

Unraveling COVID-19 Vaccine Hesitancy: Vaccine Decision Dynamics Amid an Uncertain
Environment

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Abstract

Since their invention, vaccines have proven to be one of the most impactful public health interventions available. However, despite their track record, a significant proportion of people around the world remain vaccine hesitant - either delaying or refusing a vaccine when one is available. A large body of research has tried to understand why this is: what makes someone vaccine hesitant and what could be done to make them feel more comfortable with the decision to vaccinate themselves or their children? The present research has shown that vaccine hesitancy is incredibly complex and heterogeneous, with determinants varying depending on factors such as geographic location, the disease being targeted by the vaccine and even the brand of the vaccine. The COVID-19 pandemic has added to this complexity, creating a unique decision environment with high levels of uncertainty, political polarization and risk. Understanding the determinants of vaccine hesitancy in this unique environment is important for a number of reasons. For one, preventable COVID-19 deaths continue to occur and are likely to continue occurring for the foreseeable future. At the same time, understanding vaccine hesitancy in the context of high uncertainty vaccine decisions presents us with a valuable opportunity to understand how people might react in future pandemics where a vaccine is available. In cases where mortality rates are higher than that of COVID-19, this knowledge could have a profound impact.

The aim of the research program described in this thesis is to gain a better understanding of the determinants of vaccine hesitancy in the context of the high uncertainty decision environment created by the COVID-19 pandemic. In the Introduction, I discuss the determinants of vaccine hesitancy, presenting leading models and frameworks that have been used to understand this construct in the past and suggesting ways in which these models might be updated in the context of uncertain decision environments such as the one present during the COVID-19 pandemic. In Chapter 1, I begin at a broader level, by using empirical

qualitative data gathered during the pandemic from 18 Canadians to propose a novel taxonomy of vaccine hesitancy. Eight themes emerge within this taxonomy: values, trust, social environment, personal anecdotes, environmental fluctuation, prior knowledge, perceived risk and systems of care. As shown in past research from non-COVID-19 contexts, I find that determinants of vaccine hesitancy vary significantly between individuals. In Chapter 2, I explore these differences between determinants further by focusing on two groups of vaccine hesitant individuals: soft hesitant (i.e. those who are uncertain about wanting the vaccine) and hard hesitant (i.e., those who are certain they do not want the vaccine). In particular, I use the lens of cognitive bias to understand how these groups differ, showing that hard hesitancy is not merely a “stronger” form of vaccine hesitancy relative to soft hesitancy, but rather a distinct set of attitudes. In particular, I find that hard hesitant individuals differ from soft hesitant individuals in that they present lower levels of *fear of missing out* and of *recency effect*, suggesting that hard hesitancy might feel less pressure and be less responsive to novel information - a combination that requires very unique public health strategies compared to their soft hesitant peers. I propose concrete public health messaging strategies based on these findings and continue by focusing on the role of institutions in vaccine hesitancy. In Chapter 3, I examine the role of institutional and interpersonal trust on five measures related to vaccine hesitancy. I show that while vaccine hesitancy is associated with lower scores on both institutional and interpersonal trust, institutional trust scores are significantly lower across measures, suggesting that vaccine hesitancy may be associated with an erosion of trust in institutions, leading vaccine hesitant individuals to increase their reliance on interpersonal propagated belief systems which may diverge significantly from mainstream evidence and thus support vaccine hesitancy attitudes. In Chapter 4, I discuss how these findings, taken together, might be used to craft more effective public health strategies - both in the context of the currently rising death toll of the

COVID-19 pandemic and in the context of future high uncertainty vaccination decision environments similar to the one during the COVID-19 pandemic.

Résumé

Depuis leur invention, les vaccins se sont révélés être l'une des interventions de santé publique les plus efficaces dont nous disposons. Cependant, malgré ces résultats, une proportion importante de personnes dans le monde hésitent à se faire vacciner, retardant ou refusant de se faire vacciner lorsqu'un vaccin est disponible. Un grand nombre de recherches ont tenté de comprendre les raisons de cette hésitation - ce qui fait qu'une personne hésite à se faire vacciner et ce qui pourrait être fait pour qu'elle se sente plus à l'aise avec la décision de se faire vacciner ou de faire vacciner ses enfants. Ces recherches ont montré que l'hésitation vaccinale est incroyablement complexe et hétérogène, les déterminants variant en fonction de facteurs tels que la situation géographique, la maladie ciblée par le vaccin et même la marque du vaccin. La pandémie de COVID-19 a ajouté à cette complexité, créant un environnement décisionnel unique avec des niveaux élevés d'incertitude, de polarisation politique et de risque. Il est important de comprendre les déterminants de l'hésitation vaccinale dans cet environnement unique, et ce pour plusieurs raisons. Tout d'abord, au moment de la rédaction de ce texte, des décès évitables dus au COVID-19 continuent de se produire. D'autre part, comprendre l'hésitation vaccinale dans le contexte de décisions vaccinales très incertaines nous offre une occasion précieuse de comprendre comment les gens pourraient réagir lors de futures pandémies où un vaccin serait disponible. Dans les cas où les taux de mortalité sont plus élevés que ceux de COVID-19, cette connaissance pourrait avoir un impact profond.

L'objectif du programme de recherche décrit dans cette thèse est de mieux comprendre les déterminants de l'hésitation vaccinale dans le contexte de l'environnement décisionnel très incertain créé par la pandémie de COVID-19. Dans l'introduction, je discute des déterminants de l'hésitation vaccinale, en présentant les principaux modèles et cadres qui ont été utilisés pour la comprendre dans le passé et en suggérant des façons dont ces modèles pourraient être mis à jour dans le contexte d'environnements décisionnels tels que celui de la

pandémie de COVID-19. Dans le chapitre 1, je commence à un niveau plus large, en utilisant des données qualitatives empiriques recueillies pendant la pandémie auprès de 18 Canadiens pour proposer une nouvelle taxonomie de l'hésitation vaccinale. Huit thèmes émergent de cette taxonomie : les valeurs, la confiance, l'environnement social, les anecdotes personnelles, la fluctuation de l'environnement, les connaissances préalables, le risque perçu et les systèmes de soins. Comme l'ont montré des recherches antérieures menées dans des contextes autres que celui du COVID-19, nous constatons que les déterminants de l'hésitation vaccinale varient considérablement d'un individu à l'autre. Dans le chapitre 2, j'explore plus avant ces différences entre les déterminants en me concentrant sur deux groupes de personnes hésitant à se faire vacciner : les hésitants mous (c'est-à-dire ceux qui ne sont pas sûrs de vouloir se faire vacciner) et les hésitants durs (ceux qui sont certains de ne pas vouloir se faire vacciner). En particulier, j'utilise la lentille du biais cognitif pour comprendre comment ces groupes diffèrent, en montrant que l'hésitation forte n'est pas simplement une forme "plus forte" d'hésitation vis-à-vis du vaccin par rapport à l'hésitation faible, mais plutôt un ensemble distinct d'attitudes. En particulier, je constate que les personnes fortement hésitantes diffèrent des personnes faiblement hésitantes en ce qu'elles présentent des niveaux plus faibles de *peur de manquer* et d'*effet de récurrence*, ce qui suggère que les personnes fortement hésitantes pourraient ressentir moins de pression et être moins réceptives aux nouvelles informations - une combinaison qui nécessite des stratégies de santé publique très particulières par rapport à leurs pairs faiblement hésitants. Sur la base de ces résultats, je propose des stratégies concrètes de diffusion de messages de santé publique et je poursuis en me concentrant sur le rôle des institutions dans l'hésitation vis-à-vis des vaccins. Dans le chapitre 3, j'examine le rôle de la confiance institutionnelle et interpersonnelle sur quatre mesures liées à l'hésitation vaccinale. Je montre que si l'hésitation vaccinale est associée à des scores plus faibles de confiance institutionnelle et interpersonnelle, les scores de confiance

institutionnelle sont significativement plus faibles dans toutes les mesures, ce qui suggère que l'hésitation vaccinale peut être associée à une érosion de la confiance dans les institutions, conduisant les personnes hésitantes à s'appuyer davantage sur des systèmes de croyance propagés par les personnes, qui peuvent diverger de manière significative des preuves dominantes et donc soutenir les attitudes d'hésitation vaccinale. Dans le chapitre 4, je discute de la manière dont ces résultats, pris ensemble, pourraient être utilisés pour élaborer des stratégies de santé publique plus efficaces - à la fois dans le contexte de l'augmentation actuelle du nombre de décès dus à la pandémie de COVID-19 et dans le contexte de futurs environnements de décision de vaccination à forte incertitude, similaires à ceux de la pandémie de COVID-19.

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Contribution to Original Knowledge

Chapter 1 uses an empirical approach to propose a novel taxonomy of vaccine hesitancy in the context of high uncertainty vaccination decisions. While multiple models of vaccine hesitancy exist, they are primarily derived from contexts with less inherent uncertainty - for example, ones focused on vaccines or a disease that have existed for a long time. They are also, by and large, derived without the use of a targeted experimental approach - for example, by performing a systematic literature review to inform the proposed categories. In using a targeted focus group approach, the study in Chapter 1 differentiates itself in its methodology. Furthermore, because of its focus on COVID-19 vaccine hesitancy, the proposed taxonomy is unique in providing potential insights both for the continued struggle to vaccinate people against COVID-19 and in future vaccine-preventable pandemics that create similar decision environments.

Chapter 2 focuses on understanding how cognitive bias may be helpful in differentiating between those with soft and hard vaccine hesitancy attitudes. While previous work [4] has proposed that vaccine hesitancy exists on a scale (from fully accepting to fully rejecting vaccines), my work adds the crucial nuance that while the attitudes can be laid out on such a continuum, the determinants of vaccine hesitancy likely cannot. Indeed, by comparing non-hesitant, soft hesitant and hard hesitant individuals, I show that hard hesitancy is not merely a “more intense” form of soft hesitancy but rather a distinct attitude that in some ways better resembles non-hesitancy. The study is novel in its use of an empirical test of cognitive bias to find novel determinants of vaccine hesitancy and in its ability to then use those determinants to distinguish between these two groups of attitudes.

Chapter 3 moves its focus away from the role of the individual in determining vaccine hesitancy attitudes and instead examines the role that trust plays - in particular interpersonal and institutional trust. While previous studies have generally related vaccine hesitancy to

lower levels of trust, I provide empirical evidence that while both interpersonal and institutional trust are lower in vaccine hesitant populations, institutional trust is the main driver of hesitancy. These findings lead me to suggest public health strategies focused on acknowledging broader factors behind vaccine hesitancy. For example, while much of the onus of vaccine hesitancy has been put on an individual's predispositions, I argue that in many communities that are disproportionately affected by vaccine hesitancy, historical factors such as marginalization by institutions, may also play a significant role.

Contribution of Authors

I am the first author of all three of the manuscripts presented in this thesis, with Ian Gold serving as supervisor and contributing to all stages of the development of the manuscripts.

For the first manuscript, entitled “Navigating the Uncertainty: A Novel Taxonomy of Vaccine Hesitancy in the Context of COVID-19”, I led the writing of the manuscript, conceptualized and performed the analysis and created the tables and figures. Qualitative data coding was performed by Xingyan Lin. Zoua M. Vang, Fernanda Pérez-Gay Juárez, Elizaveta Solomonova, Maya Goldenberg and Maxwell J. Smith were responsible for the project conceptualization and initial analysis. Fernanda Pérez-Gay Juárez and Zoua M. Vang were responsible for focus group coordination. Zoua M. Vang, Fernanda Pérez-Gay Juárez, Maya Goldenberg, Daniel Weinstock and Ian Gold contributed to the instrument design, and all authors contributed to the review and editing of the manuscript for the purpose of journal submission. The manuscript is published in PLOS ONE.

For the second manuscript, entitled “Distinguishing Soft and Hard COVID Vaccine Hesitancy: Psychological Mechanisms and Implications for Public Health Communication”, I led the writing of the manuscript, conceptualized and performed the analysis and created the tables and figures. Fernanda Pérez-Gay Juárez and Elizaveta Solomonova were responsible for the project conceptualization and data collection. Zoua M. Vang, Fernanda Pérez-Gay Juárez, May Goldenberg, Daniel Weinstock and Environics Research contributed to the instrument design, and all authors contributed to the review and editing of the manuscript for the purpose of journal submission. The manuscript is being prepared for submission to BMC Public Health.

For the third manuscript, entitled “Institutional trust is a distinct construct influencing vaccine hesitancy and refusal”, I led the writing of the manuscript, conceptualized and performed the analysis and created the tables and figures. Fernanda Pérez-Gay Juárez,

Elizaveta Solomonova and Esme Dervis were responsible for the project conceptualization and data collection. Zoua M. Vang, Fernanda Pérez-Gay Juárez, Maya Goldenberg, Daniel Weinstock, Maxwell J. Smith and Ian Gold contributed to the instrument design, and all authors contributed to the review and editing of the manuscript for the purpose of journal submission. The manuscript is published in BMC Public Health.

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General Thesis Introduction

If you happened to be born during the Neolithic period, you could expect to live an average of just 20–30 years [1]. For all its faults, the modern era is one of abnormally high life expectancy. One of the biggest reasons for this radical change in the human condition is vaccines. By some estimates, widespread adoption of vaccines in industrialized countries over the last century has allowed life expectancy to increase from 47 to around 80 years [2]. Indeed, while many advances in medicine have contributed to global wellbeing, vaccines are likely the single most powerful public health tool humanity has invented. Yet, for all of their merit, vaccines are far from universally accepted. Despite strong scientific consensus that they are both safe and effective [3], roughly 20–25% of people remain vaccine hesitant - i.e. they show a “delay in acceptance or refusal of vaccination despite availability of vaccination services” [4] leading to a significant number of highly preventable deaths each year. In fact, the vaccine acceptance gap is widening, leading to what many public health practitioners are calling a crisis [5].

The decision to vaccinate or not is a deeply personal choice. Therefore, there are as many types of vaccine hesitancy as there are vaccine hesitant people [6]. Nonetheless, research has tried to understand trends in the determinants of vaccine hesitancy in an effort to create better public health interventions. While a number of models have been proposed to explain why a person might be vaccine hesitant, the COVID-19 pandemic presents us with a unique decision environment that limits the relevance of past work. Factors such as the rapid progression of COVID-19, the unprecedented speed in developing novel vaccines and the significant restrictions imposed by many governments for non-vaccinated individuals have created a level of uncertainty and urgency that result in vaccination decisions that are markedly different. In the research program presented in this thesis, I will investigate the following broad question: **What are the determinants of vaccine hesitancy in the high**

uncertainty vaccination environment created by the COVID-19 pandemic? After discussing the relevant literature, I approach this question in three parts. Firstly, I look at what past models of vaccine hesitancy can tell us and use empirical data gathered during the pandemic to propose a novel model, which I then compare to those developed prior to the pandemic.

Secondly, I focus on the cognitive factors that may influence vaccine hesitancy, using a novel measure of cognitive bias to differentiate between individuals lying at different points on the vaccine hesitancy scale. Thirdly, I explore the role of institutions in vaccine hesitancy, by examining how interpersonal and institutional trust relate to vaccine hesitant attitudes. In the conclusion, I discuss what insight this three-pronged approach that focuses on broad, individual and institutional factors can provide about vaccine hesitancy in the context of COVID-19 and extrapolate how it might be helpful in informing our response in other high uncertainty vaccination environments.

Literature Review

Vaccines prevent 2–6 million deaths per year around the world [7], marking a huge step forward for humanity. However, their massive success shines a bright spotlight on deaths that could have been prevented by a vaccine but were not due to poor uptake: a figure that exceeds 1.5 million deaths annually [8] and is likely much higher in the context of a pandemic. While biotechnology and medicine accelerate toward new generations of vaccines [9], little progress has been made in reducing vaccine hesitancy. In fact, an increasing number of people feel that vaccines are unsafe and unnecessary [10]. Understanding why this is, and how we might move toward more effective vaccine uptake interventions, requires a holistic approach focused on the intersection of historical, sociodemographic and psychological factors that have been previously associated with vaccine hesitancy.

Vaccine Hesitancy in the Eighteenth and Nineteenth Centuries

Vaccine hesitancy has existed for as long as vaccines have. Understanding the historic context of anti-vaccination attitudes and related sociodemographic dynamics is important, as they provide crucial context for vaccine hesitancy today [11]. While the concept of vaccination had existed at a smaller scale for centuries earlier, the first efforts to inoculate a population can be traced back to Boston in 1721, where variolation was used to immunize against smallpox. While generally effective, this method was crude, inconsistent and had a far higher mortality rate than subsequent methods, leading to some of the first widespread anti-vaccination attitudes [11].

In 1796, a British physician by the name of Edward Jenner developed a far safer and more effective way to inoculate against smallpox [12]. Jenner showed that by taking lymph from a cowpox blister and then administering it to a child, he could confer immunity. As widespread smallpox vaccination began in the early 1800's, negative reactions grew with the

local clergy calling the procedure “unchristian” [13]. Other vaccine skeptics based their attitudes on a general distrust of medicine and an unfounded belief that smallpox was a result of decaying matter in the atmosphere [14]. As the safety and effectiveness of smallpox vaccines became evident, the British government introduced the Vaccination Acts of 1853, which made vaccinations mandatory for infants up to 3 months old, followed by the Act of 1867 which increased the age to 14 years old. Given the 1 GBP penalties for refusing the vaccine — roughly equivalent to a month’s wages for a factory worker — these laws were met with strong resistance from working class Victorians [13].

This was an important moment in the history of vaccine hesitancy simply due to the magnitude of the penalties [15]. The sum was significant for working class citizens, especially when considering that many of them had little to no savings. This meant that a disproportionate amount of harm was inflicted on lower income vaccine hesitant individuals, creating a differential level of coercion between social classes. This divide naturally created differences in how social classes reacted to the vaccine, and created a momentum in lower income communities that is the basis for many anti-vaccination campaigns and movements still in existence today.

As a result, politically active working class campaigners promoted the idea that harsh vaccine laws were a way of violating the bodies of working class infants. This gave rise to anti-vaccinationism, which was quickly absorbed into the mainstream culture. Almost as quickly as the Vaccination Acts were created, organizations such as the Anti Vaccination League and the Anti-Compulsory Vaccination League sprang up [16]. Far from being fringe, these organizations organized protests such as the Leicester Demonstration March of 1885, which gathered close to 100,000 protesters [17]. This opposition was so strong that the Vaccination Act of 1898 removed any penalties for parents who decided to object to their children being vaccinated [16]. However, to a large extent, the harm was already done, with

vaccine hesitancy being tied to political rhetoric in certain sociodemographic segments regardless of the penalty's reversal.

Soon thereafter, the same sociodemographic dynamics were exported across the Atlantic Ocean. As smallpox outbreaks started to affect the United States in the late 1800's, vaccine campaigns began. Almost simultaneously, anti-vaccinators from the UK, such as William Tebb, visited, prompting the creation of the Anti-Vaccination Society of America [16]. In 1905, the question of whether the state could legally mandate that a person be vaccinated reached the Supreme Court, which ruled that it could [18], thus strengthening the anti-vaccination argument that the state had little regard for individual autonomy and the sanctity of a person's body.

These same anti-vaccination attitudes were present around the world. For example, as Jennerian vaccines became available in Japan in the mid-1800's, a renowned doctor, Ikeda Mukei, published a book criticizing them as "a witchcraft that deceives the public." [19] Similar reactions to vaccines were present in countries like Sweden [20] and India [21]. Common themes in anti-vaccination attitudes across the world included public mistrust in government entities, political positioning of anti-vaccine movements and general concerns around vaccine safety.

A notable case study of anti-vaccination movements, which showcases these themes, comes from Quebec, Canada. In 1885, smallpox came to Montreal from the United States. Vaccination started soon thereafter but, likely due to unsanitary conditions, it caused several cases of bacterial infection. This led to a three-month pause on vaccination, which in turn gave ammunition to anti-vaccination groups to claim that the vaccine was unsafe. As the spread of the bacterial infections progressed, it disproportionately affected poor, predominantly French-speaking neighborhoods. As vaccination started up again and was made mandatory, a mob formed and led to the Montreal Vaccine Riot of 1885 [22]. While the

riot did not result in an easing of vaccine measures, and smallpox was eventually eradicated, the vaccine attitudes shaped in Canadian society have likely remained to this day just as they have in other countries [13, 23]. These attitudes are primarily focused on concerns about individual liberties and vaccine safety. As Alexander Ross, a founder of the Anti-Vaccination League of Canada wrote in 1888, “[i]t is the poor wives and children of laboring men; it is the clerks in the stores and operatives in factories and workshops; it is the workingmen and women that are threatened and driven by the hirelings of the infamous compulsory vaccination law.” [24].

Much like other health interventions, early vaccines were less effective and safe compared to today. Yet, in an effort to respond to public health crises, governments around the world weighed the pros and cons, reaching the conclusion that widely mandated vaccines could save lives. However, given the nature of vaccines and herd immunity, these measures depended on wide acceptance, leading governments to also create penalties for those choosing not to vaccinate. Given the immense disparity in incomes in much of the world of the eighteenth and nineteenth centuries, these penalties meant that working class citizens with concerns about the vaccine might be forced to take it for financial reasons. The anti-vaccination movements of this period mirrored these demographic trends, attracting the working class and giving rise to rhetoric centered on social reform combined with misleading arguments aimed at undermining vaccines [25].

Vaccine Hesitancy in the Twentieth Century

The twentieth century saw a massive rise in new vaccines against diseases such as whooping cough (1914), tuberculosis (1921), diphtheria (1926) and tetanus (1938) followed by polio (1955) and measles (1963), mumps (1967) and rubella (1969) and others [17]. As vaccination efforts became more widespread, so did anti-vaccination attitudes and organizations. These

attitudes were further strengthened by a series of serious incidents such as the one with Cutter Laboratories in 1955, where over 250 cases of polio were linked to a manufacturer's inclusion of a live polio virus in the vaccine. A second incident involved the contamination of 10–30% of polio vaccines in the US with what was thought to be a cancer-promoting virus (Simian Virus 40) between 1955 and 1963. Incidents like these gave ammunition to anti-vaccination movements, legitimizing some of their concerns around vaccine safety and the notion of individual right of choice.

Another influential incident in the evolution of vaccine hesitancy in the twentieth century was related to influenza vaccinations. In 1976 a swine flu vaccine campaign was launched in the US, resulting in over 45 million vaccinated individuals. Some later studies showed that influenza vaccines increased the baseline chance of developing Guillain-Barré Syndrome (GBS) - a rare disorder where the immune system attacks the nerves [11]. While other studies have shown that an even more significant increase in the risk of GBS is associated with influenza itself [26], GBS complications from vaccines were added to a growing list of safety concerns in vaccine hesitant groups.

Perhaps partly because of concerns like these, further research started to evaluate whether other vaccines might be associated with similar risks. One retrospective study on 20 years of diphtheria, tetanus and pertussis (DTP) vaccines described 36 cases of children who suffered neurological complications, leaving them with severe intellectual handicaps [27]. While subsequent studies showed that these risks were extremely low, this new information gave rise to the Association of Parents of Vaccine-Damaged Children (APVDC) [11] and created high levels of uncertainty and negative public sentiment around vaccines. These attitudes continued to rise and become mainstream, culminating in the 1982 NBC documentary *DPT: Vaccine Roulette*, which presented distorted results that severely impacted public trust in vaccines [11]. In fact, public opinion shifted so significantly, that pertussis

vaccine uptake in the UK declined from 81% in 1974 to 31% in 1980 [28]. While the impact was not as severe in other countries, vaccine hesitancy was now a bigger part of the mainstream than any time in recent history.

The final significant incident that fueled vaccine hesitancy in the latter part of the twentieth century was a 1998 *Lancet* study by British gastroenterologist Andrew Wakefield which alleged that the measles, mumps and rubella (MMR) vaccine had caused autism in 12 children [29]. Subsequent studies found no such link, the study was retracted in 2010, and reports later appeared that Wakefield had been paid 400,000 GBP by a team of lawyers representing a legal aid fund aiming to establish vaccination as harmful. Nevertheless, the harm to public opinion was done, with measles once again becoming endemic in the UK [30].

While anti-vaccination movements in the late nineteenth and early twentieth century centered on matters of principle and socioeconomic divides, the latter parts of the twentieth century generated a growing list of concerns — both legitimate and illegitimate — that transformed vaccine hesitancy into a far more complex phenomenon.

Modern Understanding of Vaccine Hesitancy Prior to COVID-19

While the earlier history of anti-vaccination movements is tied to specific geographic and demographic segments of the world, the growing role of global health organizations in recent decades has created the need for a more integrated understanding of vaccine hesitancy that can inform a global response. Consortia of researchers, such as the World Health Organization's (WHO) Strategic Advisor Group of Experts on Immunization (SAGE) were assembled to work toward a common understanding of an increasingly complex phenomenon. As a first step, in 2014, SAGE defined vaccine hesitancy as a “delay in acceptance or refusal of vaccines despite availability of vaccination services” [31] and proposed a framework, the 3Cs model, to guide in the study of factors related to vaccine

hesitancy. The 3Cs in SAGE's model are complacency (a lack of urgency in receiving the vaccine), convenience (the practical hurdles associated with receiving the vaccine) and confidence (a distrust in either the effectiveness or safety of the vaccine). While the 3Cs model was helpful in pointing researchers toward the most commonly encountered categories of vaccine hesitancy determinants, the framework was limited in a number of ways — notably around its ability to present nuanced sociocultural factors — which subsequent models and frameworks tried to address.

In 2016, another framework, the 5As, was proposed by Thomson and colleagues [32]. The 5As included access (the availability of a vaccine), affordability (the ability to pay for a vaccine), awareness (the knowledge that the vaccine exists), acceptance (the agreement that the vaccine is a good idea) and activation (the concrete opportunity to vaccinate) and aimed to provide a broader point of view on factors that could influence vaccine attitudes. Notably, the 5As leaned more heavily into the behavior change literature, acknowledging the role of informational factors (awareness) and behavioral triggers (activation) in the vaccination decision journey. However, while the 5As emphasized the psychological dimensions of vaccine hesitancy, it was limited in its emphasis on the social ones.

In 2018, an updated version of the 3Cs framework, the 5Cs [33], was introduced, encompassing confidence, complacency, constraints (i.e., psychological barriers such as safety concerns and structural barriers such as affordability), calculation (gathering of information followed by deliberation) and collective responsibility (the desire to protect others) [11]. The 5Cs represents a balance between structural, psychological and social factors related to vaccine uptake. While these frameworks, which continue to evolve, represent useful models for how vaccine hesitancy might arise in a general sense, vaccine hesitancy is a highly heterogeneous concept that varies based on sociodemographic and cognitive factors.

Sociodemographic Correlates of Vaccine Hesitancy

Reasons for vaccine hesitancy vary enormously between different geographic, socio-economic and demographic groupings. In general, work prior to the COVID-19 pandemic has shown that safety and efficacy concerns are, by and large, dominant in high-income countries, while low- and middle-income countries focus on factors such as cultural beliefs, historical experiences and systems of care (e.g., the healthcare system) [11]. Indeed, analysis of reports for 2015–2017 by the World Health Organization and UNICEF show that over 90% of countries report vaccine hesitancy and that the determinants vary by the income level of the country [34]. While lower income countries cited a lack of knowledge and awareness about vaccines as a key driver of hesitancy, higher income countries pointed to risk-benefit analysis as the key determinant. Within high income countries, factors such as being female, being younger than 65, having a right wing political affiliation, having a lower level of income, being part of a minority group, living in a rural area are also associated with higher rates of vaccine hesitancy [35–38]. Interestingly, in the US, high levels of income and education have also been shown to be a barrier to vaccination [39]. However, as Larson and colleagues[40] point out, the research on sociodemographic factors related to vaccine hesitancy remains fragmented, with significant differences in the predictors among different countries.

Vaccine Hesitancy in Marginalized Groups

The link between vaccine hesitancy and marginalized groups is one that has existed since the first legislation that disproportionately coerced working class British citizens into vaccinating [16]. There is a wealth of modern evidence showing higher levels of vaccine hesitancy in ethnic minority groups - for example showing that African Americans are less likely to have received the flu shot [41], less likely to vaccinate their children [42] and, more recently, that

they are less likely to be vaccinated against COVID-19 [43–45]. In a study exploring the differential attitudes toward COVID-19 vaccines in Black vs. white Americans, Morales and colleagues [46] noted that in addition to having higher rates of vaccine hesitancy, Black communities are also more at-risk when it comes to the effects of the disease and availability of treatment options. The authors suggest that these attitudes are grounded in collective experiences of racism and might in fact be a “protective health behavior” [46], whereby individuals believe that not taking the vaccine is the genuinely safer option. This point of view is supported by data showing that Black communities had higher rates of compliance with mask and social distancing guidelines during the COVID-19 pandemic [47]. Based on available evidence, it seems likely that marginalized groups, who have a unique lived experience and historic relationship with government entities, are also driven toward vaccine hesitancy by a unique set of factors [48]. Indeed, research on COVID-19 vaccine hesitancy in a Canadian sample has shown drivers of vaccine hesitancy differ between equity-deserving subgroups, with a distrust of the healthcare system being prevalent in LGBT2SQ+ and Black Canadians, fear of the speed with which vaccines were created in First Nations Métis or Inuit (FNMI) individuals and distrust of the government across Black, low-income FNMI and LGBT2SQ+ individuals [49].

The higher incidence and unique set of drivers of vaccine hesitancy in equity-deserving communities are a reflection of systemic inequities with a deep historical context. However, they are also shaped by ongoing lived experiences of discrimination which reinforce mistrust in government and healthcare systems [49]. Critically, as opposed to being the product of a lack of good information or a misjudgment, vaccine hesitancy in these communities seems to be much more substantially driven by what could be called a rational response to a history of medical mistreatment and neglect.

Psychological Correlates of Vaccine Hesitancy

Part of the complexity behind vaccine hesitancy is that it is a phenomenon which sits at the intersection of sociodemographic, systemic and psychological factors. While the decision to vaccinate or not ultimately happens at a psychological level, influences such as belonging to a marginalized community that has had negative experiences with healthcare providers, having a low level of education, which translates into a lack of confidence in the information provided by the government, can exacerbate levels of uncertainty in the vaccination decision. At the same time, that same uncertainty can be increased for psychological reasons - for example because someone simply has a lower level of uncertainty tolerance (i.e., ability to cope with uncertain situations without experiencing significant stress) [50]. For this reason, a holistic approach to understanding vaccine hesitancy must also be rooted in a solid understanding of its psychological determinants.

Past research has shown that factors such as mistrust of vaccine benefit, lower perceived seriousness of the disease and higher risk propensity were strong predictors of vaccine hesitancy [37]. In addition, factors such as lower cognitive reflection, agreeableness and conscientiousness as well as higher levels of social dominance (desire for power over others), internal locus of control (belief in controlling one's own destin) and authoritarianism (preference for strict obedience and authority) were associated with vaccine hesitancy [38]. Low trust in government and high levels of conspiracy beliefs have consistently been reported as a predictor of vaccine hesitancy [51, 52]. While these factors are generally helpful in understanding what a “vaccine hesitant” individual might look like, a similar heterogeneity exists in the psychological determinants of vaccine hesitancy as in the sociodemographic ones. Indeed, Martinelli and Veltri[53] proposed that the same psychological determinants can have different relationships to vaccine hesitancy in different groups of individuals. By

defining three unique *cognitive schemas* of beliefs (i.e., groups with different mental frameworks for organizing and interpreting information about vaccines) associated with various levels of vaccine hesitancy, they suggested that each schema shows differential associations with vaccine decisions. For example, higher risks of disease are a driver of vaccine acceptance in vaccine skeptics but not in the vaccine confident. As the authors suggest, research like this underlines the importance of understanding the “centrality of an individual’s epistemology” (i.e., their belief system) [53] in analyzing various factors related to vaccination decisions. For this reason, more fundamental aspects of decision making, such as biases and heuristics —mental shortcuts that allow us to reduce enormous amounts of information and ambiguity in the environment and perform otherwise intractable calculations about the better course of action— have started to make their way into vaccine hesitancy research [54–56].

