxiety and depression to intention to vaccinate were required to be observed. On these results, the hypothesis was not supported. Effectively, although these results suggest a causal relationship between anxiety and vaccination intention, it was in the opposite direction to that predicted, and there was no relationship between depression and vaccination intention (see Figure 14).

For completeness, in light of the warning message, alternative methods for controlling for ethnicity were applied and are reported below, under Supplementary Analyses. Whilst this

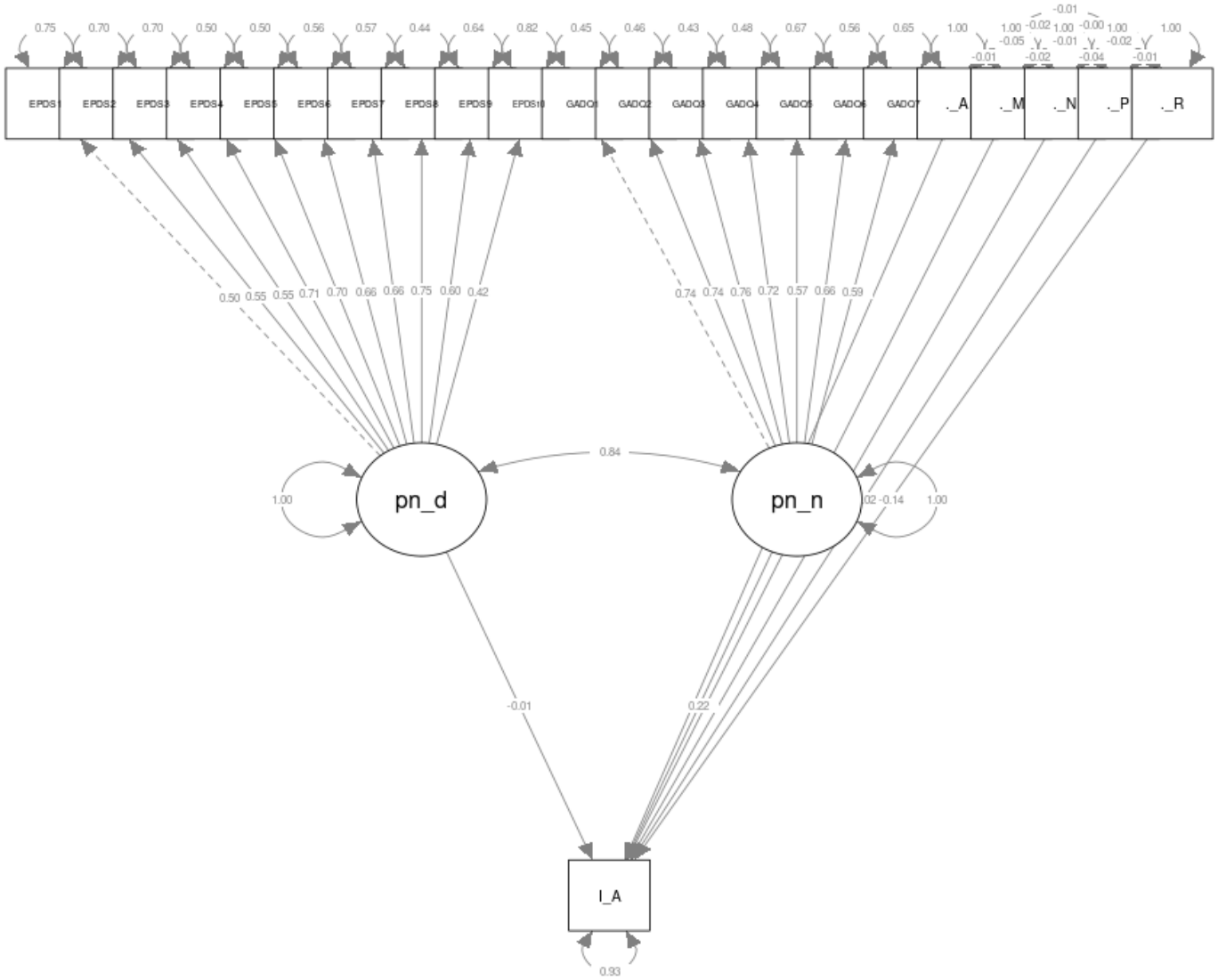
[14] An eigenvalue is a specific type of scalar (numbers or elements of a field relating to vectors – associated with a matrix equation (Hoffman & Kunze, 1971) – with particular importance in the analysis of linear transformations

[15] For completeness, simple correlations between intentions and both anxiety and depression were computed. The obtained values were both small, positive, and statistically significant (Anxiety – intentions: $r = .19$, $p < .001$, (95% CI [.09 - .29]; Depression – intentions: $r = .16$, $p = .001$, (95% CI [.06 - .26]).

was an improvement, in that it permitted the computations to run with no warning, the statistics obtained were not materially different and did not alter the conclusions reached.

Figure 14

Diagram of Causal Relationships Between Perinatal Distress and Vaccination Intentions (H5)



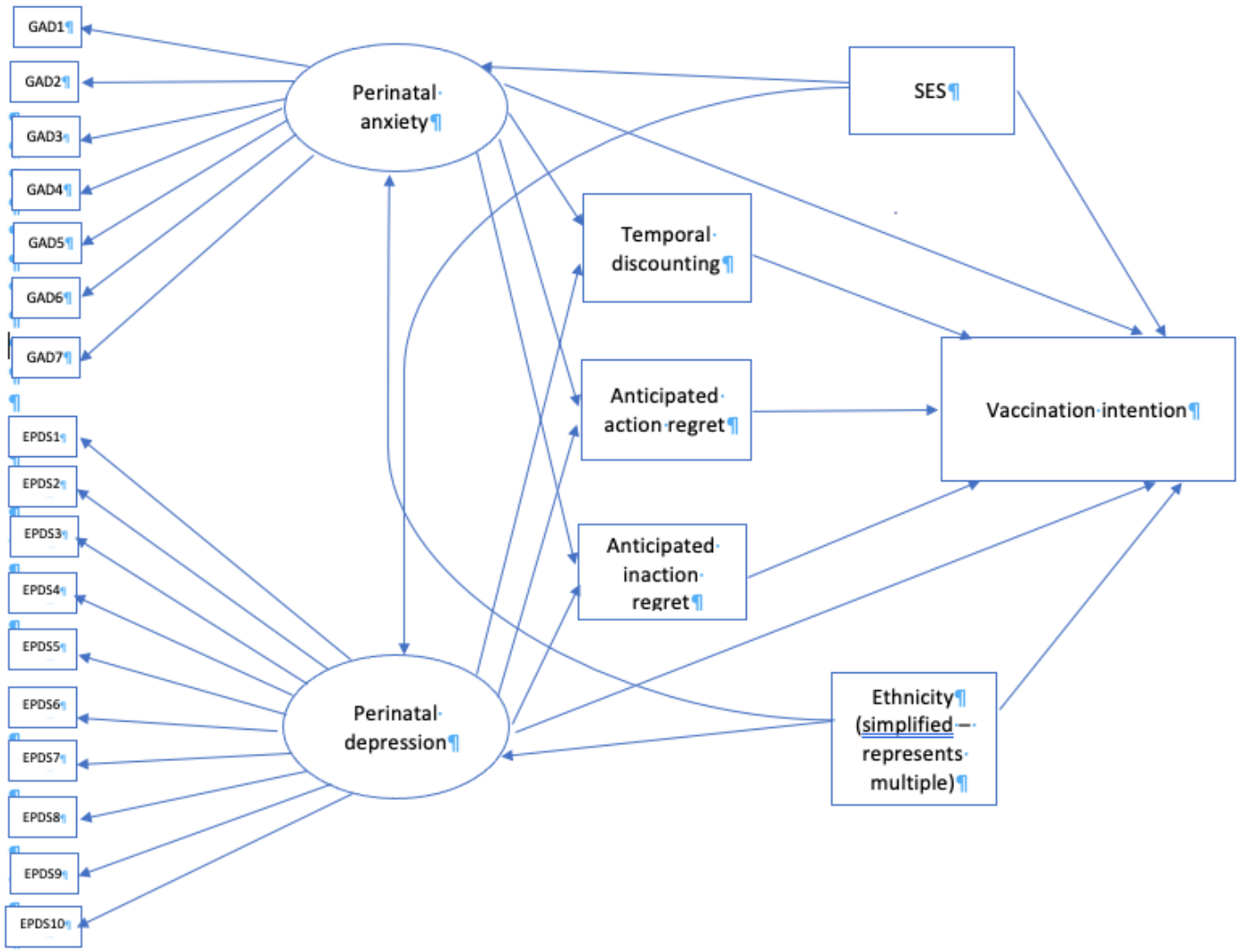
Note. pn_d: perinatal depression; pn_a: perinatal anxiety; I_A: vaccination intention

Hypothesis 6: Temporal Discounting and Anticipated Regret will Partially Mediate the Relationship between Anxiety/Depression and Vaccination Intention

Structural equation modelling was also used to test hypothesis six. The model, specified in lavaan syntax controlled for socio-economic status and ethnicity and was estimated using DWLS (see Figure 15).

Figure 15

Diagram of hypothesised Mediating effects of Temporal Discounting and Anticipated Regret on the Relationship Between Perinatal Distress and Vaccination Intentions (H6)



Two total effects were hypothesised, namely:

i. the effect of perinatal anxiety on vaccination intention; and

ii. the effect of perinatal depression on vaccination intention.

However, it was also hypothesised that the impact of both perinatal anxiety and depression on intention to be vaccinated would be mediated by three factors: temporal discounting; anticipated action regret; and anticipated inaction regret (where it was expected that anticipated action regret of vaccinating was expected to predict lower intention; and anticipated inaction regret about not vaccinating leading to illness was expected to predict higher vaccination intention). As such, six indirect effects were expected to be observed:

vii. the effect of perinatal anxiety on intention via temporal discounting;

viii. the effect of perinatal anxiety on intention via anticipated action regret;

ix. the effect of perinatal anxiety on intention via anticipated inaction regret;

x. the effect of perinatal depression on intention via temporal discounting;

xi. the effect of perinatal depression on intention via anticipated action regret; and

xii. the effect of perinatal depression on intention via anticipated inaction regret.

For hypothesis six to be considered supported in its entirety, significant, negative total effects of both anxiety and depression on vaccination intentions were required to be observed. In addition, significant, negative indirect effects via each of the six specified pathways were also required (i-vi). If none of the six indirect effects was negative and statistically significant, hypothesis six would be falsified (irrespective of the total effects). However, if one or more of the six indirect effects and the two total effects were found to be significant, hypothesis six would be at least partially supported (and also partially contradicted). However, as for Hypothesis five, running the analyses as preregistered resulted in a warning about the output.[16]

[16] "The variance-covariance matrix of the estimated parameters (vcov) does not appear to be positive definite! The smallest eigenvalue (= -5.267553e-13) is smaller than zero. This may be a symptom that the model is not identified."

Once again, although the evidence against the model having been identified is weak, additional analyses were run and are reported below (see Supplementary Analyses). As with hypothesis five, these supplementary findings are not manifestly different from the analyses as originally planned and do not alter the conclusions reached, either in terms of support for the hypothesis, nor about fit of data to the model.

In terms of the hypothesised total effects, a positive, small to medium and statistically significant total effect of perinatal anxiety on vaccination intention was observed ($\beta = 0.2$, $p = .036$). However, the total effect of perinatal depression on vaccination intention was negligible, negative and not statistically significant ($\beta = -.02$, $p = .849$).

The following indirect effects were observed, none of which were statistically significant:

i. perinatal anxiety and intention via temporal discounting: negligible, positive ($\beta = .002$, $p = .888$) ;
ii. perinatal anxiety and intention via anticipated action regret: negligible, negative ($\beta = -.02$, $p = .442$);
iii. perinatal anxiety via anticipated inaction regret: small, positive ($\beta = .11$, $p = .099$);
iv. perinatal depression and intention via temporal discounting: negligible, positive ($\beta = .004$, $p = .773$);
v. perinatal depression and intention via anticipated action regret: negligible, negative ($\beta = -.007$, $p = .730$);
vi. perinatal depression and intention via anticipated inaction regret: small, positive ($\beta = .11$, $p = .159$).

The fit statistics suggest an acceptable fit of the data to the model (χ^2 (280) = 770.01, $p <$. 001; CFI = .95; RMSEA = .05, $p < .001$; 90% CI [.05, .06]) (Hu & Bentler,

1999). However, as none of the indirect effects is statistically significant, in accordance with preregistered inferential criteria, the results do not support hypothesis six. See Figure 26 for the diagram of the statistical relationships observed between key variables of this study, in Appendix 7 due to its complexity to enable a larger representation.

Supplementary Analyses

Certain supplementary analyses were carried out, as alternatives to or in addition to those planned and outside the scope of the preregistered hypotheses. The results and explanations for each of these additional analyses performed are set out in full in Appendix 5.

These analyses were carried out where the intended analyses would not run, or ran with warning messages, and alterations were made to the intended code. The intention was to understand whether and to what extent this may have impacted results. This relates to controls for ethnicity as a confound. The impact of the decision on rank order of *undecided* in the hierarchy of vaccination intention responses was also evaluated. However, none of the results obtained impacted the conclusions about any of the six research hypotheses. The additional, exploratory analyses were conducted using only the data provided by new mothers in this sample. This was in a bid to understand the hypothesised relationships in respect of vaccine uptake in practice, as opposed to intentions. The results and conclusions reached broadly matched those for intentions.

Chapter 9: Discussion – Quantitative Hypothesis Testing

Chapter Orientation: Focus and Scope

The implications of the quantitative results of hypothesis testing are described in the preceding chapter are discussed and interpreted below. The significance of the supplementary analyses are also considered.[17]

Vaccination Intention and Regret (H1 & 2)

On these results, the hypothesised relationships between intention to vaccinate and anticipated regret (both action and inaction) were well supported. Declared intentions (whether to fully or partially vaccinate or to refuse all vaccines) were moderately to strongly related to the type and amount of regret participants anticipated would result from the decision they made (see Quantitative results section, above). For these participants, the more regret that a mother anticipated experiencing if the decision made was not to vaccinate, and baby later contracted a vaccine-preventable illness (inaction regret), the more likely a "full vaccination" response. This relationship was strongest for expectant mothers. Conversely, mothers who expected to feel highest regret if they did vaccinate and baby suffered an adverse reaction (action regret), however rare, were more likely to endorse full or partial refusal of vaccines for baby.

These findings accord with the literature on the importance of regret for vaccination-specific decisions (Brewer et al., 2007; Chapman & Coups, 2006; Chou & Budenz, 2020; Gaube et al., 2019; Weinstein et al., 2007), as well as further supporting the central role of anticipated regret in decision-making more generally (Abraham & Sheeran, 2003; Diecidue & Somasundaram, 2017; Gilovich & Medvec, 1995). Although the analyses for these

[17] Limitations and avenues for future research are not outlined in this chapter, as these are set out in the integrated discussion section of the thesis, at Chapter 12.

hypotheses were purely correlational (i.e., there were no control variables or other causal identification strategies used), the results are consistent with the theory that anticipated regret has a causal effect on vaccination intentions, giving weight to the suggestion that regret anticipated during pregnancy and postnatally (action or inaction) will likely influence vaccination decisions and behaviours. These findings align with prior research results (Motta et al., 2021), and are also supported by the findings from the content analysis performed in this study (see Chapters 11 and 12, below), suggesting that extending the understanding of the nature and breadth of expectations of regret would be helpful to the development of effective vaccination campaigns, reinforcing the importance of ensuring access to accurate, factual information about the relative risks of disease versus vaccination.

Perinatal Distress and Discounting the Future (H3)

Notwithstanding a strong theoretical basis to expect that a relationship would be found between presence and strength of perinatal anxiety/depression on the one hand, and a tendency to discount the future on the other (Cáceda et al., 2014; Norman et al., 2017; Pulcu et al., 2014; Worthy et al., 2014), the hypothesised positive relationship between distress and discounting was not supported on these results. Neither expectant nor new mothers' scores on the MCQ were correlated with their scores on either the EPDS or the GAD-7 among these participants. In fact, the negligible relationships that were observed were negative rather than positive (that is to say, the higher the discounting score, the lower the score on the respective measures of perinatal distress), although the correlation was so low that little can be drawn from this observation, either about the sample or the wider population.

Whilst this may reflect a real lack of relationship in the population, it is also possible that limited variance or restricted range in this sample contributed to the outcome (Lakes, 2013). If participants reported symptoms of depression or anxiety at all, this was

predominantly at low to moderate levels of either perinatal depression or anxiety.[18] The proportions of mild, medium, or moderate levels of depression or anxiety broadly aligned with, or exceeded, reported figures in studies of diagnosed perinatal distress in the general population (Fairbrother et al., 2015, 2016; O'Hara & Wisner, 2014), suggesting on the face of it very little risk of threat to external validity. Nevertheless, it is important to acknowledge that diagnosis was not at issue here, and the tools used to measure distress are screening tools – reliable, valid ones, but non-diagnostic nonetheless. The numbers in each of these groups quite likely meant that the statistical power to detect an effect may have been smaller than intended when setting the sample size and greater variability in the sample to increase the numbers at the more extreme ends would have been preferrable. Similarly, there was also only limited range in total discounting scores on the MCQ[19]. This was broadly consistent with patterns of results obtained across other studies of discounting with non-clinical populations, or in respect of non-clinical controls (Lim & Bruce, 2015; Löckenhoff et al., 2011; Silva & Cisneros, 2017; Story et al., 2014; Tate et al., 2015; Vuchinich, 1998; Wang et al., 2016). The spread here was very minimal, which – given the makeup of the sample obtained (in terms of symptom severity), is unsurprising giving prior research findings. It is plausible that the limited variance for all three variables adversely affected the potential to find relationships in this sample that may exist in the wider population.

[18] Although the depression scores on the EPDS ranged from 0-24, the mean score was 7.65 (*SD* 4.48), below any of the various cut-scores validated indicative of possible depression (generally ranging from 10-13 across many studies). Whilst 151 participants (39%) scored above 10, only 48 (12%) scored over 14 ("moderate") and fewer still – 12 (3%) above 19 ("severe") . The GAD-7 scores ranged from 0 to 21, the average of 4.63 (*SD* = 4.01) contrasted with cut-scores of 5, 10, 15 as indicators of mild, moderate, and severe anxiety. 202 participants (52%) scored above the "mild" indicator. However, this dropped to only 59 (15%) above "moderate", and 17 participants (4%) fell in the "severe" range for anxiety.

[19] Possible MCQ scores range between 0-0.5. In this sample, the maximum score was 0.25, with the mean across all participants 0.02 (*SD* = 0.04).

Perinatal Distress and Anticipated Regret (H4)

Given support in the research literature for a strong relationship between psychological distress and negative emotive forecasting (Clore & Huntsinger, 2007; Corrigan et al., 2014; Grupe, 2017; Hartley & Phelps, 2012; Jung et al., 2014; Maner et al., 2007; Park et al., 2016; Paulus & Yu, 2012; White, Geraci, et al., 2016; Worthy et al., 2014), it was expected that higher scores on measures of perinatal anxiety and perinatal depression would predict greater anticipated regret of a decision and its consequences (whether action or inaction regret). Once again, however, these results did not support the hypothesised relationship. For anticipated action regret, the correlation with both perinatal depression and perinatal anxiety was so small as to be negligible. The association was only a little stronger for either form of distress and anticipated inaction regret, and none of the four associations observed was statistically significant. It may simply be the case that neither perinatal anxiety nor depression predict anticipated regret. However, and in light of extensive evidence of the effect of emotion on negative forecasting, it is again possible that limited variance impacted the results, where numbers in the severe or clinical ranges of either perinatal anxiety or depression were low. As such, a purposive sampling strategy to recruit a larger number of participants and include clinical populations could potentially yield more detailed and varied results (Osborne & Costello, 2019).

Causal Effect of Perinatal Distress on a Mother's Intention to Vaccinate (H5)

The hypothesised relationships between intentions and perinatal anxiety and depression can be seen as the central foci of the study, seeking to answer the question *"*does perinatal psychological distress (whether depression, anxiety, or both) affect an expectant or new mother's intention to vaccinate baby?". The data obtained simply did not support the hypothesised relationships between either depression or anxiety and vaccination intentions. The obtained parameter for depression was negligible, negative and was not statistically

significant. However, the findings relating to perinatal anxiety were unexpected – a relationship was observed, but in the opposite direction, anxiety seemingly increasing likelihood to vaccinate, rather than reducing it.[20] The findings suggest that not only is anxiety not responsible for low vaccine uptake by mothers for their babies, but it may make them more likely to do so.

This may reflect the position in the wider population – that is to say, anxiety may in fact increase likelihood to vaccinate. However, there are several other possible explanations for these results. First, and despite reaching the target number of participants according to the preregistered plan, numbers of participants experiencing higher levels of perinatal distress were low and may have impacted the outcome of the analyses performed. The results may also have been an unintended consequence of a focus on self-declared intention, rather than actual behaviours per se (which would have required a much larger pool of new mothers), where the actual follow-through on an in-principle decision or intention might more readily be impacted by low mood. Finally, it may be relevant that the majority of participants in this sample appeared to be pro-vaccination (based on responses to open-ended questions) and anticipated much more regret if they did not vaccinate and baby became ill, than if they did and baby reacted to the vaccine.

This last possibility may be the most significant limitation that prevents confident reliance on the results to suggest that anxiety increases vaccination intention, as would appear to be the case here. Given this general stance among the participants, that the observed relationship between anxiety and intention was positive aligns with prior research evidence that – for those most concerned about illness and, accordingly, already more likely to be pro-vaccination – anxiety may increase uptake when contemplating or confronting the fear of

[20] These findings held true when controlling for confounds, even adjusting for the difficulties encountered in statistically controlling for ethnicity. Supplementary analyses performed to understand whether similar observations could be made in relation to uptake (measured by baby's vaccination status) as for intentions led to the same conclusions.

circulating illnesses (Chan et al., 2015; Scherr et al., 2017; van der Weerd et al., 2011). Paradoxically of course, anxiety has also been reported to entrench anti-vaccination views, particularly with regards to novel vaccine safety, for those whose primary concerns relate to the prospect of adverse reactions (Bish et al., 2011; Henrich & Holmes, 2009; Savas & Tanriverdi, 2010). Where anxiety is linked to preferential processing of threatening information (White, Skokin, et al., 2016), the source of the greater perceived threat (disease vs. adverse reaction) therefore seems likely to enhance a person's existing position on vaccination. A lack of balance in the sample may have limited the ability to detect a dual effect of anxiety on intention. Anxiety likely intensifies already held fears. As such, another sample that included more mothers who were opposed to vaccination and/or generally fearing the adverse effects of the vaccine, could plausibly see anxiety decrease their intention to vaccinate.

Perinatal Distress and Intention: A Role for Temporal Discounting and Anticipated Regret (H6)?

The expected relationships between perinatal distress and intention to vaccinate were not observed in this study, neither overall (whether accounting for mediating effects as in H6, or otherwise – see H5), nor via the separate effects of temporal discounting or anticipated regret (action or inaction). It had been anticipated that increased levels of both perinatal anxiety and perinatal depression would be linked to lower intention to vaccinate, and that this would be due to the effects that both forms of distress were predicted to have on a person's valuing of the protection offered by a vaccine against a future disease, as well as the effects of distress on the regret anticipated to result from the decision on vaccination. However, as

for hypothesis 5, only a weak, positive relationship was observed between perinatal anxiety and vaccination intention, and none of the other expected relationships was observed.[21]

Given the findings for the earlier hypotheses which underpinned hypothesis 6, these findings were not surprising – neither anticipated regret nor temporal discounting were found to impact intentions in this sample, nor did distress have the expected effects on intentions. It is of course possible that these results are an accurate reflection of the position in the wider population. However, the same limitations discussed above in relation to hypotheses 3-5 in particular, are also potential contributors to these results: restriction in numbers of participants across a range of distress experiences, as well low numbers in the *undecided* category. These, and other limitations, are discussed further in the final chapter of the thesis, alongside suggested improvements, or directions for future research.

[21] The results obtained on adjusting the control methodology for ethnicity led to the same conclusions, as did supplementary analyses carried out examining these relationships in relation to uptake (vs intentions, measured by declared vaccination status for baby reported by new mothers). Neither reversing nor aggregating the rank order of the *partial* and *undecided* response options for vaccination intentions altered these conclusions.

Chapter 10: Content analysis – participants' perceptions

Chapter Orientation: Focus and Scope

Open-ended questions within the survey not only served to complement the quantitative findings but were useful to identify potential avenues for further exploration in future research. This chapter describes the content analysis process and findings, together with demographic information about the 411 participants who made up the sample under the less restrictive conditions for this section of the study. Quotes from responses of participants are provided to illustrate the nature and tenor of key themes and to provide insight into the type of information gathered and how it was grouped and coded. It can sometimes be helpful to include demographic information alongside participant quotes. However, there is a risk – especially where studies are circulated between friends or acquaintances on social media – that including such detail could make it possible for some readers to identify the individual who made a specific statement. In this study, participants were reassured of anonymity and advised of the specific, limited purposes for which demographic data was collected. As such, this level of detail is not provided alongside the quotes. However, the quotes reproduced were drawn from across the whole dataset, not from one or two individuals, and were selected irrespective of the nature or type of response provided, or view espoused.

Analytic Process

Content analysis was adopted for its flexibility, lending itself as readily to an inductive as to a deductive approach (Krippendorff, 2018; White & Marsh, 2006). The ability to identify codes and themes generated in this way permits quantitative summarisation of the findings, providing an additional means of identification of important avenues for future inquiry (Bernard & Ryan, 2010). Importantly, the term "theme" is used here to indicate the

major ideas identified in the coding groups. It does not purport to elevate the evaluative process here to thematic analysis per se.

All responses to the five open-ended survey items were coded using NVivo 12 (*NVivo*, 2018). These codes were developed through repeated familiarisation and review of the data, permitting creation of a preliminary coding framework of major themes and subthemes. Tentative early groupings were checked back against the data several times to evaluate their fit, before being finalised (retained, rejected, amalgamated with others etc.), named, and operationalised. In analysing participants' statements for patterns, attention was paid to variations between participants who were expecting and new mothers. This was to identify whether any important variation might exist between the two groups of relevance to this study, or that might otherwise justify a separate focus in future research. Consideration was also given to response patterns in function of a participant's declared vaccination intentions.