A body of literature has shown that cognitive biases and heuristics are influential in decision making – particularly when a high level of uncertainty is present [57]. However, while they can be a helpful tool, decades of research has shown that they can also lead us to make systematic mistakes in how we navigate the world around us. In the context of vaccine hesitancy, Azarpanah and colleagues [56] hypothesize that three broad groups of bias may play a role in the vaccination decision context but empirical confirmation is lacking: those triggered by processing vaccine-related information; those triggered in the vaccination decision making; those triggered by prior beliefs regarding vaccination. Work by Pomares and colleagues [55] found an association between human papillomavirus (HPV) vaccine hesitancy and a number of cognitive biases demonstrating the potential role of cognitive bias as a determinant of vaccination decisions.

Vaccine Uptake Measures

The heterogeneous and complex nature of vaccine hesitancy makes designing personalized interventions difficult. Each community, and even each individual, has a unique lived experience in relation to vaccination - created by myriad historic, systemic, socio-demographic and psychological factors. As a result, there are many strategies to increase vaccine uptake, and consequently a number of different uptake measures in existence.

Public Health Policies

Mandatory vaccination policies — i.e., ones that impose a serious restriction or penalty on those choosing not to vaccinate — differ around the world. Some countries leave the decision entirely up to the individual; others, such as Australia, use a financial incentive to promote vaccination while other places, like the United States and Canada, go as far as to restrict access to the school system until children have received the appropriate vaccines [58]. Some countries, such as Slovenia, go even further, mandating vaccination within three months of birth or paying a fine [58]. Regardless of the policy implemented, these interventions are widely controversial. In the context of COVID-19, a number of vaccine policies were introduced around the world, limiting freedom of movement, access to certain services and even access to employment [59] for those choosing not to vaccinate. A number of arguments have been made for and against these measures [60], asserting, on the one hand, that mandatory vaccination saves lives and, on the other, that it is a violation of human rights.

While it is outside the scope of this review to address this debate, it is clear that mandatory vaccination policies are highly controversial. While they might be highly effective in the short term, they can also backfire, creating more harm than good in the longer term [11] and reinforcing narratives of governments as coercive and discriminatory toward communities that are more likely to be affected by the restrictions or penalties [61]. This is

not unexpected given the history of vaccine hesitancy and its strong politicization, going back to the early vaccine mandates such as the Vaccine Act of 1853.

Communication Strategies

Simple communication strategies are less coercive than vaccine mandates and can still be an effective tool in increasing vaccine uptake [62]. Indeed, communication strategies recruiting media personalities, politicians and healthcare professionals, represent the majority of a government's typical efforts in increasing vaccine uptake, recruiting media, politicians and healthcare professionals [11]. In addition to broadcasting vaccine-related messaging, governments have used personalized messaging to increase vaccine uptake. Research has shown that this can be effective in some cases, though systematic reviews reveal mixed results [63]. While these communication tools can be helpful in targeting a non-vaccine-hesitant population, they are not sufficient to overcome vaccine hesitancy due to small effect sizes. They must therefore be complemented by a broader communication strategy to make a tangible difference [64] - in particular, a strategy that is proactive, receptive to feedback and not solely focused on education. Indeed, while informational and reminder based strategies may be sufficient for a target population that is open to vaccination, public health researchers have suggested that vaccine-hesitant individuals are better served by alternative strategies. For example, Chou and colleagues [65] proposed that attending to negative emotions such as anxiety and fear and leveraging positive emotions such as hope and altruism is a useful complement to vaccine education efforts. Finally, in contrast to broad media strategies that may be effective in a vaccine-acceptant population, vaccine-hesitant individuals are more likely to respond to communication strategies that use an approach involving a social circle — e.g. community members and families [66] — as well as strategies that are highly personalized [67]. Overall, past research suggests that while communication strategies can be an effective tool in improving vaccine uptake, vaccine

hesitant populations must be based on trust and approached with tact and understanding - something that most government communication strategies have lacked in the past.

Behavioral Interventions

In recent decades, behavioral science has been used to devise a number of strategies to promote vaccine uptake [11]. Behavior change frameworks such as AACTT (Action, Actor, Context, Target, Time) and COM-B (Capability, Opportunity, Motivation, Behavior) have been proposed as tools for designing interventions, or *nudges* (i.e., interventions that gently steer individuals toward beneficial behaviors), which might help to overcome vaccine hesitancy [68]. A number of nudge interventions have used relatively simple methods such as well timed SMS and paper mail alerts, to create a significant increase in vaccine uptake [69, 70], suggesting that nudging can be effective. Tools like this can serve as a powerful alternative to more coercive policies and can, because they tap into a broader behavior change literature, also contribute to a deeper understanding of the contexts in which people make vaccination decisions [71].

While a large number of tools are available to public health professionals aiming to increase vaccine uptake, overall they are far more effective in targeting those who already hold *vaccine acceptant* beliefs and attitudes. For example, while mandatory vaccination might be effective in a vaccine acceptant individual, it may further alienate a vaccine hesitant one. Similarly, while an informational campaign or reminder coming from a government source might be informative or a catalyst for action in an acceptant population, a vaccine hesitant group with low trust in government is likely to react differently. Therefore, vaccine uptake interventions looking to specifically target vaccine hesitant individuals must focus on understanding the specific nuances of that hesitancy [11]. This has been made abundantly clear by the COVID-19 pandemic, which has created a unique environment in which vaccine hesitancy has evolved.

Unique Features of the COVID-19 Pandemic

The COVID-19 pandemic represents one of the most significant global crises in modern times. In addition to the immense death toll and countless socio-economic burdens it created, COVID-19 also exposed a number of gaps in the global pandemic response. On the one hand, it brought on unprecedented speed in the development of new vaccines using novel technology. However, it also revealed weaknesses in public health communication across the globe, leading to poor vaccine uptake and preventable deaths. One study by de Miguel-Arribas and colleagues [72] used a mathematical model of infectious disease spread to show that, in the United States, each additional percent vaccine hesitancy caused 45 deaths per million inhabitants. Given a population of 340 million and a 20% vaccine hesitancy rate, this results in 300,000 preventable deaths that were not averted due to vaccine hesitancy in the US alone. Despite decades of research on vaccine hesitancy and a number of frameworks aimed at understanding and improving vaccine uptake, vaccine hesitancy was, and continues to be, an enormous factor in the global death toll. One of the key questions we are left with as we look back at what went wrong is: **what are the unique factors brought on by the COVID-19 pandemic and pandemic response that may have contributed to vaccine hesitancy?** In this section, I discuss several factors which differentiate the vaccine decision environment during the COVID-19 pandemic compared to prior periods.

Parental versus Individual Vaccination Decisions

Much of the history of vaccine uptake efforts and of anti-vaccination movements, has been centered on vaccination decisions made by parents about their children. Since most of the government mandated vaccines primarily target young children or infants, it is unsurprising that vaccine hesitancy prior to the COVID-19 pandemic was largely a parental attitude. Consequently, a large part of our understanding of vaccine hesitancy prior to 2020 was

focused on understanding why some parents refused or delayed vaccination for their children. While parental decisions were relevant at certain points in the pandemic, most vaccination decisions have been by adults deciding whether to vaccinate themselves. Past research has shown that individual and parental vaccination decisions overlap to some extent but also differ in a number of important ways. In a comparison between attitudes toward routine child vaccines and individual COVID-19 vaccines, Shen and colleagues [73] showed that while factors such as the need for evidence-based information were similar across contexts, other factors were context-specific. Further work [74] in China showed that there was a significant difference in COVID-19 vaccine hesitancy rates between individual (20.3% hesitancy) and parental (7.8% hesitancy) contexts, which was hypothesized to be due to differential threat perception. Interestingly, severity of disease was the strongest reported factor in individual contexts, and safety of the vaccines was the strongest factor in parental contexts, perhaps indicating that parents are especially sensitive to the risks of intervening with an unsafe vaccine. It has been suggested that shifting parenting styles toward one that is *intensive* [75] (i.e., highly involved and child-centered when making decisions about daily routine) over the last few decades, especially in individualistic societies, has put a higher onus on parents, and mothers in particular, to make the “right” decision for their children as well as an increased sensitivity to potential side effects of vaccines [76].

Containment Measures

Factors such as the rapid evolution of COVID-19 variants and hospital overload led a majority of governments around the world to implement containment measures that represented a significant limitation on individual freedoms. These measures ranged from school, business and office closures, to mask mandates and limitations on transportation, to full lockdowns limiting freedom of movement in the most serious cases. While a number of government measures had been taken to limit the spread of disease prior to COVID-19, for

most people around the world, COVID-19 containment measures were a unique experience. In addition, given that containment measures disproportionately affect those whose physical presence is required to make a living, these measures had an asymmetrical effect on lower income populations around the world. In many ways, the challenges posed by these measures on working class individuals mirror the initial context which created anti-vaccination movements in the eighteenth and nineteenth centuries.

Conspiracy Theories

Given the fraught history of vaccination campaigns in the late twentieth century, it is unsurprising that a high level of overlap exists between conspiratorial beliefs and COVID-19 vaccine hesitancy [77]. While the relationship between conspiratorial beliefs and vaccine hesitancy has been shown prior to COVID-19 [78], an unprecedented number of people adopted such beliefs during the pandemic [79]. Indeed, since the onset of the pandemic, a number of conspiracy theories have emerged – including that COVID-19 does not in fact exist, that the pandemic was a planned project aimed to implant people with tracking chips or that pharmaceutical companies created the disease in order to profit from the vaccines [80]. One of the factors that further exacerbated the effect of conspiratorial thinking on COVID-19 vaccine hesitancy is the lab leak theory. In the first stages of the pandemic, a theory was put forward that the disease was caused by a virus which leaked from a research facility in Wuhan, China. While mainstream media immediately dismissed this as a conspiracy theory, further analysis showed that it is not outside the realm of possibility [81]. Researchers are still divided about the provenance of COVID-19, but the legitimization of what was first considered conspiratorial thinking may have strengthened other conspiratorial beliefs affecting vaccine uptake. To further complicate matters, the idea that COVID-19 was artificially created is aligned with historical disinformation campaigns that have decreased trust in government health interventions. For example, a disinformation campaign by the

KGB in the 1980's proposed that AIDS was created by the US government in an effort to eliminate specific parts of the population [82].

Vaccine Development Timeline

One of the most important factors that uniquely shaped COVID-19 vaccine hesitancy was the speed of development and the relative novelty of the vaccines. Initial versions of the COVID-19 vaccine were created within days of the sequencing of the virus' genome [83]. Perhaps even more impressively, especially given the novelty of mRNA vaccine technology, typical vaccine development timelines would require an average of 10.2 years in order to include preclinical animal trials, followed by three phases of clinical trials [84]. The fact that this timeline was cut by a factor of 10 is remarkable from a medical perspective – the result of quickly mobilized collaborations between academics, governments and pharmaceutical companies. However, while this speed surely saved lives, it also increased doubt in the safety and effectiveness of the resulting vaccines. This has consistently been cited as a strong driver of vaccine hesitancy around the world [85].

Misinformation and Social Media

An additional factor that distinguishes COVID-19 vaccine hesitancy from past occurrences of the phenomenon is the level of attention that it has received from the media – both mainstream and alternative media. Research has shown that higher levels of consumption of relatively unregulated media, such as social media, predict higher levels of vaccine hesitancy [77]. While a lack of regulation opens the door to systematic misinformation through these channels, recommender systems that drive content consumption are also a significant factor relating to vaccine uptake. By creating informational echo-chambers, social media outlets not only create an opportunity for misinformation to spread, but also limit the possibility that

factual information might be consumed, thus strengthening attitudes in vaccine hesitant communities.

The Game Theory of Pandemics

One interesting aspect of the decision environment created by COVID-19 is the scale and simultaneity of the decision making. Vaccination decisions in pre-pandemic contexts have typically been relevant at a particular life milestone - for example, in the first years of a child being born. Therefore, only a small portion of the global population was ever affected. This is not so in a pandemic context, where billions of people are expected to make a vaccination decision within a relatively short period of time. Thus, while game theory has been studied in the context of non-pandemic vaccination [86], the dynamics of pandemic vaccination — i.e. the fact a large portion of the globally population is being pushed to make a decision that impacts both themselves and others, while not yet knowing what others will do — makes game theory highly applicable to its study [87].

Summary

As we have seen in the preceding section, the COVID-19 pandemic created a unique combination of factors affecting vaccination decisions. Compared to routine vaccines offered prior to the pandemic, COVID-19 vaccines carried with them much higher levels of uncertainty, urgency and a completely different social dynamic where everyone was expected to vaccinate more or less at the same time. Therefore, while a rich vaccine hesitancy literature already existed prior to the pandemic, it is unclear how well it might generalize to pandemic vaccination decisions. Indeed, while vaccination decisions have always occurred at the confluence of individual and social factors, the widespread and highly uncertain nature of both COVID-19 and the resulting vaccines raise the interesting possibility that the COVID-19 pandemic increased the relative importance of social factors. This line of thinking raises an

important question: what are the determinants of vaccine hesitancy in the context of COVID-19 and how do they differ from those in a non-pandemic context? In order to answer this question, Chapter 1 uses an inductive approach to derive a novel framework for vaccine hesitancy and then compares that framework to past models of vaccine hesitancy developed prior to the pandemic.

Building on the foundational line of inquiry in Chapter 1, the remaining two chapters focus on specific aspects of COVID-19 vaccine hesitancy that are likely to be unique based on the unique context described above. Chapter 2 focuses on cognitive factors as a way to differentiate between soft and hard vaccine hesitant individuals. Public health messaging aiming to promote vaccine uptake typically focuses on a fairly narrow audience (e.g., the small number of individuals who have a child of a certain age and have not yet sought vaccination). However, in the context of COVID-19 and potentially future vaccine preventable pandemics, the audience for vaccine uptake campaigns is highly dynamic. For example, in a country such as Canada, baseline incidence of vaccine hesitancy suggests that at the start of the campaign, the majority of the target audience is vaccine acceptant. However, as those individuals receive the vaccine, the campaign is now likely to focus on soft hesitant individuals - i.e., those who may be on the fence. Finally, in the late stages of the campaign, only very resistant individuals remain. For this reason, it is critical to understand how these groups of individuals might differentially process vaccine related information. This is the question I ask in Chapter 2: how might we use commonly studied cognitive factors to differentiate between non-hesitant, soft hesitant and hard hesitant individuals?

Chapter 3 shifts the focus from individual cognitive factors to a social context that is prevalent in the framework presented in Chapter 1. In particular, I follow existing research on the role of trust in vaccine hesitancy and ask to what extent institutional trust in particular is relevant for vaccine hesitancy. From a historical perspective, the history of vaccine hesitancy

is strongly linked to an erosion of trust between people and institutions. In some cases, this is for historical reasons based on injustice, discrimination and alienation of particular groups. In other cases, the rise of new technologies such as social media and generative AI has allowed for tighter echo chambers and more efficient misinformation to propagate. Either way, the conjunction of these factors has brought a new era of anti-vaccination movements which have stoked existing feelings of distrust to new levels. Therefore, any nuanced understanding of vaccine hesitancy in the context of COVID-19 must be grounded in an understanding of these underlying issues of trust.

Overview of the Present Research

Despite a wealth of existing research on the determinants of vaccine hesitancy and a rich literature proposing models and frameworks for explaining vaccine uptake, the COVID-19 pandemic has created a unique high uncertainty decision context that requires adaptation and extension of past findings. The research presented in this thesis aims to address gaps in our understanding of vaccine hesitancy in this kind of decision environment.

Chapter 1 takes a broader approach, using qualitative data gathered during the pandemic from focus groups to propose a novel taxonomy of vaccine hesitancy that is specifically adapted to the types of high uncertainty decision environment created by the COVID-19 pandemic. By applying thematic analysis techniques to focus group transcripts of individuals that differ widely in their vaccine attitudes, I am able to apply an inductive approach to the proposed taxonomy – something that differs from the vast majority of models proposed in the past, which use a wide range of deductive techniques. The results indicate that individuals differ significantly in their reasons for being vaccine hesitant.

In light of these dramatic differences between individuals, Chapter 2 explores the vaccine hesitancy continuum that is created by high uncertainty vaccination decisions, aiming

to find the cognitive precursors that might distinguish those with soft vaccine hesitancy (those uncertain about the vaccine) versus those with hard hesitancy (those who are certain they do not want the vaccine). Interestingly, the findings show that hard hesitancy is not merely a stronger version of soft hesitancy, but rather a distinct cluster of cognitive predispositions.

Chapter 3 focuses on the role of trust on vaccine attitudes and behaviors in the context of high uncertainty vaccination decisions. In particular, given the heavy-handedness of governments around the world in the COVID-19 pandemic, and their unique position in promoting vaccination, I explore the relative impact of interpersonal and institutional trust on four distinct measures related to vaccine hesitancy.

Chapter 1

Navigating the Uncertainty: A Novel Taxonomy of Vaccine Hesitancy in the Context of COVID-19

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Abstract

Vaccine hesitancy remains a significant and evolving public health challenge. The COVID-19 pandemic has created a unique decision context with significant uncertainty caused by the novelty of the disease being targeted, unfamiliarity with the vaccines being offered, misinformation, and heavy-handed government measures. In an effort to extend our understanding of vaccine hesitancy to the high uncertainty decision environment presented by COVID-19, we present a novel taxonomy of the determinants of vaccine hesitancy, based on an inductive analysis of qualitative data gathered during the COVID-19 pandemic. We report on focus group data from a purposive sample of 18 Canadians with varying sociodemographic characteristics and COVID-19 vaccination attitudes. An inductive thematic analysis of this data reveals eight core themes related to vaccine hesitancy: values, trust, social environment, personal anecdotes, environmental fluctuation, prior knowledge, perceived risk and systems of care. We explore these core themes as well as 25 sub-themes, contrasting them with previous models of vaccine hesitancy and suggesting potential strategies for public health professionals.

Introduction

It is estimated that 14.4 million COVID-19-related deaths were prevented globally by vaccines between December 2020 and December 2021 alone [1]. However, despite being one of the most powerful and safe public health tools we have access to, vaccines are still not universally accepted. In fact, a study of over 140,000 people in more than 140 countries found that 79% of people believe vaccines are safe and 84% think they are effective [2]. These attitudes are reflected in real world behaviors - namely, vaccine hesitancy, i.e. “a delay in acceptance or refusal of vaccination despite availability of vaccination services” [3]. Despite a wealth of evidence showing the safety and efficacy of vaccines, only 75% of the global population [4] are willing to accept being vaccinated. In the context of COVID-19 vaccines, acceptance rates vary significantly around the world - for example, 97% in Ecuador, 54.9% in Russia and 23.6% in Kuwait [5]. In Canada, vaccine acceptance rates in the midst of the pandemic were at 75% [6]. While we can say that vaccines have high efficacy, as measured by their success in those who take them, the varied uptake has meant that their effectiveness, as measured by actual real world outcomes, is limited [7].

Why are people vaccine hesitant?

Vaccine hesitancy is heterogenous and context-dependent in a variety of ways. Firstly, it is important to note that while the current literature on vaccine hesitancy is focused on individuals making decisions about their own vaccination behaviors, pre-COVID vaccine hesitancy research largely focused on pediatric decisions, i.e. parents making decisions about their children [8]. While these two constructs clearly differ, research has shown that there is a significant relationship between vaccine hesitancy in the two contexts. For example, Soares and colleagues showed an association between refusal to take the flu vaccine and intention to refuse the COVID-19 vaccine [9, 10]. Secondly, it is worth noting that the exact beliefs and attitudes that underlie vaccine hesitancy shift between different diseases and even between

different vaccines targeting the same disease. For example, Brewer and colleagues [11] found that parents have different levels of hesitancy and reasons for being hesitant depending on the type of vaccine concerned (in their work, MMR versus HPV). Furthermore, work by Merkley and Loewen [12] involving 6200 participants showed even within vaccines for a single disease (COVID-19), the same vaccine elicited differential levels and sources of hesitancy. Thirdly, even in cases where research is focused on a single vaccine targeting a single disease, vaccine hesitancy may not mean the same thing from one participant to another. For example, Noni MacDonald [13] has proposed that vaccine hesitancy can better be understood along a continuum that contains various attitudes such as “refuse all with conviction”, “refuse all, but unsure”, “accept some, refuse some, delay vaccination”, “accept with doubts and concerns” and “accept all with confidence”. Finally, even when people are vaccine acceptant, it may be for different reasons, unrelated to the vaccine itself (e.g., confidence in vaccine efficacy). Alfano and colleagues [14] showed that positive attitudes toward vaccines can be for individualistic or altruistic reasons.

Given how complex vaccine hesitancy is, a large amount of past research has focused on understanding its antecedents, including individual differences in vaccine hesitancy such as demographic correlates. For example, in the context of COVID-19, being a woman, being 50 years or younger, being single, being unemployed, and living in a household with five or more people, were factors associated with increased vaccine hesitancy [15]. While findings like these allow us to understand which groups might present the biggest challenge for vaccination in a public health context, they do not necessarily provide an effective strategy for targeting those groups because they shed little light on the motivating factors underlying vaccine attitude formation. For this reason (among others), recent research has started to tackle the psychological correlates of vaccine hesitancy [11, 16, 17]. For example, Betsch and colleagues [16] showed, from a group of 1000 German participants, that confidence,

complacency, constraints, calculation, and collective responsibility are key psychological antecedents of vaccination. Hornsey and colleagues [17] used a sample of over 5000 people to show strong associations between vaccine hesitancy and conspiratorial thinking, reactance, disgust towards blood and needles, and individualistic world views.

Although empirical research is invaluable in allowing us to gain a better understanding of factors related to vaccine hesitancy, previous literature on behavior change [18, 19] has shown that understanding a decision environment in a holistic and mechanistic manner is beneficial to engendering behavior change. In recognition of this, a number of models have been proposed to explain causal factors related to vaccine hesitancy - some specific to vaccine hesitancy and some broadly related to uptake of health behaviors, but all applicable to vaccine uptake. These models, which we review below, have an advantage over questionnaire-style empirical reports of factors related to vaccine hesitancy in that they base themselves on large bodies of empirical findings and thus purport to map the terrain in order to create more evidence-based directions for future hypotheses and interventions. In an effort to better understand this terrain, we review existing models related to vaccine hesitancy and then use these models to create a search space for a thematic analysis of qualitative data from pandemic-era focus groups.

Frameworks focused on health behaviors

Health Belief Model

The Health Belief Model (HBM) was developed in the 1950s by the US Public Health Service and remains one of the most widely used frameworks for assessing and predicting the uptake of health related behaviors [20]. The HBM suggests that behaviors such as getting a vaccine are linked to a person's perception of factors such as the severity of the disease, their susceptibility to it, the benefits of taking preventive action, and the barriers to taking that

action. Changes have been made to the HBM over the years to reflect advances in behavioral science, such as the inclusion of self efficacy [21].

Theory of Planned Behavior

The Theory of Planned Behavior (TPB) was developed in the 1990s by Icek Ajzen [22] and suggests that intentions to perform a behavior, and consequently, the uptake of a behavior, can be accurately predicted from a person's attitudes toward the behavior, subjective norms around the behavior and perceived behavioral control over the behavior. The TPB differs from the HBM in that it adds a significant social layer to the causal factors behind a behavior and has therefore been an instrumental addition in healthcare contexts, explaining myriad behaviors [23]. In the context of vaccine uptake in particular, evidence suggests that while there is significant overlap between the TPB and HBM, the TPB tends to consistently outperform when used to predict real-world behaviors [24].

Taxonomies of Uncertainty

Another set of frameworks used to explain health related behaviors comes from the study of uncertainty. The link between uncertainty (i.e., the subjective feeling of ignorance about something) and vaccine hesitancy has been well documented. In fact, past studies have shown that uncertainty is one of the most critical factors associated with vaccine hesitancy [25, 26]. In a study that looked at COVID-19 vaccination efforts, Courbage and Peter [27] found that reducing uncertainty about the vaccine reliably promotes vaccination.

Vaccine decisions must often take place in an inherently uncertain environment with shifting and often conflicting recommendations. This has been all the more true during the COVID-19 pandemic, where the time horizon of recommendation changes was sometimes weeks or days [28]. Past research suggests that this type of scientific uncertainty creates

distrust in scientists and public health recommendations [29], which in turn has been shown to result in low confidence in vaccines [30] and lower vaccine uptake [31]. Indeed, perceptions of uncertainty affect trust toward all disease-related information [32], particularly in individuals with lower tolerance for ambiguity and risk. Uncertainty has also been shown to make people more pessimistic about disease treatment [33] and perhaps most importantly, lower intentions to engage in health-promoting behaviors [34]. A number of efforts have been made to taxonomize the types of uncertainty relevant to healthcare decisions in an effort to better understand and support patient experience with the overall goal of improving decision making and clinical outcomes.

Varieties of Uncertainty in Healthcare

Han and colleagues [35] proposed a taxonomy (Table 1) that separates uncertainty according to source and issue. Within sources of uncertainty lie ambiguity, complexity, and probability. Furthermore, within issues of uncertainty lie scientific, practical, and personal issues, each of which have been broken down into two or more categories.

Table 1: Han et al.'s (2011) suggested taxonomy of uncertainty

Sources of Uncertainty	Issues of Uncertainty
Ambiguity	Scientific
Complexity	Practical
Probability	Personal

Model of Uncertainty Within Complex Healthcare Settings

In response to the above proposed taxonomy, Pomare and colleagues [36] posited that uncertainties do not occur in isolation, as they argued the above taxonomy implies. The

research team examined the empirical healthcare literature to see whether or not Han and colleagues' taxonomy is applicable to the wide range of sources of uncertainty experienced by healthcare providers in the healthcare space. After examining the 94 articles that passed their criteria, their research revealed that Han and colleagues' taxonomy [35] would have benefitted from two new sources of uncertainty: systems uncertainty and ethical uncertainty. Furthermore, Pomare and colleagues' new model highlights the overlapping nature of uncertainty which they argue is a necessity and more realistic than disparate and unrelated sources of uncertainty. The taxonomy they suggest (Table 2), Model of Uncertainty within Complex Healthcare Settings (MUCH-S) splits healthcare uncertainty into three main (and overlapping) categories:

Table 2: Pomare et al.'s (2018) suggested taxonomy of uncertainty.

Personal Uncertainty	Scientific Uncertainty	Practical Uncertainty
Psycho-social Existential Ethical	Diagnosis Prognosis Causal explanations Treatment options	Structure of care Processes of care Systems

Vaccine-Specific Frameworks

In an effort to refine the focus of causal factors to specifically target vaccine uptake, a number of frameworks have been proposed that are vaccine specific.

3C Model

The SAGE working group was established by the World Health Organization in 2012 to propose a behavioral model that categorizes factors that influence vaccine uptake [13]. The

3C Model was one of the outputs of this working group. This model suggests that vaccination decisions depend on three core factors: complacency, which exists when someone does not feel that the risks of the disease warrant taking action; *convenience*, which relates to the availability, *accessibility* and quality of service related to vaccination; *confidence*, which refers to the safety and effectiveness of the vaccines, the reliability and competence of health services, and the motives of the institutions behind them.

5A Model

A broader taxonomy for determinants of vaccine uptake was proposed in 2016 by Thomson and colleagues [37], based on a review of 43 studies related to vaccine hesitancy. According to this model, vaccine uptake is influenced by: *access*, the extent to which a person can reach the vaccine; *affordability*, the ability of an individual to afford (in both financial and non-financial terms) the vaccine; *awareness*, the extent to which an individual understands the need for the vaccine; *acceptance*, the extent to which individuals accept the vaccine; and activation, the extent to which individuals receive a contextual cue urging them to get vaccinated [37].

5C Model

Betsch and colleagues [16] revisited the 3C model using an empirical approach focused on a German population. Their intention was to create a novel taxonomy that focuses on more psychological antecedents of vaccine uptake. Their resulting 5C taxonomy replaced *complacency* from the 3C model with *constraints* and suggested the addition of two factors: *calculation*, which refers to engagement in extensive information searching about vaccines; and *collective responsibility*, which refers to willingness to protect others by getting vaccinated.

The dominant models reviewed above add a more holistic and mechanistic explanatory level to the vaccine hesitancy landscape. They supplement empirical research by proposing mutually exclusive and collectively exhaustive categories of factors in a way that can better drive future hypothesis-generation and intervention design. As such, these models have been instrumental in providing insight into why people might not be engaging in vaccination. However, despite their effectiveness in a general vaccine hesitancy context, they have all been developed in contexts that have less inherent uncertainty than the COVID-19 pandemic. Notably, the pandemic introduced a combination of factors that made vaccination decisions more difficult: the novelty of the disease being targeted, the burden of government interventions being imposed, a significant amount of politicization and misinformation about vaccines, unfamiliarity with the vaccines being offered, and the rapid rate of spread and evolution of the disease. We use the phrase “high uncertainty vaccination decisions” to refer to decisions where these factors are present.

While efforts have been made to verify the extent to which the HBM, TPB, 3C, 5A and 5C models apply in high uncertainty vaccination decisions – resulting in a suggestion that the HBM and 3C are most applicable – the conclusion has been that a new model which possibly combines features of past models might be most apt [38]. Indeed, as we have seen above, past research suggests that vaccine hesitancy can differ significantly between diseases [11] and even more so between COVID-19 and non COVID-19 contexts [10].

These important differences suggest that a model of vaccine hesitancy that specifically relates to high uncertainty vaccination decisions may be an important public health tool. In order to construct this model, we draw on empirical evidence gathered during the COVID-19 pandemic. In particular, we had the following research objectives:

1. To identify the multitude of determining factors related to COVID-19 vaccine acceptance based on structured qualitative analysis of focus group data generated during the COVID-19 pandemic.
2. To develop a theoretical model of the determinants of vaccine hesitancy in the context of high uncertainty vaccination decisions based on the factors identified.

Methods

In order to meet these objectives, we collected data from focus groups with 18 adults, used an inductive thematic analysis to identify factors related to vaccine hesitancy, and then used insights from the models reviewed above to further refine and contextualize the emerging themes. This approach allowed us to propose a novel model of vaccine hesitancy adapted to a COVID-19 context. All methods and protocols were carried out in accordance with relevant guidelines and regulations and were approved by McGill University's Institutional Review Board (Ethics Approval ID: 22-10-064). In addition, informed consent was obtained from all subjects prior to data collection.

Data collection methods

Research was carried out in collaboration with Environics Research (<https://environics.ca/>), a Canadian polling and research firm, for the purpose of data collection. Participants were recruited using a purposive sampling strategy between June 23rd, 2021 and August 4th, 2021 based on their self-identified vaccination status and attitudes in a national survey of COVID-19 experiences. Survey data, which we do not report on in this study, was collected from 1541 Canadians in April and May, 2021, during which time participants were asked if they were interested in participating in follow-up focus groups. Among the 758 individuals who agreed (49%), we selected 538 profiles specifically fitting a sampling strategy selected

to include a balanced urban/rural split, a wide range of ages, ethnicities, geographical locations and income ranges. We contacted them by e-mail and 18 individuals agreed to participate in the focus groups. Data was collected in focus groups that were carried out virtually between September 7th and September 9th, 2021. Given that COVID-19 vaccines became available in Canada in December 2020, and were widely available by Summer 2021, focus groups were carried out at a time where vaccination decisions were top-of-mind for participants. A total of four focus group sessions were conducted, each lasting between 60 and 67 minutes with a mean length of 64.

The four focus groups consisted of participants with different vaccination statuses. Group 1 participants were unvaccinated individuals who indicated that they would either not get vaccinated at all or would wait a while before deciding. Group 2 consisted of vaccinated individuals who were initially hesitant about receiving a COVID-19 vaccine but ultimately chose to get vaccinated. Groups 3 and 4 consisted of young adults with mixed vaccination statuses.

The four groups included 18 adults, consisting of 13 women and 5 men. Table 3 illustrates the primary sociodemographic characteristics of the participants, including their vaccination status at the time of the focus groups. The age of the participants ranged from 26 to 68, with an average age of 44. All participants were born in Canada and identified themselves as either white (67%) or Indigenous (33%). They were from six provinces across eastern, central, and western Canada, with the majority residing in Ontario. The participants were geographically dispersed, with some living in rural areas and some in urban areas. Ten of the female participants were mothers, while none of the male participants had children. Half of the participants were low-income, and most had at least a high school degree. To maintain confidentiality, pseudonyms were assigned to the participants. Focus groups were moderated by two researchers at Environics Research: a male researcher, who has nearly 15

years experience in the healthcare industry and market research and a female researcher with over six years experience conducting qualitative research, including in virtual platforms. Two researchers from the university investigator team were also present during focus group sessions but did not moderate. Participants were asked to sign a consent form which clearly indicated the purpose of the study and were told the identities of the interviewers. The focus groups were conducted using the guide available in the S3 Appendix, which was designed by the authors, and a recording was made, which was later transcribed. No repeat interviews were carried out and transcripts were not returned to participants for correction.