Participant Descriptives: Demographics and Vaccination Intentions

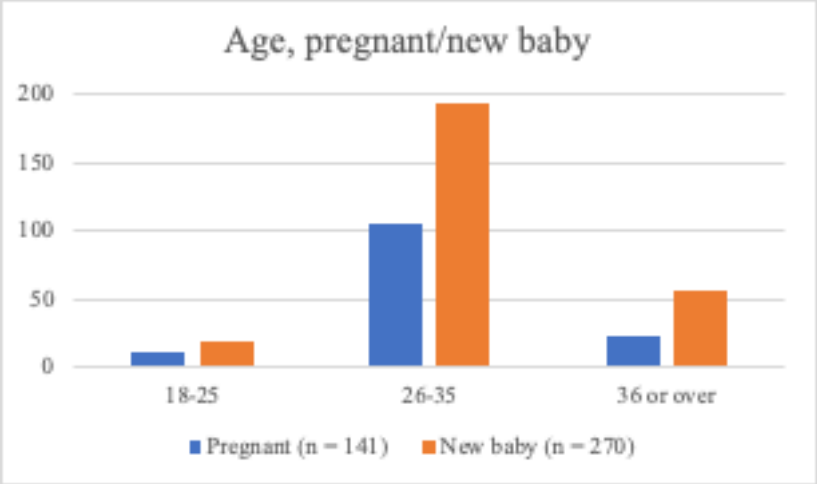
As for the quantitative part of the study, data would be retained and analysed where the above-described eligibility criteria were met (informed consent given; 18 or older; either expecting a baby (2nd or 3rd trimester) or a new mother (baby under 12 months); and living in Aotearoa or otherwise a New Zealand citizen). However, the additional preregistered requirements for the quantitative analyses (minimum 55% item completion on the depression, anxiety, regret and discounting measures) were not relevant to analysis of content of the open text items. Absent a justifiable reason to exclude these data, it was ethical that they be retained – participants expended time and effort expended to respond to each of the five items. As such, data from an additional 24 eligible participants were included, resulting in a total sample size of 411 for this section of the study.

Demographic Characteristics of Sample

The demographic characteristics and vaccination intentions of this sample pool are summarised below, with full details set out at Appendix 6 (see Table 6 to Table 9). 141 (34.31%) participants were pregnant, whereas 270 (65.7%) had a baby under the age of 12 months. As depicted at Figure 16, 299 participants (72.25%) were aged between 26 and 35.

Figure 16

Ages of Expectant and New Mothers in the Qualitative Sample



All participants but two (one expecting, the other a new mother) reported living in Aotearoa at time of survey completion. Of those in Aotearoa, 140 were pregnant and 269 were new mothers. The majority of participants (n = 335, 81.5%) identified as New Zealand European/Pākehā. The second largest ethnic group was New Zealand Māori (n = 41) representing 9.98% of the sample. See Table 8 for a full breakdown of the sample by ethnicity.

Participants' Reported Vaccination Intentions

Of the 411 participants, 323 (78.59%) intended to accept all vaccines for baby. 44 said they intended to refuse all vaccinations (44, 10.7%), and a further 33 (8.03%) said they would only accept some of the vaccines offered. Another 11 were undecided what they would do,

whether about some or all vaccines (2.68%). See Table 9, at Appendix 6, for a breakdown of intentions between expectant and new mothers.

Reported Sources of Influence on Vaccination Intention - Main Themes

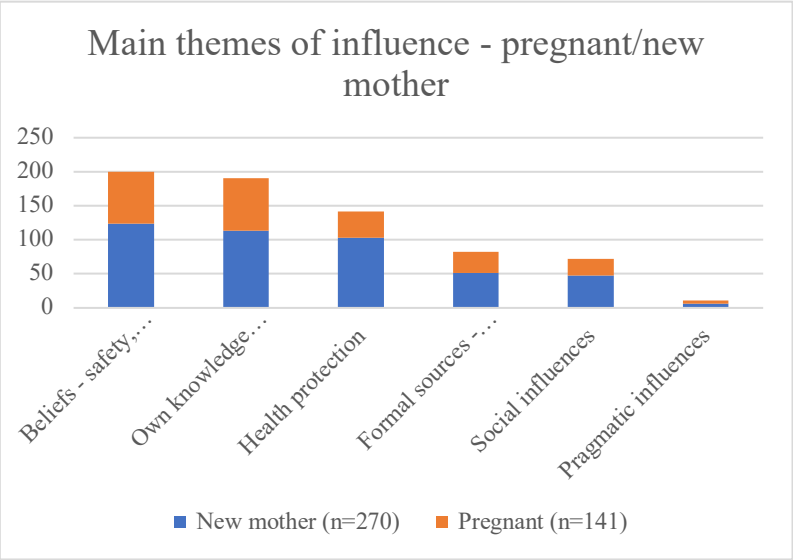
Consistent with the sizeable body of academic literature on vaccination hesitancy, factors cited by participants as relevant to their decisions were many and varied, underscoring the complexities involved when seeking to understand, accurately describe or explain vaccination behaviours. An analysis of the responses to the open question "How did you make your decision about vaccination for your baby – what were the things that influenced your decision?" suggested six broad themes:

- official sources (health officials and professionals);
- pragmatic influences (availability, childcare requirements; travel);
- social influences (whānau/family and others)
- beliefs (about safety, risk, and effectiveness);
- health protection; and
- participants' own knowledge or experience.

These groupings were relevant to participants across the dataset, irrespective either of whether the person was pregnant or a new mother, or of their stance on vaccination. The exception was the pragmatic influence category, only raised by participants who indicated an intention to vaccinate. Figure 17 depicts the number and distribution of participants' statements falling within one or more of these themes.

Figure 17

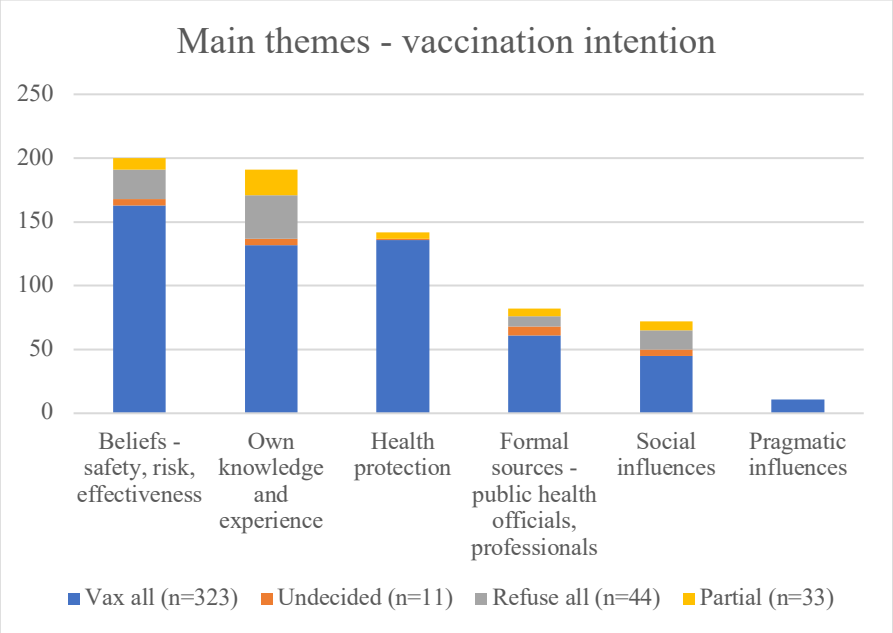
Main Themes, as Endorsed by Expectant and New Mothers



The relative numbers of participants endorsing statements pertaining to each theme in accordance with declared vaccination intention is depicted at Figure 18.

Figure 18

Main themes, by Vaccination Intention

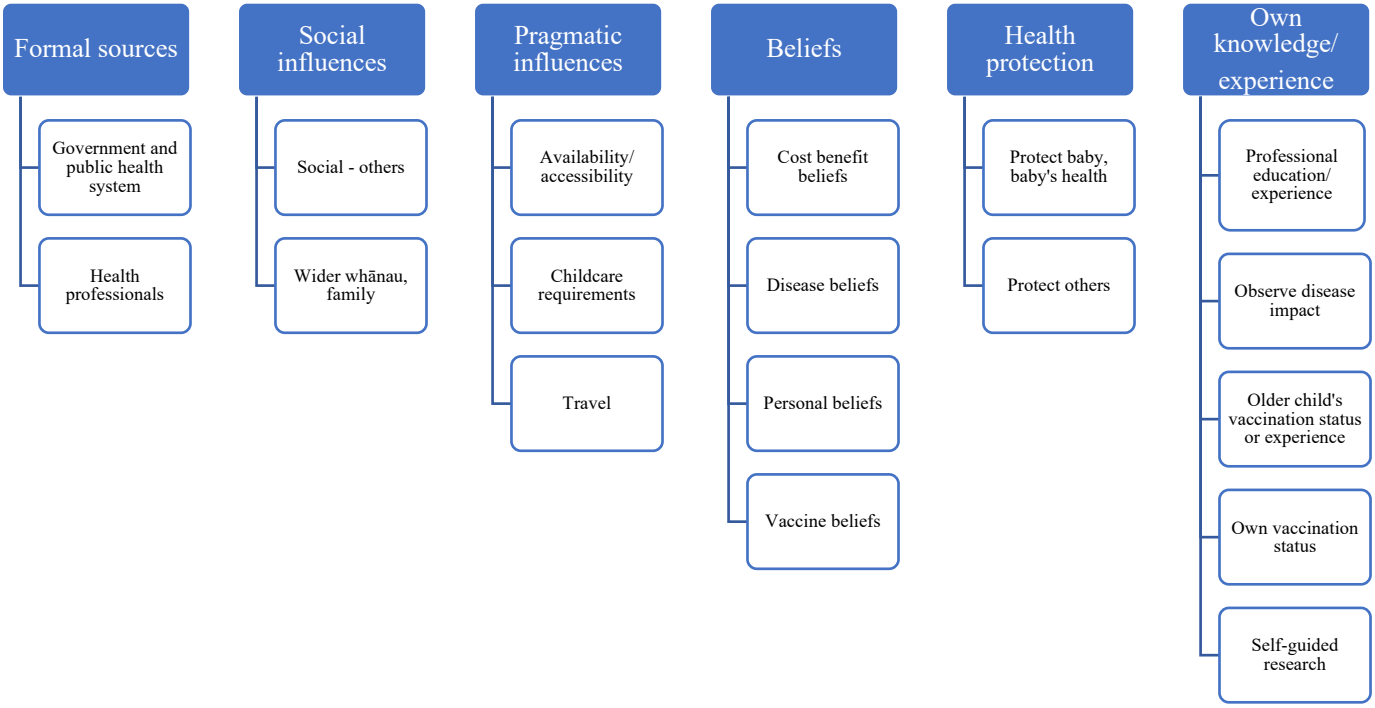


The most significant source of influence for participants – both in terms of the number of references coded to each category, and the number of individual participants who contributed one or more statements under each theme - was *Beliefs* (247 references out of a total of 1305, or 200 individuals of the total pool of 411). The next most important categories of influence were participants' *own knowledge or experience* (235 references; 191 individuals), and *health protection* (186 references; 142 individuals). *Formal sources of information or advice* and *social influences* followed (respectively 116 references, 82 individuals; and 100 references, 72 individuals). The *pragmatic influences* category was considerably smaller, with only 11 references, one from each of 11 contributing participants. However, the unique nature of the statements in this category, taken against the background of existing literature highlighting the relevance of access and availability in the field of vaccine hesitancy research justified retaining it as a separate category for discussion.

Within each of these themes, important contributing subthemes were also identified, permitting deeper insight into the nature of these sources of influence. These subthemes, and their relationship to the main themes, are depicted at Figure 19.

Figure 19

Sources of Influence – Thematic Framework



Each of these themes and their contributing subthemes are discussed in turn below, in order of the number of participants making statements that were coded against each one.

Beliefs – Safety, Risk, Effectiveness

Participants' own beliefs about vaccines – their safety, risk or effectiveness – were the most commonly referenced source of influence: over 247 references made by 200 participants. This theme encompasses all of a person's own views or opinions about science and medicine - particularly trust (e.g., "I value scientific evidence and medical expertise so I am confident in their safety"); beliefs about disease ("understanding how bad the infections can be."; "I'm more likely to have a car crash on the way to the vaccination than my child getting a preventable disease. A risk I'm prepared to take); and beliefs about vaccine safety, risk, or effectiveness (e.g., "Vaccines do not stop the disease, and can in fact make it worse in some cases."; "Vaccinations are proven to save lives and they are safe."). It also includes

wider personal beliefs such as the moral or social duty to vaccinate, or the right to make alternative lifestyle choices ("Introducing these things into our body is not part of our belief system"; "I believe that vaccination is a moral duty"), and the cost-benefit analysis and conclusions about vaccinating versus not vaccinating (e.g. "I understand my baby risks catching viruses regardless and there are risks with vaccinations but the risks of not vaccinating was more of a concern to me.").

This theme yielded important information about the type and nature of beliefs held by individuals who are either generally pro-vaccination, generally anti-vaccination, or who are still undecided about one or more vaccines, but overall showed the importance of existing beliefs for intentions.

Own Knowledge and Experience

The *own knowledge and experience* theme groups the broad array of personal exposure or events which participants consider were influential in their decision-making. This includes education and professional experience, ("I am a health professional (doctor) and therefore obviously understand the safety and efficacy of vaccination"; "I'm a nurse and a midwife, happy with evidence for some but not all") which overlaps with direct observation of the impact of disease ("Past experiences working with whānau who are anti vax and seeing their tamariki get really sick."; "Seeing babies suffer who have preventable diseases (I am a nurse)"; "Have travelled overseas and seen the effects of some of the diseases that vaccination prevents.").

For those participants with older children, the effect that a vaccine was considered to have had or, for many, the adverse effect that was avoided, was an important consideration. ("This child is my 4th and all the others have been vaccinated with no issues."; "My first child suffered terribly as a result of vaccine products"). A participant's own vaccination status is also included in this theme ("I received all my vaccinations growing up as a child, so I feel

confident that it is a safe choice for my child."; "I was vaccinated and still got whooping cough at age two. The doctors told my parents that if I hadn't have been immunised I probably wouldn't have survived it"; "my own chronic health issues and possible vaccination injuries affecting my brain and nervous system"). Although most of the 46 participants attributing importance to their own childhood experience adopted the same path for their child, four (2 vaccinated, 2 not vaccinated) reported taking the opposite decision for baby.

Finally, this theme incorporates personal research undertaken as part of the decision-making process. Research often informs a person's beliefs and, as such, there is some overlap between the *knowledge/experience* and *beliefs* categories. Ultimately, however, these descriptions of specific research conducted were classified as *knowledge/experience* to draw out the sources and nature of personal investigations undertaken to inform a decision. This theme therefore encompasses references to searches of scientific papers (in contexts other than academic or professional study or research, classified as *professional experience*), as well as vaccine manufacturer information leaflets and online information, and internet or social media searches (e.g., "Own 'research' i.e., internet searches of information regarding the safety vs risks of vaccines, social media influencers with specific medical backgrounds"; "Read research papers and books on vaccinations, the data sheets and medical books and articles on the illnesses the vaccines are for"; "Researching online - looking at info from both points of view"). The types and sources of knowledge or experiences which influence a decision on whether to vaccinate may be beneficial for future research or to help inform how or where to target information campaigns.

Health Protection

A desire to protect health (of baby, others and/or the wider community), was the next most-endorsed theme. Here, a combination of overt, surface level expression of worry for baby's wellbeing sat alongside underlying trepidation about the implications of others not

being vaccinated, for oneself, one's family; or for the wider community. This theme captures confident views on the necessity (or otherwise) of vaccines, as well as fears of potential consequences of not vaccinating. Examples of the expression of risk to baby's wellbeing include "I want my baby to be as healthy as possible. I don't want my baby to be susceptible to diseases that we can prevent."; "I wanted to do everything possible to help keep my baby safe. She was born through the help of IVF with donor egg. Minimising risk to her health and safety are very important to me and my husband"; "At the end of the day people that are for/against/on the fence about vaccines all have the same thing in common, they want the best for their child. We are not 'anti Vax' just simply questioning/looking for the best path for our whānau.".

Among participants intending to accept all vaccines, there was a strong sense of need to protect the vulnerable – in some cases specific individuals with compromised immunity – and the community as a whole ("protects not just my baby, but also those in the community who cannot be vaccinated"; "neighbours child has leukaemia and I want to help with herd immunity for her sake."; "I have a nephew who is immune compromised - I feel a responsibility to help protect people like him.") as well as a desire to play a part in the eradication of disease ("helping to prevent the resurgence of preventable illnesses and diseases"). Participants also expressed the belief that vaccination is a moral duty, their sense of responsibility a main driver for their decision: "It felt like the responsible thing to do!". However, as it could not be established whether such comments related to a sense of duty to baby, others or both, these references were not included in either the *protect others* or *protect baby* themes but rather were coded at the *personal beliefs* theme.

Formal Sources – Public Health Officials and Professionals

Formal sources of information and influence are often a focus of vaccine hesitancy research (Díaz Crescitelli et al., 2020; Dubé et al., 2013; Lee & Sibley, 2020a). Governments

and public health officials clearly have a vested interest in whether (and which) campaigns are working well, either to promote positive vaccination behaviours, or to help combat misinformation. *Formal sources* here firstly denotes those references made to the Government (Ministry of Health); to other official bodies such as the US Center for Disease Control (CDC) or the WHO ("Ministry of health recommendations/ website/ materials"; "WHO Recommended"); or to the public health system generally ("I trust our public health system in NZ"). The second subgrouping is that of health professionals such as doctors, nurses, midwives ("the doctors and nurses explained the importance and that strengthened my decision"; "Midwives, doctors and health professionals all recommended the childhood vaccines.").

Trust and pressure were raised in respect of both these subcategories ("I completely trust medical professionals."; "It made me think a lot. I feel I have been down the rabbit hole re- conspiracy theories and come full circle with my trust once again in the Western Medical System"; "There's a lot of pressure to just do it and do it neatly at the pre-selected times without any questions or wanting any information from nurse's and that. Get them done with no fuss, be good unquestioning and compliant or you're a bad parent can be the attitude some nurses and doctors have."; "Seeing the government almost forcing people to get vaccinated for a virus that has barely impacted NZers I find quite scary").

For the most part, participants referencing official sources as influential intended to fully vaccinate baby. However, for some, official or professional advice (or its interpretation) resulted in the opposite decision being taken - "I listened to my doctor but made the decision not to vaccinate". The perceived poor quality of information in the public health literature was also raised, others crediting health professionals or health information pamphlets with a decision to partially, but not fully vaccinate.

Social Influences

The *social influences* theme captures the importance of a decision-maker's social context, the wider whānau/families or friends that were considered influential in the decision-making. This included the medical or scientific backgrounds of parents or other whānau ("Family have worked in medical profession so I know how important the vaccinations are, and the risks"), others' vaccination decisions or status ("Me and siblings were all vaccinated"; "Most people do it."), as well as their spouse/partner's position on vaccines ("My husband and I discussed it and came to the decision together). For a minority of participants, pressure from others forced an unwanted decision ("Everyone saying i should and I'm stupid if i don't"). Reported negative experiences – of either vaccinating or contracting a preventable illness were also included in this theme ("Having a sibling that died of something you can now vaccinate against"; "Whānau who grew up on islands and passed young due to not having vaccines available to them at all"; "We have a family history of adverse reactions to vaccines").

Pragmatic Influences

The final theme relates to reported influences on decisions and intentions of a pragmatic or practical nature. Although a comparatively small category (cited by only 11 participants), these factors are of a very different nature from the others. Further, in the body of international vaccine hesitancy literature, pragmatic factors are considered significant contributors. As such, these were grouped as a separate theme, incorporating a need to work/the requirements of childcare centres, travel, and the availability and accessibility of vaccines (including their affordability) – "we made the decision to vaccinate them against Menz B and ACW And Y[22] - these are expensive and meant that we had to forgo some things

[22] These are optional vaccines, not on the scheudule in this country – although they are in some countries overseas – and available in Aotearoa at cost.

but at least we can rest assured the kids are covered. We have already started saving for latest baby to get theirs.".

Together, the six main themes and their various subthemes highlight the diverse nature of influences on vaccination intention, the overlap of influential sources for those both in favour of and opposed to vaccines, and underscore the challenge posed for researchers and officials seeking to combat misinformation and increase uptake.

Impact of Decision-Making on Participants

A secondary facet of the qualitative exploration related to the emotional or other personal impact participants experienced as a result of the decision-making process. Participants were asked "How did making the decision about vaccination impact you (if at all)?".[23] Whilst over half did not consider themselves to have been impacted at all ("It was a no brainer"), a sizeable minority reported a negative experience. This ranged from general distress, such as worry or anxiety – before or after the decision or vaccination itself ("You do worry sometimes that something might go wrong, so I do have heightened anxiety around vaccination time"; "There was still guilt and fear. Hoping it was the right decision, reminder of the huge life impacting decisions I have to make for my child"); distress about causing pain to baby ("I feel bad that my baby has to go through the pain of the jab but otherwise I remind myself how bad it could be if baby gets sick."); and stress arising from reading conflicting information ("Stressful! Either very scientific research papers or a tone of anti vax conspiracy. Hard to find simple easy to understand answers"). Distress was also reported as arising from others' reactions, whether medical professionals, friends, whānau, colleagues, or peers. These participants described negative judgement or evaluation, social pressure, tension

[23] Fewer data were available to explore this question, only 372 providing full responses. Some chose to leave the text box blank, while others wrote "N/A". It is possible that a N/A on non-response was equivalent to "no impact". However, with an anonymous survey, it was not possible to clarify whether this was the case, or if the item was instead skipped or not answered for another reason. As such no conclusions have been drawn about those missed or "N/A" responses.

or disagreements in relationships, avoidance by others, as well as personal guilt for not following others' advice ("I have been belittled and spoken to as if i am stupid by doctors"; "I felt guilty as I was bought up with an anti vax mother"; "My ex partners parents are anti vaxx and it caused quite a rift with his family unfortunately"; "Some friends don't want my daughter around their kids"; "It impacted my relationship as my husband does not believe we should vaccinate our child").

Other participants, however, considered the experience to have been a positive one, variously describing relief, a sense of empowerment or strength as a parent, and reassurance that they had taken the best possible course of action for baby ("Gave me comfort knowing I am doing all I can"; "It made me feel powerful and confident in protecting my baby"; "Makes us happy we are able to do what we believe is best for our family").

Whereas for some, decision-making can be a source of or contribute to distress, for others there is a clear positive impact - a sense of empowerment and agency that taking a decision may bring. It is important for professionals and policy makers to be aware of both potential responses. Given the heightened risk of depression and anxiety at the time decisions are most likely to be made, the additional stress of decision making may be detrimental for some. However, the positive benefits, if they can be capitalised on, may be a valuable tool to harness to encourage uptake.

Pandemic Effects: Relevance of COVID-19 for Decision-Makers

Health behaviours, including vaccination, often change substantially during a significant health crisis (Bults et al., 2015; Van et al., 2010). The ongoing and evolving COVID-19 pandemic provided a valuable opportunity to assess whether these participants perceived the global health emergency to have influenced their intention to accept routine vaccines for baby. Notwithstanding the focus of this study being on routine, scheduled immunisation, not the COVID-19 vaccine (which, at time of data collection was not available

for adults, much less children or infants), it was anticipated that both the health threat and the very public debate over the novel vaccine development could affect decisions. Participants were asked "Did the COVID-19 pandemic affect you and/or your decision about vaccinating your baby, and in what way*?".* Four patterns of responses across participant responses were –

- *No change* ("No, as we had already decided to vaccinate."; "No we decline vaccinating before the plandemic [*sic*]");
- *More entrenched* ("It made me more inclined to vaccine my pēpi because it had us in lockdown for so long I think it made everything so much more real for us"; "all the extra precautions people were taking to avoid spreading viruses/germs, as well as the reduced contact with people, made me feel more comfortable in following a delayed vaccinations schedule"*)*;
- *Other impact* – for example, COVID jab concerns ("worried about the long term effects of a new, quickly developed vaccine"); Disrupted routine care ("Made me cautious about taking baby to Dr's to be vaccinated in case of exposure to germs"); Illness-avoidant behaviours *(*"I had a firm stance that anyone who was unvaccinated (those who didn't have whooping cough vaccine specifically) could not see my baby until he had his first lot of immunisations. … the covid pandemic sort of impacted my decision around that and solidified me in wanting to keep my baby safe and healthy away from others germs); and
- *Covid? What Covid* ("What pandemic? There have been no extra deaths over the last ten years all cause mortality rates for countries claiming to have covid deaths. Flu, pneumonia, cancer, and heart disease deaths have all plummeted. if there is a pandemic it is of poor reporting".).

Most (310 of the 406 who completed this item – 73.35%) reported no change in their intentions. 244 maintained their pro-vaccination stance, and 34 their intention to refuse all vaccines. A further 74 (18.23%) considered their existing position to have been strengthened - 65 became more pro-vaccination, and 7 more opposed to it. Changes in position were rare (1.23%) – 2, previously undecided, said that they would now fully vaccinate. Of 3 initially intending to partially vaccinate only, 2 shifted to full refusal, and a third to full acceptance. A further 3 (0.74% - 1 undecided, 2 intending to fully refuse all vaccines) said they did not believe there is a health threat/pandemic at all, as such it could have no impact on intentions.

Vaccines of Concern to Participants Undecided or Intending Partial Vaccination

Participants who indicated an intention to refuse one or more vaccines, or who were otherwise undecided were also asked to *"please list any specific vaccines you intend to refuse*" or, *"if only [undecided about] some, please indicate which vaccines you are uncertain or are yet to decide about"*. The vaccine most often listed as a concern for participants intending to refuse vaccines (16) was for Rotavirus, with the next most likely to be refused (5) being the vaccine against varicella (chickenpox). Two more participants said that they would refuse all vaccines except one - the DTaP and MMR, Two more participants said that they would be adopting a different, delayed schedule for those vaccines they would accept.

This suggests that further research focusing on reluctance towards specific scheduled vaccines may be helpful to understanding whether to prioritise focused information campaigns about the importance, effectiveness, and disease risk by vaccine type.

Latent Themes – Fear and Confidence

Across the responses to all five open survey items, two latent themes – *Fear* and *Confidence* – were also identified. These result from a synthesis of explicit statements and

interpretation of less overt expressions of concern or certainty within the discussion. *Fear* encompasses the worries of soon-to-be and new mothers about baby's health - anxieties about disease, dying, illness and pain, or the risk of harm from vaccines ("I have seen babies with preventable diseases and I don't want it to happen to my baby"; "The diseases that vaccines prevent against are awful"; "all of the anti vaxers have made the decision harder (…) There is always that fear in the back of a mothers mind"). Trepidation about social ostracism (for mother or baby) was also evident where the decision taken went against whānau or social group norm, beliefs, or past practices, resulting in unwanted attention, pressure or tension and/or being unwelcome in certain social settings. *Confidence*, on the other hand, relates to participants' self-belief and trust in their own ability to make the best decision for baby. This is variously on the basis of knowledge, research and information gathered by formal (government/health professional advice and information; professional education and experience) and informal (whānau, friends or others; personal experience) means. "Confidence" incorporates an evident sense of safety and trust in a decision which repeats or reinforces existing knowledge and experience, such as participants' own vaccination status or an older child's response to vaccines. Examples of the expression of this theme include "I'm not an idiot who doesn't believe in science"; "I believe our bodys are strong and are made to fight disease's and foreign germs"; and "its a no brainer that i want the best for my kids and that includes health!! … why wouldn't i vaccinate to keep my kids safe!".