Table 3: Sociodemographic characteristics and vaccination status of focus group participants.

	Age	Sex	Race/Ethnicity	Province	Education	Low Income Status	Received COVID-19 Vaccine?
Group 1							
Brooke	36	F	Indigenous	BC	Some college	Yes	No
Eleanor	43	F	White	NB	HS degree	Yes	No
Heather	68	F	White	ON	Less than HS	No	No
William	44	M	White	MB	HS degree	Yes	No
Melanie	52	F	Indigenous	AB	Some college	Yes	No
Billy	64	M	Indigenous	ON	Some college	Yes	Yes
Group 2							
Julie	58	F	White	SK	HS degree	No	Yes
Patrick	53	M	White	ON	Some college	Yes	Yes
Brianna	63	F	White	ON	HS degree	Yes	Yes
Joy	49	F	Indigenous	ON	HS degree	No	Yes
Esther	60	F	White	ON	Less than HS	No	Yes
Clara	26	F	White	ON	Some college	Yes	Yes
Groups 3 and 4							
Lorry	30	F	White	ON	Bachelor's degree	No	Yes
Ethan	26	M	White	QC	Some college	No	No
Molly	26	F	White	ON	Bachelor's degree	No	No
Janet	26	F	Indigenous	ON	HS degree	Yes	No
Charles	31	M	White	AB	Bachelor's degree	Yes	No
Elise	28	F	Indigenous	AB	Bachelor's degree	Yes	Yes

Data coding and analysis

Focus group recordings were transcribed verbatim. MAXQDA Analytics, a qualitative analysis software, was used to aid in the analysis of focus group transcripts. The software was used in a manual capacity - i.e. no automated features were used to generate codes or thematic categories. Using MAXQDA enabled us to manually organize the transcript into the codes using the process detailed below and provided visualizations of critical elements using various built-in tools.

The study utilized an inductive approach to conduct a thematic analysis (Braun and Clarke, 2006), a process where researchers actively engage in the knowledge production process and consider their subjectivity as a valuable resource during the coding and theme development phases. This approach allowed for a systematic way of processing qualitative information using coded text and enabled us to provide a detailed and nuanced analysis of participants' attitudes and behaviors toward COVID-19 vaccines. The steps we took, proposed by Braun and Clarke [39], are data familiarization, code formulation, generation of themes, themes review, defining and naming themes, and report formation. A single coder, XL, was used throughout the process to ensure consistency in the coding, with other members of the research team providing guidance on the coding tree. The coder has a professional and academic background in public health and qualitative research, specifically focused on vaccine hesitancy. Participants were not asked to provide feedback on the findings.

1. **Data cleaning and familiarization:** We transcribed the data based on audio recordings, and imported the transcripts into MAXQDA, then completed the necessary pre-processing steps: removing identifying information and formatting the data for analysis. We read and re-read the transcripts end-to-end in order to familiarize ourselves with the contents and generate initial ideas for a search space.

2. **Code formulation:** Using the generated ideas as well as past models used in vaccine hesitancy as a starting point for the search space, a coder read through all of the transcripts, coding representing sections related to vaccine hesitancy in a systematic fashion across the entire dataset – both sections related to the search space and novel themes were identified, with novel themes focused on expressions of hesitancy around vaccination decisions. Memos were written down to keep track of the condensed information. A codebook was developed based on this process, and then applied to the data using MAXQDA's coding function. The data were then segmented into coded units based on the codes applied.
3. **Generation of themes:** The coder reviewed the coded data and refined the codes as necessary. New codes were added, and existing codes were merged or split based on the patterns that emerged from the data. The cycle was repeated several times to narrow down the number of codes and categorize them into identifiable themes. The codes were then analyzed and grouped into three central themes as stated in the results section.
4. **Themes review:** The complete interview data were re-read to validate that the themes were gathered in an accurate and representative way. MAXQDA was used to identify patterns within the data, and these were used to draw conclusions.
5. **Defining and naming themes:** The reviewed themes were then conceptualized and assigned clear definitions in the S1 Appendix, and memos were finalized within MAXQDA to ensure data transparency and reproducibility.
6. **Report formation:** several vital statements and features representing the data were extracted to showcase the resulting outcomes both as statements in the form of ideas and feelings and visual representations using interconnections between codes as seen in the S2 Appendix.

In order to ensure rigor in our qualitative research process and validation of our findings, we used an iterative thematic analysis process based on established analytical tools [39]. Furthermore, we recruited a diverse sample of individuals and maintained records of our processes, creating a MAXQDA codebook. Finally, we engaged in self-reflection throughout the process to better understand personal biases and report on potential sources of these biases in the limitations section.

Results

Our thematic analysis revealed 8 core themes and 25 sub-themes, all of which could be attributed to one of the three broad categories: scientific, personal, and practical. Our coder determined that these broad categories, which also appear in Pomare and colleagues' taxonomy of uncertainty, best captured the broad categories of vaccine hesitancy in the data. Table 4 below provides more information about the themes that were generated during the coding process.

Table 4: Vaccine hesitancy themes identified in the data

Category	Themes	Sub-Themes	Frequency	% of individuals
Personal	Values	Political Compass	5	22.2%
		Autonomy	29	33.3%
	Trust	Trust in the medical profession	26	38.9%
		Trust in the medical caretaker	9	44.4%
		Trust in Government	43	72.2%
		Trust in Pharmaceutical Companies	4	5.6%
		Trust in Media	18	55.6%
	Social Environment	Pressure from Close Community	18	55.6%
		Pressure for Broad Community	3	16.7%
		Pressure from Society	15	44.4%
	Personal Anecdotes	Personal Experience	3	11.1%
		Experience of those close by with vaccines	12	27.8%
		Hearsay	16	44.4%
Scientific	Perceived Risk	Short-term side effects	31	88.9%
		Long-term side effects	11	44.4%
		Risk of serious symptoms or death due to COVID-19	13	38.9%
	Prior Knowledge	Effectiveness of Vaccine	18	72.2%
		Understanding of Vaccine Function	4	22.2%
		Belief that natural immunity is better	3	11.1%
		Information Overload	15	44.4%
	Environmental Fluctuation	Possible evolution of the Vaccine	13	44.4%
		Flawed measurement of the Vaccine	22	50.0%
		Possible evolution of the Disease	4	22.2%
		Flawed measurement of the Disease	4	16.7%
Practical	Systems of Care	Being out of commission	7	27%

The S2 Appendix provides a full list of these themes, along with the supporting data extracts from the focus group transcripts. In the following sections, we provide more detailed discussion of these themes, focusing on illustrative examples that support each sub-category.

Personal

Values

In our study, values were a major source of vaccine hesitancy, with participants expressing strong feelings around the right to choose and a clash between their personal value system and public health agencies' approach to vaccination. Nine participants voiced similar concerns. For example, one participant noted that people "should be taken on [their] free will [to make vaccination decisions]," and that "it's everyone's choice what they feel is best for them." Another participant, who had already been vaccinated, stated that "it's everybody's decision, whether they want to get [vaccinated] or not...[I wish] everybody would. It might bring cases down more, less death, less sick people. But it's up to everybody." Another participant called for accepting people for who they are and their decision to vaccinate or not. "It's your decision...we should accept people for who they are [and] embrace that." As a third participant put it:

But... how they were restricting... access to certain things, and... if we don't have the vaccine... which I really didn't like... for me that... makes me... less likely to get the vaccine, because... it's not really acceptable to me. - *Ethan, 26-year-old, unvaccinated*

Words like “condescending”, “passive-aggressive”, and “pushy and exclusive” were frequently used by participants when discussing messages about COVID-19 vaccines, which

evoked feelings of “othering” and stigmatization. A participant felt as if she was being alienated from society for not getting vaccinated. "When you press people, it's going to make them push back 10 times as hard," she stated.

Trust

Throughout the focus group discussions, participants expressed varied views on the trustworthiness of medical professionals, health providers, the pharmaceutical industry, and government officials in the development, approval, and distribution of COVID-19 vaccines. Participants, who were vaccinated or intended to get vaccines in the future, cited medical professionals like Dr. Anthony Fauci as trustworthy sources of COVID-related information, who have a significant effect on individuals' vaccination decisions. For example, one participant, who was not vaccinated yet but planned to get one eventually, took Dr. Fauci's suggestions as “the gold standard” during his decision-making process.

However, not everyone shared the same confidence in medical professionals. Patrick found conflicting views from medical professionals, prompting him to turn to what he considered to be independent news companies that compared different sources of information to ensure the reliability of the COVID-related information he received. Similarly, one participant felt that legitimate sources of information were being censored to hide true risks behind the vaccine:

So those kinds of things just are raising major red flags for me, and I feel like from the doctors that have spoken out, Dr. Byron Biddle, Dr. Christina Parks, Dr. Sunetra Gupta... they're... sharing valid things and they're being censored [by the government], and that should raise red flags for everybody. - *Janet, 26-year-old, unvaccinated*

Social Environment

Social factors emerged among participants, in most cases linked to the influence of others, including friends, family, or community members. It manifested in various forms, such as social pressure to avoid vaccination or the impact of misinformation and conspiracy theories shared by others.

As noted by past research, strong ties represented a significant source of vaccine hesitancy. In some cases, this was in the direction of non-vaccination. In other cases, it was in the direction of vaccination. For example, one participant noted:

she refused to get vaccinated, but I said to her, look, I said, your father and I both work where we are in contact with people 24/7, because I work at a fast food restaurant, my husband works at a lumberyard, he's a truck driver. And I said, we don't know if we're going to end up coming in contact with someone that's not vaccinated, that has it. So she finally got vaccinated. - *Esther, 60-year-old, vaccinated*

While personal-level social pressure was generally effective, institutional pressure often backfired. For example, COVID-19 vaccine campaigns that contained messaging such as “don't be selfish, vaccinate to save others” were not well received by unvaccinated participants. Unvaccinated participants explained that the messaging made them feel shamed and separated them socially and morally from the vaccinated population. As one 26-year-old unvaccinated participant stated, the messaging implies that “you're not a good person...you're not protecting your family, maybe you even want them dead [if you choose not to get vaccinated]...it's not 'we're in this together' messaging.” Another unvaccinated participant, shared that “I find the ads are not only pushing it but they're making people who

don't choose it feel like they're outcasts and there are people who have had a lot of bad backwash from that I've heard of people actually being bullied because they don't get it.”

Personal Anecdotes

Our analysis showed that participants' hesitancy around COVID-19 vaccines was related to anecdotes derived from their personal experience as well as the experience of their strong ties. For example, as two participants noted:

My sister had terrible side effects, vomiting for two days just you know where she needed somebody to come and take care of her and that was really worrisome. -

Molly, 26-year-old, unvaccinated

I actually had a neighbor who had the Pfizer vaccine, and he had really bad side effects for a day or two after, and you know it made me kind of pause. - *Brooke,*

36-year-old, unvaccinated

Another participant was also hesitant about vaccination after her friend contracted COVID-19 despite being vaccinated.

I was... iffy about it, because my one friend, he got... the needle. And then he still got COVID. So like, I didn't know, maybe he got COVID from... the shot. - *Clara,*

26-year-old, vaccinated

Scientific

Environmental Fluctuation

In our focus group discussions, participants expressed a pervasive sense of uncertainty about the progression of COVID-19 and COVID-19 vaccines. Many of their concerns were driven by the unpredictable nature of the disease and its potential evolution, which left some feeling uneasy, even if they had been vaccinated. Two participants, for instance, shared concerns about new variants and the potential for more contagious strains to emerge:

Now... we have this fourth variant, or this one new variant... it's mutating, and that's...really scary... and they're saying that this new variant is more contagious but less harmful... that doesn't give me comfort. - *Patrick, 53-year-old, vaccinated*

I'm worried about how big COVID's going to get with the new variants; I'm worried about our society as a whole right now. - *Elise, 28-year-old, vaccinated*

Prior Knowledge

The changing nature of the disease and its vaccines led to ambiguity and confusion in COVID-related knowledge. One common confusion was around the effectiveness of vaccines. Two participants expressed concerns regarding the vaccines' ability to prevent infection and the potential for increased side effects with each booster shot. One shared her confusion around the effectiveness of vaccines:

I agree at least a couple years, because then at least they'd have had a chance to test it on a variety of different people with different conditions. - *Melanie, 52-year-old, unvaccinated*

Perceived Risk

One of the most commonly discussed sources of vaccine hesitancy in our data was related to participants' risk perceptions around vaccines. Second-hand stories of individuals experiencing severe side effects or even death after vaccination were prevalent. Two participants both heard that "people were dying or people were having really bad side effects".

Yes, I heard that people were dying getting the shot, after they got the shot that they were dying. So I was quite scared to get it. - *Joy, 49-year-old, vaccinated*

"If one is saying that there's a chance of getting a blood clot. Well, how can they say that the other two are going to be okay" one participant concluded. Their shared fear was reinforced by news that "AstraZeneca [has] already been taken off the market because of very serious side effects."

Another participant also expressed concerns that vaccines could be harmful to people with respiratory issues.

I've heard that it can be really bad for people that have respiratory issues... I have asthma, I have very bad allergies, I've had breathing problems. - *Eleanor, 43-year-old, unvaccinated*

Practical

System of care

Participants expressed concerns around the effects of being unvaccinated on access to public care systems. For example, one person shared a personal experience of being unable to access home care after having a toe amputated because he was not vaccinated.

Back on Labor Day of last year, I actually ended up in the hospital for unrelated - I had to have a toe amputated due to it being infected... after I got out of the hospital, I had a home care worker coming into my home and they basically said, because you're receiving home care, they're strong - they really wanted me [to get vaccinated]... otherwise I would lose my home care worker once every few days to help me with some things and change the bandages. So I knew that I had to have it because of, you know, the other problem I was dealing with. - *Patrick, 53-year-old, vaccinated*

Other participants shared concerns about the broader costs of remaining unvaccinated on aspects of their lives such as access to employment, accessibility of public services and travel. For example, Lorry and Janet expressed concerns about people getting fired because of their medical decisions. In addition, Lorry mentioned “the obstacles of not being able to travel... not going to concerts and the giveaways seem small to [me]”, and “the only big obstacle that [I see] would be [my] job.”

Discussion

Proposed Taxonomy

Our analysis of past frameworks suggests that, while they are useful in a non-pandemic context, a number of important gaps exist that limit their usefulness in a COVID-19 context and potentially in the context of future vaccine-preventable pandemics where high uncertainty vaccination decisions will occur. Given the demonstrated effectiveness of targeted messaging in increasing vaccine uptake, overcoming these limitations is particularly important in order to inform the design of effective public health messaging. In an effort to address the gaps in existing models, we propose a novel taxonomy of vaccine hesitancy that is grounded in our focus group findings, is specific to COVID-19, and is potentially applicable to future vaccine-preventable pandemic contexts. This taxonomy is based on the themes that emerged from our analysis of the focus group data. This means that it differs in approach from past taxonomies, a large part of which were constructed from literature reviews of determinants of vaccine hesitancy. Given that the studies included in these literature reviews did not necessarily aim to uncover the entire landscape of vaccine hesitancy determinants but rather focused on specific hypotheses, our taxonomy represents a more naturalistic approach that is unconstrained by prior hypotheses. Our taxonomy — which we refer to as the High Uncertainty Vaccination Decision (HUVD) taxonomy — is presented in Table 5.

Table 5: The High Uncertainty Vaccination Decision (HUVD) taxonomy (full definitions of themes and sub-themes provided in the S2 Appendix)

Personal	Scientific	Practical
Values	Environment Fluctuation	Systems of care
Trust	Prior Knowledge	
Social Environment	Perceived Risk	
Personal Anecdotes		

Notably, we found that focus group participants had strong feelings about their right to choose whether or not to be vaccinated. With these feelings, came a resistance to what is perceived as external pressure and restrictions tied to vaccination. However, while institutional pressures were expected to backfire, likely driven by low levels of trust, the influence of social circles was more effective in promoting vaccination. With regard to the development of the vaccines, even non-hesitant individuals felt a large degree of uncertainty and confusion about effectiveness and potential side effects, suggesting that the unique timeline in which the COVID-19 vaccines were developed may have contributed to perceived risk.

Comparison to Past Taxonomies

Our proposed HUVD taxonomy focuses on determinants of vaccine hesitancy in a COVID-19 context. Therefore, it differs in a number of ways from other models we have summarized in Table 6.

Table 6: The High Uncertainty Vaccination Decision (HUVD) taxonomy compared to previous models used in vaccine hesitancy

HBM	TPB	Han et al.	Pomare et al.	3C Model	5A Model	5C Model	HUVD
<i>Perceived Susceptibility</i>	<i>Attitudes</i>	<i>Ambiguity</i>	<i>Psycho-social</i>	<i>Complacency</i>	<i>Access</i>	<i>Convenience</i>	Values
<i>Perceived Severity</i>	<i>Subjective Norms</i>	<i>Complexity</i>	<i>Existential</i>	<i>Convenience</i>	<i>Affordability</i>	<i>Confidence</i>	Trust
<i>Health Motivation</i>	<i>Perceived Control</i>	<i>Probability</i>	<i>Ethical</i>	<i>Confidence</i>	<i>Awareness</i>	<i>Constraints</i>	Social Environment
<i>Perceived Benefits</i>		<i>Scientific</i>	<i>Diagnosis</i>		<i>Acceptance</i>	<i>Calculation</i>	Personal Anecdotes
<i>Perceived Barriers</i>		<i>Practical</i>	<i>Prognosis</i>		<i>Activation</i>	<i>Collective Responsibility</i>	Environment Fluctuation
		<i>Personal</i>	<i>Causal Explanations</i>				Prior Knowledge
			<i>Treatment Options</i>				Perceived Risk
			<i>Structure of care</i>				Systems of Care
			<i>Processes of care</i>				
			<i>Systems</i>				

In an effort to better understand the differences and similarities between our proposed taxonomy and previous taxonomies, we created the following comparison, which aims to illustrate which categories in our taxonomy might be most relevant for each category of previous taxonomies. One notable difference between our proposed taxonomy and existing taxonomies is that previous taxonomies have a much greater focus on various aspects of what we call “systems of care” - i.e. on the actual mechanics of delivering the vaccine. While systems of care are also critical in the context of COVID-19, participants in our focus groups were far more likely to bring up factors relating to uncertainty, trust and institutional pressures. These factors, which reflect the high uncertainty environment of the COVID-19 pandemic and vaccine development lifecycle, are likely to also be more relevant in future contexts where vaccine-preventable diseases emerge and require fast action. In Table 7, we further illustrate the differences between our proposed taxonomy and past taxonomies.

Table 7: A mapping of categories in the HUVD taxonomy to those of previous models

HBM	Relevant Categories from HUVD Taxonomy
Perceived Susceptibility	Perceived Risk, Prior Knowledge
Perceived Severity	Perceived Risk, Prior Knowledge
Health Motivation	Values, Prior Knowledge
Perceived Benefits	Prior Knowledge, Trust
Perceived Barriers	Systems of Care
TPB	
Attitudes	Values, Trust
Subjective Norms	Social Environment, Trust
Perceived Control	Systems of Care, Trust
Han et al.	
Ambiguity	Environment Fluctuation, Perceived Risk
Complexity	Environment Fluctuation, Prior Knowledge
Probability	Perceived Risk
Scientific	Prior Knowledge, Trust
Practical	Systems of Care
Personal	Personal Anecdotes, Trust
Pomare et al.	
Psycho-social	Social Environment, Trust, Values
Existential	Values
Ethical	Values, Trust
Diagnosis	NA (Not Relevant to Vaccination)
Prognosis	NA (Not Relevant to Vaccination)
Causal Explanations	NA (Not Relevant to Vaccination)
Treatment Options	NA (Not Relevant to Vaccination)
Structure of care	Systems of Care
Processes of care	Systems of Care
Systems	Systems of Care
3C Model	
Complacency	Perceived Risk, Values
Convenience	Systems of Care
Confidence	Trust, Social Environment, Prior Knowledge

5A Model

Access	Systems of Care
Affordability	Systems of Care
Awareness	Prior Knowledge, Social Environment
Acceptance	Trust, Prior Knowledge, Social Environment
Activation	Trust, Systems of Care

5C Model

Convenience	Systems of Care
Confidence	Trust, Social Environment, Prior Knowledge
Constraints	Systems of Care
Calculation	Prior Knowledge, Trust
Collective Responsibility	Values

Importantly, previous models focus on particular aspects of what our data showed to be relevant in a COVID-19 vaccine hesitancy context, but none of them cover all of the categories we identified. For example, the HBM focuses on individual perceptions and motivations but does not tie them to the social environment. The TPB connects better to social environments but does not capture (or too broadly captures) the scientific and environmental uncertainty that are inherent in high uncertainty vaccination decisions. The uncertainty taxonomies from Han and colleagues and Pomare and colleagues capture a wider breadth of categories but in a way that is too far removed from a vaccine context. Finally, the 3C, 5A and 5C models are more narrowly focused but tend to be more granular around systems of care (which our data suggests is not a significant driver) and less granular around confidence and acceptance, which limits the usefulness of these categories.

Overall the differences between our HUVD taxonomy and past taxonomies are reflections of the unique decision environment of the COVID-19 pandemic. A number of factors have come together to create this environment, such as: the unprecedented speed of vaccine development; novel vaccine technologies; global scale of the illness; large amounts

of media attention; large amounts of misinformation and disinformation; political polarization; unpredictable evolution of the disease and variants of concern; lockdowns and restrictions; debate about natural immunity induced by infection. Given factors like these, it is unsurprising that a taxonomy specifically adapted to a COVID-19 vaccination decision context differs substantially from previous ones. Furthermore, these factors, which are reflected in our data, contribute to a decision environment where people who are normally vaccine acceptant might refuse or, at the very least, delay a COVID-19 vaccine.

Implications of results

We believe our HUVD taxonomy provides a valuable extension of existing models to a COVID-19 context, with possible relevance to future pandemic contexts with high uncertainty vaccination decisions. Past research has shown that public health messaging that targets individuals in a personalized and stage-specific manner can improve a variety of health outcomes, such as smoking cessation [40] and vaccine uptake [41, 42]. However, successful tailoring of messages relies on having a clear understanding of the decision factors present in the target audience. Our proposed taxonomy provides a similar tool to what has been created in the past, but specific to COVID-19 vaccine hesitancy and potentially other contexts with high uncertainty vaccination decisions. Such a tool can be used to bolster existing public health strategies around COVID-19 but could also be informative for future research into factors related to vaccine hesitancy in a pandemic context where high uncertainty vaccination decisions take place.

Limitations

One major limitation of this work is that our taxonomy, while informed by qualitative data, has not yet been empirically tested in an applied setting. In addition, one must keep in mind that COVID-19 presented a unique context that may or may not generalize to other types of

high uncertainty vaccination decisions – whether in a future pandemic or in other contexts. Nonetheless our taxonomy provides a useful starting point for developing public health messaging hypotheses to be tested in the particular context where they are to be applied. Additionally, while public health messaging designers can use our taxonomy to inform hypotheses they have about the types of messaging that may be most effective, they should not assume that a particular source of hesitancy is relevant without further empirical evidence.

A further limitation is the use of purposive sampling, whereby potential participants were selected based on their self-identified vaccination status and attitudes. While this approach allows us to recruit a relevant sample, it introduces the potential for bias due to self-selection by people with stronger opinions who are interested in participating in focus groups therefore potentially excluding more moderate voices. Related to this, focus group dynamics can potentially introduce bias due to groupthink. While the focus group moderators have extensive training and experience conducting qualitative research, this potential source of bias remains. A further limitation related to the focus groups is that because of the unique situation and limited sample size, we were unable to take steps to ensure data saturation.

A limitation related to the analysis of the data is the background of the qualitative data coder. While this coder has an educational and professional background in public health and qualitative analysis and vaccine hesitancy more specifically, any coder will bring a certain level of bias which must be recognized. Given the coder's background, this bias could plausibly result in some level of confirmation bias – which we have attempted to address by carefully reviewing the raw data provided in the S2 Appendix.

Another limitation of the present study is the skew toward female and white participants in our sample. In an effort to select a sample that contains diversity in geography, educational status, income, and age, as well as a large representation of Indigenous

communities, an unintended outcome was a final sample that contained an over-representation of women and an under-representation of ethnic groups other than persons of Indigenous ancestry. Finally, as noted in the Methods section, none of the male participants had children. Given that a significant amount of vaccine hesitancy attitudes and vaccination decision experiences happen in the context of childhood vaccines, this may have limited the representativeness of our sample.

Recommendations for Future Research

Future work looking to expand on this taxonomy should focus on understanding how generalizable it is to populations in other jurisdictions and vaccine contexts. It should also make efforts to understand how our findings may be generalized to future pandemic contexts where high uncertainty vaccination decisions are inherent. In addition, we believe that work attempting to connect the taxonomy proposed here with empirical data from communication strategies will be useful in helping us understand the extent to which the taxonomy might be relevant in a real-world context, such as public health message design.

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Bridge Between Chapter 1 and Chapter 2

The choice to vaccinate is a deeply personal and complex one, making it unlikely that any single model of vaccine hesitancy will ever be broadly applicable across a wide range of contexts. In Chapter 1, I explored how the high uncertainty environment created by the COVID-19 pandemic was related to a unique mix of vaccine hesitancy determinants. A majority of past models of vaccine hesitancy are either directly based on theoretical analysis or are constructed based on a review of such analyses. In contrast, the study used an inductive approach aimed at uncovering a wider landscape of factors that are specifically salient in conversations about vaccines. Thematic analysis of the focus group data revealed eight core themes, which I then contrasted with themes identified by models of vaccine hesitancy proposed prior to the COVID-19 pandemic. The comparison revealed that, according to the data, issues around systems of care (the actual logistics and physical delivery of vaccines) play a significant role in past models but are not a major consideration in the sample. At the same time, while past models contain themes such as *confidence*, these themes proved so prevalent in the data that they required far more nuanced themes such as trust, social environment and perceived risk. The data also showed that autonomy and trust were far bigger issues than any practical considerations. Interestingly, this was particularly true in those with hard vaccine hesitancy stances (those completely rejecting the vaccine) suggesting that they might have a unique way of thinking about vaccine decisions compared to their soft hesitant peers (those unsure about the vaccine). In Chapter 2, I explore this potential difference in psychology further by asking the following question: are hard and soft vaccine hesitancy attitudes associated with distinct cognitive characteristics? While past literature has proposed that vaccine hesitancy exists on a continuum, Chapter 2 proposes that hard hesitancy is not merely a “more intensified” version of soft hesitancy, but rather a distinct phenomenon that likely requires distinct public messaging strategies.

Chapter 2

Distinguishing between Soft and Hard COVID Vaccine Hesitancy: Psychological Mechanisms and Implications for Public Health Communication

Krastev, S., Juárez, F.P.G., Solomonova, E., Krajden O., Vang Z.M., Turk, L., Goldenberg, M., Weinstock, D., Smith, M.J., McKee, T., Pilat, D., Gold, I. (2023). Distinguishing Soft and Hard COVID Vaccine Hesitancy: Psychological Mechanisms and Implications for Public Health Communication. *Manuscript in preparation.*

Abstract

Vaccine hesitancy is a complex and heterogeneous construct, varying based on factors such as the disease being targeted, the vaccine being proposed and whether the decision is about oneself or one's children. In addition, past research has proposed that, rather than being binary, vaccine hesitancy exists on a continuum from those who are relatively unsure about the vaccine to those who are certain about not wanting it. More recent research in the context of COVID-19 vaccines has suggested that different levels of vaccine hesitancy on that continuum are tied to different types of concern. Targeting individuals at different points along the vaccine hesitancy continuum therefore requires a better understanding of these groups and their decision-making styles. Cognitive style has been suggested as potentially useful in understanding vaccine hesitancy, but has not yet been empirically tested as a differentiator along the vaccine hesitancy continuum. In this paper, we ask to what extent a group of commonly studied factors can help us to differentiate between *non-hesitant*, *soft-hesitant* and *hard-hesitant* individuals. In particular, we focus on eight cognitive factors or biases that have previously been highlighted as important in the decision science literature: fear of missing out; desire for complete information; desire for risk awareness; uncertainty tolerance; recency effect; negativity bias; availability heuristic; and optimism bias. We report data from 1541 Canadian participants who vary in their vaccination status. One-way ANOVAs and Bonferroni corrected post hoc comparisons show that two of these eight — levels of fear of missing out and recency effect — differ significantly between the hard and soft hesitant group. We explore these differences and suggest what they might mean for public health practitioners working on communication strategies.

Introduction

For centuries, vaccines have served as a critical public health tool. They give us a powerful and low-cost way to prevent disease, control outbreaks, and ultimately extend human life expectancy. Since Edward Jenner introduced some of the world's first vaccines in the 1790s [1], vaccines have saved millions of lives. For example, between 1963 and 2015, more than 10 million lives were saved globally by the poliomyelitis, measles, mumps, rubella, varicella (chicken pox), herpes zoster, adenovirus, rabies and Hepatitis A vaccines [2]. Vaccines have reduced the prevalence of at least nine diseases by over 90% [3], eradicated smallpox [4] and brought polio near eradication [5].

In addition to being remarkably effective, there is overwhelming evidence that vaccines are safe. Gidengil and colleagues [6] reviewed 338 articles on vaccination safety and found only rare associations between vaccines and serious side effects, aligning with previous research [7]. A second review of 67 papers came to the same conclusion: some vaccines are associated with negative adverse outcomes, but these outcomes are exceedingly rare [8]. While adverse effects can occur, the risk reduction that vaccines provide outweigh potential risks.

Despite overwhelming consensus about the safety and efficacy of vaccines, a significant portion of the global population is vaccine hesitant, - i.e., they show a “delay in acceptance or refusal of vaccination despite availability of vaccination services” [9: 4163]. In fact, a study of over 140,000 people in more than 140 countries found that 21% of people believe vaccines are unsafe and 16% believe they are ineffective [10]. Perhaps more striking than the magnitude of those who doubt the safety and effectiveness of vaccines is the wide range of vaccine acceptance that we see in different countries across the world. In a 2021 study Sallam [38] found COVID-19 vaccine acceptance to vary significantly across geographies: for example, 23.6% in Kuwait, 53.7% in Italy, 56.9% in the US and 97% in

Ecuador. A similar heterogeneity is present within countries, with various sociodemographic groups presenting vastly different vaccine acceptance rates. These differences contribute to often already marginalized communities being at higher risk of disease. A report released in March 2021 showed that, at that time, in Manitoba, Canada, First Nations people made up 71% of COVID-19 cases and 50% of patients in intensive care units despite making up 10% of the population. In addition to its geographic and sociodemographic heterogeneity, vaccine hesitancy can even vary within the same individuals. For example, vaccine hesitancy attitudes can be different in relation to different diseases [11] and even different brands of a vaccine [12].

The vaccine hesitancy spectrum

One aspect of vaccine hesitancy that has received limited attention, and which adds to its complexity, is the vaccine hesitancy spectrum. The most common definition we have of vaccine hesitancy — the delay or refusal of available vaccines — is broad and far from binary, encompassing a wide range of beliefs, attitudes and behaviors. In fact, while some individuals are vehemently opposed to vaccines and others are completely accepting, the vast majority of the population holds beliefs and attitudes that place them somewhere in between. With this in mind, MacDonald (2015) proposed a vaccine acceptance continuum (Figure 1). In this continuum, which begins with “refuse all [vaccines] with conviction” on one side and finishes with “accept all [vaccines] with confidence”, we can see distinct groups who hold various levels of hesitancy and who vary in both their beliefs (unsure, doubts, concerns) and their behaviors (refuse all, delay, accept some and accept all).