Chapter 11. Discussion – Content Analysis: Influencing Vaccination Intentions, and the Cost of Decision-Making

Chapter Orientation: Focus and Scope

The findings of the content analysis exercise are discussed in this chapter. This sheds light on New Zealand mothers' personal perspectives on the most important influences for their vaccination intentions and decisions, as well as providing valuable context for the quantitative results.[24]

Sources of Influence

Participants most often cited their own personal beliefs or opinions; their professional or academic knowledge or other experiences; and a desire to protect the health of others, whether of baby, the community or both as the main sources of influence on their vaccination decisions. Although raised less often, external sources included information or advice from public health officials or professionals; the persuasive importance of whānau, friends or others; and pragmatic factors such as accessibility. A recent New Zealand-specific study also reported on the influence of medical officials and mass media reports but noting that this was partially mediated by affect and individual cognitions (Thaker & Cook, 2022). Given the importance placed on social context in hesitancy research (Jarrett et al., 2015; Smith et al., 2017), this may seem somewhat surprising. Nevertheless, it remains that beliefs and knowledge are formed or developed against the background of a person's social context (Attwell & Smith, 2017; Bandura & McClelland, 1977; Joffe, 2010; Moffitt et al., 2022; Wiley et al., 2020).

[24] How these findings may help inform future New Zealand-centred vaccine hesitancy research, together with limitations of this aspect the project and suggestions for future avenues of exploration are outlined in the integrated discussion chapter

These findings underscore the importance of understanding personal beliefs and opinions already held by mothers as well as whether, when, or how these may change over time (Casigliani et al., 2022; Greyson & Bettinger, 2022). As such, maximising opportunities for exposure of all individuals across the lifespan to factual, scientific information, delivered in an accessible way by credible sources, may improve the likelihood that such beliefs are well-founded and fully informed (Porat et al., 2020). Health communication is a challenging but important task that demands careful attention and planning (Kappel & Holmen, 2019; National Academies of Sciences & Education, 2017), and the earlier the better given the greater challenges in changing beliefs, as opposed to imparting information when there are no pre-existing misconceptions (van Stekelenburg et al., 2021). This could include development of social media campaigns designed to target a full range of age and socio-cultural groups, as well as utilising traditional media and educational fora to increase visibility and access to reliable and valid information about safety or risk. Crucially, existing strengths of diverse peoples within a society should be harnessed from within, with appropriate consultation and participation, when considering effective and appropriate approaches to maximise health and wellbeing (Waitoki & McLachlan, 2022). Undeniably, targeting expectant and new mothers is important, yet many participants in this study had formed their opinions or beliefs from a very early age and well in advance of motherhood. It would therefore seem that a focus on increasing access to digestible, credible scientific information for all in Aotearoa, drawing on the wealth of expertise of community leaders, would be beneficial.

Next, at the individual level, a person's experiences and the personal importance or relevance of the sources of their knowledge must be considered. The clear importance credited by these participants to the influence of their health professionals suggests that GPs, midwives, Plunket nurses etc. are well placed to combat misinformation and enhance health outcomes. However, this presupposes that such professionals are themselves well-informed

and, in Aotearoa, there remains small minority of professionals who espouse anti-vaccination views, with lowest confidence in vaccines reported among midwives (only 65.1% expressing confidence) and alternative practitioners (13.6% confident in vaccines) (Lee, Duck, et al., 2018). Education in these groups has been highlighted as critical, but in the context of the COVID vaccine roll-out in particular, complaints have been laid for consideration by both the New Zealand Medical Council and the Health and Disability Commissioner against practitioners seeking to influence their patients against accepting the vaccine (Cassie, 2021; Medical Council of New Zealand, 2021). Again, community leaders have a pivotal role in assessing and counteracting misinformation, but this requires effective engagement at each stage of the process. Caution has also been urged in terms of the tone and format of messaging to maximise effectiveness and avoid recipients feeling alienated by what might be seen as scare tactics (Ashwell & Murray, 2020). The balance to be struck is a very delicate one.

Alongside professional advice, participants also cited childhood or family experiences alongside their own vaccination status as instrumental in the formation of strongly held beliefs about risk of disease, risks, or effectiveness of vaccination, as well as the morality of choices around vaccinating. Low uptake of available vaccines for expectant mothers is concerning in light of a link between a mother's actions for personal wellbeing and those taken for baby (Pointon et al., 2022). This underscores the importance of ensuring opportunities to access information and relevant, culturally appropriate health services and advice, through the lifespan and during pregnancy in particular. Research in the future could focus on the potential beneficial impact of increasing opportunities to access information about vaccines and their means of action in the body in the national curriculum (Skinner et al., 2000), as well studies to trial targeted approaches to health messaging by officials and

professionals across settings and varying communication platforms in Aotearoa (Motta et al., 2021; Waitoki & McLachlan, 2022).

The weight attributed to health protection by pro-vaccine participants in this study emphasises the persuasive value of evidence about risks on both sides, that is, the high risk of illness and consequences of contracting these preventable diseases, versus the low risk of an adverse reaction from vaccines (Benin et al., 2006; Davis et al., 2001; Tenrreiro, 2005; Wu et al., 2008). Certainly, existing research conducted during the pandemic on hesitancy suggests that appeals to personal and collective health risks is likely to be a beneficial avenue for health communicators seeking to encourage increased uptake (Motta et al., 2021). Health professionals and public figures or community leaders who interact on an individual level with decision-makers are well-placed to uncover misconceptions held about vaccines. Assisting the hesitant in conducting a cost-benefit analysis, highlighting the benefits for health and safety of baby - and others – as well as the comparatively low risks associated with vaccination are likely to be especially beneficial, highest when delivered by a trusted and respected source. Consideration should also be given to the use of *decision-aids* – interventions and tools that facilitate individual participation in and decisions on healthcare such as informational leaflets, videos, or web-based tools (e.g. COVID vaccine decision tools for adults and children - National Centre for Immunisation Research and Surveillance Australia (2021)), demonstrated as effective in lowering decisional conflict and increasing uptake (O'Connor, 2003; Shourie et al., 2013; Vujovich-Dunn et al., 2021; Wallace et al., 2006). Ideally, these would be constructed or adapted to maximise cultural relevance for the diverse population in Aotearoa.

Surprisingly, in contrast to most vaccine hesitancy research findings (Betsch et al., 2018; Larson et al., 2014; Rainey et al., 2012), these participants did not often cite pragmatic influences. It is possible that this is a direct consequence, or at least partly attributable to, a

publicly funded national vaccination programme administered locally at medical practices and schools which have had demonstrated success in increasing uptake, in Aotearoa and internationally (Health Promotion Agency, Te Hiringa Hauora, 2018; McClure et al., 2015; Paul & Fabio, 2014; Savulescu et al., 2017; Shapiro et al., 2017; Spencer et al., 2020). However, it is also plausible that, notwithstanding the lack of cost for vaccines, indirect financial implications or geographic or other barriers to access may play a bigger part for people or communities in Aotearoa that were not accessed by this survey. There remains merit in looking to international findings relating to factors that influence the success or otherwise of interventions designed to increase uptake when seeking to address stark health inequities (Gates et al., 2021). However, future New Zealand-specific vaccination research is necessary, and international studies can only provide guidance as to potentially relevant areas of inquiry. Future studies in this area would be beneficial to extend emerging, but currently very limited, exploration the nature and ways in which pragmatic barriers – real or perceived - may contribute to rates of uptake in Aotearoa, and in which communities or geographic areas (Tafea et al., 2022).

To Vaccinate or Not to Vaccinate: The Decision-Making Toll

Although many participants did not consider themselves affected by the vaccination decision-making process, a sizeable minority (39.25%) did report being impacted by it. For some, the experience was positive, conferring a sense of safety, empowerment, or confidence. For most of this group (63.7% of those who did consider themselves to have been affected) however, the experience was a negative one. “Negative” here ranged from mild worry to ongoing guilt or anxiety, to social ostracism in social circles, including whānau, friendship circles or other parents. It is clear that, for many, the process and its outcome is fraught, an additional stressor at a time of already heightened psychological vulnerability (Biaggi et al., 2016; Leach et al., 2017). The very need to make a decision may itself exacerbate distress

(Pittig et al., 2020; Treffers et al., 2017). This is a particular challenge where the decision itself or its consequences are incongruent with personal values (Chrystal et al., 2019), such as when pressured not to vaccinate by family members, or the decision feels like a forced choice, such as to access childcare or meet other participation requirements. The significance for vaccine intentions or uptake is clear when considering that distress - in the forms of anxiety or depression - is known to compromise decision-making capability (Blanchette & Richards, 2010; Paulus & Yu, 2012; Roese et al., 2009). These participants' identification of social networks and public health professionals as key sources of influence on intentions suggests that support and guidance from trusted and respected sources is essential. The dual benefits will be alleviation of psychological difficulty as well as improvements in decision-making capacity and quality. That the decision may be difficult or be stressful should be openly acknowledged, accepting the inevitability of competing evidence, but prioritising availability of factual and readily digestible information. Mothers' sense of achievement, relief and agency is apparent in the discourse. As well as shedding light on the dynamics of distress, these findings also provide insight into the psychological or emotional benefits associated with taking decisions on vaccination that may be helpful in planning targeted campaigns of action to increase vaccine uptake.

Pandemic Effects – Vaccine Intention During a Global Health Crisis

The results here did not suggest that either being pregnant, giving birth or having a young baby during the global COVID-19 health crisis dramatically impacted or altered New Zealand mothers' vaccination intentions. Most declared no change in thinking or that they held the same views as before, if more strongly. However, where these data are cross-sectional, reliant on participants' self-reports of any shift in their intentions, this can only be tentative evidence on the impact of the pandemic – and associated perception of risk – on vaccination intentions.

A small number of individuals indicated that routine medical appointments had been disrupted. Although this represented only a limited proportion of the overall sample, these reports aligned with domestic and international research highlighting the risk posed to well-child endeavours (including immunisation) in times of heightened health anxiety (Asmundson & Taylor, 2020; Ministry of Health, Manatū Haora 2020a; Nelson, 2020). Although outside the scope of the study (the COVID-19 vaccines being neither scheduled nor available for infants at the present time), a sizeable minority also expressed concern about the safety of these new vaccines. Trepidation was not only observed in individuals opposed to vaccination generally, but also extended to mothers who indicated they otherwise intended to accept all scheduled vaccines. These reported concerns mirror similar trends reported by researchers in Aotearoa and internationally, where the now available vaccines against COVID-19 are refused at consistently higher rates than those regularly scheduled (Feleszko et al., 2021; Kanozia & Arya, 2021). The effects of a campaign of misinformation (Hotez et al., 2021; Islam et al., 2021) – together with news of the undeniably tragic, yet statistically rare adverse events associated with one of the alternatives vaccines have spread rapidly across the world (Thaker, 2021a). The phenomenon that is the internet, and social media in particular, has expedited dissemination of mistruths (Basch et al., 2021). Tactics such as designing sophisticated websites and leaflet campaigns that adopt official organisations' styles or colour palettes (Pearse, 2021), or the widespread circulation of anti-vaccination video testimony at legislative hearings on vaccine powers overseas (Charter, 2021) all lend an air of credibility to even the most extreme views (Basch et al., 2021; Loomba et al., 2021; Rzymski et al., 2021).

Fear and Confidence

The two major undercurrents running through the discourse, cutting across every theme were *Fear* and *Confidence*. Although two seemingly competing concepts, these may

better be understood in this context as sides of the same coin. Both fear on the one hand, and confidence on the other, play a powerful role in guiding decision-makers (Angie et al., 2011; Chou & Budenz, 2020; Fenton-O'Creevy et al., 2011; Ferrer & Mendes, 2018).

Whether participants intended to accept all, some, or no vaccines, fear of the consequences of the decision were key drivers for these expectant and new mothers, most anxious to do what is right for their child. The fear that their decision might be a mistake is a clear source of distress for many participants, coming in various guises. That this experience is shared by pregnant women and new mothers and is not linked to a particular category of intention (i.e., accept all, some, or no vaccines) is testament to the weighty nature of the decision, and the stress or distress it engenders in those tasked with making it. It underscores the critical importance of ensuring sufficient time and a safe space to discuss those fears and concerns, to facilitate reassurance and provision of accurate information. In this way, distress can be avoided or alleviated and confidence – the second latent driver of intention identified here – can be fostered. This matters, because confidence – whether this is faith in the ability to rely on one's own knowledge and experience, trust in the information available via the wide range of means on offer, or in belief in officials and professionals – is equally potent in influencing decisions. In some circumstances, confidence was scaffolded on academic or professional knowledge grounded in sound, scientific evidence, or otherwise on advice from educated, informed professionals. However, for others, that confidence comes from gut instinct or anecdotal reports unsupported by science, or from real but isolated and statistically improbable experiences that distort perception of risk.

Chapter 12: Integrated Discussion, Conclusions and Looking to the Future

Chapter Summary

This chapter brings together the findings from both parts of this study, outlining the respective and cumulative contributions to current research and potential clinical implications. Limitations are highlighted here, and suggestions made for future research projects.

Summary of Key Findings

Anticipated regret was found to be strongly related to vaccination intentions. Mothers who expected to feel more regret if they did not vaccinate baby, and baby later got sick (anticipated inaction regret) were more likely to intend to vaccinate. On the other hand, mothers anticipating more regret if they did vaccinate, and baby reacted badly to the vaccine (anticipated action regret) were more likely to intend not to vaccinate. The observed relationships were strong and statistically significant, supporting hypotheses 1 and 2.

It was also expected that a link would be observed between perinatal depression or perinatal anxiety and temporal discounting (a person's tendency to attribute increasingly less value to an outcome or reward as time until its receipt increases). However, the results did not support this hypothesised relationship (hypothesis 3). Nor did levels of either perinatal depression or anxiety significantly predict anticipated regret (action or inaction) (hypothesis 4).

When controlling for plausible alternative causal influences on vaccination intention (specifically SES and ethnicity), the results supported a causal role of perinatal anxiety. The observed direction of that relationship was opposite to that predicted, however – higher anxiety predicted higher intention to vaccinate. With regard to depression and intention, although the statistic obtained was negative, the relationship was not statistically significant.

Hypothesis 5 was therefore not supported on these results. As these predicted relationships were not observed, it followed that neither anticipated regret not temporal discounting were found to be mediators of the hypothesised relationship (hypothesis 6).

In terms of what participants themselves considered to be important influences on vaccination intentions, their own beliefs, knowledge or experience, and a desire to protect health (baby's, the family's, and the community) were most frequently cited. Formal sources of information were also significant for many, followed by social influences. Pragmatic factors were only mentioned by a small minority in this sample, likely reflecting the demographic of the sample ultimately obtained. Two broader themes - fear (being risk – from disease or vaccines; or of adverse social implications of a decision) and confidence (in the decision and foundation on which it rested) were evident across each of these categories of influence. This suggests that a person's perception of what is "right" or logical, as well as their lifetime experiences or education (formal or otherwise) and how this impacts what they consider to be important to ensure the promotion of health are essential components of their decisions on vaccination. Understanding these factors, together with what a person fears may result from their decision, and how confident they are that they are correct, is essential to explaining hesitancy. The difficulty for health professionals, policy makers, and health campaigners is the idiosyncratic nature of these factors, meaning that a very time consuming, individualised approach is likely most effective.

Turning to the experience of vaccination decision-making, whilst many participants did not consider themselves impacted by this process at all, for those who did, the experience was predominantly a negative one. This was the case, irrespective of whether the decision was to vaccinate or to refuse vaccines. Participants reported stress, anxiety and either worries about or experience of others' reactions and opinions, or social alienation (from friends, social and professional circles, or family). So too was the weight of responsibility,

particularly in the face of competing information. For a sizeable minority, however, making the decision was a positive exercise. For these individuals, empowerment and relief were key themes. For those intending not to fully vaccinate, certain vaccines posed more of a concern than others, the vaccine against rotavirus most often cited for rejection.

The pandemic (still in its early stages at the time recruitment and data collection were completed, and prior to the availability of a vaccine against COVID-19) was not considered by many of the participants to have impacted their intentions. For those who did consider it important to their decision-making, most said their existing position on vaccines had been reinforced (whether pro or anti). A small number reported it influencing a change in position. Only very few – all opposed to vaccines – believed that COVID was a hoax. These findings may well have been different if the study were repeated now, when COVID has finally spread throughout Aotearoa as it has in the rest of the world, and in face of the widespread publicity of the very vocal anti-vaccine/anti-mandate protests.

Albeit COVID-specific, the volume of vaccine-related research generated since the start of the pandemic provides invaluable information about the effectiveness of vaccination campaigns that can be used more generally. Key criticisms of official health information delivered during the COVID-19 pandemic included the ineffectiveness of principal routes of delivery for many sections of the population in Aotearoa, and specifically those already more vulnerable (Latif, 2021). As he stepped down from his role as Director-General of Health, Dr Ashley Bloomfield said his greatest regret concerned inadequacies in communications with the most vulnerable in this country (1 news, 2022). A longitudinal survey was started early in the pandemic to track changes and developments in New Zealanders' attitudes and intentions towards the COVID-19 vaccine (Thaker, 2021b). Interim results reported in 2021 revealed deficiencies in the communication strategies adopted. The hesitant most often cited a need for more vaccine safety data and for more information from the government, with less than half

having heard about or seen the government campaigns on television, and less than a third on radio, in newspapers or social media. Researchers and academics proposed creative solutions. These emphasised targeting individual groups, rather than nationwide approaches, increasing content meaningfulness, focusing on relevant delivery platforms and spokespersons, as well as recruiting the most influential community or group leaders to advise on and promote pro-vaccine messaging (Beall et al., 2021; Crampton et al., 2020; Dutta et al., 2020; Fernandes, 2021; Habersaat et al., 2020; Motta et al., 2021; Vogel et al., 2021). Māori in Aotearoa have long and well-established practices in terms of health and crisis management which should be harnessed in collaborative consultation to ensure effective and respectful engagement (Waitoki & McLachlan, 2022). The importance of cultural relevance for effective and equitable health promotion is far from a new concept (Dutta, 2007, 2018), drawing on strategies that have been identified – and, crucially, ensuring input from those communities most impacted – will be essential steps in reconceptualising routine vaccine information messaging and in effective health promotion and protection for the entire population (Ratuva et al., 2021; Waitoki & McLachlan, 2022).

Study Limitations

One limitation for the quantitative part of the study may have been the relatively limited variance for several of the key variables in this study, specifically perinatal distress, discounting, ethnicity, and vaccination intention. Most of these participants reported anxiety and depression below clinical levels, had low discounting rates, and only a small proportion intended not to vaccinate their children. It is likely that this led to lower power than might otherwise have been the case had there been more variance in these key variables. Future studies could therefore consider a purposive sampling method to ensure more participants across the breadth of these variables of interest.

First, mean anxiety and depression scores fell below clinical levels for either perinatal distress category, with limited data at the more elevated or extremes of perinatal distress. The proportion of participants in this sample scoring above the cut-off levels for both the EPDS and the GAD was in fact higher than prevalence of diagnosed disorders reported in the general population, if not higher than other studies where self-reported symptoms of distress are the focus: a total of 39% (151) scored above the lower EPDS cut off of 10, 12% (46) above moderate, and 3% severe. On the GAD-7, 52% scored above mild, 15% above moderate and 4% (12) above severe. Reported prevalence of (diagnosed) anxiety and related disorders or depression during the perinatal period in the general population varies considerably depending on the definition of the particular condition, and the period for which it is reported. Estimates range from 7% for severe perinatal depression to nearly 20% when including depression in its milder forms. Reported prevalence of perinatal generalised anxiety varies even more, from as low as 6% to 17.1% (Fairbrother et al., 2015, 2016; O'Hara & Wisner, 2014). In a sample of this size, even the proportions obtained equate to a very small number of people, and potentially reduced the power to detect an effect.

Similarly, there was little spread in discounting tendencies among these participants, the vast majority favouring delayed over immediate reward. This may have adversely impacted the ability to detect effects or conclusions relating to more extreme discounting. In addition, too few participants were recruited in some ethnicity categories to either be representative or, in some instances, to even permit the statistical software to reliably perform the planned analyses. The recruitment strategy also demonstrates the pitfalls in obtaining adequate ethnic representation in a sample using a broad and non-specific method, without expressly targeting particular groups.

Furthermore, there was ultimately little balance between numbers of participants in each of the respective intention response categories, the vast majority intending to fully

vaccinate, only 10% and 8% respectively endorsing the refuse all and partial options. Participants still undecided were the smallest group (2.58%), yet on the very basis that they are yet to make a decision due to worries and concerns, are potentially most susceptible to the influence of mood fluctuation. Measuring intention on a continuous scale ("how likely are you to intend to vaccinate baby"), rather than a categorical one, may have been preferable here and have increased the range of responses obtained. This imbalance towards more pro-vaccination views in the sample may also have been influenced by the study's timing. Recruitment and data collection coincided with the early stages of the pandemic when health fears were heightened (as were fears around vaccination). Given the extraordinary circumstances that participants were living through, with significant and constant attention in the media and social media to real and present health risks and on vaccine development and safety, it is possible that the data obtained was impacted by the timing of the study. For example, the very strong skew towards pro-vaccination, and overall high anticipated inaction regret scores for the majority of the sample, as well as the clear focus on future outcomes, may all have been inflated by the timing. Conducting the study at different point in time could therefore conceivably yield different results.

Another limitation relates to study design. The focus on self-declared intention, as opposed to behaviours in practice, may also have impacted the possible conclusions about the effect of perinatal distress (particularly depression) on vaccination intentions, where action in practice may more readily be impacted by low mood than intention itself (Pomp et al., 2010; Shafran et al., 2019). Supplementary, exploratory analyses were conducted on the data obtained here. However, where only new mothers were in a position to indicate what they had done in practice, as opposed to intended to do for baby, these analyses were restricted to a smaller subsample of 274, well below the number indicated by the power analyses as sufficient to achieve adequate power in order to observe an effect. Furthermore, as for the full

sample, the range of depression (or anxiety) experienced in this subgroup was limited, with only small number in the moderate or severe range. As such it is not clear how more extreme levels of anxiety or depression might impact vaccine uptake. It is conceivable that, above certain levels of distress, vaccination uptake will be adversely impacted irrespective of the nature of perceived threat or intentions in theory.

Finally, drawing causal conclusions from observational, cross-sectional data can always be difficult and, at best, are inferences. Whilst every effort was made to adequately identify plausible alternative explanations, it is always possible that other unidentified factors were at play and biased the estimates of effects (whether towards or away from zero). Another possibility may be that vaccination decision-making affects anxiety and depression. It may of course simply be the case that the results obtained do reflect the position in the wider population. This would mean that the sample size had sufficient power to observe an effect and the fact that the hypotheses were not supported was simply because the facts do not support the claims. Nevertheless, there remain clear avenues for future exploration to extend the present findings, mindful of the limitations identified as a result of conducting this research and analyses. Pursuing these avenues in the future would be justified given the sound theoretical basis for the hypotheses and that they could be conducted avoiding the pitfalls that became clear during the analysis phase of this study.

Learning from the Study and Directions for the Future

To test the results obtained here, the simplest step would be to conduct a straightforward replication of the quantitative elements of this study with a much larger sample size, using the existing analytic strategy and code. By extending eligibility to an international pool of potential participants, using online participant recruitment platforms, power to detect an effect would be increased and it would be a useful way to see if the results

obtained here were replicated, thereby increasing confidence in their being representative of the population.

Ideally, any future study should be designed to target participants more specifically across the full range of distress experiences, as well as increasing depth in terms of vaccination intentions and temporal discounting tendencies. It is likely that the recruitment strategy, driven in large part by the constraints of conducting research during the initial phases of the pandemic and lockdowns, could be improved on. Recruitment solely via social media can result in like-minded individuals sharing with each other. In addition, expectant and new mothers experiencing significant depression or anxiety seem unlikely to have wanted to begin or complete a survey of this nature. By making adjustments to ensure minimum numbers across key variables, range would increase. With greater range, the same analyses of response patterns could be expected to yield a very different pattern of results. To increase variation in the ranges of experiences of perinatal depression and anxiety, it may be necessary to recruit from clinical populations. Increasing numbers in each of the ethnicity categories controlled for is also essential to avoid the computational difficulties that arose here due to the low numbers in certain categories controlled for. Higher numbers and better distribution in a future sample would increase power to detect effects, and confidence in the representativeness of the results obtained.

Alteration to the measurement of intention, changing from a categorical to a continuous scale would be another, relatively small, shift that could potentially see quite different results – for example, the intention item could ask participants how likely they are to vaccinate baby, a scale of 0-100 anchored by “not at all – I will refuse all vaccines” to “absolutely – I will accept all vaccines for my baby, without exception”.

Another option would be to design a longitudinal study, also using a larger pool of new mothers, to evaluate any relationships between declared intentions, identified levels of

depression or anxiety, and eventual uptake in practice. Longitudinal designs, with care to also control for confounds, can also overcome some of the difficulties posed with drawing causal inference from cross-sectional data (Gangl, 2022; VanderWeele et al., 2020). Pragmatic barriers in some parts of Aotearoa should also be a particular focus of future research of this nature, again requiring recruitment across a targeted section of society. This would be a particularly important step in any future exploration also seeking to elucidate the impact of such factors on low vaccination in Aotearoa as anxiety or depression may compound their effect on access to vaccines.

Of particular salience in the wake of the COVID-19 pandemic would be to incorporate an evaluation of the effects and implications of mandating vaccines. In some countries vaccine mandates for routinely scheduled immunisations pre-dated the pandemic (Vanderslott & Marks, 2021), either generally, or for school entry specifically. However, in others, the COVID-19 vaccine was the first to be required by law triggering vehement and sometimes violent backlash (Martin & Vanderslott, 2021). The effects and implications of compulsory vaccination policy are not a new focus of research (Brelsford et al., 2017; Chirico, 2018; Holzmann & Wiedermann, 2019), but have received increased attention since the pandemic. The results of these studies are mixed, suggesting that whilst numbers may increase in the short term, the longer-term implications and potential backlash – against governments and health professionals, may have serious consequences for compliance with health campaigns and the reputation of public health authorities and vaccination more broadly (Bardosh et al., 2022; Cheng & Lepe, 2021; Druml & Czech, 2022; Karaivanov et al., 2022; Smith, 2021). A new study could include a focus on the effects of mandating and the increased availability or visibility of anti-vaccination messaging, and its effects on perinatal anxiety in particular.

Where the primary aim was to test quantitative hypotheses, the depth of the qualitative evaluation in this study was circumscribed. However, this study did not purport to be a true qualitative or mixed-methods research project and one advantage of the approach was the ability to capture reported beliefs, understandings, and experiences of a relatively large number of mothers – 411 for this part of the study, more than is often feasible in purely qualitative research. A clear avenue for future exploration would be to extend the thematic findings by designing a purely qualitative project, with a more socio-economically and ethnically diverse sample of Aotearoa's mothers, that may lead to a better understanding of the range of the crucial drivers of hesitancy and/or uptake and guide tailored interventions that may not only increase vaccination rates, but also alleviate the stress and distress of decision-making.

Clinical and policy implications

Despite the results obtained and identified limitations of this study, there are several important clinical and policy implications to be noted. These all broadly strengthen the case for additional support for mothers during pregnancy and postnatally as a means to improve not only maternal mental health, but population health more widely, not least given the known difficulties with detection of distress in the perinatal period (Signal et al., 2017, Barber et al., 2017). One of these relates to the nature, content, and means of communication of health information to the public – particularly to mothers. Another concerns avenues for further research to guide targeted health information interventions with mothers, in particular those experiencing clinically elevated levels of distress who are undecided about or struggling with the decision on whether or not to vaccinate their baby.