Figure 1: The Vaccine Acceptance Continuum, adapted from MacDonald [4]



In the context of such a continuum, the role of public health communications aiming to increase uptake is to move attitudes from the left side to the right side. However, given the stark differences between groups along this spectrum, it is unlikely that a single strategy would be effective on those who “refuse all with conviction” and those who “accept some, refuse some, delay vaccine”. Indeed, a continuum may not be an appropriate model for distinguishing between these groups. It is therefore clear that unique clusters of vaccine hesitancy attitudes are important in understanding the determinants of vaccine hesitancy and designing strategies capable of increasing vaccine uptake. This differentiation is supported by recent research from Moore and colleagues. In their work, they separated COVID-19 vaccine hesitant individuals into “little hesitant”, “somewhat hesitant” and “very hesitant” and saw that each group reported different groups of vaccine hesitancy determinants. Those who were “little hesitant” or “somewhat hesitant” were concerned about side effects and lack of complete information, while those who were “very hesitant” were concerned about risks related to conspiracy theories surrounding the safety, speed of development and approval process of vaccines as well as personal freedom. While previous studies have broadly associated vaccine hesitancy and conspiratorial thinking, this study adds the nuance of linking belief in conspiracy theories to those with more hard-line hesitancy attitudes, thus opening up a line of inquiry around thinking styles and levels of vaccine hesitancy. Indeed, given the existing link between conspiratorial thinking and cognitive bias, findings from

Moore and colleagues raise the interesting possibility that cognitive bias is a useful tool in distinguishing between distinct levels of vaccine hesitant individuals.

Cognitive bias and vaccine hesitancy

Cognitive bias is an underexplored lens through which to examine vaccine hesitancy. It is well understood that people's perceptions and reactions under uncertainty are strongly affected by cognitive biases [13–16]. Biases and heuristics — mental shortcuts that help us navigate intractable complexity in our environment but can also mislead us — have a large influence on decision making more broadly [17, 18] and a large literature on the subject may provide a more practical basis for designing public health interventions than demographic factors [20]. A recent study by Azarpanah and colleagues [19] identified 15 potential cognitive biases that may affect vaccination decision making and relate to vaccine hesitancy. While the authors propose mechanisms through which these biases may influence vaccine hesitancy attitudes, they do not report on any empirical data to verify those hypotheses. Another study [20] found that four cognitive factors explained 54% of the variance in vaccine hesitancy: skepticism, denial, optimism and preference for natural products. A further systematic review of the cognitive determinants of vaccine hesitancy by Pourrazavi and colleagues [21] reported on data across 91 studies and 1,335,138 participants and found that vaccine hesitancy was associated with lower perceived self control, lower perceived subjective norms, higher perceived stress, higher levels of fear and lower optimism. Studies like these continue to point toward a relationship between certain cognitive biases and factors and vaccine hesitancy. However, no work to date has explored how different cognitive biases might differentially relate to different levels of vaccine hesitancy. This is a gap that the current study aims to address.

In an effort to overcome this lack of knowledge, we make use of an instrument that is novel in academic research but has previously been used to test cognitive bias in industry contexts¹. While this instrument has not yet undergone a traditional peer-review process, its efficacy in industry applications provides a unique and valuable perspective. This instrument is borrowed from consumer research contexts, where it was specifically developed to differentiate between different “health personas” - i.e., individuals belonging to a grouping based on health-related attitudes and behaviors. Taking this approach allows us to explore the relative role of eight common cognitive biases in groups exhibiting different levels of vaccine hesitancy.

Hypotheses

Based on their ability to form distinct health personas, we hypothesize that these eight categories of cognitive bias will exhibit different relationships to soft versus hard vaccine hesitant individuals.

Methods

Instrument

Research was carried out in collaboration with Environics Research (<https://environics.ca/>), a Canadian polling and research firm, for the purpose of data collection. Participants had already consented to participate in online surveys through Dynata or Asking Canadians (Environics Research partners). They were asked to read and sign additional consent forms from McGill and Environics Research that provided the specifications of this study. Subsequently, participants were asked to answer demographic questions, including age, gender, ethnicity, Indigenous status, province, education, and income. Vaccination status and

¹ Environics Research

attitude (i.e., vaccinated, soft vaccine hesitancy, and hard vaccine hesitancy) were assessed via two questions in which participants first self-reported their vaccination status to differentiate between the vaccinated and unvaccinated and subsequently, depending on their response, reported either their attitude towards becoming vaccinated in the future or their hesitation when receiving the vaccine. Respondents were assessed for each of the eight categories of cognitive bias using a Likert scale question (1: Strongly Disagree; 2: Disagree; 3: Agree; 4: Strongly Agree).

While the literature on cognitive bias is rich and contains hundreds of biases, our focus is on biases that might be most likely to differentiate between soft and hard vaccine hesitant attitudes. For this reason, we focus our attention on eight bias constructs that have previously been used to distinguish between personas in the context of health behaviors. They are:

1. *Fear of missing out*: biases that contribute to a feeling of anxiety about not being part of rewarding experiences. E.g. bandwagon effect
2. *Desire for complete information*: A need for thorough information prior to feeling comfortable making a decision
3. *Desire for risk awareness*: Preference to be informed about potential risks prior to making a decision
4. *Uncertainty tolerance*: Comfort with ambiguity in uncertain situations
5. *Recency effect*: Tendency to place increased importance on recently acquired information
6. *Negativity bias*: Tendency to place increased importance on information relating to risks
7. *Availability heuristic*: Tendency to rely on information that comes to mind quickly
8. *Optimism bias*: Tendency to believe that one is less likely to suffer adverse outcomes

The exact wording of the instrument measuring these constructs is presented in Appendix A1.

A number of measures were taken to ensure the validity and internal consistency of this novel instrument. As shown in Table 1, correlations between the eight factors are low, suggesting that the measures are distinct from one another. Some moderate correlations can be observed, such as between *Desire for Risk Awareness* and *Uncertainty Tolerance* ($r = .45$) or *Recency Effect* and *Negativity Bias* ($r = .39$). However, these correlations are not strong enough to indicate that the measures are redundant or highly overlapping. Overall, the inter-factor correlation matrix provides preliminary evidence that the measures capture distinct aspects of decision-making and are appropriate for use in this study.

Table 1: Inter-Factor Correlation Matrix for the eight measures, showing that the measures are distinct from each other.

	FOMO	DfCI	DfRA	UT	RE	NB	AH	OB
Fear of Missing Out (FOMO)	1	.1	.2	.17	.3	.26	.18	-.05
Desire for Complete Info (DfCI)	.1	1	.42	.37	.07	-.02	.08	.17
Desire for Risk Awareness (DfRA)	.2	.42	1	.45	.16	.17	.17	.14
Uncertainty Tolerance (UT)	.17	.37	.45	1	.21	.2	.17	.14
Recency Effect (RE)	.3	.07	.16	.21	1	.39	.32	.06
Negativity Bias (NB)	.26	-.02	.17	.2	.39	1	.36	.09
Availability Heuristic (AH)	.18	.08	.17	.17	.32	.36	1	.17
Optimism Bias (OB)	-.05	.17	.14	.14	.06	.09	.17	1

We further investigated the validity of our eight measures by performing a Confirmatory Factor Analysis (CFA). The CFA was used to test the hypothesis that each variable represents a distinct factor. This analysis allows for a more rigorous validation of the measures, as it specifically assesses whether the observed data fit the hypothesized factor structure. The CFA results indicate that each variable loads strongly on its respective factor, with loadings ranging from .6636 to 1.1493, showing that each variable is a good indicator of its corresponding factor.

Sampling

A representative group of 1541 Canadians aged 18 and older were randomly recruited by email invitation through either Dynata (<https://www.dynata.com/>), the world's largest first-party research data platform, or Asking Canadians (<http://askingcanadians.com/>), Canada's premier proprietary research panel. The experiment was carried out between April and May, 2021. Given that vaccines became widely available in Canada at the beginning of Summer 2021, this is an important moment which served as a decision point for many Canadians.

Procedure

During April and May of 2021, participants were sent a link to the survey after being contacted by Dynata and/or Asking Canadians. The entire survey was conducted online, and could be completed on a computer or mobile device (mobile phone or tablet). There was no time limit, and participants were informed that they could withdraw from the study at any time or decline to answer any questions in the survey. Participants were not compensated given their pre-existing agreement with Dynata and/or Asking Canadians. All methods and

protocols were carried out in accordance with relevant guidelines and regulations and were approved by McGill University's Institutional Review Board (Ethics Approval ID: 22-10-064). In addition, informed consent was obtained from all subjects prior to data collection.

Data Analysis

For the purpose of analysis, we divided participants into three groups (non-hesitant, soft-hesitant and hard-hesitant) according to the following mapping of our vaccine hesitancy instrument (Appendix A3):

Non-Hesitant:

- Vaccinated and was not hesitant prior to vaccination
- Unvaccinated but planning to vaccinate

Soft-Hesitant:

- Vaccinated but was hesitant prior to vaccination
- Unvaccinated and will wait a while before deciding

Hard-Hesitant

- Unvaccinated and would not get

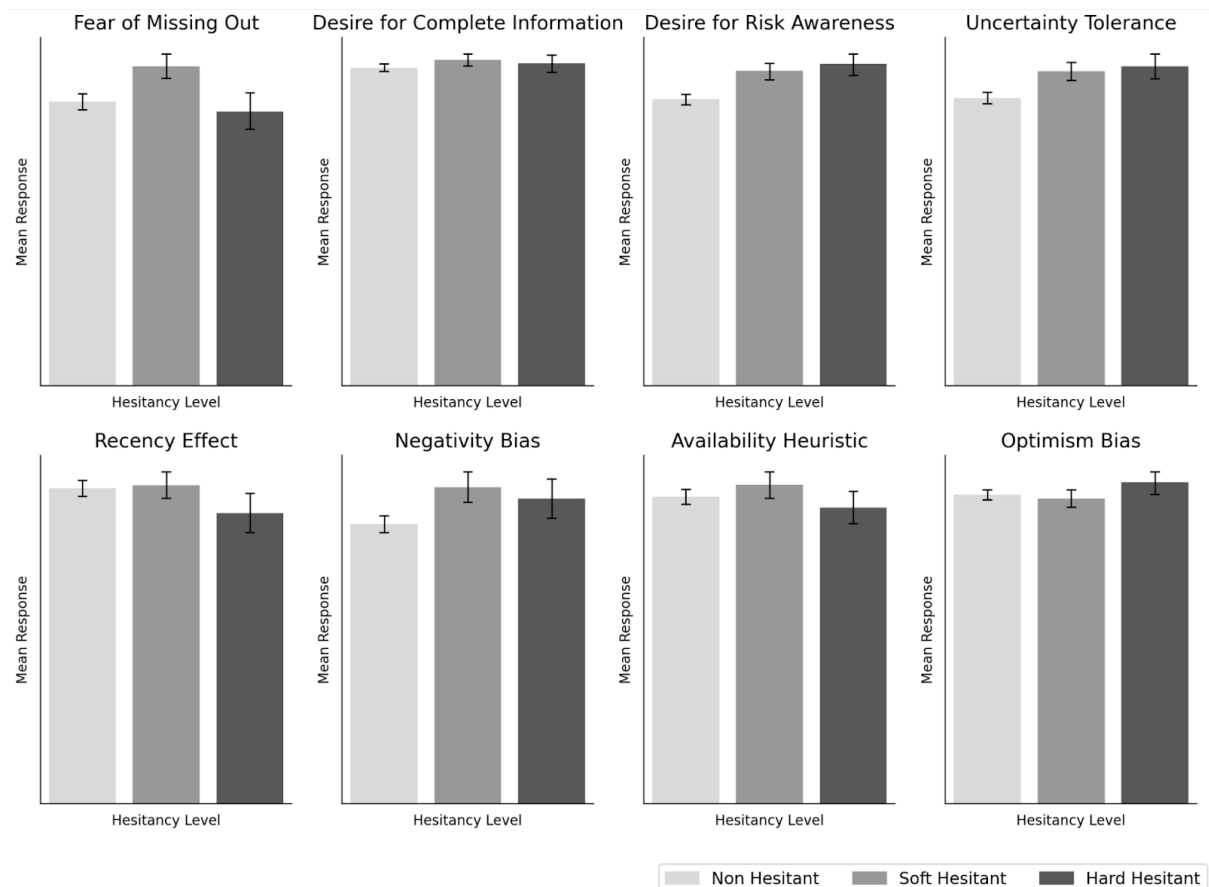
For each of our outcome measures, we performed a one-way ANOVA to test the effect of the group on the outcome measure. Where a sufficient level of significance was observed, we performed post hoc analyses using a Bonferroni adjusted pairwise comparison. This allowed us to determine which groups in particular differed with regard to the outcome measure.

Results

Sample Characteristics

Table 1 (Appendix B) presents sample characteristics across the 1541 Canadians over the age of 18 who completed our survey. Of those, 1165 (76%) had received at least two doses of an approved COVID vaccine, 168 (11%) were unvaccinated and soft hesitant, and 208 (14%) were unvaccinated and hard hesitant. The mean age of our sample was 46.4 years (range: 18 - 87). The majority of our sample were women (57%), white (71%), and had at least a high school education (85%). A representative portion of our sample self-identified as Indigenous (6%).

Figure 2: Comparing scores on the eight measures of cognitive bias across non-hesitant, soft hesitant and hard hesitant individuals



Fear of Missing Out

A one-way ANOVA was conducted to compare the effect of hesitancy status on fear of missing out. The results indicated a significant effect of hesitancy status on fear of missing out, $F(2, 1538) = 12.97, p < .001$. Post hoc comparisons using the Bonferroni correction revealed that there was a significant difference between the hard hesitant and soft hesitant groups ($p < .001$), and between the non-hesitant and soft hesitant groups ($p < .001$), while no significant difference was observed between the hard hesitant and non-hesitant groups ($p = .924$).

Desire for Complete Information

A one-way ANOVA was conducted to compare the effect of hesitancy status on the desire for complete information. The results were not statistically significant, $F(2, 1538) = 2.44, p = .087$.

Desire for Risk Awareness

A one-way ANOVA was conducted to compare the effect of hesitancy status on desire for risk awareness. The results indicated a significant effect of hesitancy status on desire for risk awareness, $F(2, 1538) = 23.88, p < .001$. Post hoc comparisons using the Bonferroni correction revealed that there was a significant difference between the hard hesitant and non-hesitant groups ($p < .001$), and between the non-hesitant and soft hesitant groups ($p < .001$), while no significant difference was observed between the hard hesitant and soft hesitant groups ($p = .975$).

Uncertainty Tolerance

A one-way ANOVA was conducted to compare the effect of hesitancy status on uncertainty tolerance. The results indicated a significant effect of hesitancy status on uncertainty tolerance, $F(2, 1538) = 17.21, p < .001$. Post hoc comparisons using the Bonferroni correction revealed that there was a significant difference between the hard hesitant and non-hesitant groups ($p < .001$), and between the non-hesitant and soft hesitant groups ($p < .001$), while no significant difference was observed between the hard hesitant and soft hesitant groups ($p = 1.0$).

Recency Effect

A one-way ANOVA was conducted to compare the effect of hesitancy status on recency effect. The results indicated a significant effect of hesitancy status on recency effect, $F(2, 1538) = 3.80, p = .023$. Post hoc comparisons using the Bonferroni correction revealed that there was a significant difference between the hard hesitant and non-hesitant groups ($p = .030$), and between the hard hesitant and soft hesitant groups ($p = .047$), while no significant difference was observed between the non-hesitant and soft hesitant groups ($p = 1.0$).

Negativity Bias

A one-way ANOVA was conducted to compare the effect of hesitancy status on negativity bias. The results indicated a significant effect of hesitancy status on negativity bias, $F(2, 1538) = 1.62, p < .001$. Post hoc comparisons using the Bonferroni correction revealed that there was a significant difference between the hard hesitant and non-hesitant groups ($p = .043$), and between the non-hesitant and soft hesitant groups ($p < .001$), while no significant difference was observed between the hard hesitant and soft hesitant groups ($p = 1.0$).

Availability Heuristic

A one-way ANOVA was conducted to compare the effect of hesitancy status on the availability heuristic. The results were not statistically significant, $F(2, 1538) = 2.60$, $p = .075$.

Optimism Bias

A one-way ANOVA was conducted to compare the effect of hesitancy status on optimism bias. The results indicated a significant effect of hesitancy status on optimism bias, $F(2, 1538) = 3.02$, $p = .049$. Post hoc comparisons using the Bonferroni correction revealed that there was no significant difference between the hard hesitant and non-hesitant groups ($p = .103$), between the hard hesitant and soft hesitant groups ($p = .059$), or between the non-hesitant and soft hesitant groups ($p = 1.0$).

Discussion

The representation of vaccine hesitancy as a spectrum encourages us to see hesitancy as a single phenomenon that comes in degrees. In contrast, the present results suggest that hesitancy is a cluster of phenomena. In particular, “hard hesitant” vaccine attitudes may not simply be more intense versions of “soft hesitant” ones, but more likely form a unique category associated with distinct determinants. In an effort to better design vaccine messaging strategies and campaigns, it is important to understand how these groups of individuals might differ. In this paper, we examine eight novel self-report measures of known cognitive bias constructs that have previously been used in an applied setting to distinguish between personas in the context of health behaviors: fear of missing out; desire for complete

information; desire for risk awareness; uncertainty tolerance; recency effect; negativity bias; availability heuristic; optimism bias. We report on data from 1541 individuals with varying vaccine attitudes and show that in two of the eight categories there are significant differences between soft and hard vaccine hesitant attitudes: fear of missing out and recency effect. In the case of recency effect, we find that soft hesitant individuals resemble their non-hesitant counterparts, while hard hesitant individuals stand out as showing significantly lower levels of the bias. In the case of fear of missing out, we find surprisingly that hard hesitant individuals more closely resemble non-hesitant individuals, while soft hesitant individuals stand out as exhibiting higher levels of the bias.

Interestingly, soft-hesitant individuals have significantly higher levels of fear of missing out compared to both their hard-hesitant and non-hesitant peers, yielding an inverse-U shape. In other words, soft-hesitant individuals appear to be particularly uncertain of their decision. This could be leveraged in public health communications to nudge individuals toward vaccination. In the case of recency effect, it is hard hesitant individuals that have significantly lower scores, while non-hesitant and soft-hesitant individuals did not differ significantly. This finding could indicate that hard-hesitant individuals are more difficult to sway with new information. This too could be used to tailor public health communications – for example by avoiding discussion of new findings.

Differences between Soft and Hard Hesitant and Non-Hesitant Individuals

When investigating the relationship between our measures of the eight biases and vaccine hesitancy, we found that significant differences between groups emerged for six out of the eight biases: fear of missing out, desire for risk awareness, uncertainty tolerance, recency effect, negativity bias and optimism bias. Desire for complete information and availability heuristic were not significantly different between groups, indicating that neither soft nor hard

hesitant individuals differed along that measure from non-hesitant individuals. Similarly, a post-hoc analysis did not reveal any significant differences between groups on optimism bias, indicating that vaccine hesitant individuals were not more or less optimistic.

Where there were significant differences, we found that higher levels of uncertainty tolerance, negativity bias and desire for risk awareness are associated with higher levels of both soft and hard hesitancy. It is possible that these variables are more important in the context of the decision environment present during the COVID-19 pandemic, hallmarked by uncertainty and lack of clear risk assessments around both the disease and vaccine. Furthermore, given that negativity bias measures the self-reported effect of negative anecdotes on decision making, it is likely that vaccine hesitant individuals are more sensitive to hearing about negative experiences with the vaccine. While public health practitioners can take note of these findings, a certain amount of uncertainty, lack of clarity around risks and existence of negative events are inherent in vaccine contexts, especially those with high uncertainty likethat of the COVID-19 pandemic. One strategy to address this is by better testing public health messaging to understand how the risks and negative events are likely to be perceived, particularly by vaccine hesitant communities.

Relevance to Public Messaging Campaigns

Overall, our findings raise the possibility that there may be differences in the cognitive mechanisms underlying different levels of vaccine hesitancy and that these levels should therefore not be treated as sitting on a linear scale, but rather as distinct clusters. The lower levels of recency effect — i.e. a weaker tendency to rely on information that has been recently acquired — in hard hesitant individuals compared to their soft hesitant counterparts may indicate stronger anchoring to existing beliefs and a different relationship to new information being presented. On the other hand, the higher level of fear of missing out — i.e.

a stronger tendency to feel a sense of anxiety about foregoing opportunities for a rewarding experience — in soft hesitant participants relative to hard hesitant ones may suggest a higher susceptibility to social influences, especially in the context of being left behind. The similarity between hard hesitant and non-hesitant individuals in the context of fear of missing out could indicate that these groups are fairly strongly rooted in their respective social and informational networks.

Historically, public health campaigns leverage tools such as emotional engagement [22–26] or providing information [27, 28] to shift behavior. Different sources of uncertainty, however, require different messages that take into account the complex nature of individual decision making, involving cognitive factors as much as cultural, historical, social, political, and spiritual ones [29–32]. Indeed, public health messaging in other contexts has benefitted from tailoring communication according to various psychological dispositions [33–35]. In the context of the differences between soft and hard hesitant individuals outlined above, our findings suggest that a certain level of nuance might be helpful in future public health campaigns, including potential tests to distinguish effectiveness in groups with different levels of vaccine hesitancy. In particular, campaigns relying on social and informational factors should closely examine the extent to which individuals at different levels of vaccine hesitancy might differentially react to these factors.

Limitations

Empirical Data

It is important to note that while we report on a general association between different levels of vaccine hesitancy and the presence of distinct cognitive biases, our study does not contain an empirical examination of different messaging strategies. Therefore, we can only suggest

that a general distinction in thinking styles may distinguish soft and hard vaccine hesitant individuals and that public health practitioners may be well served in the future by testing unique social and informational strategies targeting these two groups.

Time and Place

The generalizability of our results is limited by sampling the population of only one country; future research could build upon this by surveying populations from other countries to identify whether some of these cognitive factors are influenced by cultural context. Further, the reliability of our findings would have benefitted from a more comprehensive timeframe - that is, surveying participants over the course of a few months to see if there were any changes among the cognitive factors. Additionally, our research tackles only a small proportion of the factors that may impact vaccine acceptance and uptake, and there are likely a multitude of additional psychological processes to consider. Despite these limitations, our work contributes to a growing vaccine hesitancy literature on decision making [36, 37].

COVID-19 Context

COVID-19 represents a unique environment in which to make vaccination decisions. Factors such as the speed of development of the vaccines, the quick evolution of the disease and the politicization of vaccination status likely created unique new variations on vaccine hesitancy. In addition, while COVID-19 vaccine hesitancy is largely focused on individuals making decisions about themselves, a large portion of the vaccine hesitancy literature prior to COVID-19 is concerned with parents making vaccination decisions about their children. With these differences in mind, more research is needed to understand to what extent our findings might generalize to other contexts.

Soft versus Hard Hesitancy

While we use “soft” and “hard” vaccine hesitancy to distinguish between two purported groups of individuals, further breakdowns are likely to be useful in the future. For example, while our soft hesitant group includes both vaccinated and unvaccinated individuals who were hesitant to be vaccinated, it is likely that these two groups differ because of differences in their vaccination behavior. Similarly, one hard hesitant person may refuse all vaccines, while another may refuse only some vaccines. Furthermore, the same individual might have different vaccine attitudes about themselves versus others. In an effort to better understand the vaccine hesitancy landscape, future research is likely to benefit from a more granular categorization of vaccine hesitancy attitudes based on factors such as the ones considered here.

Future Research

The work presented here offers an initial step in understanding the cognitive correlates of various levels of vaccine hesitancy. It also lays a foundation for a more nuanced study of the psychographic variables that may distinguish individuals who present different vaccine behaviors. Given the enormous literature that exists on decision making, understanding how vaccine hesitant individuals might best be clustered according to psychological dimensions could unlock synergies with that literature. In addition, while we have explored cognitive bias as a differentiating factor between groups, a more thorough theoretical framework of the psychological factors that may act as precursors of different vaccine behaviors is likely to be a fruitful direction for future research.

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Bridge Between Chapter 2 and Chapter 3

One of the core findings of the qualitative study I report on in Chapter 1 is that trust in various entities is by far the most frequently discussed issue in the context of the COVID-19 vaccine. Given the unique context of the pandemic, the intervention of the government in both promoting the vaccine and imposing strict containment measures and the uncertainty about whether those around us might infect us, it is hardly surprising that trust is a salient theme. Indeed, studies prior to the COVID-19 pandemic have shown a strong association between deficits in trust and vaccine hesitancy. However, it is unclear to what extent this research generalizes to a COVID-19 context and whether COVID-19 vaccine hesitant individuals are overall less trusting, or whether they specifically mistrust a particular type of entity. Indeed, understanding where exactly trust deficits might lie (in individuals versus organizations) is important as it can lead us to a better conceptualization of what public messaging strategies might be most effective.

In an effort to fill this gap, in Chapter 3, I ask: to what extent do interpersonal and institutional trust relate to COVID-19 vaccine hesitancy? To answer this question, I report on data gathered from 1541 Canadians during the COVID-19 pandemic and explore the relationship between trust and hesitancy. In particular, I investigate differences in interpersonal and institutional trust.

Chapter 3

Institutional trust is a distinct construct related to vaccine hesitancy and refusal

Krastev S, Krajden O, Vang ZM, Pérez-Gay Juárez F, Solomonova E, Goldenberg MJ, Weinstock D, Smith MJ, Dervis E, Pilat D, Gold I. Institutional trust is a distinct construct related to vaccine hesitancy and refusal. BMC Public Health. 2023;23:2481.

Abstract

Vaccine hesitancy is driven by a heterogeneous and changing set of psychological, social and historical phenomena, requiring multidisciplinary approaches to its study and intervention. Past research has brought to light instances of both interpersonal and institutional trust playing an important role in vaccine uptake. However, no comprehensive study to date has specifically assessed the relative importance of these two categories of trust as they relate to vaccine behaviors and attitudes. In this paper, we examine the relationship between interpersonal and institutional trust and four measures related to COVID-19 vaccine hesitancy and one measure related to general vaccine hesitancy. We hypothesize that, across measures, individuals with vaccine hesitant attitudes and behaviors have lower trust—especially in institutions—than those who are not hesitant. We test this hypothesis in a sample of 1541 Canadians. A deficit in both interpersonal and institutional trust was associated with higher levels of vaccine hesitant attitudes and behaviors. However, institutional trust was significantly lower than interpersonal trust in those with high hesitancy scores, suggesting that the two types of trust can be thought of as distinct constructs in the context of vaccine hesitancy. Based on our findings, we suggest that diminished institutional trust plays a crucial role in vaccine hesitancy. We propose that this may contribute to a tendency to instead place trust in interpersonally propagated belief systems, which may be more strongly misaligned with mainstream evidence and thus support vaccine hesitancy attitudes. We offer strategies rooted in these observations for creating public health messages designed to enhance vaccine uptake.

Introduction

Vaccine Hesitancy

Vaccines are one of the most powerful public health tools available to humanity. Since their invention in the late 18th century by Edward Jenner [1], they have saved countless lives, drastically reducing smallpox, polio, measles, mumps and rubella, among others [2]. More recently, Watson and colleagues estimate that 14.4 million COVID-19-related deaths were prevented globally by vaccines between December 2020 and December 2021 alone [3]. Not only have vaccines been extremely effective at saving lives, they have done so at what have historically been extremely low risks of side effects [4]. However, despite overwhelming consensus that vaccines provide a net benefit, a significant (and by many measures, increasing) portion of the global population is vaccine hesitant [5] - a term with a debated definition, most recently described as “a state of indecisiveness regarding a vaccination decision.” [6].

A retrospective study of 290 surveys spanning 149 countries and 284,381 individuals showed that a significant portion of the global population does not agree that vaccines are safe, important or effective [7] - beliefs that are strongly at odds with scientific consensus. Vaccine hesitancy has a wide range of negative consequences, from the more obvious health effects on unvaccinated individuals who become infected, to the more subtle, but likely larger, consequences for increased infection rates, especially within the social circles of unvaccinated individuals. For example, de Miguel-Aribas and colleagues [8] modeled the effect of COVID-19 vaccine hesitancy in the US and found that for each one percent decrease in vaccine hesitancy, the primary and secondary effects resulted in an aggregate of 45 deaths per million inhabitants averted.

Vaccine hesitancy is a highly heterogeneous construct

Before tackling the determining factors of vaccine hesitancy, it is important to note several demographic factors that make the generalization of vaccine hesitancy research something that ought to be done with care.

Firstly, vaccine hesitancy has been a prevalent and well studied phenomenon for decades. However, prior to the COVID-19 pandemic, it was mostly studied in the context of childhood vaccinations, where parents have been the primary decision makers [9]. The COVID-19 pandemic created a renewed research interest in vaccine hesitancy in the context of adult vaccination. While this research has its own particularities related to the pandemic, COVID-19 vaccine hesitancy has been shown to overlap with parental vaccine hesitancy in a more traditional context. For example, Roberts and colleagues [10] carried out a study of over 1000 individuals and found a strong correlation between general anti-vaccination beliefs and COVID-19 vaccine hesitancy. At the same time, it is likely that the two constructs differ. To further complicate this, work by Merkley and Loewen [11] shows that different degrees of hesitancy apply to different COVID-19 vaccines, with more hesitancy associated with the AstraZeneca and Johnson and Johnson vaccines compared to Pfizer's and Moderna's vaccines. Similarly, Brewer and colleagues [12] found that parents were more hesitant about certain vaccines (e.g., human papillomavirus [HPV] compared to measles, mumps and rubella [MMR]) and that reasons for hesitancy differ between vaccines (e.g., concerns about side effects for HPV versus efficacy for MMR).

Secondly, it is important to note that while vaccine hesitancy exists globally, different regions express it very differently. A 2018 global survey of over 140,000 people [7] showed that attitudes toward vaccines, which are closely related to vaccine hesitancy, vary significantly among different parts of the world; for example 95% of people in South Asia agree that vaccines are safe, while that figure sits at 72% in North America and 50% in

Eastern Europe. Similarly, while awareness of vaccines is relatively high globally (90%), it varies from 98% in Australia and New Zealand to just 44% in Southern Africa. Dubé and colleagues [13] carried out a study that interviewed immunization managers from 13 different countries, which showed that not only the rates but also the factors involved in hesitancy differ significantly across geographies.

Thirdly, while factors affecting vaccine hesitancy are generally studied across different demographic groups, these groups can vary significantly in their expression of vaccine hesitancy. For example, Fajar and colleagues [14] carried out a meta-analysis that included 58 studies and found that factors associated with a higher likelihood of hesitancy include being a woman, being 50 years of age or younger, being single, being unemployed, living in a household with five or more individuals, having an educational attainment lower than an undergraduate degree and having a non-healthcare related job.

What causes vaccine hesitancy?

Vaccine hesitancy is a highly heterogeneous construct that, as others have pointed out, is grounded in a complex ecosystem of historical, sociocultural and psychological factors [15, 16] that vary between countries, communities and vaccines. Indeed, past research has proposed that vaccine hesitancy is better understood in a context-specific manner along a continuum rather than as a single binary measure [17] and is affected by myriad factors such as parenting styles, the role of media, public health policies, health professionals, individual decision making and political ideologies, historical context and socio-cultural norms.

Past research has described the predictors of vaccine hesitancy under the umbrella of broader behaviors - for example using the Health Belief Model (HBM) [18] and the Theory of Planned Behavior (TPB) [19]. The HBM is a theoretical framework aiming to explain a person's health-related behaviors in terms of a combination of a perceived threat and the

apparent efficacy of a behavior aiming to reduce that threat. In the context of vaccination, the HBM suggests that vaccine uptake is dependent on factors such as a person's beliefs about the severity of the disease, their susceptibility to it, as well as the vaccine's efficacy and safety. The TPB instead focuses on an individual's attitudes, social norms and perceived behavioral control to explain health-related behaviors. In contrast to the HBM, the TPB emphasizes the influence of a person's social network and their feeling of control over the vaccination decision.

While the HBM and the TPB have been applied to a broad number of health-related behaviors, including vaccination, recent research has focused on psychological constructs that are specific to vaccine-related attitudes and decisions. Standard accounts specific to vaccine hesitancy situate its causes in a wide array of factors, including knowledge and information, past experiences, perceived importance of vaccination, risk perception and trust, subjective norms, religious and moral convictions, communication and media, public health and vaccine policies and health professional recommendations [9]. Expanding on this research, several models have been proposed to explain the causes of vaccine hesitancy. For example, 1) the 3Cs model, developed by the World Health Organization's (WHO) SAGE group in 2014, whereby vaccine hesitancy is determined by complacency, convenience and confidence; 2) the 5As model, which includes access, affordability, awareness, acceptance and activation [20]; and 3) the 5Cs model, which expands on the 3Cs to include confidence, complacency, constraints, calculation and collective responsibility [21].