Undeniably, the critical timeframe for vaccination decision-making and, for half of all childhood vaccines, their administration coincides with the risk period for perinatal anxiety and depression. The cumulative evidence from the research literature summarised and

reported here overwhelmingly suggests that there is a sound basis to expect that psychological distress impacts decision-making (Blanchette & Richards, 2010; Clore & Huntsinger, 2007; Corrigan et al., 2014; Grupe, 2017; Hartley & Phelps, 2012; Jung et al., 2014; Maner et al., 2007; Park et al., 2016; Paulus & Yu, 2012; Roese et al., 2009; White et al., 2016; Worthy et al., 2014). Research also supports the proposition that decision-making on vaccination can itself contribute to new or heightened distress (Biaggi et al., 2016; Ferrer & Mendes, 2018; Leach et al., 2017; Pittig et al., 2020; Shourie et al., 2013; Treffers et al., 2017). Many participants in this study reported stress, worry and anxiety due to needing to make a decision on vaccination for baby. Given research findings on the implications for healthcare – including immunisation – in presence of psychological distress (Borowsky et al., 2003; Druss et al., 2002; Hassouneh & Dunsiger, 2022), routinely screening for psychological distress, and increased assistance or support for decisions on vaccination could potentially improve uptake (especially in those either undecided or concerned about both perceived risks of vaccines and risk of disease), as well as see a possible reduction in distress.

These results also provide support for the proposition that the outcome that a mother expects will cause most regret will influence vaccination intentions (Brewer et al., 2007; Chapman & Coups, 2006; Lagoe & Farrar, 2015; Leder et al., 2014; Weinstein et al., 2007). Despite the unexpected direction of the observed anxiety-intention relationship, the results in this study also support the notion that heightened anxiety (even at sub-clinical levels) about the most feared outcome affects intentions in the opposite direction of that outcome (Hartley & Phelps, 2012; Jung et al., 2014; Maner et al., 2007; Maner & Gerend, 2007). Simply put, most mothers in this sample feared the effects of disease, much more than an adverse vaccine reaction, and the presence of mild to moderate anxiety increased their intention to vaccinate. It could be that a more evenly distributed sample (in terms of the type of regret anticipated)

would see anxiety also decrease intention to vaccinate where the individual's greater concern was the vaccine, rather than the disease.

On this basis, understanding the source and nature of the regret anticipated, and providing targeted and timely reassurances on an individual level will be important. Recognising the implications of delayed vaccines may also be an indicator of stress or distress to be investigated, and support in the form of additional information and reassurances may be warranted in respect of specific vaccines not as long-established (Erchick et al., 2022; Lee et al., 2018; Lee & Sibley, 2020; Mijović et al., 2020; Nganga et al., 2019). Capitalising on the influence of regret by emphasising the consequences most likely to be considered important to individuals, with attention to careful, accurate messaging of personal and collective risk from disease, will likely be powerful tools (Christy et al., 2016; Cox et al., 2014; Hamama-Raz et al., 2016; Leder et al., 2014). Recent research in Aotearoa on the COVID-19 vaccine specifically found trust in health officials to be significantly associated with vaccine intention, but that this relationship was partially mediated by affective and cognitive attitudes (Thaker & Cook, 2022). Coercive tactics may have unintended and long-term consequences for trust in the health system and compliance with public health measures (Bardosh et al., 2022; Smith, 2021; Ward et al., 2022). As such careful, targeted messaging, from credible sources for the particular audience, is critical to the success of campaigns intended to increase uptake (Ashwell & Murray, 2020; Betsch, 2011; Betsch et al., 2012; Chou & Budenz, 2020), alongside attention to individual affect and cognitions (Thaker & Cook, 2022).

Concluding Remarks

What a mother expects to regret most – acting to vaccinate, or deciding not to – is a good indicator of vaccination intentions. This proposition is deceptively complex, however. What underlies that expected regret, for example knowledge, beliefs, a sense of responsibility

or worry, is different for every person, may be difficult to shift, and invariably impacts the nature and intensity of regret. It suggests that reassurances and support, sharing in some of the decision-making burden and helping to shoulder some of the responsibility for the decision may be as – or more - important than a purely informational strategy about the respective merits or risks of vaccination.

Given the majority of participants in this study tended to favour full vaccination and, taken together with a very low number of participants with scores at the extreme end of the anxiety scale, the results suggest that anxiety (at least at lower levels) may in fact contribute positively to protective health behaviours where the perceived threat is from disease. However, it is plausible that anxiety in a person who fears an adverse reaction from a vaccine will increase attention to this perceived threat, and therefore be less likely to vaccinate, whether partially or fully. What is unclear and would merit further exploration in the future is how the most extreme levels of anxiety – or depression – impact on intentions as well as behaviour in practice (i.e., uptake), for example whether decision paralysis may become a factor at a certain level of distress, irrespective of the nature of perceived threat.

Overall, the fear that a decision might be the wrong one for baby is a source of significant distress for many mothers, one that may both exacerbate and be exacerbated by perinatal anxiety. That this experience is shared by expectant and new mothers and not linked to a particular category of intention (i.e., accept all, some, or no vaccines), is testament to the weighty nature of the decision. It underscores the critical importance of ensuring sufficient time and a safe space to discuss those fears and concerns, to provide reassurance alongside accurate information. Well-timed information, delivered by a respected source may be able to alter the decision-making course and outcome. In this way, distress can be avoided or alleviated and confidence – the second latent driver of intention identified here – can be fostered.

Notwithstanding the results obtained in this study, the cumulative evidence from content analysis and an extensive review of the literature justify further exploration and support the contention that improvements in maternal mental health may also improve physical health outcomes – not only for baby, but for the wider population. Increased, routine screening for perinatal distress – anxiety in particular, and providing individualised, targeted support for mothers making decisions on vaccination would likely see multiple benefits – identifying more mothers at risk, and alleviating vaccine decision-making as a source of stress at what may already be a difficult time. It is hoped that this study may prompt further research in this area, as well as help to justify an increased focus on and funding to improve perinatal mental health in Aotearoa.

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Appendices

Appendix 1: Survey materials

Survey information sheet

Kiwi mums and childhood vaccine decisions

Kia ora, ni sa bula, talofa lava, ahlan, ni hao and hello!

Thank you for reading about my study. This information set out on this page sets out in detail what is involved if you decide to participate.

If you are either pregnant (in your second or third trimester), or you've given birth to a baby in the past 12 months, I'd love your help! Some extra requirements are that you are 18 or older, and you are either living in New Zealand or you're a New Zealand citizen (wherever you might be in the world right now).

Read on to find out more. If it sounds like something you're happy to be a part of, click the "I consent" button at the end of this page to start the survey.

SURVEY INFORMATION
This is a formal invitation for you to participate in this research.

Project Description
This aim of this project is to learn more about the thoughts and decisions on vaccination by people who are pregnant or have recently given birth Aotearoa. In particular, we are interested in the relationship between feelings and intentions or decisions to vaccinate or not to vaccinate baby.

Researcher Introduction: a bit about me
I'm a Clinical Psychology student at Massey University in Auckland, in my second year of the Doctoral programme. My particular research and clinical interests are in the area of maternal mental health and wellbeing. My supervisors for this project are Drs Matt Williams, Joanne Taylor, and Stephen Hill.

What's involved?
If you did decide to participate, you will be answering some questions about your views on vaccination and how you have been feeling recently. These are mostly multi-choice but for some of them, you can choose to add more information if you like. We'll also be asking some general questions to confirm your age and whether you are a New Zealand citizen or resident, and about your ethnicity and household income too.

However, your answers will not be connected to you at any time, and you won't get a "score" – the information you provide is important to understand patterns, but this is not in any way an evaluation of you personally.

The whole survey should take you about 15-20 minutes, depending a little on how much additional information you decide to include. You can also pause and return to it at a later time. If you decide for any reason you don't want to participate after all, you can stop at any point, no questions asked! If you do pause or stop, make sure that you close the tab or your screen if you have any concerns about privacy.

Are there any risks?
The questions in this survey are taken from real screening "tests" about mood and about how people approach decisions. There is a small chance that some of the questions could make you uncomfortable. The questions could make you wonder about your own thoughts, feelings or mood, or even about those of someone you know or care about.

If you are worried that the questions may be distressing, please do not proceed with the survey. If you do start, and you feel uncomfortable, you can stop at any time. There is no obligation to complete the survey. The support information will be repeated in an automatic message if you do decide to withdraw.

If you did find the questions upsetting or concerning, or if you wanted to know if you meet criteria for a mood disorder, or if you just wanted more information, we recommended contacting your GP, Plunket, or the Perinatal Anxiety and Depression Aotearoa (PADA). The websites for PADA (https://pada.nz/) or Plunket (https://www.plunket.org.nz), are a good place to start. Information about additional national helplines can also be found on the Mental Health Foundation website (https://www.mentalhealth.org.nz/get-help/in-crisis/helplines/). This information, and links to online versions measures that some of the questions come if you are interested in taking them are provided again when you exit the survey, whether you finish it or not.

Participant Identification and Recruitment
We will be recruiting participants by advertising on social media, word of mouth, email distribution and other electronic advertising, as well as targeted advertising through charitable support and social groups such as Plunket and PADA.

For every survey taken, Massey University will make a donation of $2 each to both Plunket and Perinatal Anxiety and Depression Aotearoa (PADA). These are organisations that provide support, information and education for individuals, their whānau and family, as well as to professionals.

As an additional incentive, you can also choose to enter the draw for a chance to win one of two $100 "prezzy cards" to spend as you choose.

Data Management
If you do take part, you won't need to provide any contact information if you don't want to. Even if you would like to know the study results, or you want to be entered into the prize draw, we will only ask for an email address and this won't be able to be linked back to your answers, at any time. Once the study is over, and the prize winners and study information has been sent out, all contact information will be deleted.

The data itself will be anonymous at all times. Initially, it will only be accessible by the project team. Once it has been analysed, data anonymity will be checked again, and then it will be made available online, in an open-access data repository. This de-identified data will be stored indefinitely and available to other researchers or members of the public from this repository. No identifiable data will be included, nor kept.

Participant's Rights

You are under no obligation to accept this invitation. If you do decide to participate, you have the right to:

- decline to answer any particular question or questions, or
- to decide to stop answering questions at all, at any time; and
- ask any questions about the study at any time.

Project Contacts

Sarah Kember
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Dr Matt Williams
M.N.Williams@massey.ac.nz

This project has been reviewed by the Massey University Human Ethics Committee: Northern, Application NOR 20/63. If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact:

Dr Fiona Te Momo (Committee Chair)
Massey University Human Ethics Committee: Northern
Phone: 09 414 0800 (extn 43347)
Email: humanethicsnorth@massey.ac.nz

Ngā mihi, ni sa moce, nofo a, tofā soifua, ila al-liqa, bai bai la, bye and thanks again!

Sarah Kember

Surveys (main survey and contact information survey)

Main survey

Start of Block: Informed consent

[Informed consent]
Thank you for reading this far!

Please choose one of the two options below to either confirm you are happy to go ahead as a survey participant, or to exit the study before going any further.

By clicking the "I consent" button below, you acknowledge that: - you have read this information sheet and understand what is involved in this study;
- you have been informed about the nature and source of the questions in the survey;- your participation is voluntary;- you understand there is a potential for some people to find some of the questions distressing;- you are aware that you will not receive a "score" or any diagnosis;
- you know that you can choose not to answer any question and that you can stop responding to the questions at any time and for any reason.

- ○ I consent, please begin the study
- ○ I do not consent or wish to participate

Skip To: End of Survey If Thank you for reading this far! Please choose one of the two options below to either confirm... = I do not consent or wish to participate

Skip To: End of Block If Thank you for reading this far! Please choose one of the two options below to either confirm... = I consent, please begin the study

End of Block: Informed consent

Start of Block: Demographic information

[Age]
Please select your age range from the list below:

- ○ 17 or under
- ○ 18 to 25
- ○ 26-35
- ○ 36 or over

Skip To: End of Survey If Please select your age range from the list below: = 17 or under

[Citizen]
Are you a New Zealand citizen?

- Yes
- No

Skip To: Ethnicity If Are you a New Zealand citizen? = Yes

Skip To: Residence If Are you a New Zealand citizen? = No

[Residence]
Are you living in New Zealand at the moment?

- Yes
- No

Skip To: Ethnicity If Are you living in New Zealand at the moment? = Yes

Skip To: End of Survey If Are you living in New Zealand at the moment? = No

[Ethnicity]
Which ethnic group or groups do you belong to?

- NZ Māori
- NZ European/Pākehā
- Samoan
- Tongan
- Cook Islands Māori
- Niuean
- Chinese
- Korean
- Indian
- Other - please state (e.g. Fijian, Australian, Dutch, Japanese, Tokelauan)
  _____

Think of this ladder as representing where people stand in Aotearoa/New Zealand. At the top of the ladder are the people who are the best-off financially. At the bottom are the people who are the worst-off financially. **Where would you place yourself on this ladder?** Please

click on the rung to place a dot where you think you stand at this time in your life, relative to other people in Aotearoa/New Zealand.

End of Block: Demographic information

Start of Block: Vaccination information

Please select the option which applies to you:

- I am currently pregnant
- I have a baby (or multiples) aged 12 months or younger

[Due date]
What month is your baby (or babies) due to be born?

- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December

[Birth date]
What month was your baby (or babies) born in?

▼ January ... December

Which of the following is most true for you (please select one option):

- ○ I intend to fully vaccinate my baby
- ○ I intend to partially vaccinate my baby (please list any specific vaccines you intend to refuse) _____
- ○ I intend to refuse all vaccinations for my baby
- ○ I am still undecided

Skip To: Influencing factors If Which of the following is most true for you (please select one option): = I intend to fully vaccinate my baby

Skip To: Medical reason If Which of the following is most true for you (please select one option): = I intend to partially vaccinate my baby (please list any specific vaccines you intend to refuse)

Skip To: Medical reason If Which of the following is most true for you (please select one option): = I intend to refuse all vaccinations for my baby

Skip To: Medical reason If Which of the following is most true for you (please select one option): = I am still undecided

Which of the following is most true about your baby's immunisation status right now (please select one option):

- ○ My baby has received all vaccinations due by age
- ○ My baby has received some, but not all vaccinations due by age
- ○ My baby has not received any vaccinations due by age

Skip To: Intention - mothers If Which of the following is most true about your baby's immunisation status right now (please selec... = My baby has received all vaccinations due by age

Skip To: Intention - mothers If Which of the following is most true about your baby's immunisation status right now (please selec... = My baby has received some, but not all vaccinations due by age

Skip To: Intention - mothers If Which of the following is most true about your baby's immunisation status right now (please selec... = My baby has not received any vaccinations due by age

[Intention - mothers]
Which is most true about your intentions for vaccination of your baby?

- o I intend to fully vaccinate my baby
- o I intend to partially vaccinate my baby (please list any specific vaccines you intend to refuse) _____
- o I intend to refuse all vaccines for my baby
- o I am still undecided about some or all of the vaccinations (if only some, please indicate which vaccines you are uncertain or are yet to decide about) _____

Skip To: Influencing factors If Which is most true about your intentions for vaccination of your baby? = I intend to fully vaccinate my baby

Skip To: Medical reason If Which is most true about your intentions for vaccination of your baby? = I intend to partially vaccinate my baby (please list any specific vaccines you intend to refuse)

Skip To: Medical reason If Which is most true about your intentions for vaccination of your baby? = I intend to refuse all vaccines for my baby

Skip To: Medical reason If Condition: I am still undecided about ... Is Not Empty. Skip To: Have you been advised by a doctor tha....

[Medical reason]
Have you been advised by a doctor that your baby must not receive a vaccine or vaccines for any reason?

- o Yes - please describe and state if this applies to all vaccines or any specific vaccine(s) _____
- o No

Skip To: Influencing factors If Have you been advised by a doctor that your baby must not receive a vaccine or vaccines for any r... = Yes - please describe and state if this applies to all vaccines or any specific vaccine(s)

Skip To: Influencing factors If Have you been advised by a doctor that your baby must not receive a vaccine or vaccines for any r... = No

[Influencing factors]
How did you make your decision about vaccination for your baby – what were the things that influenced your decision?

_____

[Decision impact]
How did making the decision about vaccination impact you (if at all)?

_____

[COVID impact]
How did the COVID-19 pandemic affect you and/or your decision about vaccinating your baby?

_____

End of Block: Vaccination information

Start of Block: EDPS

In this second block, there are 10 statements.[25] Please choose the answer that best describes you **over the past seven days**

I have been able to laugh and see the funny side of things
- o As much as I always could
- o Not quite so much now
- o Definitely not so much now
- o Not at all

I have looked forward with enjoyment to things
- o As much as I ever did
- o Rather less than I used to
- o Definitely less than I used to
- o Hardly at all

I have blamed myself unnecessarily when things went wrong
- o Yes, most of the time
- o Yes, some of the time
- o Not very often
- o No, never

[25] Edinburgh Postnatal Depression Scale. Cox (2019); Cox and Holden (2003); Cox et al., (1987). Scale reproduced with permission of the authors who allow use in this way, conditional on respect to copyright by providing appropriate credit to authors and source.

I have felt worried and anxious for no very good reason

- No, not at all
- Hardly ever
- Yes, sometimes
- Yes, very often

I have felt scared or panicky for no very good reason

- Yes, quite a lot
- Yes, sometimes
- No, not much
- No, not at all

Things have been getting on top of me

- Yes, most of the time I haven't been able to cope at all
- Yes, sometimes I haven't been coping as well as usual
- No, most of the time I have coped quite well
- No, I have been coping as well as ever

I have been so unhappy that I have had difficulty sleeping

- Yes, most of the time
- Yes, sometimes
- Not very often
- No, not at all

I have felt sad or miserable

- Yes, most of the time
- Yes, quite often
- Not very often
- No, not at all

I have been so unhappy that I have been crying

- Yes, most of the time
- Yes, quite often
- Only occasionally
- No, never

The thought of harming myself has occurred to me

- ○ Yes, quite often
- ○ Sometimes
- ○ Hardly ever
- ○ Never

End of Block: EDPS

Start of Block: GAD-7

GAD[26] intro In this set of questions, you are asked to do a similar task. There are 7 statements.

Over the past 2 weeks, how often have you been bothered by the following problems?

	Not at all	Several days	Over half the days	Nearly every day
Feeling nervous, anxious or on edge	○	○	○	○
Not being able to stop or control worrying	○	○	○	○
Worrying too much about different things	○	○	○	○
Trouble relaxing	○	○	○	○
Being so restless that it's hard to sit still	○	○	○	○
Becoming easily annoyed or irritable	○	○	○	○
Feeling afraid as if something awful might happen	○	○	○	○

End of Block: GAD-7

Start of Block: Anticipated regret

[26] Spitzer et al. (2006). Copyright – free to use.

In this section, two scenarios are presented, one for each item. Please consider the scenario and how much regret you would feel **about that decision**, then indicate on the scale, from 0 to 100, where on the scale best represents that feeling.

Note: this is not a question about how upset or sad you might feel about what happens, it is a question about whether you would regret the decision you made. For example, in a scenario where injury happens on holiday, the injury itself may be upsetting, but where one person might regret going on holiday at all, another person might only regret the accident, not the decision to go on holiday.

If I decided to vaccinate my child and s/he had a severe adverse reaction requiring medical attention, I expect I would feel:

	Absolutely no regret — The most regret possible
	0 10 20 30 40 50 60 70 80 90 100
Adverse reaction to vaccine	

If I decided not to vaccinate my child and s/he later got sick from an illness that a vaccine could have prevented against, I would expect to feel:

	Absolutely no regret — The most regret possible
	0 10 20 30 40 50 60 70 80 90 100
No vaccine and got sick	

End of Block: Anticipated regret

Start of Block: Temporal discounting

The next blocks of questions are about how you think about the present and the future. **Please note: the questions are designed to help us understand your preferences only, no money award will be made, regardless of the selections you make here.**
For each item, please choose the response that fits best for you.

[ITEMS OF THE MONETARY CHOICE QUESTIONNAIRE (KIRBY ET AL., 1999) OMITTED FOR COPYRIGHT PURPOSES.]

End of Block: Temporal discounting

Start of Block: Prize draw/results notification

Prize/Results Would you like to either enter the prize draw, and/or be notified when the study report is available? (selecting yes will take you to a separate survey to ensure your contact details remain separate from your responses to the survey. You will be able to choose to enter the draw, or be notified of the results, or both).

- Yes please - take me to the external survey
- No thank you

End of Block: Prize draw/results notification

Second, separate survey: Prize draw and results notification

Start of Block: Default Question Block

Q3 Would you like to enter the prize draw to win one of two $100 prezzy cards?

- Yes please - you can reach me on this email _____
- No thank you

Q2 Would you like to be notified of the results of the study when they are available?

- Yes please - you can contact me on this email _____
- No thank you

End of Block: Default Question Block

Appendix 2: Advertising

Advertising Content

Vaccination and maternal mental health in Aotearoa

SOCIAL MEDIA/EMAIL CONTENT/FLYER

KIWI MUMS AND CHILDHOOD VACCINES
New and soon-to-be mums are important decision makers on vaccination for their babies. How individuals think and feel impacts decision making but little research has been done in Aotearoa specifically to date. As part of my doctoral degree in clinical psychology, I'm doing a study about how these thoughts and feelings affect decisions on vaccines in Aotearoa/New Zealand.

If you are currently pregnant (in your second or third trimester) or if you have given birth to a baby in the past 12 months, I would love your help. You need to be 18 and either live in New Zealand, or be a kiwi overseas. You can read more and, if you like, get involved here [URL/QR code], or drop me a line –sarah.kember.3@uni.massey.ac.nz

The feel-good factor? for every completed survey, Massey will be donating $2 each to two great charities - Plunket and to Perinatal Anxiety and Depression Aotearoa (PADA). You can also choose to enter the draw to win one of two $100 "prezzy cards".

Thank you! Ngā mihi nui!

Sarah

SUGGESTED NEWSLETTER INSERT (For PADA, Plunket and GPs/other organisations)

VACCINATION DECISION-MAKING AND MOTHERS' MENTAL WELLBEING

Have you ever wanted to participate in research? Would you like to play a part in increasing our knowledge about vaccination in Aotearoa? Sarah Kember is carrying out this study, as part of her qualification as a Doctor of Clinical Psychology, with the help of her supervisors Drs Williams, Taylor and Hill.

The study is about the decisions that people who are pregnant or have recently given birth to a baby make about vaccination, and how thoughts and feelings can affect those decisions. If you are currently pregnant or have had a baby in the last 12 months, Sarah would love your help. As long as you are over 18, and you are living in New Zealand, or are a NZ citizen overseas, you can participate.

Whatever your thoughts, or even if you are still undecided, you can take part. You would answer some questions in an online survey, and your participation would be entirely anonymous. Your answers will not be linked to your name or any contact information you may provide.

If you would like to know more, you can get in touch with Sarah by email - sarah.kember.3@uni.massey.ac.nz.

The feel good factor? For every completed survey, Massey will be donating $2 each to two great charities - Plunket and to Perinatal Anxiety and Depression Aotearoa (PADA). And to say thanks to you personally, you can also enter the draw to win one of two $100 “prezzy cards”.

NEWSLETTER INSERT (short version)

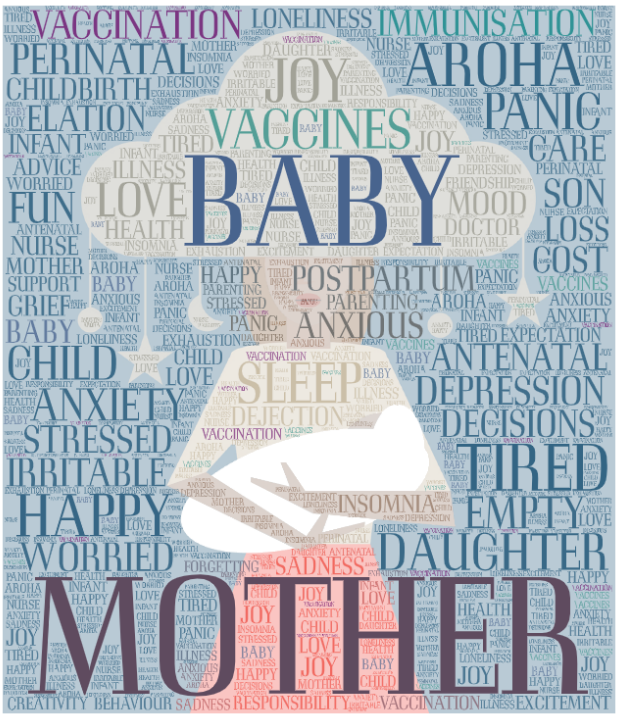
VACCINATION DECISION-MAKING AND A MOTHER’S WELLBEING

If you’re pregnant, or have had a baby in the past 12 months, Massey researchers would love your help. The is study about the decisions that parents who have given birth in Aotearoa (and those who soon will be) make about vaccination, and how their thoughts and feelings can affect those decisions.

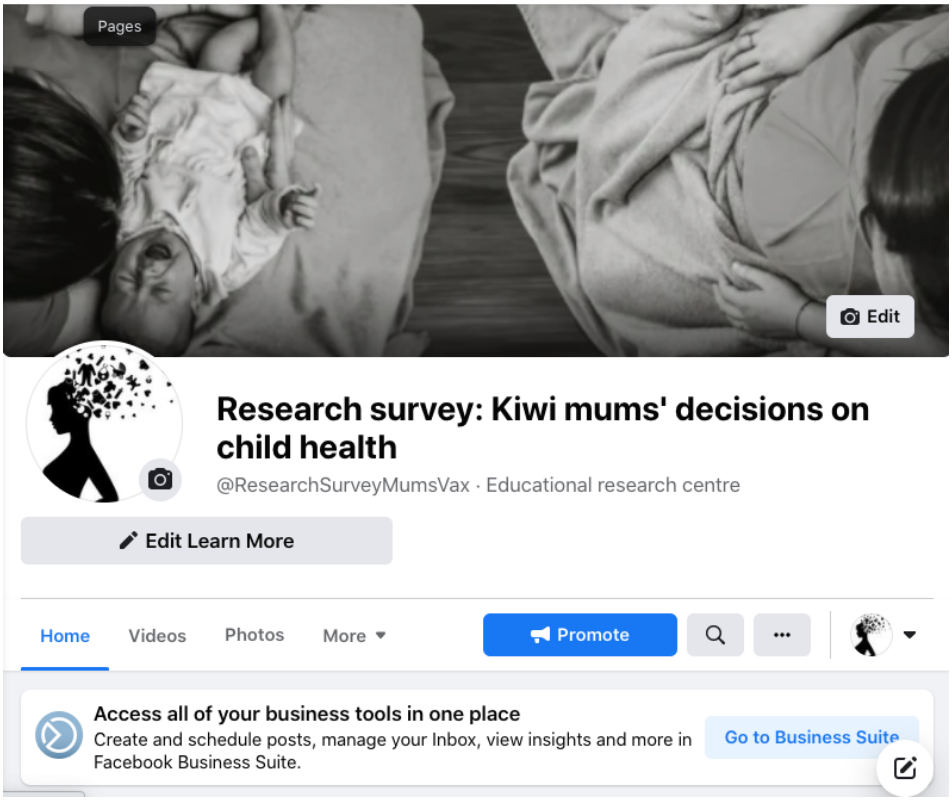
What’s involved? If you’d like you participate, you would answer some questions online anonymously. It will take you roughly 15-20 minutes. More information here about the study is set out here [SURVEY URL], or feel free to write to sarah.kember.3@uni.massey.ac.nz.

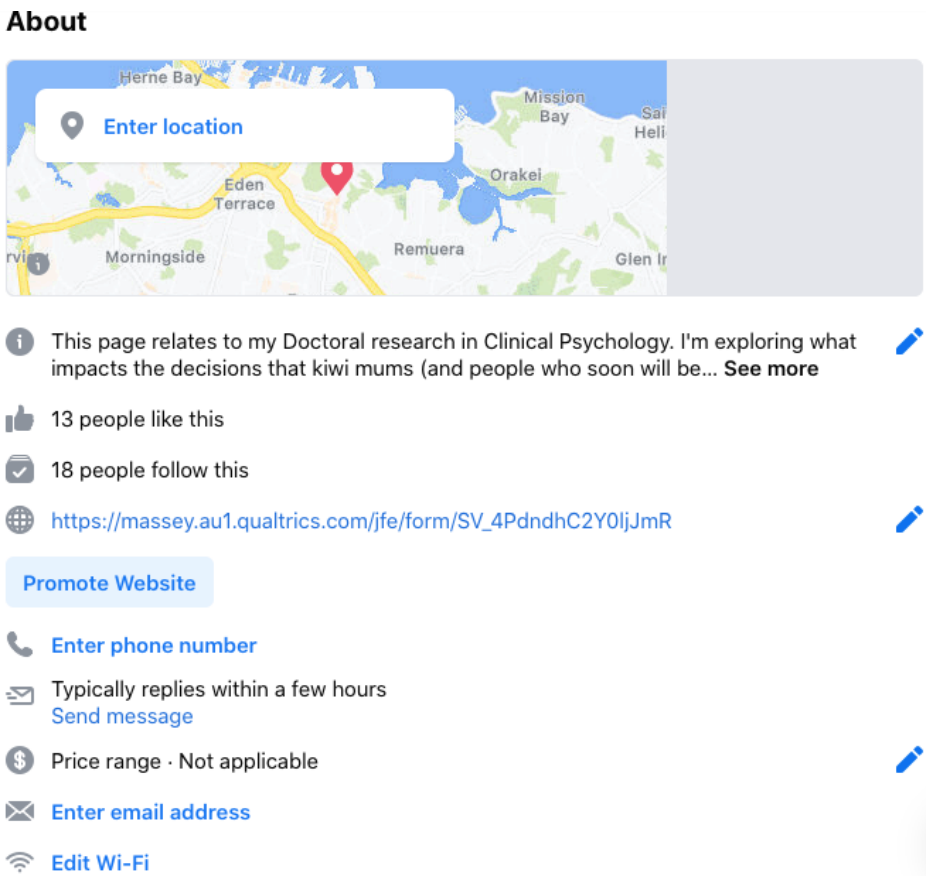
Your answers will not be linked to your name or any contact information you may provide at any time. The feel good factor? For every completed survey, Massey will be donating $2 each to two great charities - Plunket and to Perinatal Anxiety and Depression Aotearoa (PADA). And to say thanks to you personally, you can also enter the draw to win one of two $100 “prezzy cards”.

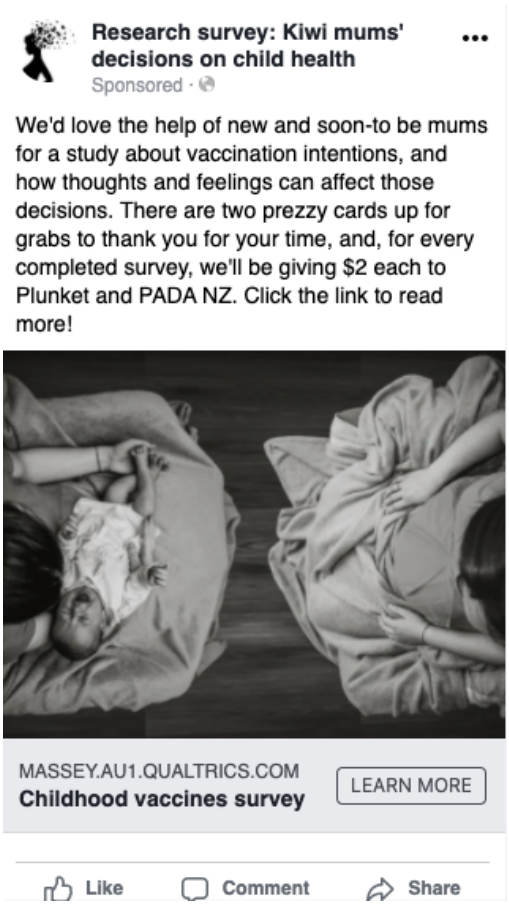
Accompanying image – created in WordArt online



Facebook Page and Advertisement






Research survey: Kiwi mums' decisions on child health
Sponsored ·
We'd love the help of new and soon-to be mums for a study about vaccination intentions, and how thoughts and feelings can affect those decisions. There are two prezzy cards up for grabs to thank you for your time, and, for every completed survey, we'll be giving $2 each to Plunket and PADA NZ. Click the link to read more!
MASSEY.AU1.QUALTRICS.COM
Childhood vaccines survey
LEARN MORE
Like
Comment
Share


Performance
NZ$274.84 spent over 29 days.
Link Clicks
1,108
Reach
30,976
Cost per Link click
$0.25
Activity
Post engagement
1259
Link clicks
1108
Post reactions
71
Post comments
44
Post shares
16
See less

Appendix 3. OSF Preregistration

For convenience, the preregistration is set out below, exactly replicating the publicly available document at https://osf.io/hzunr/.

Study Information

Title
Vaccination in Aotearoa: the role of anticipated regret, temporal discounting and maternal mental health

Authors
Sarah Kember (Supervised by Drs Matt Williams, Stephen Hill and Joanne Taylor) – Massey University, NZ

Contact: sarah.kember.3@uni.massey.ac.nz

Description

The central aim of this study is to examine the case for the causal effect of perinatal psychological distress – pre and postnatal depression or anxiety – on vaccination intentions and behaviours. Specifically, the strength and direction of any correlation between vaccination behaviours and depression and/or anxiety will be evaluated, while controlling for plausible confounding variables.

An additional, related aim is to qualitatively explore individuals' own understanding of the wider influences on their decisions and behaviours. If, as is expected, the results of this study support a causal link between perinatal psychological distress and vaccination behaviour, this will provide invaluable evidence justifying an intensive focus on and expenditure of resource to improve mental health for women in pregnancy and postnatally. Beyond intrinsic benefits to women and, consequently, for the child and family as a whole, this could precipitate improvement in vaccination rates and population health overall. These outcomes are considered an essential contribution to vaccination knowledge, rendered all the more urgent by the ongoing global health crisis. COVID-19 is undeniably an international health emergency, but so too are rising rates of endemic disease in the face of decreased confidence in or accessibility of vaccines. The New Zealand-specific context is crucial to population health in Aotearoa given evidence of the role of societal factors on vaccination, including culture, traditions, history, government campaigns or media coverage).

Hypotheses

Quantitative hypotheses

Based on the theories of temporal discounting and anticipated regret, the following relationships are expected to be observed:

1. Mothers who anticipate greater "inaction regret" (i.e., regret they expect to experience if they choose not to vaccinate and their child later contracts a vaccine-preventable disease) will be more likely to intend to vaccinate their child. This will be demonstrated by a negative[27], statistically significant relationship between inaction regret and vaccination intention.
2. Mothers who anticipate greater "action regret" (i.e., regret that they expect to experience if they choose to vaccinate and their child has an adverse reaction to a vaccine) will be less likely to intend to vaccinate their child. This will be demonstrated

[27] See footnote 2, above.

by a positive, statistically significant relationship between action regret and vaccination intention;[28]

3. Experience of depression and anxiety will result in a bias toward discounting the future. This will be demonstrated by a positive, statistically significant relationship between temporal discounting (scores on the MCQ; Kirby et al., 1999) and:
    i. perinatal depression (scores on the EDPS); and
    ii. perinatal anxiety (scores on the GAD-7;)

   (Lempert & Pizzagalli, 2010; Paulus & Yu, 2012).
4. Higher levels of depression and anxiety (as measured by scores on the EPDS and GAD-7) will predict greater anticipated regret (Giorgetta et al., 2012; Jung et al., 2014; Maner et al., 2007; Paulus & Yu, 2012; Worthy et al., 2014). This will be demonstrated by positive, statistically significant relationships between each of:
    a. perinatal depression and action regret;
    b. perinatal depression and inaction regret;
    c. perinatal anxiety and action regret; and
    d. perinatal anxiety and inaction regret.
5. Results will support a causal effect of both perinatal anxiety and depression on a mother's vaccination intentions. Controlling for plausible confounding variables, identified via a systematic literature search, this will be demonstrated by a statistically significant negative relationship between presence and severity of symptoms of perinatal anxiety and depression as predictors, and vaccine intentions as the outcome variable.
6. The relationship between anxiety and depression as predictors and vaccination intentions as an outcome variable will be partially mediated by temporal discounting and anticipated regret.

Qualitative research question

Whilst a quantitative approach permits testing of specific, explicit hypotheses, in any study of human decision-making, it is also important to ask individuals what influenced them. As such, qualitative exploration has been included in this study to answer the question about what soon-to-be and new mothers perceive as important factors that led to their intention to either vaccinate or to refuse vaccine(s) for their baby. Participants will be asked questions to elicit the drivers and impact of their vaccination behaviours.

Content analysis will allow underlying phenomena associated with participants' intentions, decisions and actions to be explored from responses to these items, and for common themes important to mothers in Aotearoa to be identified. Content analysis is a flexible approach to research which provides a means for researchers to identify and examine patterns from text (Neuendorf & Kumar, 2015; White & Marsh, 2006). These patterns are coded, usually by assignment of a label. Depending on the research aims of the particular study, the content analysis process may be deductive, inductive, or a mixture of both (Grbich, 2012; Krippendorff, 2018). A deductive approach will involve the identification of themes which are then coded to be counted and examined objectively to test an existing theory. Inductive content analysis organises and analyses the text to discover and describe latent meanings. An inductive approach will be adopted here to answer the open research question about individual participants' perceptions of what the key factors were that influence their vaccination intentions for their babies.

Understanding unarticulated drivers for vaccine decisions (whether pro- or anti-vaccine) is important for the development of targeted, effective campaigns of action. It will also provide

[28] See footnote 2, above.

valuable context for the discussion of results and assist in identifying future relevant pathways to extend the research proposed here.

Design Plan

In this section, you will be asked to describe the overall design of your study. Remember that this research plan is designed to register a single study, so if you have multiple experimental designs, please complete a separate preregistration.

Study type

Observational study (anonymous, cross-sectional survey, conducted online).

Blinding

No blinding is involved in this study.

Study design

The design of the study is cross sectional, observational research, conducted by electronic survey.

Sampling Plan

Existing data

Registration prior to creation of data: As of the date of submission of this research plan for preregistration, the data have not yet been collected, created, or realized.

Data collection procedures

Participants must be over 18 and either New Zealand citizens or living in New Zealand at time of survey completion. Recruitment will be via a combination of online advertising, using social media (primarily Twitter, Facebook and the social media pages of charitable organisations including PADA and Plunket), with the option to also use email mail outs and traditional advertising methods such as posters/flyers.

The survey and participant responses will be administered and stored electronically, using the Qualtrics survey platform (Qualtrics, 2019), in the Massey University cloud based storage system.

Sample size

An estimated 390 participants will be necessary to ensure sufficient power for this study, allowing for any. As such, to allow for any necessary data exclusion in accordance with the exclusion criteria specified below.

Sample size rationale

To ensure sufficient power for all of the specified analyses, a power analysis was performed for the SEM, conducted using the pwrSEM app, a calculator designed to analyse power for parameter estimation in structural equation modelling created by Wang and Rhemtulla (2020). The minimum sample size estimated using this method was 230 participants. However, as this method of estimation rests on input of auxiliary assumptions, to ensure sufficient power and to enhance robustness of the study, the final target sample size was increased by 50% to 345 participants. Next it was important to allow for any necessary data exclusion in accordance with

the criteria described below. As such, recruitment will continue until the number of responses reaches at least 390.

Stopping rule

Data collection will continue until at least 390 responses in Qualtrics with a status of "Finished" have been collected. This is necessary to ensure sufficient data to permit the planned analyses after any necessary data exclusion, in accordance with specified criteria (see below for further detail). The Quota function within Qualtrics will be used to stop the data collection process once the required target has been met.

Variables

Measured variables

Measured variables are:

- Perinatal depression
- Perinatal anxiety
- Anticipated regret
- Temporal discounting
- Intention to vaccinate
- Current vaccination status of child (new mothers only)

Including identified plausible confounds:

- Socioeconomic status
- Ethnicity

These are defined and will be assessed/measured as described below:

Perinatal **-** The meaning of "perinatal" in this study is broader than the definition of the DSM-5 specifier "with peripartum onset". This is applicable to symptoms of depressive, bipolar and schizophrenia spectrum disorders with onset during pregnancy or the first four weeks postpartum. These restrictive parameters are controversial, many clinicians and researchers opposing both the time frame and the limited disorder categories to which the specifier applies (Koukopoulos et al., 2020; Park & Kim, 2018; Segre & Davis, 2013; Sharma & Mazmanian, 2014). Argument in particular centres on a need for specific recognition of prenatal distress triggered by rapid but time-limited hormonal change (Batt et al., 2020). In practice, there is considerable variation on how clinicians or researchers define the postpartum period. Although some limit this to the first six months after birth, others extending it to up to 2.5 years afterwards, on average the most widely adopted timeframe is from mid to late pregnancy up to 12 months after a baby's birth (Goodman, 2004; Romano et al., 2010; Seth et al., 2016).

A potential participant will be eligible for the study, therefore, if they are either:

a. in their second or third trimester of pregnancy; or
b. have had a baby no more than 12 calendar months prior to completing the survey

Perinatal depression: perinatal depression (presence and severity) will be measured using the the Edinburgh Postnatal Depression Scale (EPDS), a ten-item self-report screening tool developed in 1987 by Cox, Holden, and Sagovsky. Participants' depression score will be their total score on the EPDS.

Perinatal anxiety: Perinatal anxiety is operationalised for the purpose of this research as symptoms of generalised anxiety disorder (GAD). Despite commonly observed symptomology of a range of anxiety and anxiety related conditions perinatally (for example the cleaning or checking seen in obsessive compulsive disorder (OCD)), GAD is the most prevalent form of anxiety disorder experienced by women perinatally, and at higher rates than observed in the general population (Fisher et al., 2012; Meades & Ayers, 2011; Wenzel et al., 2005). It is highly comorbid with most other anxiety disorders, including OCD (Goldstein-Piekarski et al., 2016; Grant et al., 2005; Misri et al., 2015; Nutt et al., 2002). The seven-item GAD-7 is a brief but reliable screen for GAD (Spitzer et al., 2006), including with a perinatal population (Barthel et al., 2014; Essiben et al., 2018; Loughnan et al., 2019; Misri et al., 2015; Simpson et al., 2014; Sinesi et al., 2019). Scores on the GAD-7 will be used here as an operational definition of anxiety level.

Anticipated regret: Anticipated regret will be measured with two items, each describing possible outcomes of a decision to accept or refuse a vaccine (e.g., "*If I decided not to vaccinate my child and s/he later got sick from an illness that a vaccine could have prevented against, I would expect to feel…").*The first of these items measures action regret, the second inaction regret. Responses will be recorded on a 0-100 visual analogue scale, anchored by statements *"absolutely no regret"* to *"the most regret I could possibly feel".*

Temporal discounting: Somewhat counterintuitively, the balance of evidence suggests that health-specific discounting measures have only a weak relationship with health behaviour and are a less sensitive predictor (at best) than a monetary discounting example, irrespective of the broader topic or context of the research (Baker et al., 2003; Chapman & Coups, 2006; Kim & Nan, 2019; Petry, 2003; Story et al., 2014). As such Kirby's Monetary Choice Questionnaire (1999) will be used in this study to measure temporal discounting. This 27-item measure is used extensively in research since it was developed, initially to assess impulsivity and steepness of discounting in presence of addiction. Participants are asked to select either "*Smaller reward today"* or *"Larger reward in the specified number of days"* in response to questions taking the format *"Would you prefer $54 today, or $55 in 117 days".* The wording of each item is identical, with changes to the monetary value and number of days.

Kirby et al. (1999) designed the MCQ to permit estimation of a discounting rate parameter (*k)* based on a participant's pattern of responses to each of the 27 items, as described in detail in their article. Each response is allocated either a 0 (where the smaller, immediate reward is selected) or a 1 (where the larger, delayed reward is selected). However, these are also weighted, to reflect the variation in amounts, and extent of the imagined delay.

A person's temporal discounting rate is on the basis of a score derived from the calculation of where a participant's answers fall on reference discounting curves (steeper curves indicating higher tendency to discount future outcomes).

Intention to vaccinate: Intention to vaccinate will be assessed by a targeted question asking the participant to select the most true response option from a list of four - intention to fully vaccinate; partially vaccinate; refuse all vaccinations; undecided (e.g., *"I intend to fully vaccinate my baby"*). New mothers are also asked about the child's current vaccination status as a means to gauge whether there has been a delay, irrespective of intention.

Baby's vaccination status (new mothers only): Baby's vaccination status will be gauged by the response to an item that asks mothers to select from one of three options. These are "*my baby has received all vaccinations due by age"; "my baby has received some but not all vaccinations due by age"; "my baby has not received any vaccinations due by age".*

Socio-economic status: The MacArthur Ladder of Subjective Social Status will be adopted to measure socio-economic status (Adler et al., 2000). This is a single-item measure of self-perceived relative status, with a focus on wealth and economic position. It more accurately taps "socio-economic status" as a potential confound here where the impact of a person or household's financial position may contribute to both psychological distress and to pragmatic barriers to accessing vaccines. Psychometric evidence from research conducted across a wide range of peoples and ages, in diverse settings, provides strong support for use of this scale (Amir et al., 2019; Cundiff et al., 2013; Giatti et al., 2012; Goodman et al., 2001; Hoebel et al., 2015).

Participants view an image of a ladder and are asked to "*Think of this ladder as representing where people stand [in Aotearoa]."* The item in the original measure then reads: "*At the top of the ladder are the people who are the best off – those who have the most money, the most education, and the most respected jobs. At the bottom are the people who are the worst off – those who have the least money, least education, the least respected jobs, or no job. The higher up you are on this ladder, the closer you are to the people at the very top; the lower you are, the closer you are to the people at the very bottom.*". Participants are then asked: "*Where would you place yourself on this ladder?"* and to "*Please place a large "X" on the rung where you think you stand at this time in your life relative to other people in [New Zealand]".*

The item wording has been modified from the original to more specifically tap self-perceived relative economic wealth, as opposed to education or employment status and to avoid any potential for offence distress arising from the question wording. The item in the survey will now read:

> "*Think of this ladder as representing where people stand in Aotearoa/New Zealand. At the top of the ladder are the people who are the best off financially. At the bottom are the people who are the worst off financially.*
>
> ***Where would you place yourself on this ladder?***
> *Please click on the rung to place a dot where you think you stand at this time in your life, relative to other people in Aotearoa/New Zealand."*

Ethnicity: Ethnicity data will be collected using the categories adopted for official purposes by the New Zealand Government, such as the Census (Statistics New Zealand, 2018). Participants will be able to select as many ethnicities as are applicable. For analytic purposes, however, where multiple ethnicities are selected, prioritised ethnicity will be adopted. This methodology, outlined in the Health Information Standards Organisation (HISO) Protocols (Ministry of Health, Manatū Hauora, 2017), is the most used output in the health and disability sector in Aotearoa. Respondents are allocated to a single ethnic group using specified "prioritisation tables", the aim being to ensure that, where there is a need – as here – to assign a single ethnicity, *"ethnic groups of policy importance or small size are not swamped by the New Zealand European ethnic group".* It does not equate to an assumption that the respondent identifies more strongly with the prioritised group.

Cut-scores will not be used to assign participants to categories (e.g., "anxious"/" not anxious") on the basis of their responses. This is because the aim of the study is not to diagnose, but to identify and understand the strength and direction of the hypothesised causal relationship between perinatal psychological distress and vaccination decisions. Dichotomising the variables here would not only be artificial and unnecessary, but potentially damage the validity of conclusions reached. This can occur for example, due to a loss of statistical power to detect an effect or a false positive or possible masking of non-linearity between groups (Altman & Royston, 2006). In addition, where the research question relates to a relationship between variables, a continuous score provides a more precise indicator of that relationship than is possible using a dichotomous classification such as presence or absence of disorder.

Identification of confounds

Plausible genuine confounds, as opposed to mediating variables, were identified further to an extensive literature review. Graphical causal modelling is a conceptual tool that assists with isolating those specific variables, among the many others also associated with the variables of interest, that are most likely to be genuine confounds (Rohrer, 2018). It is these variables that must be statistically controlled for, as opposed to mediating variables, for example (Greenland & Morgenstern, 2001; McNamee, 2003). Relevant variables associated with depression and/or anxiety and with vaccination intentions decisions were then mapped in a directed acyclic graph (DAG), produced in DAGitty (Textor et al., 2016) to help clarify which truly could be considered confounds.

As a result of this process, two plausible confounds were identified requiring control in this study. These are:

- socio-economic status (SES) (Coelho et al., 2011; Grant et al., 2011; Hayman et al., 2017; Leach et al., 2017; Osam et al., 2020; Schuller & Probst, 2013); and
- ethnicity (Coelho et al., 2011; Deverick et al., 2016; Forster et al., 2017; Freed et al., 2011; Hayman et al., 2017; Liu & Tronick, 2013; Mukherjee et al., 2016; Osam et al., 2020; Underwood et al., 2017; Waldie et al., 2015; Wilson et al., 2015).

A third potential confounding variable was also identified: misinformation about vaccination. However, there is a lack of evidence that conclusively supports or rejects the impact of anti-vaccination messages on perinatal psychological distress (British Medical Association, 2019; Deverick et al., 2016; Ju et al., 2015; Khajuria, 2020; Kim, 2019). Furthermore, it is much more likely that exposure to this type of information acts as a mediator in many instances – anxiety creating an aversion to perceived risk from vaccination prompting a search for information to confirm these fears (Tafuri et al., 2014; Tomljenovic et al., 2019; Wolfe et al., 2002). As such, this variable would not be a true confound and, in these circumstances, controlling for exposure to misinformation would lead to a biased estimate of the relationship of interest in this study. On balance, the decision has been taken here not to control for the effect of misinformation but it is a factor that does merit further specific exploration in a future study.

Indices

Each participant's responses to the various sections within the survey will be converted into a score on the variable of interest. The indices for each variable will be calculated as follows:

Perinatal depression: Participants' depression score will be their total score on the EPDS, created by summing each participants' responses to the ten EPDS items.

Perinatal anxiety: Participants' anxiety score will be their total score on the GAD-7, summing their responses to each of the seven items.

Anticipated regret: Participants will each have two "regret" scores, one for action and one for inaction regret. The score itself will be the value assigned by the participant out of 100 in response to each of the two regret items.

Temporal discounting: Scoring the MCQ is more complex. Responses to each item are assigned a value of 0 or 1, where 0 is for selection of the smaller, immediate reward (SIR), and 1 for selection of larger, delayed reward (LDR). The calculation of an overall discounting rate is necessary, however, to account for variation between the items in terms of the amounts of money and extent of the delay.

Kirby et al. (1999) designed the MCQ to permit estimation of a discounting rate parameter (*k)* based on a participant's pattern of SIR and LDR responses to each of the 27 items, as described in detail in

their article. In essence, a person's temporal discounting rate score is derived from calculating where their responses fall on reference discounting curves (steeper curves indicating higher tendency to discount future outcomes). Scores can be calculated by hand following the instructions outlined by Kirby et al. (1999), or by fitting a logistic regression as described by Wileyto et al. (2004). The relevant function is $V = A/(1+kD)$, where V is the present value of the delayed reward, A is the delayed reward itself, D is the delay. A *k* value will generally fall between 0 and 0.5, with smaller values indicating less discounting (and tendency to prefer delayed over immediate reward). In essence, the aim is to find the value of *k* that best explains a participant's responses as a whole.

Since the publication of the MCQ and revised versions, tools have been developed to facilitate calculation of *k,* such as the automatic scorer developed at the Center for Applied Neuroeconomics at the University of Kansas will be used (Kaplan et al., 2014). Each participant's *k* value represents their rate of temporal discounting.

Intention to vaccinate: The intention score will be the particular numeric value (1-4) assigned to response option, where intention scores are:

1 = refuse all
2 = undecided
3 = partial intended
4 = accept all

Baby's vaccination status (new mothers only): A score for baby's vaccination status from 1-3 will be based on the selected response option. These are:

1 = none by age
2 = partial – some by age
3 = full by age

Socio-economic status: The SES "score" is the number assigned to the rung selected by the participant as best representing their economic wealth relative to the rest of the country. These range from 1, at the bottom, to 10, at the top, where the top (10) represents highest self-perceived economic wealth, relative to others in Aotearoa.

Ethnicity: This is a nominal variable, and the categories selected – as prioritised – will be used for the purpose of controlling for confounds (see further, below – "Identification of confounds").

Analysis Plan

Statistical models

The research hypotheses will be tested using a range of statistical analyses. For hypotheses 1 and 2, a Spearman's rho (r) correlation will be computed to estimate the strength and direction of the relationships, as described below. The remainder of hypotheses 3-6 will be tested using structural equation modelling (SEM).

Structural equation modelling (SEM) provides the means by which relationships between variables can be estimated and controls applied to the confounds identified. In this way, causal conclusions can be drawn from cross-sectional survey data. The SEM also enables effects of measurement error to be accounted for (Westfall & Yarkoni, 2016). All quantitative analyses will be performed using a combination of R (R Core Team, 2013) and Jamovi (jamovi, 2020), itself built on R. Specifically, the lavaan software package (Rosseel, 2012) will be used to estimate the statistical models in this study.

Data obtained from the surveys will first be "cleaned" to identify and evaluate missing data points, and exclude incomplete or invalid responses, as per the specified exclusion criteria. All hypotheses will be tested using the full sample.

Hypothesis 1: Mothers who anticipate greater "inaction regret" (i.e., regret they expect to experience if they choose not to vaccinate and their child later contracts a vaccine-preventable disease) will be more likely to intend to vaccinate their child.

A Spearman's rho correlation will be computed to test hypothesis one, as one of the variables is ordinal. This is nonparametric measure of rank correlation will permit description of the statistical dependence (that is, the relationship, its direction and its strength) between inaction regret and vaccination intention.