Beyond informational models of vaccine hesitancy

Given the gap between scientific consensus on vaccine safety and effectiveness and hesitancy rates, there has been a deliberate and expensive effort by governments around the world to close this gap using clearer communication strategies. Lack of high quality information has been deemed such an issue that it has led the WHO to state we are fighting an *infodemic* [22]

- i.e., that messaging strategies aiming to overcome lack of correct information about vaccines might be the front-line of our vaccination uptake efforts. Unfortunately, there is a growing amount of evidence that suggests communication strategies focused on filling an information gap have largely failed [23], leading some to suggest that approaching vaccine hesitancy from the assumption it is a gap in information or rationality takes the onus away from governments [16, 24].

Indeed, while misinformation is clearly related to vaccine hesitancy, evidence suggests the link may be complicated. As Goldenberg [16] has argued at length, the postwar reduction in vaccine acceptance in the industrialized north is more likely to be the result of an erosion of trust in institutions [16], and in medicine in particular [25], due to factors such as a legacy of social exclusion [26], under-representation and unethical treatment of marginalized groups in health research [15] and historical trauma [16], which has led to a situation where scientific consensus is, for the vaccine hesitant, largely irrelevant. This situation is reminiscent of conspiracy thinking - another case where mainstream evidence is disregarded for a variety of reasons. In fact, a strong link between conspiratorial thinking and vaccine hesitancy has been documented, suggesting a possible overlap in the causal factors behind these phenomena. For example, Hornsey and colleagues [5] sampled over 5000 participants across 24 countries, showing a strong association between vaccine hesitancy and conspiratorial thinking. In fact, Stoler and colleagues [27] showed that belief in conspiracy theories was the biggest predictor of vaccine hesitancy.

As argued by Grasswick [28], the relationship between scientific communities producing that consensus and lay communities is such that epistemic merit is earned by more than simply “following the standards of normal science”. As is the case in individuals holding conspiracy beliefs, even in situations where good science practices are followed, if the producer or messenger of a particular insight is deemed untrustworthy, the message is likely

to be ignored. This means that trust is a necessary (and perhaps sufficient) component of vaccine acceptance and a key factor in vaccine hesitancy, which has received insufficient attention in the past and has had limited impact on the shaping of public health strategies [29].

Trust and Vaccine Hesitancy

A large body of literature exists on trust, from a wide variety of fields, yielding many possible definitions. One common definition is that trust is a “willingness to accept vulnerability based on positive expectations of the intentions or behavior of another” [30]. Trust is a complex relational practice happening within particular socio-political contexts [31]. In the context of group collaboration, trust has been shown to facilitate positive outcomes including information sharing and task performance [32]. Findings about trust and cooperation carry over to a vaccine context, where it is widely acknowledged that lack of trust is a key predictor of vaccine hesitancy [33], and is associated with lower vaccine uptake [34]. However, given the large number of actors — both other people (i.e., requiring interpersonal trust) and institutions (i.e., requiring institutional trust) — that a person may consider when making a vaccination decision, we know surprisingly little about how trust toward these various “others” relates to vaccine hesitancy.

Interpersonal and institutional trust

There is a growing literature on the factors that affect interpersonal trust [35, 36]. An individual’s behaviors can be understood through the ability to infer mental states of others, known as the Theory of Mind, using cues such as facial features, body language and eye contact [37]. In addition, an individual has a history of actions that can be attributed directly to them which can be translated into markers of trust such as honesty, reliability and competence [38]. Therefore, psychosocial signals offer a good explanatory model for trust

toward individuals and small groups where interpersonal connections occur. However, they are less effective at explaining trust in institutions, where other factors related to connectedness and past experiences become more relevant [39, 40].

Institutions have been conceived of in various ways - through a structural-functional lens (i.e. as an interconnected system), as described by scholars including Peter Scott [41], and as a set of rules and goals put together by actors into a cohesive whole that has an identity by those such as John Meyer [42]. Whichever conception is used, institutions differ drastically from individuals in the ways they engender trust. For this reason, while past studies may be construed to refer to “trust” in a vaccine hesitancy context under the premise that it is a single construct, they are in fact referring to very different constructs that we would expect to behave differently. Indeed, interpersonal and institutional trust are distinct. While both result in the same behavior (i.e., a “willingness to accept vulnerability based on positive expectations of the intentions or behavior of another”), past studies have shown that institutional trust is more closely related to the concept of social identity and belonging [43], while interpersonal trust is more closely based on social appeal [44].

The decline in institutional trust during the latter half of the 20th century and early 21st century, caused by a variety of factors such as political polarization, economic inequality, government inefficiency and social media echo chambers, has had a profound effect on vaccine hesitancy [16]. The effect of this decline has been heterogeneous across different communities, with minority communities who may have been the victims of mishandling of public health crises, historical mistreatment and marginalization, exhibiting higher levels of mistrust in institutions. Research shows that this erosion in institutional trust has affected vaccination decisions [45–48] in a way that is perhaps exacerbated in those communities. Indeed, a comprehensive review by Sapienza and Falcone [34] on the role of trust in COVID-19 vaccine hesitancy suggests a complex relationship between the two. For

example, they found positive correlations between levels of trust in the COVID-19 vaccine and being male, being older, and having a higher level of income. In the context of institutional trust, they found that trust in government generally relates positively to COVID-19 vaccine acceptance - the one exception being trust in the Trump government, which had a negative relationship with COVID-19 vaccine acceptance. This example underscores an important distinction between studies that might be measuring trust in a specific institution (e.g. the current government at that moment) versus trust in institutions more generally.

A growing amount of research on vaccine hesitancy has focused on trust. While many past studies treat trust as a single construct or focus on measures of trust that relate to specific entities or institutions, *trust in institutions* in a more general sense, is likely to be a distinct construct that is particularly relevant to citizen behaviors, such as vaccination, that require engagement with large public agencies.

Objectives and Hypotheses

In order to gain a better understanding of institutional trust as a potential factor related to vaccine hesitancy, our present objective is to investigate the trust attitudes of vaccine hesitant and non-hesitant individuals in relation to interpersonal and institutional contexts. We hypothesize that vaccine hesitant individuals have distinct trust attitudes toward individuals and institutions. More specifically, we hypothesize that those with high levels of hesitancy-related attitudes and behaviors, as measured by several related constructs (COVID-19 vaccine hesitancy, COVID-19 vaccine concerns, general vaccine hesitancy, COVID-19 conspiracy thinking and COVID-19 vaccination status), are more likely to exhibit low levels of trust that are specific to an institutional context. In other words, we hypothesize that trust deficits reported in vaccine hesitant individuals by previous research are in fact deficits specific to institutional trust.

Methods

Sample and Data Gathering Procedure

In collaboration with Environics Research [49], a Canadian polling and research firm, a representative group of 1541 Canadians aged 18 and older were randomly recruited by email invitation through either Dynata [50], the world's largest first-party research data platform, or Asking Canadians) [51], Canada's premier proprietary research panel. Participants had already consented to participate and were asked to read and sign additional consent forms from McGill University and Environics Research that provided the information pertinent to the present study. Subsequently, participants were asked demographic questions, including age, gender, ethnicity, Indigenous status, province, education, and income. A summary table of sample characteristics can be found in Appendix A.

During April and May of 2021, participants were sent a link to the survey after being contacted by Dynata and/or Asking Canadians. The entire survey was conducted online, and could be completed on a computer or mobile device (mobile phone or tablet). There was no time limit, and participants were informed they could withdraw from the study at any time or decline to answer any questions in the survey. Participants were not compensated given their pre-existing agreement with Dynata and/or Asking Canadians.

Measures

Questions assessed levels of trust and four factors that have been previously found to relate to vaccine hesitancy: conspiratorial thinking, COVID-19 vaccine hesitancy, general vaccine hesitancy, and COVID-19 vaccination status. The instruments used can be found in Appendix B.

Trust

Trust was measured using interpersonal and institutional trust self-report, based on OECD guidelines [52], which were previously used in the COVIDiSTRESS survey (n= 173 429 respondents in 48 countries) [53, 54] and its follow-up study (n=15, 700)[55]. Measures of trust were split into two groups: *interpersonal trust*, composed of family, friends, acquaintances, classmates, co-workers and roommates; *trust in institutions*, composed of federal government, local government, WHO, healthcare system, police, scientists, physicians, mainstream media and pharmaceutical companies. Cronbach's Alpha for each of these groups, as determined using the Pingouin package on python, yielded an alpha of .802 for *interpersonal* and .894 for *institutional*, which indicates a good level of internal consistency between the variables making up each of these composite measures.

COVID-19 Vaccine Hesitancy

In line with past work [56–58], COVID-19 vaccine hesitancy was determined based on a combination of vaccination status and two other factors: for those who were vaccinated, we used the level of reported hesitancy prior to vaccination; for those who had not been vaccinated, we evaluated their vaccination intentions. This instrument (Section B1 of Appendix B) allowed us to divide participants into groups based on the level of COVID-19 hesitancy that they exhibited. In particular, the following groupings were made; note that Group 1 includes two subgroups:

- 1a: Vaccinated and Non-hesitant
 - *Answered “Yes” to “Knowing that vaccinations against COVID-19 have begun, have you received the COVID-19 vaccination?”*

- *Answered 1–3 (Not Hesitant to Neither hesitant nor Non hesitant) to “Thinking back, how hesitant were you about a COVID-19 vaccination prior to receiving one?”*
- 1b: Unvaccinated and Non-hesitant
 - *Answered “No” to “Knowing that vaccinations against COVID-19 have begun, have you received the COVID-19 vaccination?”*
 - *Answered “Yes, I would get a vaccination as soon as one became available to me” to “When the COVID-19 vaccination becomes available to you, would you get vaccinated or not?”*
- 2: Vaccinated and Hesitant
 - *Answered “Yes” to “Knowing that vaccinations against COVID-19 have begun, have you received the COVID-19 vaccination?”*
 - *Answered 4–5 (Hesitant or Extremely Hesitant) to “Thinking back, how hesitant were you about a COVID-19 vaccination prior to receiving one?”*
- 3: Unvaccinated and Soft-Hesitant
 - *Answered “No” to “Knowing that vaccinations against COVID-19 have begun, have you received the COVID-19 vaccination?”*
 - *Answered “Not sure” or “Yes, I would eventually get a vaccination, but would wait a while first” to “When the COVID-19 vaccination becomes available to you, would you get vaccinated or not?”*
- 4: Unvaccinated and Hard-Hesitant
 - *Answered “No” to “Knowing that vaccinations against COVID-19 have begun, have you received the COVID-19 vaccination?”*

- *Answered “No, I would not get a COVID-19 vaccination” to “When the COVID-19 vaccination becomes available to you, would you get vaccinated or not?”*

For the purpose of our analysis, the four groups that resulted allowed us to distinguish between those with no COVID-19 vaccine hesitancy (defined as vaccinated or unvaccinated and non-hesitant) and those with COVID-19 vaccine hesitancy (vaccinated and hesitant, unvaccinated and soft-hesitant, or unvaccinated and hard-hesitant). The subgroup sizes for the four groups were as follows: 972 individuals were included in Group 1; 193 were included in Group 2; 168 were included in Group 3; 208 were included in Group 4.

COVID-19 Vaccine Concerns, General Vaccine Hesitancy and COVID-19 Conspiratorial Thinking

COVID-19 vaccine concerns, general vaccine hesitancy and conspiratorial thinking were measured using the instruments described in Appendix B. For the purpose of t-tests, each outcome variable was split into two groups: a “hesitant” group, composed of everyone who scored above the median on that measure; a “non-hesitant” group, composed of everyone who scored at or below the median for that measure. The cutoff for the groups was as follows: 2.40 for conspiratorial thinking, .17 for COVID-19 vaccine concerns and 0 for general vaccine hesitancy. The sizes of the corresponding subgroups were as follows: 720 for the non-hesitant conspiratorial thinking group; 821 for the hesitant conspiratorial thinking group; 839 for the non-hesitant COVID-19 concerns group; 702 for the hesitant COVID-19 concerns group; 1422 for the non-hesitant general vaccine hesitancy group; 119 for the hesitant general vaccine hesitancy group. In addition, 1131 individuals were unvaccinated for COVID-19 and 410 were vaccinated.

Data Analysis

To investigate the relationship between interpersonal and institutional trust and the four outcome measures (conspiracy thinking, COVID-19 vaccine hesitancy, general vaccine hesitancy, and COVID-19 vaccination status), we calculated eta correlation ratios between our dependent and independent variables using the statsmodels package [59]. Eta correlation ratios were used instead of Pearson's correlation ratios because of the ordinal nature of our variables. We then used a bootstrap method in order to assess the statistical significance of the differences between these correlations. Utilizing the bootstrap method, a non-parametric approach that imposes no assumptions about the underlying population distribution, enabled us to empirically estimate the sampling distribution of our statistics of interest [60]. This approach is particularly advantageous as it is robust against violations of normality assumptions, which can be a concern in traditional parametric tests. By employing the bootstrap method, we not only addressed potential concerns about the validity of our results but also provided a transparent and interpretable representation of the uncertainty surrounding our estimates. We also split each of the outcome variables into high and low groups based on their median score, and conducted two t-tests for each variable using the statsmodel package: one between interpersonal and institutional trust in the high group, and another in the low group. To enhance the robustness and validity of our statistical inferences, we applied the bootstrap method with scikit-learn, pandas, and numpy Python packages to resample the data with replacement, thereby obtaining distributions for the correlation coefficients and t-statistics.

Results

Our results report on a sample of 1541 participants; sample characteristics are included in Appendix A.

Eta Correlation Ratio between trust in each entity and vaccine hesitancy measures

Table 1: Matrix showing the relationship between trust in each specific entity and the five measures related to vaccine hesitancy, as quantified by the Eta Correlation Ratio. A post-hoc examination of the net change in means across the trust categories was conducted for each variable pair, with relationships classified as either 'Increasing' or 'Decreasing', based on whether the mean of the predictor variable was higher for the last category of the trust variable than for the first. This allowed us to ascertain the direction of the effect which was Negative for all 75 pairs.

	COVID-19 Vaccine Hesitancy	COVID-19 Vaccine Concerns	General Vaccine Hesitancy	COVID-19 Conspiracy Thinking	COVID-19 Vaccination Status
Interpersonal Trust					
Trust family	.145	.134	.109	.133	.131
Trust Roommates	.140	.135	.086	.115	.160
Trust Friends	.146	.140	.109	.130	.193
Trust Classmates	.164	.155	.048	.122	.113
Trust co-workers	.161	.145	.066	.122	.142
Trust Acquaintances	.179	.159	.075	.158	.133
Institutional Trust					
Trust police	.208	.214	.109	.238	.178
Trust local govt	.308	.258	.197	.310	.329
Trust Pharma	.322	.264	.232	.333	.235
Trust Fed govt	.336	.277	.220	.342	.353
Trust Media	.319	.271	.230	.332	.356
Trust doctors	.347	.297	.263	.332	.363
Trust Healthcare system	.374	.292	.271	.367	.378
Trust WHO	.374	.326	.260	.377	.457
Trust scientists	.498	.414	.306	.432	.564

As a first step in our analysis, we created an eta correlation ratio matrix showing the relationship between trust in each of the entities and the five measures related to vaccine hesitancy (Table 1). The results showed that stronger eta correlations ratios were present for institutional entities across all five measures. In particular, the strongest correlation ratios were between trust in scientists and vaccination status ($\eta = .564$), trust in scientists and COVID-19 vaccine hesitancy ($\eta = .498$) and trust in the WHO and COVID-19 vaccination status ($\eta = .457$). A post-hoc examination of the net change in means across the trust categories was conducted for each variable pair, with relationships classified as either 'Increasing' or 'Decreasing', based on whether the mean of the predictor variable was higher for the last category of the trust variable than for the first. This allowed us to ascertain the direction of the effect, which was Negative for all 75 pairs.

COVID-19 Vaccine Hesitancy

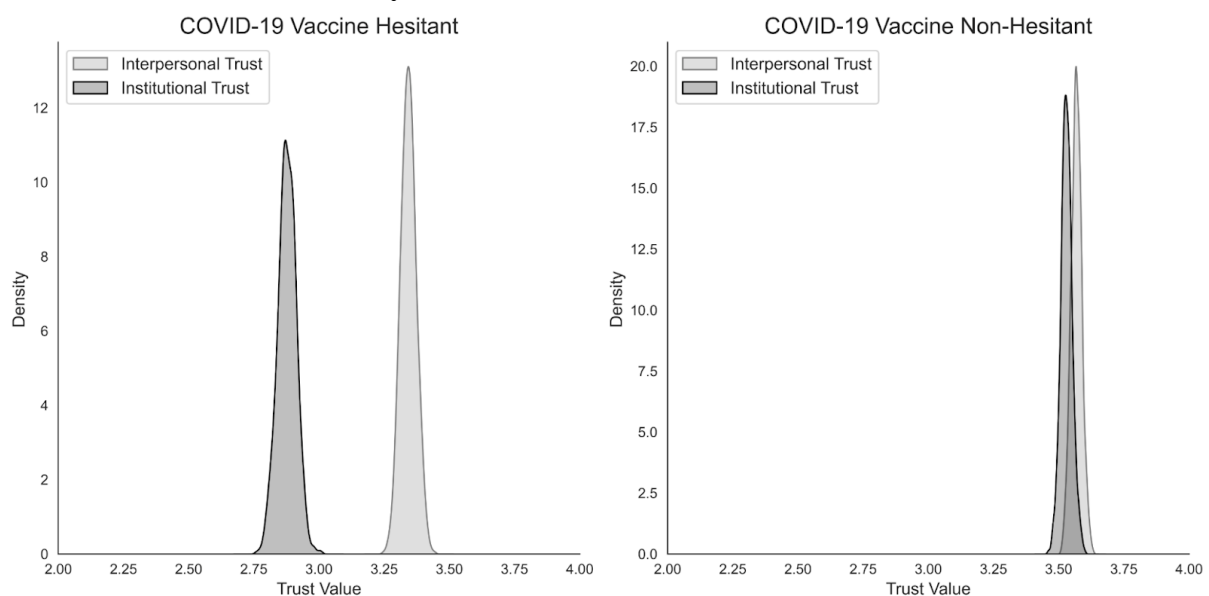


Figure 1a: Individuals exhibiting COVID-19 vaccine hesitancy showed significant differences between levels of interpersonal trust and institutional trust, whereas those with no COVID-19 vaccine hesitancy did not.

We next sought to investigate the association between high and low levels of COVID-19 vaccine hesitancy and varying degrees of interpersonal and institutional trust. Participants were categorized as hesitant and non-hesitant based on the method described above. Our analysis revealed that hesitant individuals displayed overall reduced trust ($M = 3.06$, $SD = .70$) compared to their non-hesitant counterparts ($M = 3.54$, $SD = .58$; $t(1539) = -14.54$, $p < .001$).

We segregated trust scores within each group into interpersonal and institutional trust components and computed the difference between the two (Figure 1a). The hesitant group exhibited a significant discrepancy between interpersonal ($M = 3.343$, $SD = .029$) and institutional trust ($M = 2.879$; $t(567) = 9.951$, $p < .001$), while this distinction was not observed in the non-concerned group. Further comparison of the two differences revealed that the concerned group exhibited a significantly larger disparity between institutional and interpersonal trust ($M = -.467$, $SD = .820$) than the non-concerned group ($M = .038$, $SD = .648$; $t(1539) = p < .001$).

We conducted an eta correlation ratio analysis to explore the relationship between COVID-19 vaccine concerns as a categorical variable and each type of trust as a continuous variable. The results indicated a stronger eta correlation ratio between institutional trust and hesitancy, compared to that between interpersonal trust and hesitancy ($\eta = .256$ for interpersonal vs. $\eta = .509$ for institutional trust). The bootstrapped 95% confidence interval for the difference in correlations ranged from $-.304$ to $-.197$, suggesting that institutional deficits in institutional trust had a significantly stronger association with hesitancy.

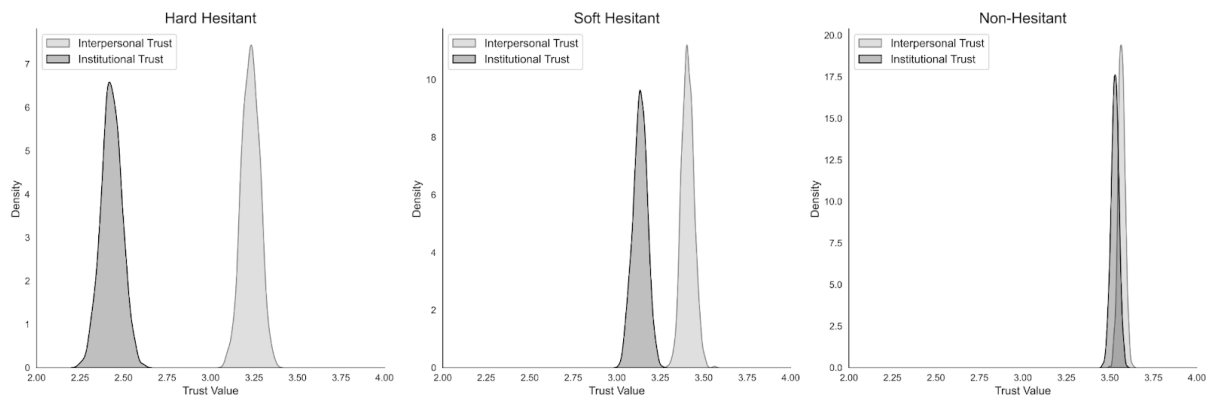


Figure 1b: *The differences in interpersonal versus institutional trust increase as hesitancy increases, with hard hesitant individuals exhibiting significantly larger delta than soft-hesitant individuals, who in turn exhibit significantly higher delta than non-hesitant individuals.*

Finally, we split participants into three groups: hard hesitants (score = 4 on the measure as defined above); soft hesitants (score = 2 or score = 3) and non-hesitants (score = 1) in order to determine the extent to which institutional trust deficits might relate to different hesitancy levels (Figure 1b). Non-hesitant individuals showed no significant difference between interpersonal and institutional trust ($M = 3.567$, $SD = .019$ for interpersonal; $M = 3.530$, $SD = .023$ for institutional; $t(970) = 1.294$, $p = .196$). Soft hesitant individuals and hard hesitant individuals did show significant differences between types of trust ($t(359) = 5.099$, $p < .001$ for soft-hesitant and $t(206) = 1.190$, $p < .001$ for hard hesitant individuals). An analysis of the delta between trust types in soft-hesitant and hard-hesitant individuals revealed a significant difference between the two. Our results suggest that as hesitancy grows, mistrust in institutions has a significantly stronger association with hesitancy.

COVID-19 Vaccine Concerns

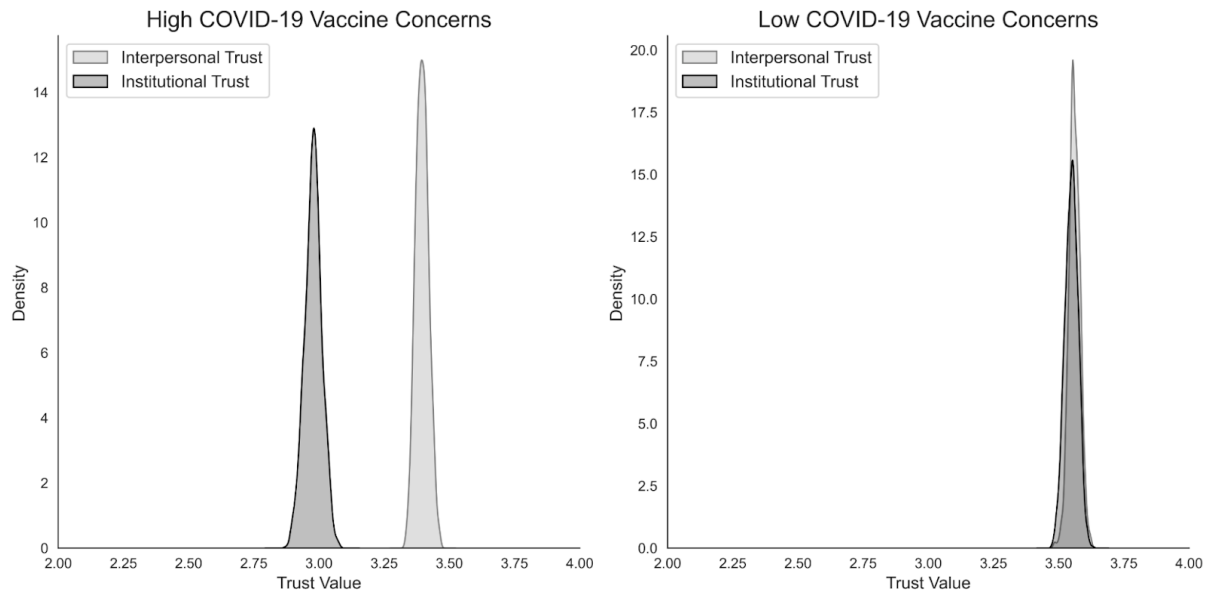


Figure 2: Individuals exhibiting COVID-19 vaccine concerns showed significant differences between levels of interpersonal and institutional trust, whereas those with no COVID-19 vaccine concerns did not.

Next, we sought to investigate the association between high and low levels of COVID-19 vaccine concerns and varying degrees of interpersonal and institutional trust. As a reminder, this construct (Appendix B, Instrument B4) refers to a series of potential concerns about the COVID-19 vaccine and its production. Participants were categorized into concerned and non-concerned groups based on whether they had a score of either more than or less than/equal to .17 (the median) in that measure. This analysis revealed that concerned individuals displayed overall reduced trust ($M = 3.14$, $SD = .69$) compared to their non-concerned counterparts ($M = 3.55$, $SD = .59$; $t(1539) = -12.54$, $p < .001$).

Subsequently, we segregated trust scores within each group into interpersonal and institutional trust components and computed the difference between the two (Figure 2). The concerned group exhibited a significant discrepancy between interpersonal ($M = 3.393$, $SD = .025$) and institutional trust ($M = 2.978$, $SD = .033$; $t(700) = 1.124$, $p < .001$), while this distinction was not observed in the non-concerned group. Further comparison of the two

differences revealed that the concerned group exhibited a significantly larger disparity between institutional and interpersonal trust ($M = -.417$, $SD = .791$) than the non-concerned group ($M = .02$, $SD = .651$; $t(1539) = 1.822$, $p < .001$).

Lastly, we conducted an eta correlation ratio analysis to explore the relationship between COVID-19 vaccine concerns as a categorical variable and each type of trust. The results indicated a stronger correlation ratio with institutional trust relative to interpersonal trust ($\eta = .227$ for interpersonal vs. $\eta = .496$ for institutional trust). The bootstrapped 95% confidence interval for the difference in correlations ranged from $-.321$ to $-.217$, indicating that the difference was statistically significant.

General Vaccine Hesitancy

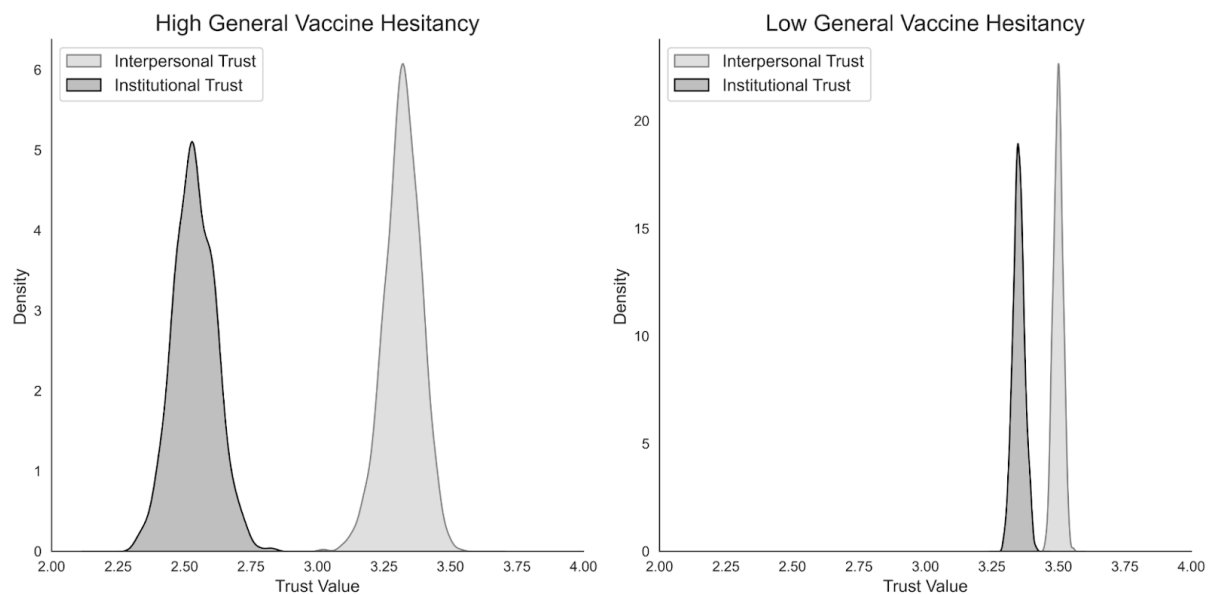


Figure 3: Individuals exhibiting general vaccine hesitancy showed significant differences between levels of interpersonal and institutional trust. Those with no general vaccine hesitancy also showed significantly lower institutional versus interpersonal trust. However, the delta in the high hesitancy group was significantly higher than the delta in the low hesitancy group.

We explored the association between high and low levels of general vaccine hesitancy and varying degrees of interpersonal and institutional trust. Participants were categorized into

hesitant and non-hesitant groups based on whether they had a score of 0 or more than 0 (the median) in that measure. This analysis revealed that general vaccine hesitant individuals displayed overall reduced trust ($M = 2.85$, $SD = .71$) compared to their low concern counterparts ($M = 3.41$, $SD = .65$; $t(1539) = 903$, $p < .001$).

We again segregated trust scores within each group into interpersonal and institutional trust components and computed the difference between the two (Figure 3). The hesitant group exhibited a significant discrepancy between interpersonal ($M = 3.319$, $SD = .070$) and institutional trust ($M = 2.537$, $SD = .079$; $t(117) = 7.404$, $p < .001$), as did the non-hesitant group ($M = 3.499$, $SD = .017$ for interpersonal; $M = 3.351$, $SD = .021$ for institutional; $t(1420) = 5.465$, $p < .001$). However, a comparison of the two differences revealed that the hesitant group exhibited a significantly larger disparity between institutional and interpersonal trust ($M = -.781$, $SD = .869$) than the non-hesitant group ($M = -.148$, $SD = .713$; $t(1539) = 7.731$, $p < .001$).

Lastly, we conducted an eta correlation ratio analysis to explore the relationship between general vaccine hesitancy as a categorical variable and each type of trust. The results indicated a significantly stronger correlation ratio with institutional trust relative to interpersonal trust ($\eta = -.229$ for interpersonal vs. $\eta = -.394$ for institutional trust). The bootstrapped 95% confidence interval for the difference in correlations ranged from $-.264$ to $-.067$, indicating that the difference was statistically significant.

Conspiracy Thinking about COVID-19

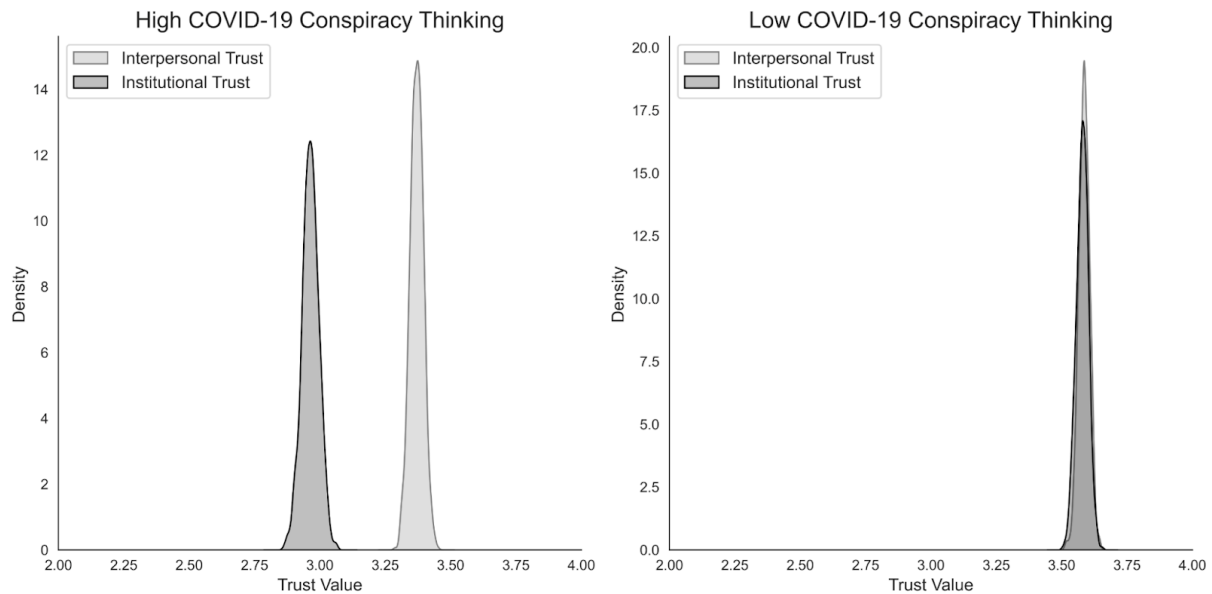


Figure 4: Individuals exhibiting high COVID-19 conspiratorial beliefs showed significant differences between levels of interpersonal and institutional trust, whereas those without COVID-19 vaccine hesitancy did not.