Hypothesis 2: Mothers who anticipate greater "action regret" (i.e., regret that they expect to experience if they choose to vaccinate and their child has an adverse reaction to a vaccine) will be less likely to intend to vaccinate their child

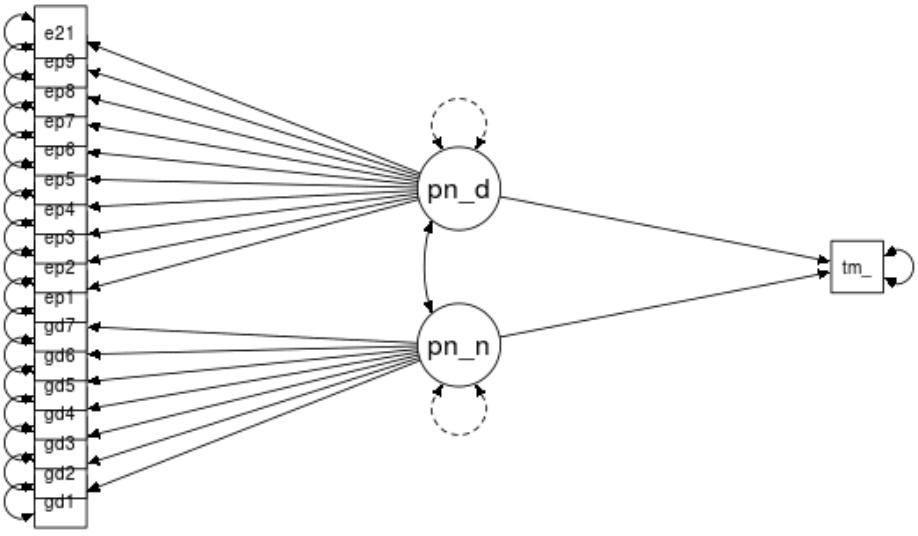
As for hypothesis one, Spearman's rho will be computed to test the relationship between action regret and vaccination intention.

Hypothesis 3: Experience of depression and anxiety will result in a bias toward discounting the future. This will be demonstrated by a positive relationship between temporal discounting (scores on the MCQ; Kirby et al., 1999) and:

a. perinatal depression (scores on the EDPS); and
b. perinatal anxiety (scores on the GAD-7;)
(Lempert & Pizzagalli, 2010; Paulus & Yu, 2012).

To test hypothesis 3, the path model below (coded in lavaan syntax) will be estimated using Jamovi or R. Firstly, the relationship between perinatal depression and temporal discounting will be estimated (hypothesis 3(a)) and, secondly, the relationship between perinatal anxiety and temporal discounting (hypothesis 3(b):

```
pn_anx =~ gad1 + gad2 + gad3 + gad4 + gad5 + gad6 + gad7
pn_depr =~ epds1 + epds2 + epds3 + epds4 + epds5 + epds6 + epds7 + epds8 + epds9 + epds210
temp_disc ~ pn_anx + pn_depr
```



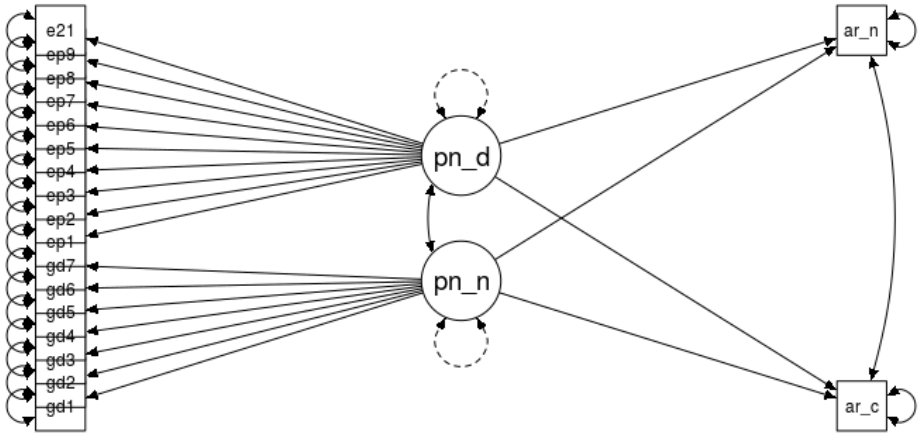
Both relationships will be estimated using maximum likelihood (ML) in lavaan.

Hypothesis 4: Higher levels of depression and anxiety (as measured by scores on the EPDS and GAD-7) will predict greater anticipated regret (Giorgetta et al., 2012; Jung et al., 2014; Maner et al., 2007; Paulus & Yu, 2012; Worthy et al., 2014). This will be demonstrated by:

a. *a substantial positive relationship between perinatal depression and anticipated action regret;*
b. *a substantial positive relationship between perinatal depression and anticipated inaction regret;*
c. *a substantial positive relationship between perinatal anxiety and anticipated action regret; and*
d. *a substantial positive relationship between perinatal anxiety and anticipated inaction regret.*

SEM will be used to test hypothesis 4 (see models described below in lavaan syntax).

```
pn_anx =~ gad1 + gad2 + gad3 + gad4 + gad5 + gad6 + gad7
pn_depr =~ epds1 + epds2 + epds3 + epds4 + epds5 + epds6 + epds7 + epds8 + epds9 + epds210
ar_action ~ pn_depr
ar_inaction ~ pn_depr
ar_action ~ pn_anx
ar_inaction ~ pn_anx
ar_inaction ~~ ar_action
```



Hypothesis 5: Results will support a causal effect of both perinatal anxiety and depression on a mother's vaccination intentions. Controlling for plausible confounding variables, identified via a systematic literature search, this will be demonstrated by substantial negative relationships between presence and severity of symptoms of perinatal anxiety and depression as predictors, and vaccine intentions as the outcome variable.

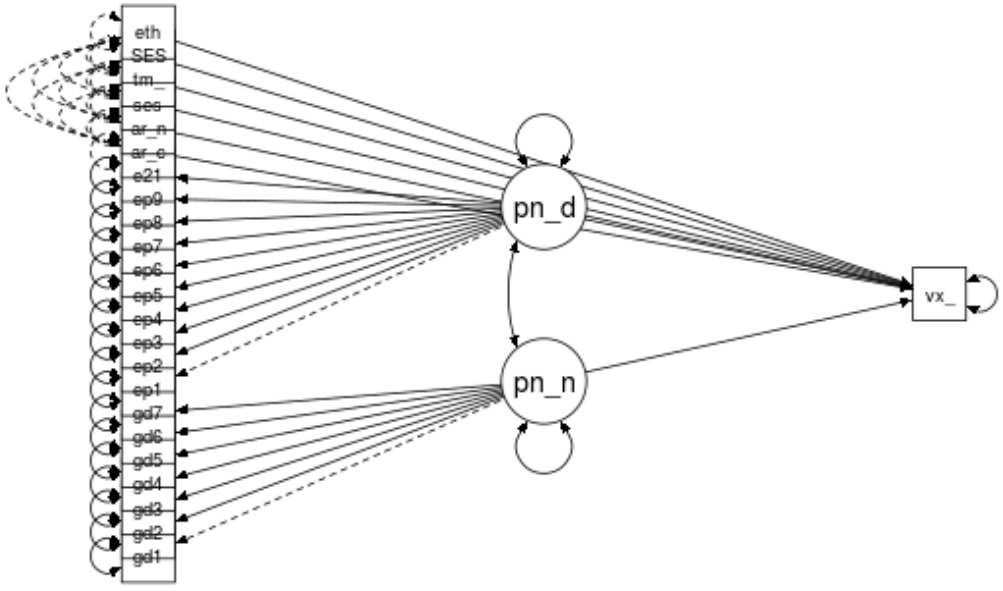
Hypothesis 5 will be tested by specifying an SEM in which intention to vaccinate is an observed (ordinal) dependent variable, and anxiety and depression are latent independent (continuous) variables. In this model, it is important to control for the confounding effects of SES and ethnicity. Ethnicity is a nominal variable and will be represented by a number of dummy variables that cannot be precisely described at this stage – the sample makeup will determine the ethnicities selected and prioritised and this cannot be determined ahead of time. As such, at the time of final data analysis, the predictor variable "ethnicity" in the code set out here will be replaced by ethN-1 dummy variables, where ethN is the number of observed ethnicities in the sample.

Diagonally weighted least squares (DWLS) will be used to estimate this relationship. The model to be applied is displayed below in lavaan syntax.

```
Vax_SEM_Model <-
    #definitions
        # pn_anx : perinatal anxiety
        # pn_depr : perinatal depression
        # gad1-gad7 - GAD-7 items 1 to 7
        # epdss1-epds10 - Edinburgh scale items 1 to 10
        # ar_action: anticipated action regret
        # ar_inaction = anticipated action regret
        # temp_disc = temporal discounting
        # vax_intent = intention to vaccination
        # ses = socio-economic status


    # latent variable definitions
    pn_anx =~ gad1 + gad2 + gad3 + gad4 + gad5 + gad6 + gad7
    pn_depr =~ epds1 + epds2 + epds3 + epds4 + epds5 + epds6 + epds7 + epds8 + epds9 +
                epds210

    # regressions
        vax_intent ~ pn_depr + pn_anx + ar_action + ar_inaction + ses + temp_disc + SES +
        ethnicity
```



In addition to inferential criteria (outlined below), DWLS will be used to estimate the model, together with robust standard errors and a Satorra-Bentler-scaled test statistic. The fit of the model proposed will be assessed by calculation of the root mean square error of approximation (RMSEA) and the comparative fit index (CFI), interpreted according to guidance outlined by Hu and Bentler (1999). Fit will be considered supported only if both the RMSEA is less than 0.06, and the CFI is greater than 0.95 (Hu & Bentler, 1999).

Hypothesis 6: The relationship between anxiety and depression as predictors and vaccination intentions as an outcome variable will be partially mediated by temporal discounting and anticipated regret.

Hypothesis 6 will be tested by specifying an SEM – see below in lavaan syntax. As socio-economic status and ethnicity have been identified as plausible confounding variables, they will be statistically controlled for in this model, estimated using DWLS.
Two total effects are expected, namely:

i. the effect of perinatal anxiety on vaccination intention; and
ii. ii. the effect of perinatal depression on vaccination intention.

However, it is also hypothesised that the impact of both perinatal anxiety and depression on intention to vaccinated are mediated by 3 factors, namely temporal discounting, anticipated action regret, and anticipated inaction regret. As such, six indirect effects are expected to be observed:

i. the effect of perinatal anxiety on intention via temporal discounting;
ii. the effect of perinatal anxiety on intention via anticipated action regret;
iii. the effect of perinatal anxiety on intention via anticipated inaction regret;
iv. the effect of perinatal depression on intention via temporal discounting;
v. the effect of perinatal depression on intention via anticipated action regret;
vi. the effect of perinatal depression on intention via anticipated inaction regret;

```
Vax_SEM_model <- '
#outcome variable model
        vax_intent ~ (b1_td*temp_disc) +(b2_ar*ar_action) + (b3_ir*ar_inaction) +
        (b4_pn_anx*pn_anx) + (b5_pn_depr*pn_depr)

#mediators of the relationship between perinatal anxiety and vaccination intentions
        temp_disc ~ a1_anx*pn_anx + ses + ethnicity
        ar_action ~ a2_anx*pn_anx + ses + ethnicity
        ar_inaction ~ a3_anx*pn_anx + ses + ethnicity

#mediators of relationship between perinatal depression and vaccination intentions
        temp_disc ~ a1_depr*pn_depr + ses + ethnicity
        ar_action ~ a2_depr*pn_depr + ses + ethnicity
        ar_inaction ~ a3_depr*pn_depr + ses + ethnicity

#indirect effects (a*b)
        # perinatal anxiety via mediators
                # effect of anxiety on vaccination intention, via temporal discounting
                        ab1_anx := a1_anx*b1_td
                #effect of anxiety on vaccination intention, via anticipated action regret
                        ab2_anx := a2_anx*b2_ar
                #effect of anxiety on vaccination intention, via anticipated inaction regret
                        ab3_anx := a3_anx*b2_ir

                # effect of depression on vaccination intention, via temporal discounting
                        ab1_depr := a1_depr*b1_td
                #effect of depression on vaccination intention, via anticipated action regret
                        ab2_depr:= a2_depr*b2_ar
                #effect of depression on vaccination intention, via anticipated inaction regret
                        ab3_depr := a3_depr*b3_ir

#itotal effects where total := c + (a1*b1) + (a2*b2) + (a3*b3)
        total_anx := c_anx +ab1_anx + ab2_anx + ab3_anx
        total_depr := c_depr + ab1_depr + ab2_depr + ab3_depr
```

As for hypothesis 5, in addition to the inferential criteria by which support for the hypothesis will be gauged, model fit will also be reported, as assessed by calculation of the following statistics:

- root mean square error of approximation (RMSEA; the residual – i.e. the error in the model);
- comparative fit index (CFI; the discrepancy between the data and the model, adjusted for sample size); and
- chi square (the difference between the expected and observed statistics).

Fit statistics will be interpreted according to guidance outlined by Hu and Bentler (1999). Fit will be considered supported only if both the RMSEA is less than 0.06, and the CFI is greater than 0.95 (Hu & Bentler, 1999). Chi square will also be reported to understand the difference between the expected and observed statistics but to provide additional information, rather than as part of the inferential criteria that supports or refutes this hypothesis.

Transformations

As outlined above, ethnicity is a nominal variable and will be represented by a number of dummy variables. At this stage, given the actual makeup of the sample will determine the ethnicities selected and prioritised, these cannot be precisely described ahead of time.

In these circumstances, at the time of final data analysis, the predictor variable "ethnicity" in the code above will be replaced by dummy variables "ethN-1", where ethN is the number of observed ethnicity categories in the sample.

Inference criteria

Inference criteria are outlined for each quantitative hypothesis, below:

Hypotheses 1 and 2: relationship between "inaction regret" or "action regret" and vaccination intention

Spearman's rho correlation will be calculated to assess the magnitude and direction of the relationship between the subjectively reported expectation of inaction regret (hypothesis 1) and action regret (hypothesis 2) and declared vaccination intention.

These hypotheses will be supported where the correlation between scores is positive [(action regret) or negative (inaction regret)] and statistically significant ($p < .05$, 2-tailed).

Hypothesis 3: impact of perinatal depression/anxiety on temporal discounting

Relationship between temporal discounting scores and perinatal depression scores (hypothesis 3(a)) or perinatal anxiety scores (hypothesis 3(b)) will be assessed by computation of a correlation statistic, as derived from the SEM output in R/Jamovi.

The hypothesis will be considered supported if the correlation between scores is positive and statistically significant ($p < .05$, 2-tailed).

Hypothesis 4: greater severity of perinatal depression and anxiety will predict greater anticipated regret

Higher levels of depression and anxiety (as measured by scores on the EDPS and GAD-7) will predict greater anticipated action regret (Jung et al., 2014; Worthy et al., 2014), demonstrated by positive relationships between:

- perinatal depression and anticipated action regret;
- perinatal depression and anticipated inaction regret;
- perinatal anxiety and anticipated action regret; and
- perinatal anxiety scores and anticipated inaction regret.

Each of these hypotheses will be considered supported where the standardised regression path derived from the SEM output in R/Jamovi is positive and statistically significant ($p < .05$, 2-tailed).

Hypothesis 5: causal effect of perinatal anxiety and depression on vaccination intention

To conclude that the data supports hypothesis 5, statistically significant ($p < .05$, 2-tailed) regression paths from perinatal anxiety and depression to intention to vaccinate must be observed.

Hypothesis 6: temporal discounting and anticipated regret will mediate the relationship between anxiety/depression and vaccination intention

For hypothesis 6 to be considered supported in its entirety, significant (negative) total effects of both anxiety and depression on vaccination intentions must be observed. In addition, significant (negative) indirect effects via each of the six indirect pathways specified below must also be observed (i-vi).

If none of the six indirect effects is negative and statistically significant, hypothesis six will be considered to be falsified (irrespective of the total effects).

However, if one or more of the six indirect effects and the two total effects are significant, hypothesis 6 will be considered to be partially supported (and, therefore, also partially contradicted).

Data exclusion

Survey responses will be considered invalid and excluded in their entirety if one or more of the following is true (in addition to any failure to meet eligibility criteria):

- the response to an attention check question ("*This is an attention check question, please select "smaller reward today*"), embedded in the block of items drawn from the MCQ was anything other than "*Smaller reward today*", or who do not respond to this item at all, suggesting the participant was not attending to item content;
- responses assigned a status by Qualtrics of 1 (preview), 2 (test), 8, 9, or 12 (possible spam or duplicate responses).
- With the exception of a missed response to the vaccination intention item, which is required, a missed answer or answers to a small number of questions will not automatically exclude an entire survey, however a minimum of 55% of the items from the substantive sections of the survey (EPDS items; GAD-7 items; temporal discounting and anticipated regret).

Missing data

Where participants have missed items, but fewer than the specified criteria for exclusion, responses to those items will be imputed using single expectation-maximisation imputation, as implemented in missForest (Stekhoven & Buehlmann, 2012).

Appendix 4: Frequency Distribution Graphs

Descriptive statistics for scores on the key variables in this study – perinatal depression, perinatal anxiety, temporal discounting, and anticipated regret, were reported in the Quantitative Results section (Chapter 8, above). Plots were omitted in the text for brevity and are produced here. Histograms of anticipated inaction and action regret are found, respectively, at Figure 20 and Figure 21. Figure 22 is a histogram of participant perinatal depression scores on the EPDS, whereas Figure 23 represents scores on the MCQ – temporal discounting, and Figure 24 anxiety scores on the GAD-7. A frequency plot of participant vaccination intentions is at Figure 25.

Figure 20

Anticipated Regret Scores Across the Full Study Sample

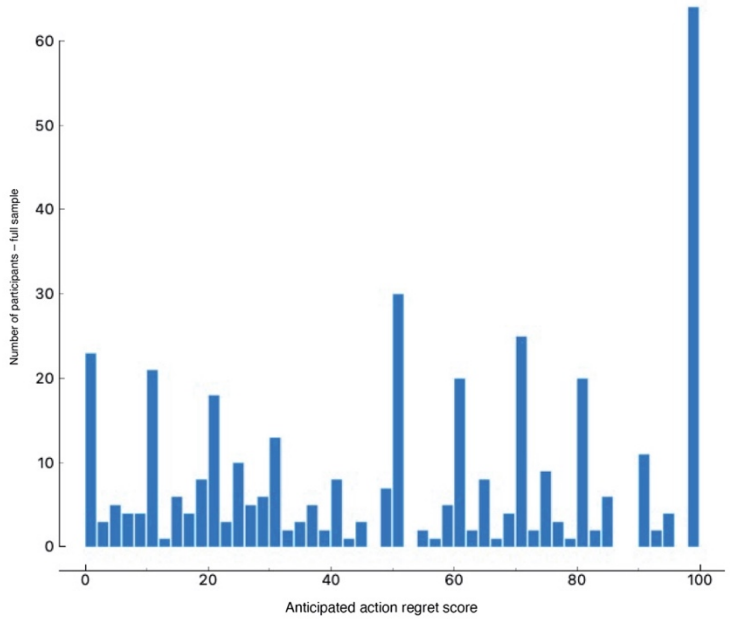


Figure 21

Anticipated Inaction Regret Scores Across Sample

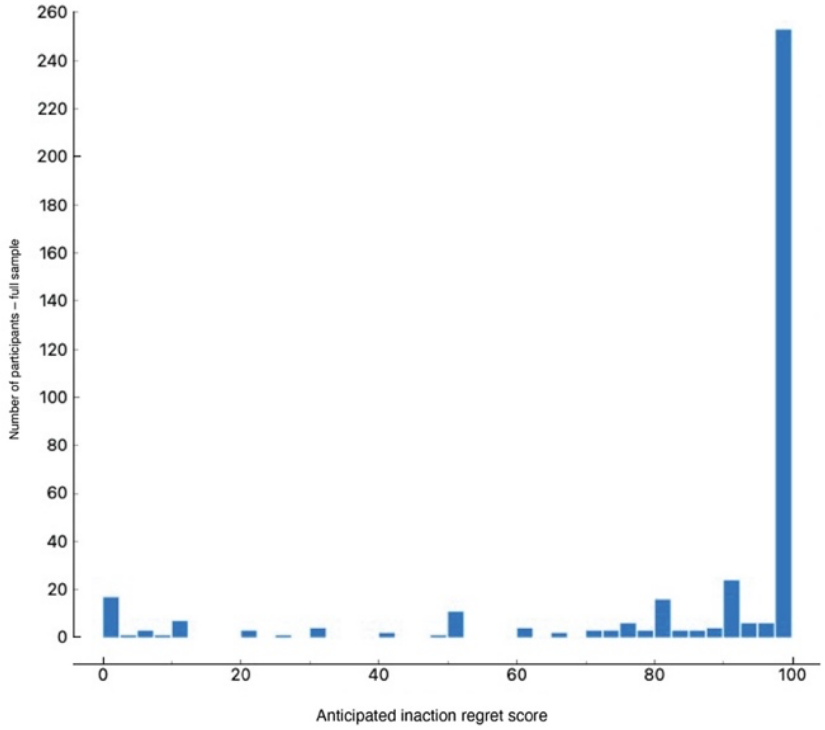


Figure 22

Participant Perinatal Depression (EPDS) Scores

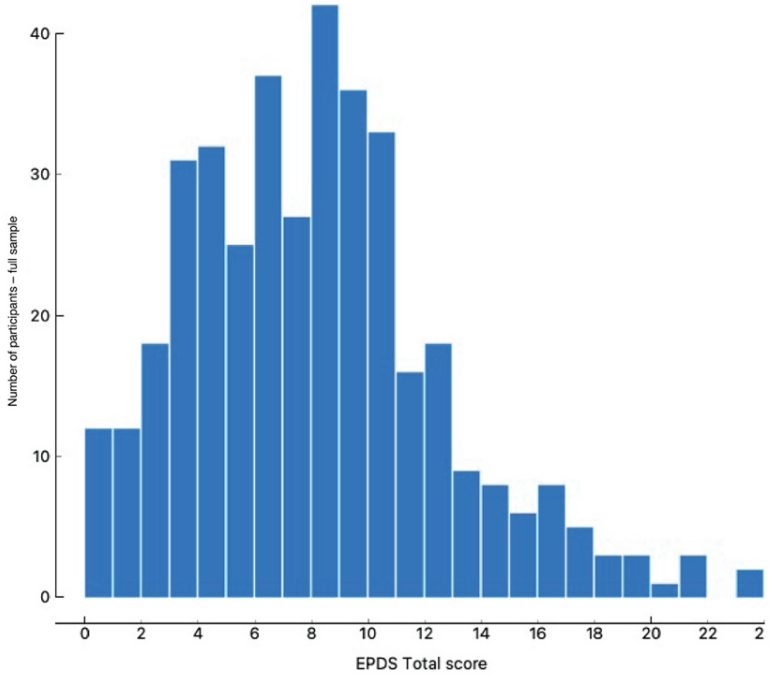


Figure 23

Temporal Discounting (MCQ) Scores

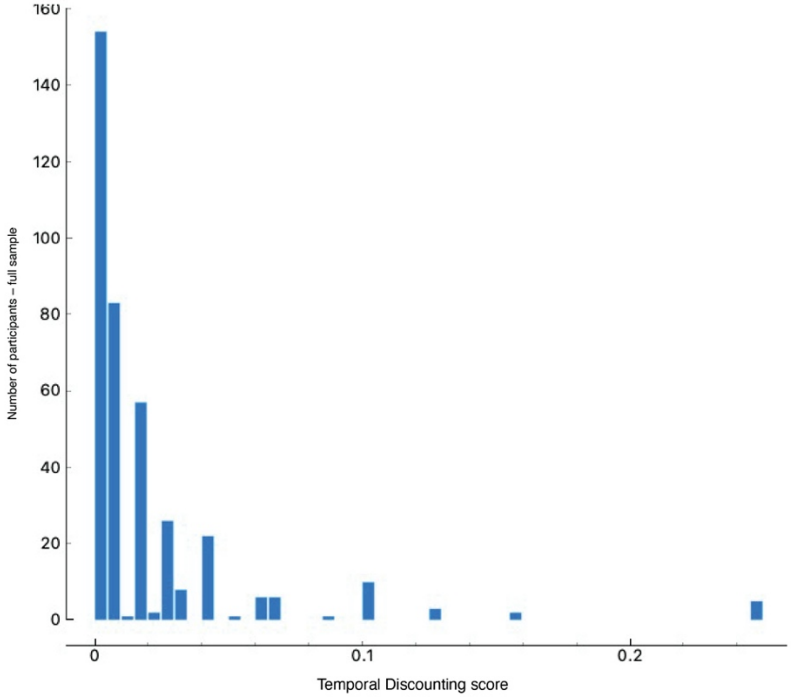


Figure 24

Participant Anxiety (GAD) Scores

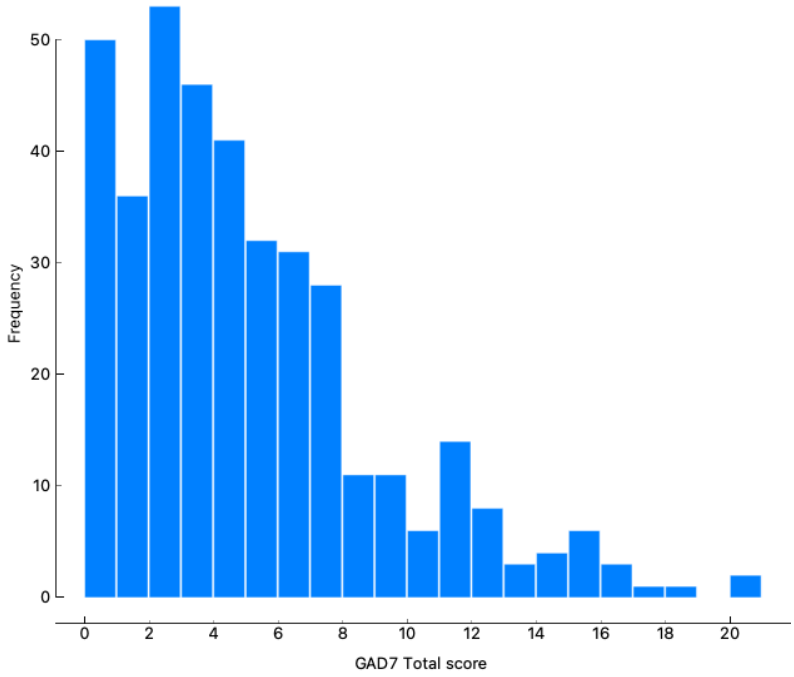
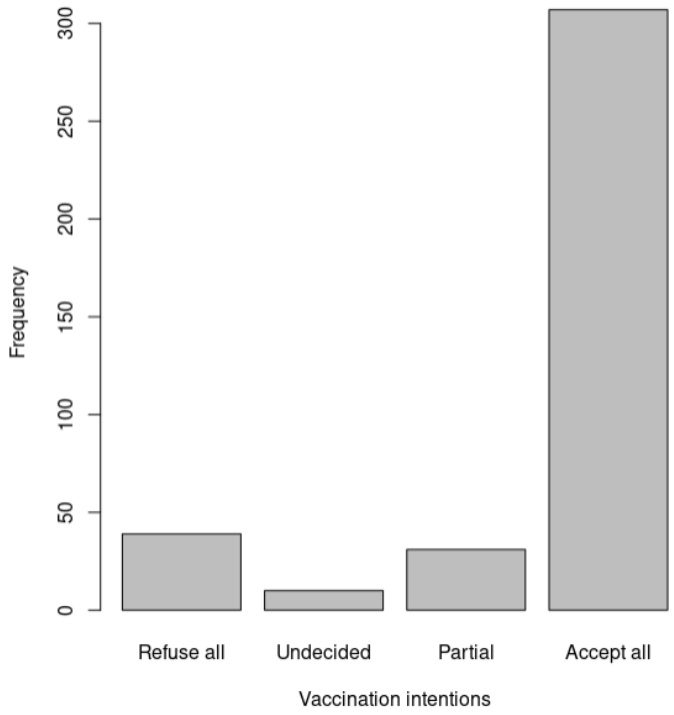


Figure 25

Declared Vaccination Intentions of Participants



Appendix 5: Supplementary Analyses

Two sets of supplementary analyses were carried out in this study. The first was to evaluate the impact of making changes to planned approaches adopted in this study – the analysis code for controlling for confounds, and the rank order placement of "undecided" in the hierarchy of vaccination intentions. The second were exploratory analyses to evaluate whether, on the basis of the data already available, a focus on uptake (as opposed to intentions) might yield a different pattern of results.