Next, we sought to investigate the association between high and low levels of COVID-19 conspiracy thinking and varying degrees of interpersonal and institutional trust. Participants were categorized into high and low conspiracy thinking groups based on the median (0). Our analysis revealed that high conspiracy thinking individuals displayed overall reduced trust ($M = 3.13$, $SD = .69$) compared to their low conspiracy thinking counterparts ($M = 3.58$, $SD = .56$; $t(1539) = -14.24$, $p < .001$).

Subsequently, we segregated trust scores within each group into interpersonal and institutional trust components, and computed the difference between the two (Figure 4). The high conspiracy group exhibited a significant discrepancy between interpersonal ($M = 3.372$, $SD = .025$) and institutional trust ($M = 2.963$, $SD = .032$; $t(728) = 9.995$, $p < .001$), while this distinction was not observed in the low conspiracy group. Further comparison of the two differences revealed that the high conspiracy group exhibited a significantly larger disparity

between institutional and interpersonal trust ($M = -.407$, $SD = .794$) than the low-conspiracy group ($M = .007$, $SD = .643$; $t(1539) = 1.809$, $p < .001$).

Lastly, we conducted an eta correlation ratio analysis to explore the relationship between COVID-19 vaccine concerns as a categorical variable and each type of trust. The results indicated a stronger correlation ratio with institutional trust ($\eta = -.516$) compared to interpersonal trust ($\eta = -.258$). The bootstrapped 95% confidence interval for the difference in correlations ranged from $-.305$ to $-.208$, indicating that the difference was statistically significant.

COVID-19 Vaccination Status

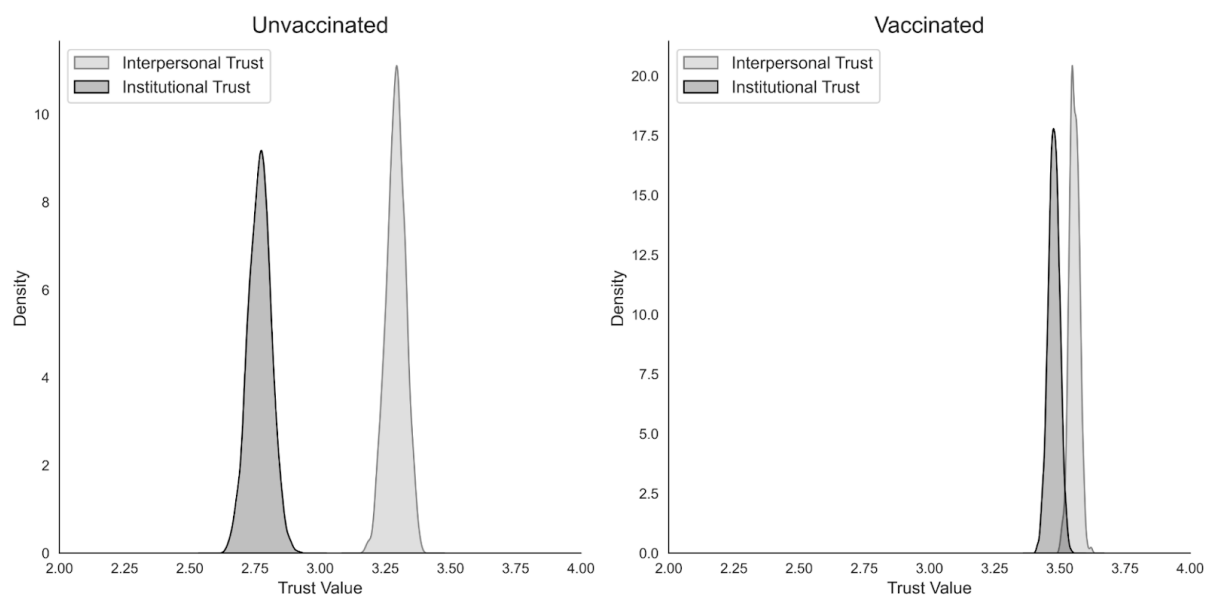


Figure 5: Individuals that were unvaccinated for COVID-19 showed significant differences between levels of interpersonal and institutional trust. Vaccinated individuals also showed significantly lower institutional versus interpersonal trust. However, the delta in the high hesitancy group was significantly higher than the delta in the low hesitancy group.

Finally, we examined whether institutional trust would be associated with COVID-19 vaccination status. We saw that the overall level of trust is lower in the unvaccinated versus the vaccinated ($M = 2.98$, $SD = .72$ versus $M = 3.51$, $SD = .59$; $t(1539) = 14.76$; $p < .001$).

When segregating the trust scores within each group into interpersonal and institutional trust components (Figure 5), we found the unvaccinated group exhibited a significant discrepancy between interpersonal ($M = 3.289$, $SD = .037$) and institutional trust ($M = 2.767$, $SD = .042$; $t(408) = 9.176$, $p < .001$), as did the vaccinated group ($M = 3.556$, $SD = .017$ for interpersonal; $M = 3.478$, $SD = .022$ for institutional; $t(1129) = 2.801$, $p < .01$). However, while both groups showed significant difference in interpersonal versus institutional trust, a comparison of the two differences revealed the unvaccinated group exhibited a significantly larger disparity between institutional and interpersonal trust ($M = -.524$, $SD = .840$) than the vaccinated group ($M = -.078$, $SD = .670$; $t(1539) = 9.697$, $p < .001$).

Lastly, we conducted an eta correlation ratio analysis to explore the relationship between vaccination status and each type of trust. The results indicated a significantly stronger association of vaccination status with institutional trust relative to interpersonal trust ($\eta = .248$ for interpersonal vs. $\eta = .443$ for institutional trust). The bootstrapped 95% confidence interval for the difference in correlations ranged from $-.246$ to $-.145$, indicating that the difference was statistically significant.

Summary Graphs

Given the hypothesized relatedness of the constructs we used (COVID-19 vaccine hesitancy, COVID-19 vaccine concerns, general vaccine hesitancy, COVID-19 conspiracy thinking and COVID-19 vaccination status), a summary graph of comparisons was created (Figure 6). As can be seen, plotting the relationships between each of these constructs and each type of trust shows that the two trust scores tend to be far more aligned in non-hesitant individuals across all measures relative to their counterparts, where institutional distrust is a clear driver of the overall lower trust levels.

Comparison of interpersonal and institutional trust across high and low hesitant individuals

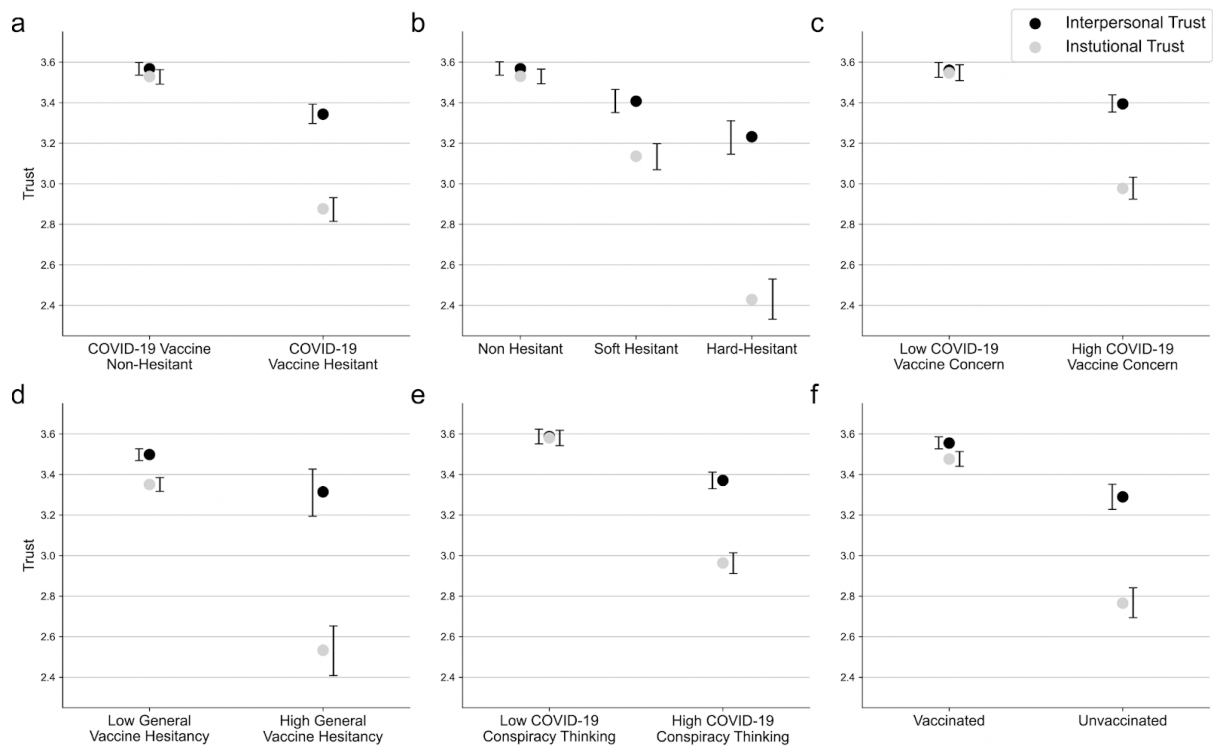


Figure 6: Summary plot of the comparisons between interpersonal and institutional trust across a) low versus high COVID-19 vaccine hesitancy; b) non-hesitant, soft hesitant and hard hesitant in regards to COVID-19 vaccines; c) low and high COVID-19 vaccine concerns; d) low and high general vaccine hesitancy; e) low and high COVID-19 conspiracy thinking; f) vaccinated and unvaccinated. Error bars represent the 5th and 95th percentile of the bootstrapped means as described above.

Discussion

We set out to test whether individuals exhibiting various vaccine hesitancy-related beliefs and behaviors have a different trust profile from those who do not. Consistent with our hypothesis, we found that vaccine hesitancy and other related factors (COVID-19 vaccine concerns, COVID-19 conspiracy thinking, general vaccine hesitancy, COVID-19 vaccine hesitancy and COVID-19 vaccination status) are associated with lower levels of trust specific to institutions.

Our analysis revealed a distinct relationship between trust in institutions, such as scientists and the WHO, and vaccine hesitancy. This relationship was first measured using an eta correlation ratio between 15 different entities and our five vaccine hesitancy related measures. Results revealed that all of the strongest relationships were between the five measures and distrust in institutions; in particular, distrust in scientists and vaccination status ($\eta = .564$), followed by distrust in scientists and COVID-19 vaccine hesitancy ($\eta = .498$), and distrust in the WHO and COVID-19 vaccination status ($\eta = .457$).

Next, we grouped trust in interpersonal entities (Cronbach's Alpha of .802) and trust in institutions (Cronbach's Alpha of .894) and found a significant discrepancy in levels of interpersonal and institutional trust among individuals exhibiting COVID-19 vaccine hesitancy. While hesitant individuals displayed overall reduced trust ($M = 3.06$, $SD = .70$) compared to non-hesitant counterparts ($M = 3.54$, $SD = .58$; $t(1539) = -14.54$, $p < .001$), we observed that the hesitant group exhibited a significant discrepancy between interpersonal ($M = 3.343$, $SD = .029$) and institutional trust ($M = 2.879$; $t(567) = 9.951$, $p < .001$). This discrepancy was not observed in the non-hesitant group, suggesting that institutional trust deficits may be more closely associated with vaccine hesitancy. Importantly, we found that hesitant individuals also had lower levels of interpersonal trust compared to their non-hesitant counterparts. We performed the same analyses across all of our measures and found the difference in institutional versus interpersonal trust was significantly larger for groups exhibiting higher COVID-19 vaccine concerns, higher COVID-19 conspiracy thinking, higher general vaccine hesitancy and lack of COVID-19 vaccination (Figure 6).

Our findings are generally aligned with the existing literature on the relationship between trust and vaccine hesitancy. For example, in a study of over 13,000 people and 19 countries, Lazarus and colleagues [61] found that higher levels of trust in information from government sources was linked to a higher likelihood to accept a vaccine. Interestingly, the

same study found that trusting information from the government was also related to a higher propensity to positively respond to vaccine information coming from their employer. This relationship between trust in one institution and another is not surprising in the context of our findings, which include both governmental and non-governmental institutions, but raises the possibility that changes in trust toward one institution may influence trust toward other seemingly unrelated institutions.

This is reflected in past research, which has reported trust in specific institutions as important for vaccine uptake, but has done so in a way that does not unify these findings under the broader umbrella of institutional trust. For example, research by Palamenghi and colleagues [62] on 968 Italian citizens early on in the pandemic revealed similar insights, concluding that trust in scientific institutions is a key factor in vaccine uptake. In a non-COVID-19 vaccination context, Schmid and colleagues [63] found that influenza vaccine hesitancy is strongly related to distrust in health authorities. Similarly, research by Schwarzsinger and colleagues [64] reported that trust in health policy and services was a key factor in vaccine hesitancy, while Dror and colleagues [65] suggested that distrust in preventative healthcare is a key factor. While our research supports findings like these, the relatively high Cronbach's alpha (.894) we reported within institutional trust measures suggests that a broader view of this construct may be warranted. On this view, past research proposing trust in large entities as significantly related to vaccine uptake should perhaps be interpreted, to some extent, as reporting on different dimensions of the same construct - institutional trust. Such a view is broadly aligned with past thinking on trust in institutions, which suggests that it is defined by the power-dynamic between individuals and institutions rather than the specific institutional relationship and context that is present. However, future research is required to understand the extent to which *institutional trust* can be thought of as more than just a sum of its parts, as well as the effect this may have on vaccine hesitancy.

Our findings revealed that while lower general levels of trust were present in vaccine hesitant individuals across all measures, there was a significantly larger difference between interpersonal and institutional trust in that group than in the non-hesitant group across all five measures. Furthermore, in the case of COVID-19 conspiracy thinking and COVID-19 vaccine hesitancy, results showed that there is a significant difference between institutional and interpersonal trust for the hesitant but not for the non-hesitant group ($M = -.467$ versus $M = .038$, respectively, for COVID-19 vaccine hesitancy; $M = -.407$ versus $M = -.007$, respectively, for COVID-19 conspiracy thinking). Again, these findings suggest that there is an institutional trust deficit specific to those individuals exhibiting vaccine hesitancy-related attitudes.

Our results indicate that overall levels of trust (across interpersonal and institutional entities) are lower in vaccine hesitant individuals. Consistent with past research [66], we found lower levels of interpersonal trust in individuals who scored higher on measures of vaccine hesitancy. However, consistent with past work by Goldenberg [67], we found institutional trust to be significantly more strongly associated with vaccine hesitancy than interpersonal trust. This lack of balance between institutional and interpersonal trust, which we did not observe in the non-hesitant group, raises the possibility that hesitant individuals may be basing their vaccine decisions on alternative information sources. For example, a lack of trust in institutions may push a vaccine hesitant individual to instead rely on advice sourced from their social group. Past research has shown that strong ties tend to exist between vaccine hesitant individuals [68], further supporting the idea that distrust in institutions is likely to create vaccine hesitant echo-chambers. Given that vaccine-hesitant individuals in our sample have a higher relative trust toward non-institutional entities, our findings add to an increasingly supported narrative suggesting that vaccine hesitancy is predominantly a

social phenomenon related to trust rather than a cognitive phenomenon related to deficits in decision making.

Public Health Implications

The results presented here suggest that current public health strategies that are used to increase vaccine uptake might be effective for individuals who have higher levels of institutional trust, but have a weaker and possibly counterproductive effect on groups with low institutional trust. Given that marginalized communities are the most likely to have lower levels of institutional trust [16], they likely present the biggest challenge for public health professionals.

Past research has shown that the way information about vaccines is presented is critical to ensure a positive effect on vaccine uptake [69–71]. Our research builds on this by suggesting that while fast dissemination of critical information by large entities such as the WHO is important (in particular during a pandemic that is extremely dynamic), lower trust levels on the part of vaccine hesitant individuals toward institutions indicate that, beyond a certain vaccine uptake point, it may be beneficial to emphasize a more community-focused strategy that leverages strong ties. The extent to which different communication strategies (broad versus community focused) are compatible is an important question for future research.

Importantly, in the context of a time-bound vaccination campaign (such as the ones we are likely to encounter in future pandemics), as time goes on, the target population for public health messages shifts from one that is predominantly vaccine acceptant to one that is predominantly vaccine hesitant. Because the attitudes toward institutions between these groups are drastically different, it is very likely that in order to optimize vaccine uptake, messaging strategies must change as the target audience does. While at the beginning we can assume that only a minority of the target are vaccine hesitant and an institution-derived

diffusion strategy (e.g., the WHO) is likely to be effective, as vaccination rates climb, a higher and higher percentage of the target group is composed of vaccine hesitant individuals with low institutional trust for whom a message from the WHO is likely to be counterproductive. Therefore, an inflection point likely exists, after which the dominant strategy should be changed. It is worth noting here that while differences in institutional trust were significantly higher in hesitant compared to non-hesitant individuals, hesitant individuals did also show lower interpersonal trust scores. Therefore, while public health strategies targeting hesitant individuals may be generally more successful by shifting toward strong ties at an inflection point, even those strong ties may be less effective in increasing vaccine uptake relative to the strong ties of non-hesitant individuals.

While it is difficult to say where this inflection point lies or what precise strategies should be used before and after it occurs, public health messaging architects should be aware that the very same message is likely to be received quite differently as the composition of their audience changes to include predominantly vaccine hesitant individuals. Based on these findings, it seems that public health messaging should be based on a closer monitoring of the target audience's *trust balance* - i.e. the extent to which their total trust is based on interpersonal versus institutional relationships.

Our findings, along with past research on institutional trust, suggest that a messaging strategy originating in strong ties may be more effective with hesitant individuals. Therefore, we encourage policymakers to pre-empt or reduce messaging that evokes out-group feeling, distinctiveness, or 'Othering' of those who remain unvaccinated. Effective strategies may include outreach through local community networks and familiar contacts. A *chorus* of peer-led voices is more likely to be welcomed over top-down approaches.

In addition to shifting messaging strategies from ones focused on institutions to ones that leverage strong ties, in the context of the importance of institutional trust, public health

agencies have a responsibility to attempt to rebuild trust in the individuals that have lost it. As noted by Goldenberg [16, 72], the understanding of institutional trust as the crux of the vaccine hesitancy problem creates a strong need for conciliation between public health agendas and the needs of communities. Therefore, while immediate strategies should focus on strong ties, longer term efforts should focus on engaging communities in an equitable and transparent manner that is sensitive to the historical causes of mistrust and aimed at correcting systemic inequities.

Limitations

While the data presented in this paper raise the possibility that people with different vaccine attitudes and behaviors show differential sensitivity to institutions compared to individuals when building trust, our findings come with a number of caveats. First and foremost, while our study revealed a strong link between trust profiles and vaccine hesitancy-related measures, the cross-sectional design prevents us from drawing any causal conclusions about the relationships between these variables.

Timing

The COVID-19 pandemic was profoundly disruptive. Given that the data collected in this study was from that time period, it is possible that factors relating to the pandemic affect trust-size sensitivity. For example, people who are generally low on the vaccine hesitancy continuum may show attitudes and behaviors that exaggerate their baseline level of doubt because of the higher level of uncertainty associated with the pandemic - for example, due to factors such as the rapid development of the pandemic, the fast-changing evidence base, changes in vaccine policies and a perceived rush in developing the vaccines.

Geography

Data for this study was collected in Canada, and vaccine attitudes vary greatly among some countries. Therefore, any application of the insights reported here should make efforts to contextualize and validate these insights in a localized sample. This is particularly important given the following factors. First, Canada's publicly-funded universal healthcare system is likely to raise a distinct set of problems of access and affordability. Second, the relationship between citizens and the healthcare system, is different compared to countries such as the United States, and this is very likely to affect how free-of-charge vaccines such as the ones against COVID-19 are perceived,. In other words, free vaccines may be perceived differently in a place where healthcare is generally free compared to one where it is not. Third, Canada's multicultural society provides an interesting backdrop against which to assess institutional trust. As shown by past research, deficits in institutional trust are more common in particular communities. Therefore, our findings should be confirmed with closer studies of those communities, in a transparent and collaborative fashion, before they are directly applied to create messaging strategies that target vaccine uptake.

Reported Trust

While our instrument collects reported trust data about a number of different groups, we do not actually measure trust in any non-self-reported manner. While past research on trust has taken a similar approach, we recognize that self-report may not always translate into behavior. Therefore, those looking to apply this research to predict behaviors relying on trust should validate that the effects apply to those behaviors as well.

Future Directions

While our work shows the relationship between trust and various vaccine-related attitudes and behaviors, it does not characterize the entities to be trusted beyond *interpersonal* and *institutional*. Despite relatively high Cronbach's Alphas for each of these groups, it is unlikely that this is truly a binary distinction. Future work looking to expand on these insights should test whether more nuanced aspects of an institution (for example, feeling of connectedness to that institution, perceived transparency, perceived interconnectedness, etc.) might be better predictors of trust sensitivity than institutional status alone.

Furthermore, while we looked at the relationship between trust and measures of vaccine hesitancy, it is likely that a number of mediating variables exist between these two measures. Future work looking to understand how levels of institutional trust might relate to vaccine-related attitudes should look at possible psychological parameters that may mediate trust sensitivity, as understanding those could make this work generalizable to a large number of contexts.

Finally, in the context of past work on institutional trust and vaccine hesitancy [16], future work should endeavor to better understand how the findings gleaned from our study relate to individual communities. Deficits in institutional trust (and the vaccine hesitancy outcomes that follow) are more strongly felt in marginalized communities that have historical reasons for that mistrust. Therefore, efforts to understand how trust might be repaired is critical. Barring that, investigating how public health strategies can best circumvent institutions when targeting vaccine uptake in those communities is also important.

Conclusion

Interpersonal and institutional trust are distinct concepts [73]. Importantly, as we shift from one to the other, typical social cues (and the related body of scientific research) become less relevant and a different set of conditions must be met for trust to form [74].

We set out to find out whether institutional trust is distinctly related to attitudes and behaviors that the vaccine hesitant tend to exhibit - COVID-19 vaccine hesitancy, COVID-19 vaccine concerns, general vaccine hesitancy, COVID-19 conspiracy thinking and COVID-19 vaccination. The data presented in this paper shows that all of these outcome variables are more strongly related to institutional rather than interpersonal trust levels.

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General Thesis Discussion

The decision to vaccinate or not is a deeply personal one, shaped by a multitude of psychological, sociodemographic and historical factors. For this reason, vaccine hesitancy is highly complex and heterogeneous, manifesting differently across countries, ethnic groups, diseases, vaccines and time horizons. Yet, for all of its complexity, vaccine hesitancy is a remarkably useful construct, and gaining a better understanding of it allows us to generate more effective vaccination campaigns. In some cases, increasing vaccine uptake by a few percent might mean thousands of lives saved. In other cases, such as with a highly infectious vaccine-preventable pandemic with a high (e.g. 50%) mortality rate, a small additional uptake could save millions of lives. In such a case, a 70% vaccination rate, the approximate current baseline around the world, means the eradication of a significant portion of the world. Conversely, if in the coming decades we can increase uptake levels to 100%, then we could find the eradication of vaccine-preventable diseases limited only by the speed of development and efficacy of the vaccines themselves. And yet, while we may learn how to eradicate diseases such as smallpox over decades, it is unclear that we have the toolkit to increase vaccine uptake in the case of a highly deadly and fast moving pandemic. Building such a toolkit has been a low priority as pandemics are (fortunately) few and far between. However, the tragic circumstances of the COVID-19 pandemic provide just such an opportunity to learn how people might make vaccination decisions in a highly uncertain environment. This has allowed us to ask: what are the determinants of COVID-19 vaccine hesitancy and how can they help us better understand the high uncertainty vaccination decisions that happened during the COVID-19 pandemic?

Summary of Main Findings

The present thesis addresses this question at three different levels. In Chapter 1, I take a broad approach, starting with a survey of past models and frameworks used to explain the determinants of vaccine hesitancy prior to COVID-19. Using a thematic analysis of qualitative data gathered from focus groups during the pandemic, I found eight core themes and 25 sub-themes that were prevalent in the context of vaccine decisions. By using an inductive approach and a sample of Canadians that varies widely in their vaccine attitudes and behaviors, I was able to propose a novel taxonomy of vaccine hesitancy. When contrasting this taxonomy with past models and frameworks, I found that issues around autonomy and trust are far more prevalent, while issues around systems of care and logistics were less so. Given the urgency of the pandemic and the government's containment measures and vaccine mandates, these findings make sense.

In Chapter 2, I investigated the role of individual thinking styles on levels of vaccine hesitancy. In particular, I focused on the vaccine hesitancy continuum that has previously been proposed by the SAGE group of the WHO and is widely used to understand vaccine hesitancy attitudes. I asked: do cognitive styles linearly predict soft (unsure about the vaccine) and hard (sure about not wanting the vaccine) vaccine stances, or does each type of stance relate to a distinct profile? To answer this question, I analyzed survey data from 1541 Canadians gathered during the pandemic, investigating the relationship between eight categories of cognitive bias previously associated with health behaviors and levels of hesitancy. I found that in the case of two of these categories of bias – fear of missing out and recency effect – there is a significant difference between soft and hard hesitant individuals. Interestingly, I also found that in the case of fear of missing out, hard hesitant individuals more closely resembled their non-hesitant peers than those with soft vaccine hesitancy. These

findings suggest that, rather than being on a strict continuum, COVID-19 vaccine hesitancy attitudes are likely better thought of as clusters of beliefs associated with unique features.

Armed with a better understanding of the broad determinants of COVID-19 vaccine hesitancy and of the belief clusters that might form, I shifted the focus to another explanatory level: the role of trust in institutions. While previous research has shown strong associations between trust in various entities and vaccine hesitancy, I was interested in the extent to which interpersonal versus institutional trust would relate to five different measures of vaccine hesitancy. By analyzing data from a sample of 1541 Canadians, I found that while vaccine hesitant individuals do indeed tend to have overall levels of trust compared to their non-hesitant peers, this trust deficit is primarily driven by a lack of institutional trust. Furthermore, as opposed to the case of cognitive bias, which does not always linearly relate to levels of vaccine hesitancy, the data shows that lack of institutional trust is significantly higher in hard versus soft vaccine hesitant individuals. The findings suggest that vaccine hesitant individuals might, for lack of trust in institutions, be forced to rely on personally propagated belief systems that are more likely to be based on misinformation.

Key Themes and Implications

The present work adds to a significant body of literature on vaccine hesitancy as well as to a growing literature on vaccine hesitancy in the context of COVID-19. It still remains to be seen how these two literatures will be integrated. On the one hand, COVID-19 provided an opportunity to collect an unprecedented amount of data on vaccine hesitancy, giving rise to a number of insights that might be broadly applicable in other contexts. On the other hand, as I discussed at length in the introduction, vaccine hesitancy, as a construct, is highly context dependent, and a number of factors make COVID-19 vaccination a unique decision context that likely gives rise to a distinct range of vaccine hesitancy types. That being said, while these factors differentiate the COVID-19 pandemic from other contexts where vaccine hesitancy has been studied in the past, they may plausibly generalize to future vaccine-preventable pandemics. In the following section, I discuss key findings from the research presented in this thesis as they relate to existing narratives of vaccine hesitancy, future scenarios involving high-uncertainty vaccination decisions and public health responses.

Inductive Vaccine Hesitancy Models

The taxonomy proposed in Chapter 1 is generated using an inductive approach – i.e., in a bottom-up manner accomplished by analyzing transcripts of conversations about vaccines rather than in a top-down, survey-based, hypothesis-driven manner. This approach to constructing a model of vaccine hesitancy has distinct advantages which make it a good complement to top-down approaches. For one, deductive approaches can only be as thorough in their findings as the hypotheses they (or the third-party studies they survey) have formed. This means that the categories included in those models are likely biased by the hypotheses generated. While both top-down and bottom-up approaches have their merits, I believe that it

would be a benefit to future work on models of vaccine hesitancy to top-down approaches with a broader inductive approach based on observation.

Unique Frameworks for High Uncertainty Vaccination Decisions

In the introduction, I explored a wide array of factors that have made the COVID-19 pandemic a unique decision context with regard to vaccination: the emphasis on individual decision making as opposed to parental decisions; the intensity of containment measures; the significant and widespread role of conspiratorial beliefs; the novel technology and development timeline of the vaccines; the role of technology and social media in misinformation campaigns. I also explored research showing that vaccine hesitancy can express itself differently depending on a particular context. Given this unique constellation of factors, it stands to reason that vaccination decisions in the context of COVID-19 are different, as argued in Chapter 1. However, one critical implication of the findings, which remains to be tested, is that they may generalize to other situations which share those factors. In other words, future pandemics that warrant a fast and widespread adoption of a novel vaccine may elicit vaccine hesitancy attitudes that are not unlike those observed during the COVID-19 pandemic. The extent to which the findings might generalize to such a situation remains to be determined through empirical work, but the work presented here may serve as a useful starting point.

Institutional Trust as Key Driver

One of the key findings reported on in this thesis is that, while lower levels of trust are generally related to vaccine hesitancy, this relationship seems to be primarily driven by mistrust in institutions. Given the important role that institutions play in developing, promoting and administering the COVID-19 vaccine, understanding vaccine hesitancy in a high uncertainty decision environment may require a better understanding of the population's

relationship to institutions. For example, past research has shown that institutional trust is generally lower in minority groups [88], suggesting that interventions to increase vaccine uptake might need to take on a very different form in those communities in order to be effective [89]. Indeed, while dominant narratives within the vaccine hesitancy literature have focused on the role of misinformation or a lack of understanding on vaccine hesitancy, the role of erosion of trust toward institutions — sometimes for very legitimate reasons such as historical mistreatment or current marginalization — should not be underestimated.

Vaccine Hesitancy Clusters versus Continuum

While past research has described vaccine hesitancy as lying on a continuum, my research suggests that, in at least some ways, individuals with different levels of hesitancy are better described as being situated in clusters. In other words, those with “hard hesitancy” attitudes (i.e. completely reject vaccination) do not necessarily exhibit stronger versions of the attitudes present in “soft hesitant” individuals. This is important in the context of the design of public health messaging, especially as the target audience of that messaging shifts; for example, while a majority of the audience may be soft hesitant in the beginning, only the hard hesitant may remain vaccine hesitant later on.

Strengths of the Present Research

Multidisciplinary approach

Vaccine hesitancy is highly complex and heterogeneous. As a result, a number of competing narratives exist in the research literature on vaccine hesitancy. One strength of the research presented in this thesis is the multifaceted nature of the studies. For example, the idea that institutional trust is related to vaccine hesitancy is often seen, in the literature, as being at odds with ideas of personal bias driving hesitancy. By starting at a broad level and using an

inductive approach in Chapter 1, I was able to identify a number of factors related to COVID-19 vaccine hesitancy and then focus on factors (personal versus institutional explanatory levels) that, while found at a different level of explanation, are likely complementary.

Study Design

Another key strength of the research presented here is the study design. Firstly, the quantitative studies are based on a large Canadian sample size of 1541 participants. The same sample was used to recruit participants for participation in focus groups for the third study (Chapter 1). The large sample size representing communities across Canada, and the cohesive research program design, allowed us to generate findings that had a higher degree of internal reliability. For example, we can compare findings on trust in institutions to findings on cognitive bias and level of hesitancy because both are based on data collected at the same point in time from the same participants.

Study Timing

Another strength of this thesis is the focus on a single research program completed at an appropriate point in time. Pandemics are fortunately a rare occurrence. This means that there are few opportunities to study decision making in pandemic contexts. However, understanding how these types of decisions are made is critical - especially in the context of a potential future pandemic that is both vaccine-preventable and has a high infection and mortality rate. Given advancements in biotechnology, the confluence of these factors is not entirely unlikely - laboratory leaks may occur and vaccine development technology is likely to accelerate. Therefore, it is likely that if such a pandemic were to occur, the bottleneck would be vaccine hesitancy. Understanding how decisions are made in such contexts might make a tangible difference in improving vaccine uptake, especially in vulnerable

communities which have historically been shown to be more vaccine hesitant. By focusing on a point in time when vaccines were widely available but a large level of uncertainty was still present around COVID-19 and the novel vaccines, the study presents a rare opportunity to understand what might drive this kind of uptake in the future.

Limitations and Future Directions

Geography

Despite these strengths, the present work also has important limitations which may provide directions for future lines of inquiry. One major limitation across all three studies presented in this thesis is the geographical focus on Canada. Vaccine hesitancy varies significantly among countries in the extent to which it is present, the ways in which it expresses itself and in its determining factors. There are a number of considerations that are relevant to the Canadian context. Firstly, Canada has a publicly funded healthcare system which elicits different baseline attitudes toward healthcare services compared to other countries such as the United States. Secondly, Canada's multicultural population, including a significant portion of Indigenous communities, provides a unique sociodemographic context. Given that vaccine hesitancy, particularly in the context of institutional trust, is likely related to alienation and marginalization, it is possible that these communities represent unique attitudes which do not fully generalize to other places. Finally, vaccine hesitancy varies among communities as well. Given the limited sample size, I was not able to systematically compare findings across geographies and communities within Canada. Therefore, future research should look to confirm the extent to which the findings generalize to locations within Canada and to other countries.

Self-report Measures

Another important limitation of the work presented here is that a number of measures I use for trust and cognitive bias are self reported. While past research has taken a similar approach, it is important to recognize that this methodology is inherently weaker than one that uses an experimental measure. Therefore, future research should aim to validate these findings with more rigorous methods. This is especially important in the context of testing the viability of real-world interventions.

Study Timing

The studies presented here aim to provide a useful snapshot of vaccine hesitancy attitudes, beliefs and behaviors at an important point during the pandemic (April - May, 2021 for Chapters 2 and 3; September, 2021 for Chapter 1). Given that vaccines became widely available in Canada at the beginning of Summer 2021, this is an important moment which served as a decision point for many Canadians. However, it is important to recognize that Canada's vaccine rollout occurred in stages, with older individuals receiving the vaccine first. Therefore, older individuals in the sample were likely at later stages of their decision journey compared to their younger counterparts. Future work aiming to control for this should devise a strategy to understand where in the vaccination journey a particular individual is at the moment of study.

Empirical Evidence

One final limitation of the work presented in this thesis is that it does not provide any empirical evidence of the effectiveness of interventions tested using strategies derived from the data. Therefore, while I can hypothesize that the findings might translate into useful interventions, public health researchers should use an empirical approach to determine whether that is the case.

Conclusion

Vaccine hesitancy is remarkably complex. It is shaped by a history that is as long as that of vaccination itself and now sits at the intersection of psychological, sociocultural and structural issues. Nevertheless, just as humanity made great strides with the invention of vaccines, we must make progress in vaccine uptake. Pandemics with far higher mortality rates than that of COVID-19 are certainly possible. Therefore, there are plausible scenarios where the ability to guarantee widespread adoption of a vaccine could make an existential difference for humanity. The work presented here takes initial steps to understand the high uncertainty decision environment created by the COVID-19 pandemic. By combining several complementary approaches at different levels of analysis, this research also supports the view that future research aiming to understand vaccine hesitancy must be holistic to be effective.

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Appendix: Chapter 1

S1 Appendix: Definitions of themes identified in the qualitative data

1. Personal

- 1.1.** *Value-based:* This theme arises when individuals have different values or beliefs that may influence their vaccination decision. This could include religious or cultural beliefs, personal values, or ideological positions.
 - 1.1.1.** *Religion:* Respondents believe that getting COVID-19 vaccines may violate their religious regulations or beliefs.
 - 1.1.2.** *Culture:* Respondents' uncertainty about COVID-19 vaccines is triggered by a mix of broader cultural and attitudinal factors, including anti-authoritarian worldviews, conspiracy ideation, or an alignment with alternative/complementary or holistic health.
 - 1.1.3.** *Political Compass:* Respondents regard the COVID-19 vaccination campaign as highly politicized and question vaccines due to potential political ties.
 - 1.1.4.** *Ethical Consideration:* Respondents worry that they may crowd out prioritized populations' vaccine supply.
 - 1.1.5.** *Autonomy:* Individuals worry about having the freedom to make their own decisions regarding vaccination.
- 1.2.** *Trust-based:* This theme refers to a lack of trust in the institutions, individuals, or processes involved in the development, approval, and distribution of the vaccines. This could include mistrust of the pharmaceutical industry, healthcare providers, or government officials.

- 1.2.1. Trust in the medical profession:* Respondents regard medical doctors as unreliable information sources for making vaccination decisions.
- 1.2.2. Trust in the medical caretaker:* Respondents regard medical caretakers (e.g., a nurse) as unreliable sources of information for making vaccination decisions.
- 1.2.3. Trust in Government:* Respondents' trust level in government alters their decision to vaccinate according to governmental recommendations or responses.
- 1.2.4. Trust in Pharmaceutical Companies:* Respondents mistrust pharmaceutical companies or manufacturers.
- 1.2.5. Trust in Science:* Respondents believe that scientists are biased and that the scientific method is just a veil for pushing a political agenda.
- 1.2.6. Trust in Media:* Respondents are unsure which media provide reliable information on COVID-19.
- 1.3. Social: This theme arises from the influence of others, including friends, family, or community members. This could include social pressure to avoid vaccination, or the influence of misinformation or conspiracy theories shared by others.*
 - 1.3.1. Pressure from Close Community:* Attitudes of respondents' close social circle impact their view on COVID-19 vaccines. The close social circle includes friends and family, with whom respondents have a close relationship.
 - 1.3.2. Pressure for Broad Community:* Attitudes of respondents' broad community impact their view on COVID-19 vaccines. “Community”

refers to people respondents may not know in person or have close relationships with but with whom they share identities.

1.3.3. *Pressure from Society:* Respondents feel that unvaccinated populations are discriminated against and stigmatized as selfish or “anti-vax.”

1.4. *Anecdotal:* This theme refers to personal experiences or anecdotes that may have influenced attitudes toward vaccination. This could include negative experiences with vaccines in the past, or anecdotes shared by others about their experiences with vaccines.

1.4.1. *Personal Experience:* Respondents' uncertainty is triggered by their bad experiences with vaccines in the past.

1.4.2. *Experience of close others with vaccines:* Respondents' uncertainty is triggered by bad experience of close others with vaccines.

1.4.3. *Hearsay:* Extensive anecdotes around COVID-19 vaccination circulating on social media that trigger respondents' uncertainty on vaccines.

2. Scientific

2.1. *Risk-based:* This theme relates to perceptions of risk associated with getting vaccinated. This could include concerns about the potential side effects of the vaccines, or fear of contracting COVID-19 from the vaccine itself.

2.1.1. *Short-term side effects:* Respondents are concerned about short-term side-effects (e.g., pain in the arm, headache, etc.).

2.1.2. *Long-term side effects:* Respondents are concerned that the COVID-19 vaccines are untested and could cause unknown side effects in the long term.

- 2.1.3.** *Risk of serious symptoms or death due to COVID-19:* Respondents worry about the possibility of severe illness or death caused by COVID-19.
- 2.2.** *Knowledge-based: This theme refers to a lack of knowledge or understanding about the safety, effectiveness, or other aspects of the vaccines. This could include uncertainty about the scientific evidence supporting the vaccines, or confusion about how the vaccines work.*
- 2.2.1.** *Effectiveness of vaccine:* Respondents are unsure about the effectiveness of the COVID-19 vaccine in preventing COVID-19 infection or reducing symptom severity.
- 2.2.2.** *Understanding of vaccine function:* Respondents misunderstand the mechanism of action of COVID-19 vaccines.
- 2.2.3.** *Belief that natural immunity is better:* Respondents prefer to rely on natural immunity rather than artificial interventions, like vaccination, in preventing COVID-19.
- 2.2.4.** *Belief in alternative medicine:* Respondents take alternative medicine as a substitute for vaccination.
- 2.2.5.** *Information Overload:* Respondents are exposed to mixed or inconsistent messages asserting positive and negative views of COVID-19 vaccines, which cause confusion about which information is correct and which information sources are reliable.
- 2.3.** *Environment: This theme reflects the probabilistic nature of the world, the imperfection of measurements, etc.*

- 2.3.1. *Possible evolution of the vaccine:* Respondents worry about the evolution of the vaccine (e.g., that it will be a monthly forced vaccination).
- 2.3.2. *Flawed measurement of the vaccine:* Respondents worry that the methods to measure the effectiveness of the vaccine are flawed.
- 2.3.3. *Possible evolution of the disease:* Respondents worry that the evolution of COVID-19 will reduce the relevance and effectiveness of the vaccine.
- 2.3.4. *Flawed measurement of the disease:* Respondents worry that the detection strategies for COVID-19 do not work as designed.

3. Practical

- 3.1. *System of Care:* This theme relates to the processes or systems in place for administering the vaccines. This could include concerns about access to the vaccines, difficulties in scheduling appointments, or confusion about the vaccination process.
 - 3.1.1. *Concern about booking:* Respondents are concerned about friction during the process of booking COVID-19 vaccines.
 - 3.1.2. *Vaccine supply:* Respondents have not received the vaccine due to limited vaccine supply.
 - 3.1.3. *Being out of commission:* Respondents worry that vaccine side effects will make them unable to meet the responsibilities.
 - 3.1.4. *Loss of access to public services:* Respondents worry that not being vaccinated may cause them to lose access to certain public services.
 - 3.1.5. *Time cost:* Respondents worry about the time required (for example, away from work) to get vaccinated.

- 3.1.6.** *Vaccine cost:* Respondents worry that they cannot afford the COVID-19 vaccine.
- 3.1.7.** *Transportation cost:* Respondents worry that they need to pay extra fees to get vaccinated (i.e., transportation cost).

S2 Appendix: Results of MaxQDA Analysis

Personal

We found that despite being exposed to similar information and changing circumstances, participants made different choices based on a variety of factors, including their level of trust in different information sources, the influence of their social circles, and their own values and beliefs.

Value-based

For most participants, the decision to vaccinate or not is related to a number of broader cultural and attitudinal factors. For example, Lorry and Elise observed the highly politicized trend of COVID-19 vaccine campaigns. According to Elise, “just in Alberta, it’s become very politicized... because of support and losing the future election is on the line.” Lorry also commented that “COVID vaccines are now up there with religion and politics for things you don't want to talk about with people that you don't really know.” While none of the participants took vaccination decisions as strong indicators of individuals’ political positions, we found that participants’ distrust of politicians affected their decisions. Janet’s trust in potential serve outcomes of COVID-19 collapsed once she found “political gains” and “financial ties” between medical professionals and big foundations.

we've heard about the restaurants [banning vaccinated individuals], but are they going to start allowing... children to go to school without that vaccine or because they have religious or political affili... it as opposed to someone who's just medically has a problem with it? So... what's going to happen? Are the schools going to be allowed to say, sorry, little Timmy can't come to school if you don't vaccinate him. (Patrick, 53-year-old, vaccinated)

In addition to political ideologies, participants also linked their vaccination decisions to the freedom of an individual to make their own choices. Five unvaccinated participants (Eleanor, Ethan, Molly, Charles, and Janet) discussed feeling forced or experiencing limited autonomy because of vaccination campaigns that included pro-vaccine messages and vaccine passports, causing resistance toward vaccination. Ethan and Molly expressed dissatisfaction with the idea of a vaccine passport, stating that such restrictions would make him less likely to get vaccinated.

But... how they were restricting... access to certain things, and... if we don't have the vaccine... which I really didn't like... for me that... makes me... less likely to get the vaccine, because... it's not really acceptable to me. (Ethan, 26-year-old, unvaccinated)

The vaccine passport, that is something that concerns me more than motivates me. I can go without going to a restaurant, it's not going to break me. I can...handle that, if i'm not comfortable with it, giving me ultimatums... maybe it's my stubborn side, maybe it's my Dutch side, but it's going to make me push back... it just feels too forced, and for that reason I stand by my "I need more time and I need to make a decision that's best for me and that i'm comfortable with and have the freedom to choose. (Molly, 26-year-old, unvaccinated)

Words like “condescending”, “passive-aggressive”, and “pushy and exclusive” were frequently used by participants when discussing messages about COVID-19 vaccines, which evoked feelings of exclusion and stigmatization. Janet felt as if she was being "exterminated" from society for not getting vaccinated. "When you press people, it's going to make them

push back 10 times as hard," she stated. Such a sentiment was shared by Molly, who discussed how her attitudes toward vaccines were shifted by pro-vaccine messages from the government and social media.

From the start, I was ... pro-vaccine. But ... it was actually when it became such a push [and] ... I started to feel like I didn't have a choice or I was going to be penalized [for not being vaccinated that I became more hesitant] ... I feel like they're trying to be neutral, ... but I do find that it's fairly ... passive aggressive ... The message that comes across is: 'don't be selfish, vaccinate to save others.' Or 'vaccinate to save yourself' ... I don't like that ... It's a message like I was cornered, ... not feeling like I have a choice ... that honestly makes me push back against [getting vaccinated] ... I just don't feel like I can make a decision that's best for me. And I'm not trying to be selfish, and that's where I get frustrated with ... the media messages ... I want to make the best decision for me, and I don't think I'm being selfish by choosing, at this point, not to get the vaccine. (Molly, 26-year-old, unvaccinated)

Nine participants voiced out that people "should be taken on [their] free will [to make vaccination decisions]," and "it's everyone's choice what they feel is best for them." Esther, who had already been vaccinated, stated that "it's everybody's decision, whether they want to get [vaccinated] or not...[she wishes] everybody would. It might bring cases down more, less death, less sick people. But it's up to everybody." William called for accepting people for who they are and their decision to vaccinate or not. "It's your decision...we should accept people for who they are [and] embrace that."

Trust-based

Throughout the focus group discussions, participants expressed varied views on the trustworthiness of medical professionals, health providers, the pharmaceutical industry, and government officials in the development, approval, and distribution of COVID-19 vaccines. Trust toward these entities influenced the information sources they seemed to rely on.

Participants who were vaccinated or intended to get vaccines in the future cited medical professionals such as Dr. Anthony Fauci as trustworthy sources of COVID-related information. For example, Billy, who was not vaccinated yet but planned to receive one eventually, took Dr. Fauci's suggestions as "the gold standard" during his decision-making process.

Dr. Fauci is basically the gold standard for you know scientists who know, and so I pretty much relied on him... Dr. Fauci and the experts that go on TV. They've also clarified the side effects (Billy, 64-year-old, unvaccinated)

Elise also expressed her preference for having medical experts deliver COVID press releases.

I have a lot of friends who work for Alberta Health Services, so mostly i've been trying to get more information from them, as well as doctors and government websites... I would like if we had more medical experts, or at least working infectious disease experts, to be the ones doing the COVID press releases right now. (Elise, 28-year-old, vaccinated)

Not everyone shared the same confidence in medical professionals. Patrick found conflicting views from medical professionals, prompting him to turn to independent news companies that compared different sources of information to ensure the reliability of the COVID-related information he received.

I listen to different health sites and all that, but I started finding a lot of conflict in what they were saying, including Dr. Fauci... He was one day he was saying it wasn't caused in the lab, you know... the official sites weren't giving the right news. So I actually started turning to alternative news, independent news companies and found that... they would compare notes from all the different sources. And then through a company called News Guard, they would be able to distinguish what was real and what was [not real]... it gave me a little bit of a better understanding rather than only taking it from one source. (Brooke, 53-year-old, vaccinated)

Trust in medical professionals also made some participants more susceptible to misinformation and fake news. For instance, William cited a statement made by Dr. Michael Eaton in an interview with Life Site News as “proof” of COVID-19 safety and noted that “we are dealing with a conspiracy which is beyond the carnage.”

from April 7 2021, Life Site News, Dr. Michael Eaton, Pfizer's former Vice President chief scientist for allergy and respiratory, who spent 32 years in the industry leading new medicines research and retired from the pharma-school giants with the most senior research position in his field, spoke with Life Site News on an interview. He addressed the demonstratively false propaganda from governments in response to COVID 19, including the lie quote of dangerous variants, the totalitarian potential for

vaccine passports and the strong possibility we are dealing with a conspiracy which is beyond the carnage. (William, 44-year-old, unvaccinated)

When it comes to pharmaceutical companies, the landscape was completely different. Janet voiced out that there is insufficient liability for vaccine manufacturers, which she argued should be in place to encourage safer vaccine development.

I don't think that there's enough liability for - well there's no liability for the manufacturers, right now, and I think there needs to be, because I think that if there was it would push them to be safer. Because when you're being liable for the lawsuits instead of the tax payers, then you're kind of pushed to make them as safe as they could possibly be, regardless of an extra 10 cents a cost provide... I think that they're [vaccines] a good concept, a good design, but they're not being pushed to be as safe as they could be because the manufacturers aren't being held liable, not in Canada, not in the States. (Janet, 26-year-old, unvaccinated)

Participants' medical caretakers played a key role in their vaccination decisions.

Unvaccinated participants such as Melanie chose not to vaccinate based on the recommendations of specialists. After speaking with two oncologists, Melanie and her doctors agreed that while she was at high risk of contracting COVID, she faced an even higher risk of getting sick or worse from the vaccine due to her medical conditions. Consequently, she decided not to get vaccinated, opting to follow the advice of her oncologists over her family doctor.

With the talk that I've had with two oncologists, we just agreed that I'm a high risk of getting COVID, but I'm a higher risk of getting sick or worse from the shots, so [I decided to not get vaccinated]... My family doctor said it would be okay, it would be safe. My two oncologists said no don't because of the chance of a blood clot, so I went with the odds of the two oncologists agreeing because they're more involved in my health issue than the family doctor. (Melanie, 52-year-old, unvaccinated)

Medical caretakers' opinions also contributed to the uncertainty in Brooke's decision about getting vaccinated. Her doctor informed her that, given her health conditions, she could experience a severe reaction to the vaccine. This information left her unsure about whether to proceed with vaccination.

my doctor alone told me with my conditions that there's a chance that I would have a bad reaction to the shot. My doctor wasn't even 100% sure on what of side effect would happen to me because of having a certain arthritises I have and scoliosis and my lungs being filled with liquid already, he wasn't sure what would have happened if I took the shot, muscle or anything wise, so he said, you can take it. But there, you will have a bad reaction, so that kind of put me on the fence. (Brooke, 36-year-old, unvaccinated)

In contrast, some vaccinated participants made their decision to get vaccinated based on their medical caretakers' recommendations, even if they were initially hesitant. For instance, Esther mentioned that the Arthritis Society played a crucial role in her decision to get vaccinated. Their outreach and encouragement to get the vaccine for her safety convinced her to proceed.

I didn't feel I had enough [information to make vaccination decisions]... I got arthritis, severe osteoarthritis, so I had the Arthritis Society, I've signed up to them and they've been sending me emails about messages... because I wasn't sure if I was going to get the vaccine or not, but they recommended me getting it... because they, [the Arthritis Society] said because I have osteoarthritis, I've had two knee replacements in nine years. They're like, You should get the vaccine for safety, for your safety and well-being. So I got it.

Similarly, Joy, a 49-year-old woman who was initially hesitant to get vaccinated, changed her mind after her pharmacist reassured her that her risk of side effects was manageable.

I heard that people were dying getting the shot, after they got the shot that they were dying. So I was quite scared to get it... I've had allergies and like anaphylactic to stuff before, so I was really worried about getting it, because in the beginning they said anyone with anaphylactic couldn't get the shot. So when [my pharmacist] talked to me about it and he said, it's OK now, they did studies, and you should be OK. So I finally did it. (Joy, 49-year-old, vaccinated)

During the focus group discussions, we observed that participants generally showed trust towards medical professionals and caretakers. However, it became apparent that suggestions from medical caretakers carried more weight and had a greater influence on the participants' attitudes and decisions. This could be attributed to the perception that medical caretakers possessed a deeper understanding of their individual medical condition and were therefore better suited to make decisions in their best interests.

Nevertheless, trust towards medical professionals and caretakers can be undermined when there is a perceived political or financial conflict of interest. For example, Janet shared how her attitude changed after discovering financial ties between the Gates Foundation and Neil Ferguson from the Imperial College of London: “for the first two or three weeks, I mean, I was very serious about it... and I find out Bill Gates funded those too. So it’s just like, how can you trust, you know when there’s all of these financial ties, political gains.” Later, she expressed concern about censorship from the government to doctors “that have spoken out” and were “sharing valid things.”

So those kinds of things just are raising major red flags for me, and I feel like from the doctors that have spoken out, Dr. Byron Biddle, Dr. Christina Parks, Dr. Sunetra Gupta... they're... sharing valid things and they're being censored [from government], and that should raise red flags for everybody. (Janet, 26-year-old, unvaccinated)

Janet was not the only participant who became hesitant when they perceived political intervention.

I think science in general is what I trust, but who I don't trust is politicians For instance, Toronto has a great medical health doctor... they're being allowed to give us great information, but the politicians are trying to spin it. That's where I have a problem with it. (Brooke, 53-year-old, vaccinated)

Other participants questioned politicization trends around COVID-19. Elise expressed her concern that “it's become very politicized- a lot of stuff is being done right now, because of

support and losing the future election is on the line.” and stated that she would like “more medical experts, or at least working infectious disease experts, to be the ones doing the COVID press releases right now.”

specifically my issue is just related to our provincial government, I would like if we had more medical experts, or at least working infectious disease experts, to be the ones doing the COVID press releases right now. Just in Alberta, it's become very politicized... because of support and losing the future election is on the line. (Elise, 28-year-old, vaccinated)

Other participants maintained their faith in the government. Six participants cited governmental websites like Health Canada as one of their main information sources. And two participants cited approval from Food and Drug Administration (FDA) as supporting evidence during their decision-making process. But the impact of FDA approval is limited. Billy stated that FDA approval did not “help in at all fears” of COVID-19 vaccines’ side effects. Molly expressed her “wanting an FDA approval” of COVID-19 vaccines but her story about chicken pox vaccines implied that FDA approval did not determine whether or not she trusts vaccines.

The vaccines [my kids] have had gone through the normal FDA approval before I would allow them to have it. But that being said, I struggled with say giving the chickenpox vaccine. And part of the reason of that, and I did end up giving it to to my son and my daughter, because I looked into it and I found that the risk of side effects were so small, and it had been FDA approved, and I looked into that. But the main

reason I was hesitant on giving it to them or having them get it... was because chicken pox isn't a deadly disease. (Molly, 26-year-old, unvaccinated)

In addition to governmental information sources, participants use traditional media such as CTV, CBC and CNN, search engines like Google and Yahoo, and social media platforms like Facebook and Twitter. Both vaccinated and unvaccinated participants were exposed to multiple information sources. Nevertheless, vaccinated participants (Julie, Clara, and Lorry) seemed to place higher trust in governmental or mainstream media sources, such as CTV and Health Canada, while unvaccinated participants (Eleanor, Ethan, Molly in group C) appeared to place greater trust in social media platforms. This contrast becomes more apparent when considering comments from Lorry, a 30-year-old vaccinated participant, and Molly, a 26-year-old unvaccinated participant:

So I get the majority of my news from CBC and different other like local news, CTV... and then my doctor sends out like newsletters with COVID updates, usually once a month, and then I as well follow City of Ottawa, puts out a lot of sort of information through social media even Instagram. So I follow all those news sources that I rely on for reputable information and... I see a lot on social media and a lot through word of mouth and through friends, but... I take that with a grain of salt, I don't really believe much of what I see on Twitter, so my main news sources would be CBC, CTV usually. (Lorry, 30-year-old, vaccinated)

I... would say Facebook. I spend a lot of time kind of scrolling, which I don't like... the news sources just pop up. Now that being said, they still are... reputable sources such as... CNN and CBC, CTV. Putting out articles that other people have shared, but

I don't particularly like reach out and look for information and it's kind of what pops up. (Molly, 26-year-old, unvaccinated)

The level of consistency in released information may contribute to their different vaccination choices. While information overload added uncertainty for both vaccinated and unvaccinated participants, unvaccinated participants, who considered social media as their main information source, faced a more inconsistent and diverse range of information.

There's a lot of mixed messages on social media that I've seen... but you don't really know... if it's credible, like you always have that wonder like is it right, is it not right... it plants the seed of doubt... I have read and absorbed and heard a lot of [horrible stories about getting vaccinated] so like I said it plants the seed of doubt in there, like it makes you wonder... Cause some of those things might actually be real. (Eleanor, 43-year-old, unvaccinated)

Social

Social uncertainty — arising from the influence of friends, family, or community members — emerged as a key theme. Pressure from participants' close community, such as friends and family members, directly affected participants' perceptions of COVID-19 vaccines. Julie, Joy and Brianna made clear statements that they trust their families' opinions the most on COVID-related issues.

Close community pressure seemed to have a significant impact on participants' vaccination decisions, even in cases where participants did not explicitly state it. Among vaccinated participants, we heard a number of stories about how close social circles encouraged them to

get vaccinated or how they themselves encouraged others to get vaccinated. When asked how their social circle reacted to her decision to get vaccinated, Esther mentioned that her parents “were happy” about it. She later shared her experience persuading her oldest daughter to get vaccinated, citing the potential exposure to COVID-19 due to their jobs.

she refused to get vaccinated, but I said to her, look, I said, your father and I both work where we are in contact with people 24/7, because I work at a fast food restaurant, my husband works at a lumberyard, he's a truck driver. And I said, we don't know if we're if we're going to end up coming in contact with someone that's not vaccinated, that has it. So she finally got vaccinated. (Esther, 60-year-old, vaccinated)

Patrick took a different approach when persuading his nephew to get vaccinated, highlighting the benefits of being vaccinated for travel purposes.

I actually had my nephew say he was worried about the vaccine and all that, and the way that we finally convince him to get it is because he loves to travel, he was supposed to go to Finland sometime this winter and it's like, hey, you can't go if you're not vaccinated. And so then he went and got vaccinated. (My sister had , 53-year-old, vaccinated)

Some participants felt pressure from their close communities, not necessarily due to explicit attitudes, but rather due to their desire to protect loved ones. For example, Clara said: “I was scared of my daughter and my family because my dad has a bad like breathing problems, so like I was scared of she’s going to get it or, you know, because it wipes out family sometimes.” Esther shared a similar feeling of “being scared to get it [COVID-19]” because

“it’s not much [about] me, it’s the fact that if I get it, I can’t see my dad for a while because of him being ill.”

Unvaccinated participants responded quite differently. Their close friend circles remained neutral or shared hesitancy about vaccination. Ethan noted that he received different opinions from his friends.

Some... really didn't have much of an opinion, some didn't care, some of them were like the same like me... they weren't planning to get the vaccine... some of my other friends were... encouraging me to get it, and other ones... were... really pushing me to to get it... a lot of different opinions.(Ethan, 26-year-old, unvaccinated)

Molly, on the other hand, found her support from her close friend circles, which also shared her hesitancy towards getting vaccinated.

I have a friend, a circle of friends that are hesitant about the vaccine. And we're all coming from the same place of if you feel comfortable getting vaccinated, please do, do what you feel comfortable with, but please respect our decision not to at this time.
(Molly, 26-year-old, unvaccinated)

In some cases, the pressure to get vaccinated may come from wider communities that participants are part of. Molly mentioned that her father felt “excluded” and left “out of everything” because “he’s not vaccinated”.

he can't get vaccinated and he's feeling like... completely out of every thing now because he's not vaccinated... it's like horrible because he's lived here for seventy-six years. And he said now he doesn't feel like he belongs at all like the government's totally made him feel like he's a nobody, he said... it's not like necessary to me because and it's not like... he's against vaccines. He gets the flu shot, he gets every other vaccine except for this one. (Molly, 26-year-old, unvaccinated)

Molly was not the only one who noted this kind of exclusionary experience. Six participants shared that unvaccinated individuals are discriminated against and stigmatized by society, being labeled as “selfish” or “anti-vaxxers.” Patrick said: “They’re all getting labeled as Karens because... of the old anti-vaxxer thing.” Similarly, Brianna observed that “I haven't really heard anything about people not getting it and other people saying things about them, except for the self-being selfish or something like that.” Julie, Brianna, Molly, Esther, Ethan, and Janet stated that it is “unfair” to label unvaccinated individuals as “selfish ” as “it’s an own personal choice” and people “should take on their own free will.”

Participants reported that social pressure is often reinforced by targeted COVID-19 vaccine campaigns that contain messaging such as “don't be selfish, vaccinate to save others.”

Unvaccinated participants further explained that the messaging made them feel shamed and separated them socially and morally from the unvaccinated population. As Janet, a 26-year-old unvaccinated participant stated, the messaging implies that “[The messaging] implied [that] ... you’re not a good person...you’re not protecting your family, maybe you even want them dead [if you choose not to get vaccinated]...it’s not ‘we’re in this together’ messaging.” Eleanor, another unvaccinated participant, shared that “I find the ads are not only pushing it but they're making people who don't choose it feel like they're outcasts and

there are people who have had a lot of bad backwash from that i've heard of people actually being bullied because they don't get it.”

The feelings of exclusion could be exacerbated by the concept of the vaccine passport. Participants expressed concerns that unvaccinated individuals may be banned from restaurants, events, or even school, leading to feelings of isolation and alienation. Ethan shared his experience of being rejected by a barbecue group because he was not vaccinated. Molly commented that the vaccine passport “concerns me more than it motivates me.” Patrick viewed the idea of banning unvaccinated individuals from restaurants or travel as a “sort of totalitarian thing” and questioned: “Are they going to start allowing... children to go to school without that vaccine or because they have religious or political affiliations... it as opposed to someone who's just medically has a problem with it?”

Anecdotal

We found that participants' personal experiences with COVID-19 vaccines or the virus itself could greatly influence their vaccination decisions. For instance, Joy, a participant in our research, experienced uncertainty about COVID-19 vaccines due to her negative reaction to the Moderna vaccine. She felt unwell for two months after receiving her second dose, which led her to question the efficacy of COVID-19 vaccines compared to other vaccines, at least for her personally.

I never had any reactions, and after I got my two shots of Moderna, I've been like so sick. And it's been like two months since I had my second shot, and I'm still feeling horrible. So for that reason, I don't really think they're as good as the other vaccines, at least for me personally. (Joy, 49-year-old, vaccinated)

On the other hand, Brianna's experience with negative effects resulting from COVID-19 drove her to get vaccinated. She mentioned that she still deals with lingering side effects, such as the loss of smell and taste, which she found to be a terrible ordeal. Brianna's experience with the virus and its lasting impact convinced her of the importance of getting vaccinated to prevent further complications.

I have more side effects that I'm still dealing with from having COVID-19... that was like crazy. And I still find that at different times that I can't smell or I can't taste... Because it was a terrible... thing. And if people only knew how terrible it is, and then there's still the lasting effects from it, too. That's what - that's what got me [vaccinated]. (Brianna, 63-year-old, vaccinated)

Among unvaccinated participants, stories about negative experiences of having extreme side effects of COVID-19 vaccines were prevalent. Janet shared her friend's experience of having a collapsed lung and being temporarily paralyzed after getting vaccinated. "Very serious injuries...not just minor injuries" she emphasized, "that scares [her], especially in the younger population where COVID doesn't really affect too much."

because I know people with injuries to the AstraZeneca and the Pfizer vaccine. Very serious injuries, as I stated before, not just minor injuries. Not life threatening either, but I would still consider a collapsed lung pretty serious and the temporary paralysis of the other boy happened on the road, so you know he could have been in a very serious car accident, he had to use his chin to pull himself over because he lost feeling

from the neck down. So that scares me, especially in the younger population... where COVID doesn't really affect too much. (Janet, 26-year-old, unvaccinated)

Similarly, Molly and Patrick heard stories from their families and neighbors about adverse side effects from the vaccines, which contributed to their uncertainty.