Amended Code for Ethnicity Controls: Hypotheses 5 and 6

The intended approach to controlling for ethnicity caused the programme to run with warnings about reliance on the output. As such, alternative methods of controlling for ethnicity were considered and run in an attempt to better understand the results obtained.

There was a very strong correlation between the European and New Zealand Māori ethnicities, implying a potential problem with *multicollinearity* (where one variable is highly correlated with one or more of the other independent variables creating a problem because it gives a good indication of a collection of possible predictors, but may not similarly yield valid results about individual predictors). This, taken together with the very small size of the other dummy variable groupings, and remaining as faithful as possible to the HISO hierarchy for prioritised ethnicity (Ministry of Health, Manatū Hauora, 2017), suggested that a valuable alternative analysis would have Māori ethnicity vs. other as the sole dummy variable for control purposes. This effectively put Māori at the top of the hierarchy. However, as outlined below, whilst this ran without warning messages, the resulting output neither alters the conclusion about support for either hypothesis five or six, nor conclusions about model fit.

Hypothesis 5

On the same alternative basis described above for hypothesis 6, (i.e., controlling only for Māori vs. other ethnicity), the observed relationship between perinatal depression and

intention was negligible, and statistically insignificant (β = -.007, *p* = .951)). The observed relationship between perinatal anxiety and intention, was small to medium, statistically significant but positive (β = .22, *p* = .035). As such, this hypothesis was also not supported.

The data were an acceptable fit to the model in accordance with the criteria preregistered (χ^2 (167) = 668.96, $p < .001$, comparative fit index (CFI) = .96, root mean square error of approximation (RMSEA) = .06, $p < .001$, 90% CI [.06, .07]).

Hypothesis 6

The results obtained using the alternative method to control for ethnicity (which do not materially alter conclusions reported above on the main analyses in terms of support for the hypothesis or model fit) are as follows -

A small to medium, positive, statistically significant total effect of perinatal anxiety on vaccination intention was observed (β = 0.201, *p* = .036). However, the total effect of perinatal depression on vaccination intention was negligible, negative and not statistically significant (β = -.021, *p* = .846).

The following indirect effects were observed, none of which statistically significant:

i. perinatal anxiety and intention via temporal discounting: negligible, positive (β = .001, *p* = .908) ;
ii. perinatal anxiety on intention via anticipated action regret: negligible, negative (β = -.017, *p* = .454);
iii. perinatal anxiety on intention via anticipated inaction regret: small, positive (β = .110, *p* = .101);
iv. perinatal depression and intention via temporal discounting: negligible, positive (β = .004, *p* = .786);
v. perinatal depression and intention via anticipated action regret: negligible, negative (β = -.008, *p* = 725);
vi. perinatal depression on intention via anticipated inaction regret: small, positive (β = .1, *p* = .156);

The fit statistics showed acceptable fit of the data to the model (χ^2 (212) = 747.99, $p <$. 001; CFI = .96; RMSEA = .05, p < .001; 90% CI [.05, .06]) (Hu & Bentler, 1999).

As none of the indirect effects is statistically significant, in accordance with preregistered inferential criteria, notwithstanding a good fit of the data to the proposed model, the results do not support hypothesis six.

Undecided – Determining Rank in the Intention Hierarchy

In order to measure vaccination intentions, participants were asked to choose from response options to indicate whether they intended to fully or partially vaccinate baby, or otherwise refuse all vaccines. However, this would have artificially forced a false response for those participants still weighing their decision. A such, a fourth option permitted an *undecided* response to be recorded. The difficulty then was where to place to *undecided* in the intentions rank order – was this closer to fully vaccinate, or to refuse all? In the main analyses, as per the preregistration, *undecided* was assigned a value of 2, placed one rank above *refuse all* and one below *partial*. This was on the basis that an undecided participant had not concluded that baby would not be immunised, but neither could it be assumed that any or all vaccines would ultimately be accepted. However, of those still uncertain about their intentions, it could reasonably be anticipated that some would ultimately decide to accept partial or full vaccination for baby.

As such, in order to understand whether the results might be impacted by the preregistered rank order hierarchy, two variations on the analyses were run for the applicable hypotheses (1, 2, 5 and 6). In the first of these, undecided was re-ranked and placed between *partial* and *accept all*. The new ordering was therefore: 1 = *refuse all*, 2= *partial*; 3 = *undecided*; 4 = *accept all*. For the second iteration, *partial* and *undecided* were combined.

The results of the first of these alternative approaches are outlined below. For the second, approach (aggregating *partial* and *undecided*, hypothesis six did not run properly, returning an error message suggesting the reduced number in the rank ordering from 4 to 3 did not permit reliable computations). The full code is available at https://osf.io/hzunr/.

Hypotheses 1 and 2: Regret and Intention

For the revised order analyses, large, statistically significant correlations were observed between vaccination intention and both inaction ($r(385) = 0.64$, 95% CI [.58 – 0.7], $p < .001$) and action regret ($r(385) = -0.53$, 95% CI [-.60– -0.45, $p < .001$).

Similarly, where *partial* and *undecided* were aggregated, the observed relationships were also large and statistically significant – correlation of intention and inaction regret: $r(385) = 0.64$, 95% CI [.58 – 0.7], $p < .001$; correlation of intention and action regret: $r(385) = -.53$, 95% CI [-.60 – -0.5], $p < .001$.

Hypotheses 3 and 4: Distress and Discounting; Distress and Regret

As these computations did not address intention, there was no change in the output.

Hypothesis 5: Distress and Intention

Taking the reversed order ranking first, the observed relationship between perinatal depression and intention was positive but negligible and statistically insignificant ($\beta = -.013$, $p = .905$)). The observed relationship between perinatal anxiety and intention, was small to medium, positive but also statistically insignificant ($\beta = .2$, $p = .063$). Consequently, the hypothesis was not supported.

The data were an acceptable fit to the model in accordance with the criteria preregistered ($\chi^2 (218) = 501.56$, $p < .001$, comparative fit index (CFI) = .97, root mean square error of approximation (RMSEA) = .045, $p < .001$, 90% CI [.04, .05]).

Next, where partial and undecided were aggreged, the perinatal depression and intention relationship remained positive, negligible, and statistically insignificant ($\beta = .004$, p

= .970)). The observed relationship between perinatal anxiety and intention, was small to medium, positive but here was statistically significant (β = .209, p = .043). As such, the hypothesis was partially supported, and partially refuted (as in the main analyses).

The data were an acceptable fit to the model in accordance with the criteria preregistered, with near to identical fit statistics obtained as for the reverse order analysis (χ^2 (218) = 501.71, $p <$. 001, comparative fit index (CFI) = .97, root mean square error of approximation (RMSEA) = .045, p < .001, 90% CI [.04, .05]).

Hypothesis 6: Mediating Effects of Discounting and Regret on Distress and Intention

For the reversed order version, a small, positive, total effect of perinatal anxiety on vaccination intention was observed (β = 0.18, p = .068). However, on this ordering of *undecided* the total effect was not statistically significant. The total effect of perinatal depression on vaccination intention was negligible, negative, and not statistically significant (β = -.001, p = .989).

The following indirect effects were observed, none of which statistically significant:

i. perinatal anxiety and intention via temporal discounting: negligible, positive (β = .001, p = .893);
ii. perinatal anxiety on intention via anticipated action regret: negligible, negative (β = -.016, p = .442);
iii. perinatal anxiety on intention via anticipated inaction regret: small, positive (β = .111, p = .095;
iv. perinatal depression and intention via temporal discounting: negligible, positive (β = .003, p = .773);
v. perinatal depression and intention via anticipated action regret: negligible, negative (β = -.007, p = 732);
vi. perinatal depression on intention via anticipated inaction regret: small, positive (β = .104, p = .161);

The fit statistics showed acceptable fit of the data to the model (χ^2 (280) = 770.04, $p <$. 001; CFI = .92, RMSEA = .05, p < .001; 90% CI [.05, .06]) (Hu & Bentler, 1999).

As none of the indirect effects is statistically significant, in accordance with preregistered inferential criteria, the results do not support hypothesis six.

Analyses for hypothesis six did not run for the aggregated version, however warning messages were produced in lavaan[29] which meant that relevant statistics were not returned in the output, relating also to model fit and the defined parameters. However, none of these results was materially different, whether on the reversed scaling or aggregated versions. As such, the conclusions reached as to the hypotheses themselves and to the fit of models remain unchanged. It is possible that the very small number of *undecided* responses in the dataset was not enough to make any difference.

Understanding Uptake: Exploring the Relationships Between Intention, Regret and Uptake in Practice

Subjectively reported intention was the focus in this study, rather than objectively measurable behaviour (albeit also self-reported). However, in the interests of understanding the relationship between vaccination intention and behaviour, and behaviour and perinatal distress, additional exploratory analyses were performed using the data provided by new mothers about their infants' vaccination status as at the date of survey completion. In the

[29] "Error in if (ncol(S) == 1L) { : argument is of length zero
In addition: Warning message:
In lav_model_vcov(lavmodel = lavmodel, lavsamplestats = object@SampleStats, :
lavaan WARNING:
Could not compute standard errors! The information matrix could
not be inverted. This may be a symptom that the model is not
identified.";
"Warning message:
In .local(object, ...) :
lavaan WARNING: fit measures not available if model did not converge"

survey, mothers of new babies were asked an additional question – "*Which of the following is most true about your baby's immunisation status right now (please select one option).*" To increase validity of the responses, the item also stated "*If you are unsure which vaccinations are due at what stage, please click here for the current New Zealand immunisation*" where the word "here" was hyperlinked to the immunisation schedule table. The three available response options were: "*My baby has received all vaccinations due by age so far"; "My baby has received some vaccinations due by age, but not the others"; "My baby has received none of the vaccinations on the schedule*", respectively scored 3, 2 and 1 for analysis purposes. "Uptake" therefore is measured by new mothers' reports as to the vaccination status of baby, current as at the date of survey completion.

Intentions and Uptake

Firstly, the relationship between uptake and intentions was evaluated. This was to identify any potential incongruity between declared intentions and reported behaviours of the new mothers in this sample.

A Spearman's rank order correlation was computed to understand the relationship between a mother's intention about vaccination overall, and her vaccination behaviour (to date of survey completion). The result obtained was large, positive, and statistically significant – $r(248) = .69$, 95% CI [.61, .75]; $p < .001$.

For these participants, the relationship between their declared intentions to vaccinate and the vaccination status of their baby was strong and positive – mothers who more strongly endorsed an intention to fully vaccinate also more likely to report full vaccination status (to date of survey completion).

Uptake and Regret – for Comparison with H1 and H2

A large, positive, and statistically significant correlation was observed between mothers' anticipated inaction regret (regret about not vaccinating) and their uptake of vaccines for baby ($r(248) = .49$, 95% CI [.38, .57]; $p < .001$.

Between anticipated action regret (regret about vaccinating) and vaccine uptake, the correlation was moderate to large, statistically significant, and negative $r(248) = -.37$, 95% CI [-.47, -.26]; $p < .001$.

As for intentions, the nature of a mother's anticipated regret predicted whether vaccines were administered to baby. For the new mothers in this sample, the nature of the regret they expected to feel as a result of their decision (i.e., whether to vaccinate or to not vaccinate), was strongly related not only to their intentions, but also to their actions in practice. Babies of mothers who expected to experience greater regret about acting (to vaccinate) were less likely to be fully vaccinated for age (if at all), and babies of mothers who anticipated greater inaction regret (i.e., regret about not vaccinating) were more likely to be fully vaccinated for their age.

Exploring Causal Effect of Perinatal Distress on Vaccination Uptake

The same SEM was used to examine a potential relationship between perinatal distress and uptake as for intentions (see hypothesis 5). The ethnicity controls once again needed adjustment as the *residual* category (1 person for the full sample) was empty for the new mothers group, and the resulting lack of variance prevented the analysis from running in lavaan. Removing the "residual" ethnicity category as a control permitted the analysis to be performed.

The observed relationship between perinatal depression and uptake was small, negative, and statistically insignificant ($\beta = -.06$, $p = .499$). The observed relationship between perinatal anxiety and uptake was small to medium, positive and statistically

significant (β = .20, p = .019). As such, and mirroring the results relating to intentions, there is support for a relationship between vaccine uptake and perinatal anxiety, in the opposite direction to that predicted.

The data were an acceptable fit to the model in accordance with the criteria preregistered (χ^2 (201) = 418.31, p < . 001, comparative fit index (CFI) = .97, root mean square error of approximation (RMSEA) = .05, p = .016, 90% CI [.04, .06]).

As was observed in relation to intentions (hypothesis 5), whilst perinatal depression did not appear to affect uptake, the results supported a causal role of anxiety in reducing uptake of childhood vaccines but in the opposite direction to that predicted. Again, the lack of range in the sample (and the lower number in the subsample of new mothers) could plausibly have prevented the ability to detect an effect of depression on uptake.

Temporal Discounting, Anticipated Regret as Mediators of the Uptake-Distress Relationship

As above, after removing the *residual* ethnicity category as a control, there being no participant within that category in the new mothers subgroup, the following results were observed.

The total effect of perinatal anxiety on vaccine uptake was small to medium, statistically significant, but positive (β = .19, p = .019). The total effect of perinatal depression on uptake was negligible, negative, and not statistically significant (β = -.07, p = .409).

The observed indirect effects were:

i. perinatal anxiety and uptake via temporal discounting: negligible, positive and statistically insignificant (β = .008, p = .430);
ii. perinatal anxiety on uptake via anticipated action regret: no effect observed, and statistically insignificant (β = 0.00, p = .979);
iii. perinatal anxiety on uptake via anticipated inaction regret: negligible, positive and statistically insignificant (β = .03, p = .350);

iv. perinatal depression and uptake via temporal discounting: negligible, negative and statistically insignificant (β = - .002, p = .684);

v. perinatal depression and uptake via anticipated action regret: negligible, negative (β = -.02, p = .289);

vi. perinatal depression and uptake via anticipated inaction regret: small, positive, statistically insignificant (β = .08, p = .06);

The fit statistics showed acceptable fit of the data to the model (χ^2 (263) = 594.24, p < . 001; CFI = .96; RMSEA = .05, p < .001; 90% CI [.05, .06]) (Hu & Bentler, 1999).

These results were materially similar to the original analyses performed.

Appendix 6: Demographic Characteristics and Vaccination Intentions (content analysis)

Table 6

Participants' Demographic Characteristics: Age, NZ Status

		Full sample		Pregnant		New mother	
Variable	Label	N (Tot 411)	%	N (Tot 141)	% of total sample (Tot 34.3%)	N (Tot 270)	% of total sample (Tot 65.7%)
Age	18-25	31	7.54%	11	2.68%	20	4.87%
	26-35	299	72.75%	106	25.79%	193	46.96%
	36+	81	19.71%	24	5.84%	57	13.87%
New Zealand status	Living in NZ	409	99.51%	140	34.16%	269	65.45%
	NZ citizen overseas	2	0.49%	1	0.24%	1	0.24%

Table 7

Self-Perceived Relative Socio-Economic Status (SES)

		N (395)	%	N (Tot 134)	% of total sample (33.92%)	N (Tot 261)	% of total sample (66.1%)
SES	1	3	0.76%	1	0.25%	2	0.51%
	2	6	1.52%	3	0.76%	3	0.76%
	3	26	6.58%	5	1.27%	21	5.32%
	4	39	9.87%	12	3.04%	27	6.83%
	5	64	16.2%	19	4.81%	45	11.39%
	6	94	23.8%	32	8.1%	62	15.7%
	7	99	25.06%	42	10.63%	57	14.43%
	8	51	12.91%	15	3.8%	36	9.11%
	9	11	2.78%	3	0.76%	8	2.02%
	10	2	0.51%	2	0.51%	-	-

Note – SES: self-reported socio-economic status, where 1 represents lowest and 10 the highest perceived economic wealth, relative to others in Aotearoa

Table 8

Ethnicities Endorsed by Participants, and Corresponding Level 1 Prioritisation

	N	Corresponding prioritised ethnicity
All ethnicities endorsed		
NZ Māori	41	NZ Māori
Fijian	1	Pacific
Cook Islands Māori	1	Pacific
Tongan	1	Pacific
Samoan	5	Pacific
Tokelauan	1	Pacific
Tahitian	1	Pacific
Vietnamese	1	Asian
Filipino	3	Asian
Chinese	4	Asian
Indian	3	Asian
Pakistani	1	Asian
Sri Lankan	1	Asian
Latin American	2	MELAA
French	4	European
Dutch	3	European
Swedish	1	European
German	1	European
Danish	1	European
American	4	European
Canadian	3	European
Irish	2	European
British/English	12	European
Scottish	2	European
Australian	6	European
South African/South African-European	8	European
Other European, not specified	4	European
NZ European/Pākehā	335	European
Residual categories (“human”/not specified)	2	Residual

Note: MELAA – Middle Eastern, Latin American, African

Table 9

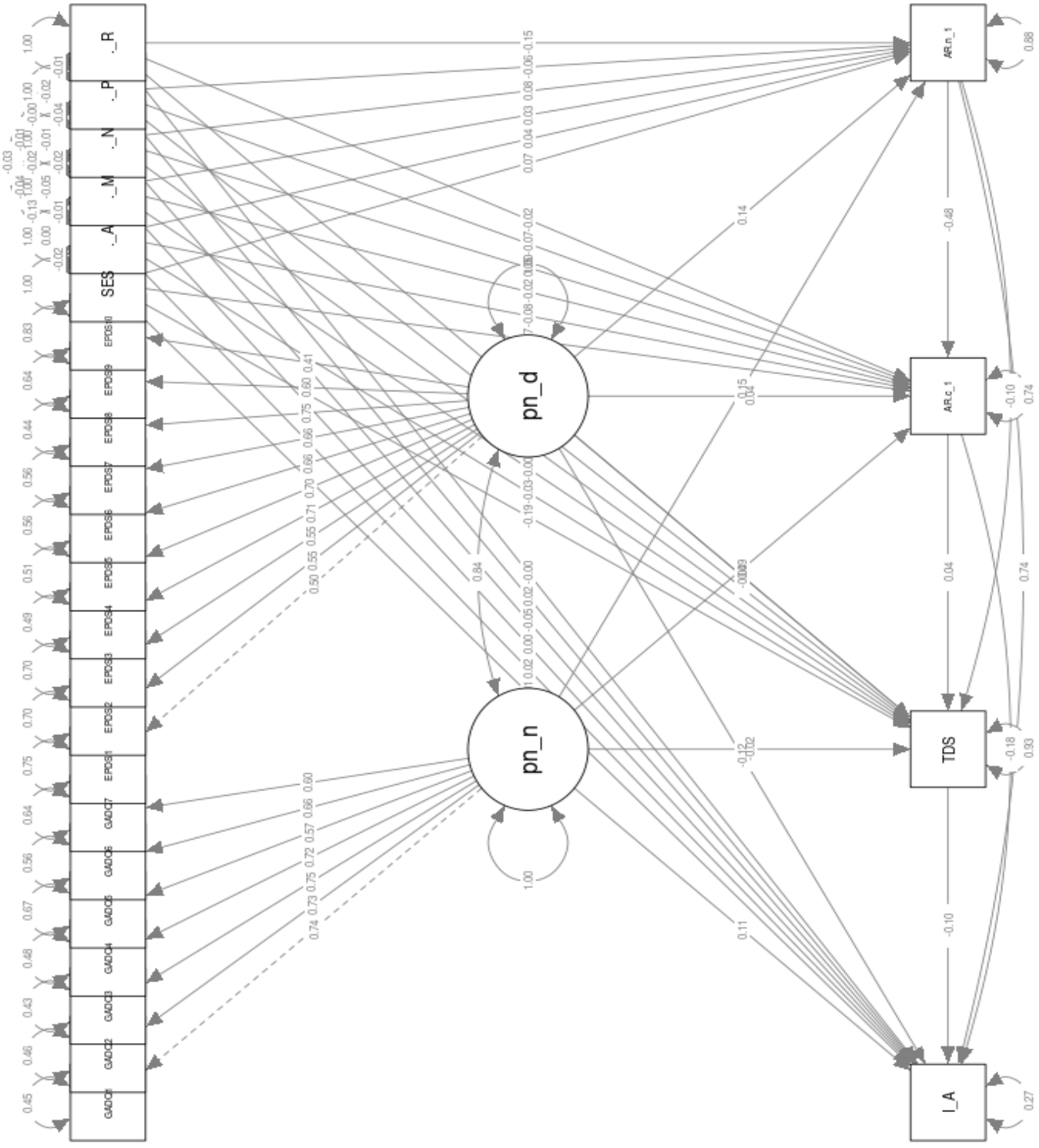
Participants' Reported Vaccination Intentions

		Full sample		Pregnant			New mother		
		N (Tot 411)	%	N (Tot 141)	% of total sample (34.3%)	% of pregnant	N (Tot 270)	% of total sample (65.7%)	% of new mothers
Vaccination	Accept all	323	78.59%	108	26.28%	76.59%	215	54.43%	79.63%
intention	Partial	33	8.03%	9	2.19%	6.38%	24	5.84%	8.89%
	Refuse all	44	10.7%	22	5.35%	15.6%	22	5.35%	8.15%
	Undecided	11	2.68%	2	0.49%	1.42%	9	2.19%	3.34%

Appendix 7: Diagram of Statistical Relationships Between Key Variables

Figure 26

Statistical Relationships Observed Between Hypothesised Relationships of Key Study Variables, and Role of Anticipated Regret and Temporal Discounting



Note. pn_n: perinatal anxiety; pn_d: perinatal depression; I_A: vaccination intentions; TDS: temporal discounting; Arc_1: anticipated action regret; ARn: anticipated inaction regret

Appendix 8: Research Case Study

CASE STUDY #1: RESEARCH

Vaccination and maternal mental health: The importance of my doctoral research for development of my clinical practice during my internship year

Sarah Kember ([redacted])
Massey University

Academic supervisors: Dr Matt Williams, Dr Stephen Hill, A. Prof Joanne Taylor
Clinical supervisor: Dr Simon Bennett

This research case study represents the research of Sarah Kember, conducted between 2020 and 2022, and reflections on her role as Intern Psychologist at the Massey University Psychology Clinic (Wellington) in 2022. It is presented in partial fulfilment of the requirements of the qualification of Doctor of Clinical Psychology at Massey University. Special thanks go to my supervisors, to the organisations who supported this work (Auckland Medical Research Foundation, Whānau Āwhina (Plunket), and Perinatal Anxiety and Depression Aotearoa (PADA), Lovell and Berys Clark Scholarships), to my family, and to each and every participant.

Supervisor	Candidate
Associate Professor Joanne Taylor	Sarah Kember
Massey University (Palmerston North)	[redacted]

_____ _____

Abstract

This case study was completed during my year as an Intern Psychologist. It outlines my doctoral research, carried out to better understand the potential relationship between maternal psychological distress in the perinatal period (specifically depression and anxiety), and personal perspectives on key influences on mothers' vaccination decisions for their babies. The process of designing and conducting this research contributed to the development of my clinical practice in several ways, as I reflect in this case study. Alongside the value of engaging in one's own research in developing as a scientist-practitioner, this experience has caused me to consider first-hand the impact of decision-making stress on psychological wellbeing; the toxic impact of social media; the extraordinary pressures of modern motherhood; and the depth and complexities of health inequality in Aotearoa. Together, these factors have contributed to my professional, and my personal, growth.

Keywords: Reflexive practice; perinatal anxiety and depression; vaccination decision-making

Part 1. Overview of Research

Childhood vaccine uptake in Aotearoa – as overseas – is consistently lower than necessary for population immunity (Lane et al., 2018; Ministry of Health, Manatū Hauora, 2020c). Understanding drivers of vaccine hesitancy and missed vaccinations is a critical issue for population health. This study investigated a possible relationship between low uptake and maternal mental distress, specifically perinatal depression and anxiety.

The study was planned in 2019, before COVID-19 swept the world, and long before any vaccination was developed, let alone scheduled. Nevertheless, it was important to consider the impact of the pandemic on decisions around vaccination given the timing of recruitment and data collection.

Study Aims and Research Rationale

The central aim of this study was to examine the case for the causal effect of perinatal psychological distress – namely pre- and post-natal depression or anxiety – on expectant and new mothers' vaccination intentions and behaviours for their newborn babies. Perinatal depression and anxiety were the focus for several reasons. Firstly, cognitive function, and decision-making in particular, can be severely impacted by both depression and anxiety (Clore & Huntsinger, 2007; Corrigan et al., 2014; Grupe, 2017; Hartley & Phelps, 2012; Jung et al., 2014; Maner et al., 2007; Park et al., 2016; Paulus & Yu, 2012; White et al., 2016; Worthy et al., 2014). Psychological distress can also be exacerbated by the pressure of having to take a decision (Pittig et al., 2020; Treffers et al., 2017). High levels of risk-avoidant decision-making have been observed in presence of anxiety (Giorgetta et al., 2012; Maner et al., 2007), attributed to factors including altered belief systems and intolerance of uncertainty (Paulus & Yu, 2012). In the context of depression, individuals often view their future negatively, or cannot imagine it at all, impacting the anticipation and value of future reward (temporal discounting) (Lempert & Pizzagalli, 2010; Paulus & Yu, 2012; Yang et al., 2014).

Regret is associated with anhedonia and heightened anxious arousal (Roese et al., 2009) and prospection (looking to the future) is often reduced in presence of high levels of distress (White et al., 2016; Worthy et al., 2014). In the context of vaccination, decisions are present-moment, relating to future threat and protection. High anxiety or depression was hypothesised to predict greater perception of risk and a lower likelihood of risk-taking.

Next, high rates of depression and anxiety are reported in the perinatal period, estimated between 10% to 20% (Fisher et al., 2012; World Health Organization, 2020d, 2022a). Depression is the main cause of disability in mothers, and worst for indigenous mothers and those in lower income brackets (Bowen et al., 2014; Fisher et al., 2012; Ghaedrahmati et al., 2017). During this period, generalised anxiety disorder (GAD) is reported in higher rates than for the general population and is the most prevalent form of anxiety for expectant and new mothers (Fisher et al., 2012; Meades & Ayers, 2011; Wenzel et al., 2005).