My sister had terrible side effects, vomiting for two days just you know where she needed somebody to come and take care of her and that was really worrisome. (Molly, 26-year-old, unvaccinated)

I actually had a neighbor who he did, he had the Pfizer vaccine, and he had really bad side effects for a day or two after, and you know it made me kind of pause. (Brooke, 53-year-old, vaccinated)

Clara was also hesitant about vaccination after her friend contracted COVID-19 despite being vaccinated.

I was... iffy about it, because my one friend, he got... the needle. And then he still got COVID. So like, I didn't know, maybe he got COVID from... the shot. (Clara, 26-year-old, vaccinated)

On the other hand, Ethan, who remains unvaccinated, mentioned that his mother and friends experienced no side effects after vaccination, which may contribute to his intention to get vaccinated in the future.

I had like like my mother, for example, and another... friend and they had the vaccine and they both said that they didn't have any like side effects (Ethan, 26-year-old, unvaccinated) ,

The influence of the word-of-mouth, even from unknown individuals, shaped participants' attitudes towards COVID-19 vaccines. Our conversations with Patrick gave us insights into how participants' attitudes change when they are exposed to different anecdotes. In the focus group, Patrick initially shared his experience talking with “one of the guinea pigs”, who “tried seven different vaccines ... And... had no side effects to any of them.” This experience made him more certain about vaccine safety, as he noted: “there's got to be some safety there.” He ended up getting Moderna shots, however, he later mentioned that his neighbor's severe adverse reactions to a Pfizer vaccine made him pause during the decision-making process.

Anti-vaccination campaigns, on social media like Facebook and Twitter, also affected participants. Participants in Group A reported that they found more “horror stories” than “good information about the vaccine” on social media. Lorry from Group C added that “the people who are the loudest on social media tend to be the people who are really against the vaccine and want everybody to know it on [her] Facebook.” Even though she “[doesn't] want to get into those types of conversations”, she had “notched [them] down in [her] confidence levels [because she had been] ... seeing so many anti-vaxxers ... [on] Facebook ... [that] sort of accidentally [had] gotten into [her] head a little bit.” Participants like Eleanor acknowledged the lack of credibility of some stories posted on social media but admitted that “[those horror stories about vaccines plant] the seed of doubt in [his mind]... cause some of those things might actually be real.”

Scientific

Scientific uncertainty was another category of themes that was prevalent in our focus group discussions.

Environment

Participants expressed a pervasive sense of uncertainty about COVID-19 and COVID-19 vaccines. Many of their concerns were driven by the unpredictable nature of the disease and its potential evolution which left some feeling uneasy even if they had been vaccinated. Elise and Patrick, for instance, shared concerns about new variants and the potential for more contagious strains to emerge:

"Now... we have this fourth variant, or this one new variant it's mutating, and that's...really scary... and they're saying that this new variant is more contagious but less harmful... that doesn't give me comfort." (Patrick, 53-year-old, unvaccinated)

"I'm worried about how big COVID's going to get with the new variants; I'm worried about our society as a whole right now." (Elise, 28-year-old, vaccinated)

Some participants expressed skepticism and doubt about the true nature of COVID-19, suggesting the possibility of flawed measurement or flawed understanding of the disease by experts. Molly, for example, questioned why COVID-19 is considered more important than other viruses:

"For this virus to be so important over others... it does make me concerned... why the government needs to have control over this situation." (Molly, 26-year-old, unvaccinated)

Others noted conspiracy theories around the non-existence or exaggerated impact of COVID-19. Julie shared her brother's view on COVID-19:

"It's with my brother because he doesn't want to get [the vaccine]... he thinks it's a conspiracy, and... it's like the flu." (Julie, 58-year-old, vaccinated)

Such conspiracy theories were prevalent during the pandemic, as Patrick, Billy, Brianna, and Lorry shared their experiences of being exposed to such information. Lorry, for example, shared that she had "notched [them] down in [her] confidence levels [because she had been] ... seeing so many anti-vaxxers ... [on] Facebook ... [that] sort of accidentally [had] gotten into [her] head a little bit." Brianna shared a similar feeling, saying that she knows "it's an unknown thing" but that "no one really had this before...it was uncertain."

As our conversations continued, we found that uncertainty regarding the probabilistic nature of the disease extended to perceptions around COVID-19 vaccines. The changing nature of the vaccination development process and rollout plan triggered inconclusive arguments and questions around the effectiveness and side effects of vaccines. Some participants attributed the ambiguity to the relatively short research and development period. Six participants (Janet, Melanie, Eleanor, Brooke, Ethan, and Patrick) explicitly stated that they believe the vaccines had not been adequately tested before being rolled out. When asked about an acceptable trial period, participants expected "a couple of years," allowing time to test the vaccine on a diverse range of individuals with different conditions.

Interviewer: Anyone that mentioned the trial period is there, you know, there was there were some comments it wasn't tested long enough. what what comprises long enough, like what would be long enough?

Eleanor: I'd say at least a couple years or more, you know there wasn't even that. A few years. (Eleanor, 43-year-old, unvaccinated)

Melanie: I agree at least a couple years, because then at least they'd have had a chance to test it on a variety of different people with different conditions. (Melanie, 52-year-old, unvaccinated)

The prospect of regular booster shots further fueled skepticism. Brooke (unvaccinated) and Joy (vaccinated) both pointed out the ongoing booster campaign makes people more doubtful about its effectiveness. Brooke stated “keep bringing out new ones” is “the only reason” why she doesn’t trust COVID-19 vaccines. She questioned, “How reliable are the actual vaccines if we have to keep getting vaccinated every five months?”

The other reason I don't trust them is they have to keep bringing out new ones, and I've heard and read and talked to other people that they're talking about even after taking the third dose, that five to six months later you're gonna have to take another dose... How reliable is the actual vaccine, if we have to keep getting vaccinated every five months? (Brooke, 36-year-old, unvaccinated)

I think that maybe if they did some more studies on it and more information about the results... it was kind of more rushed, and I understand it's a pandemic and they had to rush, but if they maybe waited a bit longer instead of... started so soon, because even now they're saying now we need a third shot. And then people are saying we're going

to need a shot every year. I just think... all these things are making people more doubtful about getting the vaccine and more hesitant. (Joy, 49-year-old, vaccinated)

During our conversations, we also discovered that participants were worried about the possibility of inaccurate assessment of the vaccine due to the relatively short research and development period. Although not explicitly stated, participants expressed uncertainty and concern that potential adverse consequences of vaccination had not been thoroughly tested.

Well, if one is saying that there's a chance of getting a blood clot. Well, how can they say that the other two are going to be okay from – are going to be okay and you're going to be okay from it, when they haven't been properly tested. (Melanie, 52-year-old, unvaccinated)

Yeah I agree it's like pushed out so fast and it's like okay, good luck with that, no we don't know a lot about it but good luck. (Heather, 68-year-old, unvaccinated)

I was... thinking that usually most vaccines or anything...cures for cancer or whatever, take a long time before you find out if they're safe or not. (Brianna, 63-year-old, vaccinated)

In focus groups, participants seemed to grapple with the question, "Is there anything else about COVID-19 that we don't yet know?"

Knowledge-based

The changing nature of the disease and its vaccines led to ambiguity and confusion in COVID-related knowledge. One common confusion was around the effectiveness of vaccines. Both Eleanor and Brooke expressed concerns regarding the vaccines' ability to prevent infection and the potential for increased side effects with each booster shot. Eleanor shared her confusion around the effectiveness of vaccines:

I was wondering a lot well how effective, is it... does risk for certain side effects go up every time you get a booster you know... questions led to more questions, I just found that there wasn't enough clarity to it. (Eleanor, 43-year-old, unvaccinated)

Brooke raised concerns about the apparent contradiction between the vaccines' purported safety and the ongoing precautions taken by vaccinated individuals:

Actually, that makes a good point, everyone that's double vaccinated, makes it kind of confusing when the people who aren't vaccinated still need to wear masks and social distance. If the vaccine was so safe, why is everyone double vaccinated still wearing masks? (Brooke, 36-year-old, unvaccinated)

More participants were uncertain about vaccines' efficacy in preventing transmission, durability over time, and for those who previously contracted the virus, while they widely held belief that vaccines can protect individuals to some extent.

Can we still spread it to others with the vaccination?... I don't know if it's true that you can still get COVID, if you get it. (Clara, 26-year-old, vaccinated)

is it still as strong as it was at protection, like right after? Or did it weaken? (Joy, 49-year-old, vaccinated)

This skepticism was further fueled by reports of vaccinated individuals contracting and spreading COVID-19. One participant, Joy, who had received the vaccine, expressed her skepticism as she personally did not know anyone who had contracted COVID-19 and had been extremely sick. Later on, Joy expressed her continued skepticism by stating “by getting the vaccine, I’m protecting myself, but even if I had the vaccine, I can still spread COVID to somebody who doesn’t.” This realization did not serve her motivation to protect her high-risk father from COVID-19.

it's stopping people from getting super sick... I haven't seen it personally, I also haven't had any friends that have gotten COVID and been extremely sick... I feel like there's a...gap of knowledge and... I just want to wait and see... my father in law is sort of high risk, he's diabetic so he has all of his vaccines. And... he tried to say to me, you need to go get your vaccine so that you don't spread it to me. And... to me is... where i'm seeing a lot of misinformation, where i've been told that vaccine doesn't stop us from spreading it... it stops that individual from getting it, so by getting the vaccine i'm protecting myself, but even if I had the vaccine, I can still spread COVID to somebody who doesn't. (Joy, 49-year-old, vaccinated)

The confusion around vaccines' efficacy implied participants' lacking knowledge in how vaccines work. In our discussion, Clara used the word "iffy" to describe her feelings when her friends contracted COVID-19 despite being vaccinated. "Maybe he got COVID from the shot" Clara further shared, suggesting that she may not fully understand the pharmacological mechanism of the vaccine in the first place.

I was...iffy about it, because my one friend, he got the [vaccine]. And then he still got COVID. So...I didn't know, maybe he got COVID from... the shot. (Clara, 26-year-old, vaccinated)

Given the indeterminacy of vaccine outcomes, unvaccinated participants turned to alternative methods, such as strict self-quarantine, and relying on their own natural immunity to protect themselves. These beliefs in alternative methods and natural immunity may stem from risk perceptions on vaccines' side effects, which we will discuss later in this article. Eleanor expressed her "biggest fear" about "not enough being known about long-term side effects" and her preference for a "natural approach". Heather strongly agreed with Eleanor and added that "fear of long term (side effect)" and "so much unknown" about vaccines led her to "rely on my own immunity". Participants, with beliefs in alternative methods, shared similar concerns. Melanie, recovering from her cancer, "cut people off" and told her friends "it's probably better that we FaceTime or texts or call", because her oncologists agreed that "I'm a high risk of getting COVID, but I'm a higher risk of getting sick or worse from the shots". Similarly, Brooke adapted her daily routine to minimize exposure to the virus, such as relying on online grocery shopping and avoiding physical contact with people or objects.

Several unvaccinated participants expressed a preference for a "natural approach" to protect themselves, citing concerns about the vaccines' long-term side effects and a desire to rely on their own immune systems. Eleanor expressed her "biggest fear" about "not enough being known about long-term side effects" and her preference for a "natural approach". Heather strongly agreed with Eleanor and added that "fear of long term (side effect)" and "so much unknown" about vaccines led her to "rely on my own immunity".

I've heard that it can be really bad for people that have respiratory issues. I have, like I said I have asthma, I have very bad allergies, I've had breathing problems... I'm also worried about long term effects things that people don't know about yet... I tend to take a more natural approach to my health, I'm not on any medications or anything like that, it's all about just eating certain things, meditation, stuff like that, yes, and putting your mind in the right kind of focus. I just – I'm not a big person with doctors and stuff so I try to take a natural approach to things. (Melanie, 52-year-old, unvaccinated)

what they said was exactly what I could say... the fear of long term. So much is unknown about it. Side effects, everything like that... So I kind of look after my own health and rely on my own immunity. (Heather, 68-year-old, unvaccinated)

Although most participants in our study reported obtaining their knowledge about the pandemic and vaccines from official government sources such as the Public Health Agency of Canada, they also sought information from alternative sources such as mainstream media, independent investigators, and anecdotal evidence from friends and social media. Exposed to an abundance of information, participants found information, which presented positive and

negative views and experiences with COVID-19 vaccines, conflicting and hard to keep up with. For example, Ethan shared contrasting experiences with COVID vaccines from his friends and a taxi driver.

My mother... and another... friend... they had the vaccine and they both said that they didn't have any... side effects, but then... a taxi driver... said that he had like side effects after the second dose... so... I found that... they gave a lot of information.
(Ethan, 26-year-old, unvaccinated) ,

Julie noted the fickle nature of information released.

It was just, there's so much information out there about it. And each day it would sort of change. (Julie, 58-year-old, vaccinated)

This exposure to contracting perspectives led to confusion among the participants about which information is accurate and which sources are reliable. Charles, who is unvaccinated, described his experience over the past one and a half years as going “from uncertainty to confusion.” He explained, “we’ve been getting a lot of information from different sources. And we want to get the information from reliable sources, and to be sure that the information that we are getting is true... that is where the confusion comes in now because we don’t even know where I mean these sources that we should trust.”

everyone kind of expressed a bit of like confusion, or that there's like mixed messages, or that there's different information kind of out there which is maybe leading to a bit of kind of lack of confidence in the in the information that's available.

Janet: Yeah (Janet, 26-year-old, unvaccinated)

Risk-based

One of the most commonly discussed themes was related to participants' risk perceptions of vaccines. First and second-hand stories of individuals experiencing severe side effects or even death after vaccination were prevalent. Joy and Esther both heard about "people were dying or people were having really bad side effects".

Joy: Yes, I heard that people were dying getting the shot, after they got the shot that they were dying. So I was quite scared to get it. (Joy, 49-year-old, vaccinated)

Esther: I heard the same, people were dying or people were having really bad side effects. (Esther, 60-year-old, vaccinated)

A neighbor of Patrick experienced "really bad side effects for a day or two after [getting Pfizer]" which made him "pause" vaccination decisions.

I actually had a neighbor who he did, he had the Pfizer vaccine, and he had really bad side effects for a day or two after, and you know it made me kind of pause. But then I actually found out I was getting the Moderna one, and I didn't have any side effects whatsoever. (Brooke, 53-year-old, vaccinated)

"if one is saying that there's a chance of getting a blood clot. Well, how can they say that the other two are going to be okay from – are going to be okay," Melanie concluded. Their

shared fear was reinforced by news that “AstraZeneca [has] already been taken off the market because of very serious side effects.”

For participants with pre-existing medical conditions, the risk of COVID-19 vaccines is even harder to manage because they are unsure how the vaccines will interact with their health issues or medication. Melanie noted that, according to his cardiologist, his blood disorder put him at a high risk of developing blood clots.

My thing was with my cardiologist... because, again, there are some serious side effects that like... myocarditis, inflammation of the heart muscle... if I get COVID-19 it would be worse so ... that's why [I decided not to get vaccinated].
(Melanie, 52-year-old, unvaccinated)

Eleanor also expressed concerns that vaccines could be harmful to people with respiratory issues.

I've heard that it can be really bad for people that have respiratory issues... I have asthma, I have very bad allergies, I've had breathing problems. (Eleanor, 43-year-old, unvaccinated)

Brooke was “on the fence” because her doctor “wasn’t even 100% sure of what side effect would happen to me because of having certain arthritis”. Later on, she asked, “if I was on a medication and if I take the COVID vaccine, is it going to counteract my other medication and cause whatever that was helping to fail?”

We observed similar ambiguity when it comes to long-term side effects. Eleanor was “worried about long-term effects things that people don't know about yet that can happen years down the road like what of that.”

My biggest fear about this whole thing is that... it was new it came out quickly and not enough is known about long term side effects. Everyone that's taking it... you're the test subject and... they don't really know what's going to come of this whole thing in the long run... I'm fearful of the long term effects it can have not, just immediate effects of just taking the vaccine right away... I've even heard things...that affects on women with their their fertility and menstrual problems and stuff, like I have heavy menstrual now, I mean I couldn't even imagine if I had that sort of side effect
(Eleanor, 43-year-old, unvaccinated)

Charles' friends “don't want to get the vaccine because of some of the information that they get, that if you get a vaccine you are going to, maybe after two years”.

some people, like some of my friends, they don't want to get the vaccine because of some of the information that they get, that if you get a vaccine... maybe after two years, you are going to die or something... they're saying that the government is using that to reduce the population. (Charles, 31-year-old, unvaccinated)

Risk perceptions surrounding COVID-19 vaccines co-exist with risk perceptions related to the disease itself. However, we observed noteworthy variances in risk perceptions among vaccinated and unvaccinated participants, which may lead to their divergent vaccination decisions.

Most unvaccinated participants considered themselves at low risk of severe symptoms or death related to COVID-19. Molly, who is 26, cited her demographic group as “considered very low risk” and mentioned that she lives in an area with minimal cases. William said he doesn’t “know anyone that’s died from” COVID-19. Same as Janet, who knew “people with injuries to the AstraZeneca and the Pfizer vaccine” but didn’t see where COVID really “affects too much” the “younger population”.

On the contrary, we found that vaccinated participants are more concerned about potential risks from COVID-19 itself. “COVID would definitely kill me, so I chose to take it [COVID-19 vaccines],” said Billy, who at the same time had heart inflammation and could potentially die from it. Charles believed “it’s better to get a vaccine rather than getting COVID,” even though he fully acknowledged the potential side effects that vaccines may trigger. Similarly, Elise was “concerned just about the long-term effects of this vaccine” and didn’t “believe that it completely stopped COVID” but for him “avoiding hospitalization [due to COVID] was the biggest choice.” For vaccinated populations, “the risk of not getting the vaccine outweighed” the risk of unknown side effects, which lead to their vaccination decisions.

Practical

Practical uncertainty refers to themes related to the processes and systems in place for administering the vaccines.

System of care

Most participants shared concerns about the potential cost of being unvaccinated, which could include concerns about unemployment, inaccessibility to certain services, or travel

bans. Lorry and Janet expressed concerns about people getting fired because of their medical decisions. For Lorry, “the obstacles of not being able to travel... not going to concerts and the giveaways seem small to [her]”, and “the only big obstacle that [she sees] would be [her] job.” Janet shared her friends’ stories about being fired for making their own medical decisions. She made it clear that “making sure that [her] population is very safe is a top of [her] concern”, therefore “[she] was pretty much [sure] that she was going to get [vaccinated]”

Participants were concerned about more than just employment. Patrick shared a personal experience of being unable to access home care after having a toe amputated because he was not vaccinated.

Back on Labor Day of last year, I actually ended up in the hospital for unrelated - I had to have a toe amputated due to it being infected... after I got out of the hospital, I had a home care worker coming into my home and they basically said, because you're receiving home care, they're strong - they really wanted me [to get vaccinated]... otherwise I would lose my home care worker once every few days to help me with some things and change the bandages. So I knew that I had to have it because of, you know, the other problem I was dealing with. (Patrick, 53-year-old, vaccinated)

Janet mentioned that her friends’ children cannot play hockey because of their vaccination status which triggered Janet’s concerns about what will happen if her son is in the “must-vaccinated” age group. Interestingly, two participants shared their experiences using the potential cost of being unvaccinated to pose pressure on their vaccinated family members. Patrick made it clear to his nephew that he cannot go to Finland if he is not vaccinated, which

nudged his nephew to overcome the safety concern and decide to get vaccinated. Esther's daughter had "no other choice" but to get vaccinated to see her sister who went to school in London and got vaccinated.

Interview Guide for Focus Groups

GENERAL QUESTIONS

- How has the COVID-19 pandemic affected you personally?

TRUST QUESTIONS

- Where have you been getting your main information about the pandemic and vaccine research and roll out?
- PROBE: If unresponsive, list of prompts:
 - Social media
 - Government websites, i.e. PHAC, Health Canada, Quebec public health
 - News reports
 - Friends and family
 - Physician, nurse, pharmacist
- Overall, do you feel you have enough information to make confident decisions about your health and the vaccines?
- If you are not totally confident, what would it take to increase your confidence?

VACCINE SAFETY, ACCESS, & HESITANCY

- In general, how safe are vaccines?
- How safe do you think the COVID vaccines are?
- PROBE: What has influenced your ideas about the safety (or lack thereof) of COVID vaccines?
- PROBE: What would change your mind?
- Can you name a concrete venue (social media post, newspaper article, etc) that has influenced your ideas about the safety (or lack thereof COVID vaccines)?
- There have been some media reports that one-third Canadians are reluctant to take a COVID vaccine. How much do you share in these concerns?

FOR UNVACCINATED GROUP:

- How likely is it that you will get a COVID vaccine (once one becomes available to you)?
- Likely/very likely: What are the reasons why you want to be vaccinated? -
- Unlikely/very unlikely: What are the reasons why you do not want to be vaccinated?
- Unsure: What are the reasons why you are unsure about getting vaccinated?

- All : Have you experienced any limitation in access to vaccines that prevents you to get vaccinated?
- Do the following government initiatives change your opinion, making it more or less likely to get vaccinated?
- -Lotteries/Cash Prizes/Scholarships
- -Implementation of a COVID passport for non-essential activities
- -Travel restrictions for unvaccinated citizens

FOR VACCINATED GROUP:

- What are the reasons why you decided to get vaccinated
- What were the reasons why you were unsure about getting vaccinated?
- How easy or hard was it for you to get vaccinated? Did you experience any limitation in access to vaccines that delayed your vaccination?
- Did the following government initiatives change your opinion or influenced in your decision to get vaccinated?
- -Lotteries/Cash Prizes/Scholarships
- -Implementation of a COVID passport for non-essential activities
- -Travel restrictions for unvaccinated citizens

SOCIAL ACCEPTABILITY

- How did people around you take your decision to get/to not get vaccinated?
- Do you feel they accepted your decision? Has this generated problems in your social circle?

CLOSING

- Is there anything related to the pandemic or COVID vaccines that we haven't talked about but that you think is important for us to know?

Appendix: Chapter 2

Appendix A: Instruments

A1: Cognitive Factors

The eight cognitive factors of interest were determined by assessing the answers to the following question:

A1.1: Fear of Missing Out: When I feel as if I'm about to lose or miss out on something, I tend to get quite anxious.

A1.2: Desire for Complete Information: I like to have complete information before I make any decisions so I know what I'm getting into and can avoid making mistakes.

A1.3: Desire for Risk Awareness: I need to know the various risks involved in making a decision, otherwise I just won't make any choice at all.

A1.4: Uncertainty Tolerance: Compared to most people, I need a higher degree of certainty that the risks are known before I will jump into making a decision.

A1.5: Recency Effect: I'd have to admit that my decision making is often highly influenced by recent things I have read or heard.

A1.6: Negativity Bias: It may not be completely fair, but if I know of even one example of someone being unhappy with a product, I will avoid it.

A1.7: Availability Heuristic: The best products are those that come the most easily to mind (so long as they have a good reputation).

A1.8: Optimism Bias: I almost always find that the judgments and decisions I've made work out well in my favor.

A2: COVID-19 Vaccine Hesitancy

COVID-19 vaccine hesitancy was determined by assessing the answers to the following question:

A2.1: Knowing that vaccinations against COVID-19 have begun, have you received the COVID-19 vaccination?

1: Yes

2: No

A2.2: When the COVID-19 vaccination becomes available to you, would you get vaccinated or not?

1: Yes, I would get a vaccination as soon as one became available to me

2: Yes, I would eventually get a vaccination, but would wait a while first

3: No, I would not get a COVID-19 vaccination

4: Not sure

A2.3: Thinking back, how hesitant were you about a COVID-19 vaccination prior to receiving one?

1: Was not hesitant

2

3: *Was neither hesitant nor not hesitant*

4

5: *Was extremely hesitant*

A3: Definitions of Non-Hesitant, Soft Hesitant and Hard Hesitant

Non-Hesitant:

1: Vaccinated & Non-hesitant - A2.1: 1 (vaccinated); A2.3: 1, 2 or 3 (non hesitant prior to vaccination)

1: Unvaccinated & Non-hesitant - A2.1: 2 (unvaccinated); A2.2: 1 (intend to vaccinate as soon as possible)

Soft-Hesitant:

2: Vaccinated & Hesitant - A2.1: 1 (vaccinated); A2.3: 4 or 5 (hesitant prior to vaccination)

3: Unvaccinated & Soft-Hesitant: A2.1: 2 (unvaccinated); A2.2: 2 or 4 (would wait a while first or not sure)

Hard-Hesitant

4: Unvaccinated & Hard-Hesitant: A2.1: 2 (unvaccinated); A2.2: 3 (would not get vaccinated)

Appendix B: Sample Characteristics

The table below presents sample characteristics across the 1541 Canadians over the age of 18 who completed our survey. Of those, 1165 (76%) had received at least two doses of an approved COVID vaccine, 376 (25%) were unvaccinated vaccine hesitant. The mean age of our sample was 46.4 years (range: 18 - 87). The majority of our sample were women (57%), white (71%), and had at least a high school education (85%). A small portion of our sample self-identified as Indigenous (6%).

Table 2: Sociodemographic characteristics of the sample

	Total		Vaccinated	
	N	%	N	%
	1541	100%	1165	76%
Age				
18-25	159	10%	110	69%
26-35	304	20%	199	65%
36-45	236	15%	158	67%
46-55	281	18%	219	78%
56+	561	36%	479	85%
Gender				
Man	653	42%	515	79%
Woman	879	57%	642	73%
NA/Other	9	1%	8	89%
Ethnicity				
Black	53	3%	31	58%
East Asian	91	6%	70	77%
Indigenous	89	6%	60	67%
Latino	25	2%	19	76%
Middle Eastern	27	2%	21	78%
South Asian	70	5%	62	89%
Southeast Asian	20	1%	19	95%
White	1091	71%	829	76%
Do not know	16	1%	11	69%

Prefer not to answer	25	2%	17	68%
Other	66	4%	47	71%
Indigenous Status				
Yes, First Nations	42	3%	28	67%
Yes, Métis	42	3%	28	67%
Yes, Inuk (Inuit)	5	0%	4	80%
No, not an Indigenous person	1419	92%	1084	76%
I prefer not to answer	32	2%	20	63%
Province				
Alberta	152	10%	109	72%
British Columbia	207	13%	161	78%
Manitoba	46	3%	33	72%
New Brunswick	35	2%	20	57%
Newfoundland and Labrador	20	1%	15	75%
Northwest Territories	0	0%	0	NA
Nova Scotia	40	3%	31	78%
Nunavut	0	0%	0	NA
Ontario	624	40%	475	76%
Prince Edward Island	7	0%	5	71%
Québec	368	24%	284	77%
Saskatchewan	42	3%	32	76%
Yukon	0	0%	0	NA
Other	0	0%	0	NA
Education				
Less than high school	53	3%	33	62%
Completed some high school	177	11%	113	64%
High school graduate or equivalent	445	29%	332	75%

Technical college, community college or CEGEP	386	25%	297	77%
Completed some university, but no degree	112	7%	90	80%
University graduate	226	15%	184	81%
Completed some post-graduate school, but no degree	44	3%	30	68%
Completed post-graduate school	98	6%	86	88%
Income (CAD)				
Less than \$10,000	129	8%	82	64%
\$10,000 to \$19,999	315	20%	231	73%
\$20,000 to \$29,999	365	24%	268	73%
\$30,000 to \$39,999	213	14%	162	76%
\$40,000 to \$49,999	109	7%	81	74%
\$50,000 to \$59,999	71	5%	55	77%
\$60,000 to \$69,999	60	4%	46	77%
\$70,000 to \$79,999	52	3%	44	85%
\$80,000 to \$89,999	30	2%	23	77%
\$90,000 to \$99,999	48	3%	40	83%
\$100,000 to \$199,999	97	6%	88	91%
\$200,000 or more	11	1%	10	91%
Prefer not to answer	41	3%	35	85%

Appendix: Chapter 3

Appendix A: Sample Characteristics

The table below presents sample characteristics across the 1541 Canadians over the age of 18 who completed our survey. Of those, 1165 (76%) had received at least two doses of an approved COVID vaccine, 376 (25%) were unvaccinated vaccine hesitant. The mean age of our sample was 46.4 years (range: 18 - 87). The majority of our sample were women (57%), white (71%), and had at least a high school education (85%). A small portion of our sample self-identified as Indigenous (6%).

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\$200,000 or more	11	1%	10	91%
Prefer not to answer	41	3%	35	85%

Appendix B: Instruments Used

B1: COVID-19 Vaccine Hesitancy

COVID-19 vaccine hesitancy was determined by assessing the answers to the following question:

B1.1: Knowing that vaccinations against COVID-19 have begun, have you received the COVID-19 vaccination?

1: Yes

2: No

B1.2: When the COVID-19 vaccination becomes available to you, would you get vaccinated or not?

1: Yes, I would get a vaccination as soon as one became available to me

2: Yes, I would eventually get a vaccination, but would wait a while first

3: No, I would not get a COVID-19 vaccination

4: Not sure

B1.3: Thinking back, how hesitant were you about a COVID-19 vaccination prior to receiving one?

1: Was not hesitant

2

3: Was neither hesitant nor not hesitant

4

5: Was extremely hesitant

B2: Trust

Trust in various groups of varying sizes was determined by assessing the answers to the following question:

B2.1: On a scale of one to five, in general how much do you trust the following people and institutions where one being not at all and five being completely (1: Not at all; 2: Little; 3: Neither trust nor don't; 4: Somewhat; 5: Completely):

Family

Friends

Acquaintances

Classmates

Co-workers

Roommates

The federal government

The local government

The World Health Organization (WHO)

The healthcare system

The police

Scientists/COVID-19 Researchers

Physicians/Medical doctors

Mainstream Media (i.e., news outlets)

Pharmaceutical companies

B3: Conspiratorial Thinking

Conspiratorial thinking in relation to COVID-19 was determined by calculating an equally weighted average to answers of the following questions:

B3.1: How much do you agree with the following statements (1: Strongly disagree; 2: Somewhat disagree; 3: Neither agree nor disagree; 4: Somewhat agree; 5: Strongly agree):

- 1. Governing bodies knew about COVID-19 long before the public*
- 2. There is a cure for COVID-19, and it is being withheld from the public*
- 3. COVID-19 was purposefully created by a larger governing body*
- 4. 5G mobile networks are related to the spread of COVID-19*
- 5. COVID-19 was created/engineered in a lab*
- 6. COVID-19 is a hoax and scientists are lying to us*
- 7. A large governing body is planning to implant microchips for global surveillance through the COVID-19 vaccination plan*
- 8. George Soros has played a role in creating the pandemic or is benefiting from it in some way*
- 9. Governments are exaggerating the seriousness of the COVID-19 situation in order to control the population*
- 1. Hospitals are registering every death from other causes as a COVID death if the person had tested positive in the last 28 days*

B4: COVID-19 Vaccine Concerns

COVID-19 vaccine concern were determined by calculating an equally weighted average to answers of the following questions:

B4.1: *What concerns, if any, do you have about the COVID-19 vaccine? (checkboxes, values 0-1):*

- 1. I am concerned about side effects from a coronavirus vaccine*
- 2. I am concerned the coronavirus vaccine will not be effective*
- 3. This vaccine's production has been rushed and is therefore not safe*
- 4. The vaccine will somehow be used to infringe on my privacy*
- 5. I believe the vaccine will be used to harm the population*
- 6. I have no concerns about the COVID-09 vaccine*

B5: General Vaccine Hesitancy

General vaccine hesitancy was determined by calculating an equally weighted average to answers of the following questions:

B5.1: *What concerns, if any, do you have about the COVID-19 vaccine? (checkboxes, values 0-1):*

- 1. In general, vaccines are not safe*
- 2. In general, vaccines are not necessary*

Appendix C: Trust delta comparisons

Table 3: Comparison of the trust deltas (institutional - interpersonal trust) between the high and low hesitant groups.

Group 1	Group 2	M1	SD1	M2	SD2	T Statistic	p-value
COVID-19 Vaccine Hesitant	COVID-19 Vaccine Non-Hesitant	-.467	.819	-.038	.647	-11.343	<.001
High COVID-19 Vaccine Concerns	Low COVID-19 Vaccine Concerns	-.417	.790	-.013	.650	-11.008	<.001
High General Vaccine Hesitancy	Low General Vaccine Hesitancy	-.781	.865	-.148	.713	-9.131	<.001
High COVID-19 Conspiracy Thinking	Low COVID-19 Conspiracy Thinking	-.407	.793	-.007	.642	-1.927	<.001
Unvaccinated	Vaccinated	-.524	.839	-.078	.670	-1.763	<.001