Thirdly, it is during this very time that mothers are at increased risk of anxiety and depression that may compromise their decision-making that decisions on vaccination must be made. In Aotearoa, 16 of the 22 scheduled vaccines are due in childhood, 9 of which are due in baby's first year (Ministry of Health, Manatū Hauora, 2020b). Research results suggest that decisions on infant and child health – including vaccination – still rest primarily with mothers, rather than parents or caregivers more broadly (Lee et al., 2020; Litmus, 2013; McGuigan, 2012; Statistics New Zealand, 2013). Lastly, emerging international research supports a possible link between low uptake and perinatal psychological distress (Osam et al., 2020; Ozkaya et al., 2010; Turner et al., 2003; Zajicek-Farber, 2008).

The impetus for the study was to contribute evidence regarding any relationship between perinatal psychological distress and vaccination behaviour that might justify an intensive focus on and expenditure of resource to improve mental health for women in

pregnancy and postnatally. As well as clear benefits for mothers, there would be a flow on effect for the child and family as a whole. In addition, it was hoped that the findings might precipitate improvement in vaccination rates and population health overall. Adding to vaccination knowledge was rendered all the more urgent by the global health crisis that is the COVID-19 pandemic, occurring against a backdrop of rising rates of endemic disease and decreased confidence in (and, for some, accessibility of) vaccines. New Zealand-specific research is crucial to population health in Aotearoa given the role that societal factors such as culture, traditions, history, and local public health campaign have on vaccination.

Research Hypotheses and Questions

Based on the theories of temporal discounting and anticipated regret, the following relationships were expected to be observed:

1. Mothers who anticipate greater "inaction regret" (i.e. regret they expect to experience if they choose not to vaccinate and their child later contracts a vaccine-preventable disease) will be more likely to intend to vaccinate their child. This would be demonstrated by a positive, statistically significant relationship between inaction regret and vaccination intention.[1]
2. Mothers who anticipate greater "action regret" (i.e. regret that they expect to experience if they choose to vaccinate and their child has an adverse reaction to a vaccine) will be less likely to intend to vaccinate their child. This would be demonstrated by a negative, statistically significant relationship between action regret and vaccination intention.
3. Experience of perinatal depression and anxiety will result in a bias toward discounting the future. This would be demonstrated by a positive, statistically significant relationship between temporal discounting and:

a. perinatal depression; and

b. perinatal anxiety.

4. Higher levels of perinatal depression and anxiety will predict greater anticipated regret. This would be demonstrated by positive and statistically significant relationships between each of:

a. perinatal depression and action regret;

b. perinatal depression and inaction regret;

c. perinatal anxiety and action regret; and

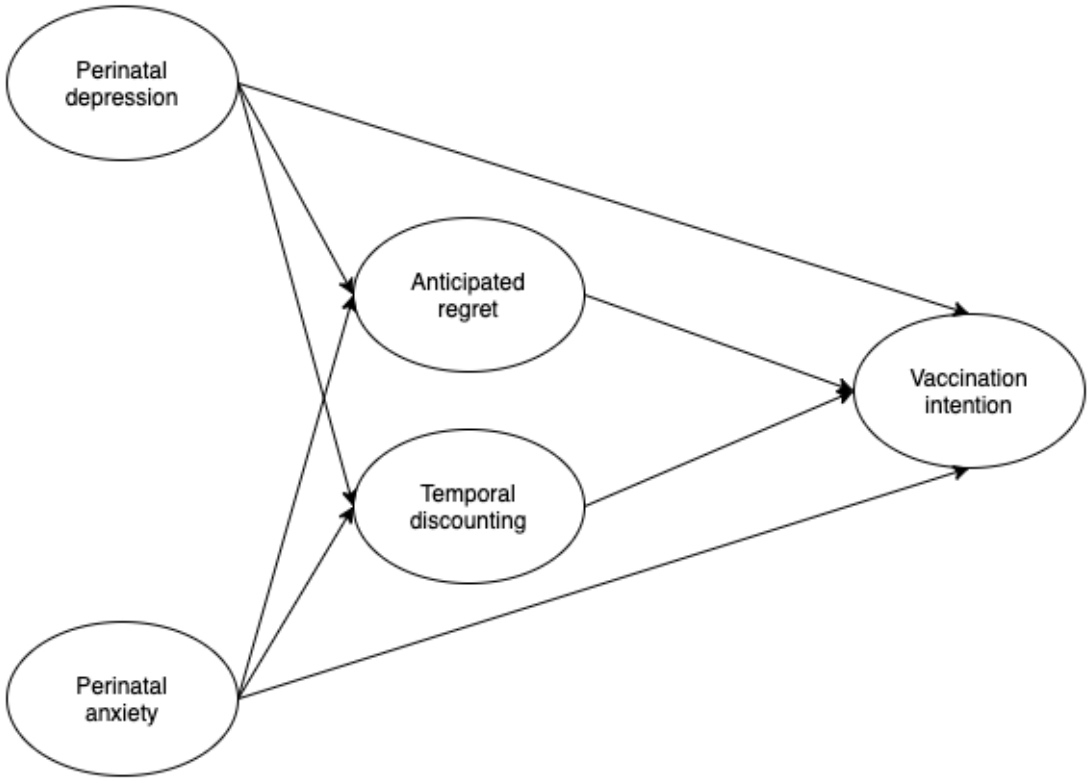
d. perinatal anxiety and inaction regret.

5. Results would support a causal effect of both perinatal anxiety and depression on a mother's vaccination intentions. Controlling for plausible confounding variables, identified via a systematic literature search, this will be demonstrated by a statistically significant negative relationship between presence and severity of symptoms of perinatal anxiety and depression as predictors, and vaccine intentions as the outcome variable.

6. The relationship between anxiety and depression as predictors and vaccination intentions as an outcome variable would be partially mediated by temporal discounting and anticipated regret (see Figure 1).

Figure 1

Causal Effects of Perinatal Distress on Vaccination Intentions – Mediating Pathways



The study also explored what expectant and new mothers perceive as important influences on their vaccination intentions. This was addressed by a series of brief items, not text-limited, to which participants could respond as they saw fit.

Research Methods

The study was designed as cross-sectional, observational research, carried out by anonymous electronic survey (Qualtrics, 2019). The approach and analytic strategy were primarily quantitative, but a qualitative element was introduced to give insight into personal experiences and perceptions of vaccination decisions and what influenced these.

This study was preregistered on the Open Science Framework (OSF) on 7 April 2021 – see https://osf.io/hzunr/. Preregistration enhances accountability and transparency, enabling

replication (Flake & Fried, 2019). Ensuring confidence in the conclusions reached s crucial where changes in public policy and expenditure may be indicated. As per preregistration requirements, no data were collected, created or realised prior to uploading the plan for design and analysis of the study.

Participants

Through advertising and promotion primarily on social media, 387 expectant and new New Zealand mothers (residing in or otherwise citizens) were recruited for the quantitative analyses. Data from an additional 23 participants was retained for the content analysis (total 411), as the restrictive parameters for data inclusion were not all relevant for the second part of the study. Participant ethnicity and socio-economic data were also obtained to allow for statistical control as both were identified as plausible confounds for the distress-intention relationship. Eligible participants were aged 18 or over and either pregnant (second or third trimester) or had a baby aged 12 months or under when they completed the survey. "Perinatal" was therefore defined more broadly in this study than in the DSM-5 "with peripartum onset" specifier. The DSM allows for this categorization only up to 4 weeks postpartum, a controversial limitation and widely disregarded by clinicians in practice (Goodman, 2004; Romano et al., 2010; Seth et al., 2016).

Procedure

Participants completed the survey questions, including items drawn from existing measures of anxiety and depression alongside questions about vaccination intentions. Postnatal participants were also asked about their baby's current vaccination status. Demographic data (age; month due date/baby's birth month; NZ citizen or resident status; ethnicity; and subjective socioeconomic status) were collected to permit control of confounds, and open-ended questions collected information about influences on vaccine intentions. The survey was administered electronically via Qualtrics (2019). The survey

landing page set out detailed information about the study. Endorsement of the informed consent item was necessary to launch the survey. For quantitative analyses, a participant's data were excluded if they failed to meet eligibility criteria (age, citizenship, pregnant/new mother status), did not select the directed option in the attention check item, or that were identified by Qualtrics as a possible spam or duplicate response. Participants were also required to have responded to a minimum of 55% of the items across the substantive sections of the survey (measures of perinatal distress, temporal discounting, and anticipated regret). For the content analysis, responses were only ineligible where consent or eligibility criteria were not met.

Measures

To measure perinatal depression and anxiety the ten-item Edinburgh Postnatal Depression Scale (EPDS) and the seven-item measure of generalised anxiety disorder, the GAD-7, were selected. Both are well-validated but brief screening measures and have been widely used clinically and in research for perinatal populations (Cox, 2019; Cox & Holden, 2003; Cox et al., 1987; Ekeroma et al., 2012; Loughnan et al., 2019; Misri et al., 2015; Spitzer et al., 2006). Anticipated regret was measured by response to two purpose-designed items (e.g. "If I decided not to vaccinate my child and s/he later got sick from an illness that a vaccine could have prevented against, I would expect to feel…"), whereas Kirby's Monetary Choice Questionnaire (1999) was used to measure temporal discounting. Four response options were provided to statements (e.g. "I intend to fully vaccinate my baby") to measure vaccination intention ("Refuse all"; "Undecided"; "Partial"; "Accept all"), and baby's vaccination status was scored based on whether a mother endorsed "My baby has received all vaccinations due by age"; "My baby has received some vaccinations due by age"; or "My baby has not received any vaccinations due by age".

To measure the identified confounds, participants selected as many options for ethnicity as were relevant to them from a possible nine – the most frequently endorsed groups in Aotearoa – or "other", with a text entry option to provide this information. Prioritised ethnicity was then adopted for analytic purposes (Ministry of Health, Manatū Hauora, 2017). Socio-economic status was measured using the MacArthur Ladder of Subjective Social Status (Adler et al., 2000), with some minor adaptations to reflect the New Zealand context, and to tap self-perceived relative wealth more specifically, rather than education or employment status.

Inferential Criteria and Analytic Strategy

The overall quantitative analytic strategy comprised three key stages: identifying potential confounds; ascertaining which of these would plausibly result in bias; and analysis of data using structural equation modelling (SEM) in R (R Core Team, 2013) to permit statistical control of those confounds. Inference criteria were specified for each of the quantitative hypotheses, as follows:

- *Relationship between "inaction regret" or "action regret" and vaccination intention (H1, H2):* Spearman's rho correlation to assess the magnitude and direction of the relationships between declared vaccination intentions and both inaction regret (H1) and action regret (H2). These hypotheses would be considered supported where the correlation between scores obtained was statistically significant and either positive (in respect of action regret) or negative (in respect of inaction regret) ($p < .05$, 2-tailed).
- *Impact of perinatal depression/anxiety on temporal discounting (H3):* computation of a correlation statistic, as derived from the SEM output in R. The hypothesis would be supported if the correlation was positive and statistically significant ($p < .05$, 2-tailed).

- *Greater severity of perinatal depression and anxiety will predict greater anticipated regret (H4):* demonstrated by statistically significant relationships where the standardised regression path derived from the SEM output in R was positive, and statistically significant ($p < .05$, 2-tailed).
- *Causal effect of perinatal anxiety and depression on vaccination intention (H5):* statistically significant ($p < .05$, 2-tailed) regression paths from perinatal anxiety and depression to intention to vaccinate observed from SEM analyses.
- *Temporal discounting and anticipated regret will mediate the relationship between anxiety/depression and vaccination intention (H6):*significant (negative) total effects of both anxiety and depression on vaccination intentions derived from SEM analyses were to be observed, together with significant (negative) indirect effects via each of six indirect pathways .If none of the six indirect effects was negative and statistically significant, hypothesis six would be falsified (irrespective of the total effects). However, if one or more of the six indirect effects and the two total effects were significant, hypothesis six would be partially supported (and, therefore, also partially contradicted).

To explore underlying phenomena associated with participants' intentions, decisions and actions, content analysis was used to evaluate responses to the open-ended questions in the survey. Content analysis is a flexible approach, permitting researchers to identify and examine patterns from text and then coding these patterns by assignment of a label (Neuendorf & Kumar, 2015; White & Marsh, 2006). This process may be deductive, inductive, or a mixture of both (Grbich, 2012; Krippendorff, 2018). An inductive approach was adopted here, permitting organisation and analysis of the text to discover and describe latent meanings. The first step was to become familiar with the data, through careful and repeated examination of text generated by participants. Using NVivo 12 software (*NVivo*,

2018), patterns were identified then coded, by assignment of labels to permit organisation of these patterns and generation of themes.

Results and Conclusions

Of six quantitative research hypotheses, two were supported. Both types of anticipated regret were strongly correlated with vaccination intention (inaction regret/intention: $r = .64$, $p < .001$; action regret/intention: $r = -.53$, $p < .001$) (H1, H2). However no relationship was observed between either perinatal depression or anxiety and temporal discounting (depression/discounting: $\beta = -.06$, $p = .592$; anxiety/discounting: $\beta = -.01$, $p = .902$) (H3). Neither depression nor anxiety predicted anticipated regret overall as none of the results obtained were statistically significant (depression/action regret $\beta = -.03$, $p = .836$; depression/inaction regret $\beta = .14$, $p = .160$; action regret/anxiety ($\beta = .02$, $p = .889$; inaction regret/anxiety $\beta = .15$, $p = .096$) (H4). Further, depression did not have the expected causal effect on vaccination intentions and, whilst anxiety did, it was in the opposite directed to that predicted (anxiety: $\beta = .22$, $p = .035$; depression: $\beta = -.007$, $p = .951$) (H5). The depression-intention relationship was negligible, and despite a moderate, statistically significant anxiety-intention relationship, the direction was positive. The results also failed to support the final hypothesis (partial mediation of the distress-intention relationship by temporal discounting and anticipated regret) – the indirect effects were not statistically significant (H6). In summary, the results supported a strong relationship between anticipated regret (action or inaction) and vaccination intentions. Further, perinatal anxiety was found to have a causal impact on vaccination intentions, although it was not in the expected direction – increasing, rather than decreasing likelihood to vaccinate. Further, this was not via effects on anticipated regret or temporal discounting. The implications are that anticipated regret (action or inaction) will likely be highly influential on vaccination decisions and behaviours. Several limitations were identified, however, primarily relating to limited variance in the sample that

likely impacted the ability to defect an effect. In particular, there were insufficient data at the extremes of distress to reliably conclude that either depression or anxiety, in their extreme forms, would not have the effects originally hypothesised.

Content analysis organised participants' perspectives of the influences on their vaccination intentions into six main categories - beliefs (safety, risk, and effectiveness); own knowledge or experience; health protection; formal sources (health officials and professionals); social influences (whānau/family and others); and pragmatic influences (availability, childcare requirements; travel). The most often cited sources were their own personal beliefs or opinions, professional/academic knowledge or experience, and a desire to protect the health of others (baby's and/or the community's). External sources were less frequently raised. These findings underscore the importance of understanding beliefs, opinions and knowledge already held, and how they are formed. Two latent themes – fear and confidence - were also identified. "Fear" reflects a mother's worries – primarily about baby's health but also about possible social ostracism (for mother or baby) due to the decision. "Confidence" relates to self-belief and trust in their judgment in making this decision, demonstrating the sense of safety and trust that comes from acting in accordance with or that reinforces existing knowledge and experience. Several participants reported feeling empowered by the decision they made.

An additional facet of the analysis related to the emotional or personal impact for participants of taking the decision on vaccination for baby. A sizeable minority (40%) considered that they were affected. For some, this was in a positive way – describing a sense of safety, empowerment, or confidence. However, for most who said they were affected, the experience was a negative one. This ranged from the experience of mild worry to ongoing and high levels of guilt or anxiety, or being rejected by whānau, friends or other social circles. For many, the process and its outcome were fraught, an additional stressor at a time

of already heightened psychological vulnerability, the very need to make a decision potentially exacerbating distress. It was clear that this was an especially difficult decision where the decision contemplated (and, sometimes, ultimately taken) was incongruent with personal values (e.g., pressure to vaccinate/not vaccinate by partner; deciding to vaccinate due to childcare requirements etc.). That these participants signalled social networks and public health professionals as critical sources of influence on their intentions suggests that increasing support and guidance from trusted, respected sources would likely alleviate the decision-making burden, and associated distress. Improving decision-making capacity would result, alongside a reduction in stress or distress. Capitalising on the reported positive experience should also be considered – in supporting decision-making, focusing on a mother's agency in making this decision, rather than a cost-benefit analysis purely assessing the "least worst" outcome may be a more valuable tool to encourage uptake.

Overall, these results suggest that targeting the sources of information and the nature of regret will be a powerful tool when devising effective vaccination campaigns. Clinically, intensifying a focus on maternal mental health, identifying, and working to alleviating a mother's fears, providing early, accurate information alongside supported decision making can be expected to positively contribute to population health, as well as to maternal mental health.

Part 2. Reflexive Observations

In many ways, the importance of my experience as a researcher to my work as a scientist-practitioner cuts across each of the reflections in this case study. In this section, I reflect on my critical approach to research, the effects of social media and "fake news", being truly tolerant of views opposite to my own – even where these are counter to my own values and gaining a deeper understanding of the problem of fairness in research and access to services.

Scientist-Practitioner Perspective

Reflexivity in the context of conducting this research goes beyond an evaluation of whether and how my personal views or preferences might have given rise to bias in the study design, analysis or conclusions. It has been the most comprehensive opportunity for me to remain constantly vigilant in evaluating the sources I access and cite, also making me a more critical consumer of the research on which I base clinical decisions for clients. Certainly, becoming an advocate for - and now a practitioner of - open science opened my eyes to the number of articles where no similar control is exercised. However, a more startling discovery – faced with findings that did not support my predicted outcomes – was the realisation of how tempting it must be to change the purported focus or aim of research after the effect to tell a different story. Without preregistration, it would be simple to adjust (or not have) inferential criteria, or to conduct different analyses to those originally envisaged. For researchers and academics whose livelihoods and reputations depend on publication, with journals that expect proven predictions, the stakes are high. Engaging in methodologically robust, preregistered, open research has made me a better, more critical consumer of information and a more analytical clinician, better able to review, analyse and select evidence-based approaches for my clients. I believe that I am better able to identify methodologically rigorous studies and to evaluate the science behind a treatment, or a particular measure, before considering whether it is valid or appropriate for a particular client. I have also reflected on the difference in the importance of openness and transparency in both research and in clinical practice, but how very different these are. Whereas, in research, not deviating from the preregistered plan is vital to increasing trust in the results, in clinical practice, flexibility and change are what is crucial, being open to revising and updating ideas and the path forward, in close collaboration

with one's client. The principles of open science remain important, but for very different reasons.

That "fake news" and conspiracy was a relevant theme in the research also added to my development. For those fortunate enough to have had a robust grounding in scientific practice and exploration, it can be difficult to understand why facts and scientific evidence do not suffice to persuade others to a different view. Carrying out this particular study exposed me to the arrogance of my assumption, firstly for failing to account for mistrust in the particular authority promoting the "facts"; secondly for presuming equitable access to knowledge and information; and thirdly for ignoring the power of personal experience, emotion and – for so many – the much greater reassurance in joining with like-minded others, particularly where those others provide support and sense of community.

Social Media and the Fake News Effect

Until I began working on this study, my online presence and public profile were minimal, my preference being to remain behind the scenes. My digital footprint was small, settings carefully restricting access to information about me to friends and family. As a result, my digital world largely reflected real life – an echo chamber in which my views, beliefs and thoughts broadly matched those of the people I elected to engage with on these platforms. Stepping outside this comfort and familiarity to not only engage with but to invite comment – at times attack - from others whose views were very different to my own was confronting. It provided some valuable, albeit unpleasant, insight into a life through social media or in the public eye. By advertising in this way, I created a platform for communication and exposed myself as its owner to indiscriminate contact from any other person who accesses the site. Vaccination is a divisive issue and being "trolled" for the first time, subjected to online vitriol by others I had never met, and probably would not say the same things to me in person, gave me insight into the lives of those who engage in social media on a regular basis.

Working with adolescents at the clinic in particular, but in fact with all clients in this digital age, the importance of social media platforms and the centrality of communication with friends via a device is clear. Whilst I of course have access to the same devices and sites, understanding first-hand the vulnerability that comes when a life is lived online, and the inescapability of negative comments or personal attack when it lives in your pocket has been an unwelcome, but important revelation. In this way I had just a small taste of the excitement and nervous anticipation that can come from creating an online profile, and the impact that personal attack from unseen others can have on mood and anxiety, even in the absence of pre-existing challenges.

The experience also exemplified some the very difficulties discussed in my thesis, namely the difficulty in correcting misinformation and the power of a social media platform to bring together like-minded people. The first visits to my Facebook page were from an individual strongly opposed to vaccination, who quickly shared this with others and a small following grew. Nothing on the site promoted vaccines, in fact this was an invitation to express views through the survey. It was clear that the individuals who started commenting had not read what the study was about, but it was equally clear that any attempt to explain or clarify would only add fuel to the fire. I was accused of many things, the most extreme being that I was a baby killer. In discussion with my supervisors, I carefully monitored the page to ensure comments were removed as quickly as possible. I felt strongly that leaving the comments up was creating a space for the dissemination of misinformation and potentially give rise to more anxiety for others reading them. If I could not get to the comments quickly enough, a conversation would start, and the momentum would grow. When a person was blocked, it led to more vindictive words, but at least only I could see these. As more and more people began to access the site and the survey and shared it with their friends online, the balance of the comments began to shift. The overall experience unsettled me more than I ever

anticipated but gave me some unwanted but nevertheless useful insight into the effects of being trolled and the ability for an online profile or platform to provide a soapbox, even when the speaker has (deliberately or otherwise) misinterpreted its purpose. I also wondered whether these behaviours were solely the consequence of the "keyboard warrior" phenomenon – the disconnection from reality and human engagement desensitising people to the impact of their words – or whether (or in addition), the communal anxiety of the pandemic, at that time still in its early stages, heightened emotions to an extent that certain individuals felt compelled to take action, irrespective of the consequences.

Exposure to and Tolerance of Views Different – Or Opposite to my Own

Ultimately, most of the participants opposed to vaccination who went on to complete the survey expressed their views in a very different way. They explained their worries, fears or concerns and formation of their views coherently, outlining key influences. This too was an important experience for me, and I found myself frequently carrying out a self-reflexive assessment of my partiality, in assigning codes and selecting exemplars for the content analysis section of my study in particular. I had written about the polarising nature of the vaccination debate, and the extent to which views at both extremes are entrenched but had not quite envisaged the power of my own position to potentially influence my analysis or approach, much less my opinion of others, until I was in the middle of my research. Really listening to the voices of the participants, their fears as well as their confidence, was grounding and humbling. It gave me an appreciation of how difficult it is to simply abandon what we believe or have been taught and to be truly open to hear what is important to another person, even if that view goes against our own. In my research, particularly when engaging in the content analysis, I realised how much my own strongly held views might prejudice the analysis. I had to deliberately and consciously put aside any internal dialogue or judgemental response to comments or explanations offered, and really listen to what was being said.

Instead of contemplating a counter-argument, I just had to stop and take in and truly try to understand where this individual was coming from, their experience, opinion, and decision, and to respect it for what it was, without seeking to change it or represent it to better fit any perspective or agenda of my own. The same is true in any therapy room – being present, open and genuinely receptive to the individual, listening to and accepting their experience without judgement or criticism is vital to the therapeutic relationship and process.

In considering the difficulty of shifting views, I also had cause to reflect on the power wielded in a professional role to influence changes in opinion and the responsibility that must be recognised and taken seriously. Even as an intern, clients and their family members looked to me for guidance and appreciating the role that health professionals play in shaping a person's decisions is vital. Recognising this imbalance in power is critical to ensure that information is imparted responsibly and to remain always cognisant of the potential for something to be misconstrued. I consider this reflection to be among the more important during my internship and something that I must always bear in mind to safeguard the therapeutic relationship.

Recognition of Perinatal Distress

A straightforward and perhaps obvious impact of this study was my increased exposure to and understanding of the complexities of psychological distress in the perinatal period, and the difficulties in ensuring this is adequately recognised and treated. The ubiquity of missed and misdiagnosis, on a global scale, is manifestly a problem for countless mothers and their families, further complicated where there are challenges to accessing services that the new mother trusts. Even if there is no formal diagnosis of depression or anxiety, the pressures and changes in role cannot be underestimated, including the weight of responsibility for making decisions that impact baby such as vaccination. It highlighted for me the danger in only identifying or referring for services where a cluster of symptoms fits a

specific set of criteria, rather than recognising more subtle signs of distress – for example a mother hoping to see a pattern and get more sleep scrupulously recording timing and detail of every feed and nappy; irritability and lack of enjoyment of older children; expressed regret about a loss of identity; reported confusion about what the "right" thing to do might be for baby, in many situations. Recognition, validation and support would go a long way to alleviate and address symptoms which cause or increase distress. The highly restrictive DSM-5-TR criteria for what constitutes the perinatal period at all is an excellent example of a system that demands that a consumer fit a mould, rather than considering the individual and their personal experience. Aotearoa does not have an insurance-driven medical model and it seems that many problems – perinatally or otherwise – could more easily be tackled if psychological interventions were more routinely applied to address stress and distress, irrespective of whether a specific pattern or cluster of symptoms is present.

Fairness in Research and Access to Services

It is easy to intellectualise difficulties in ensuring representative samples for research and the fundamental importance of overcoming this challenge. In practice, securing a truly representative sample is more difficult. Student research in particular is conducted to a timeframe which is generally tight. Time and resources limit what is feasible and never more so than during a pandemic when travelling – even within a city - to make personal contact or to promote research to a wider audience became an impossibility. My recruitment strategy was narrower than I ever imagined I would take, purposive sampling being a necessary approach to ensure the feasibility – and ethicality – of the project, not least given the additional complications around consultation, promotion, and face-to-face discussion occasioned by COVID. It was frustrating and sobering to realise how often groups of people are likely indirectly excluded from research for reasons that have nothing to do with – in fact may be contrary to - the investigator's intention, nor the wider benefits to a project.

Similarly, the complexities of accessing information and services became clear in carrying out this project. Although the difficulties in some overseas countries were more obvious, it became clear that my privilege had blinded me – despite a desire to understand and learn more - to the true depth and complexities of the health inequities in Aotearoa. Vulnerability goes beyond the surface level overt marginalisation and discrimination to a much deeper entrenched discrimination and mistrust that predispose entire communities to reject advice. Health campaigns will always miss the mark where consultation with all groups and means of message delivery that are relevant to all people are not employed. It also made me reflect – and not for the first time – on the real dangers of a mental health system that is primarily accessible to those who not only have adequate resources but who trust in the system.

Concluding Remarks

At first glance, it might not be as clear how this research project might have helped my professional development as a clinician. However, for reasons outlined above, I feel it has contributed extensively to my professional – as well as my personal – growth. I am so grateful to all the mothers who took the time to engage with the survey and to explain the reasons for their views on vaccination, and how they came to be formed, but also for this opportunity to develop and learn from the experience. Certain reflections were uncomfortable but necessary learning that I believe have already begun to help be a more tolerant, mindful, curious, and analytical clinician in the therapy room. I am looking forward to continuing to build on this experience to deepen my self-reflection and continue to grow as a clinician over the years to come.

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