COVID-19 Vaccine Hesitancy in the South Asian Community in Canada

SOCIODEMOGRAPHIC FACTORS ASSOCIATED WITH VACCINE HESITANCY IN THE SOUTH ASIAN COMMUNITY IN CANADA

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Lay Abstract

The South Asian community in Canada has been disproportionately impacted by the COVID-19 pandemic. This study aims to understand the sociodemographic factors influencing vaccine hesitancy between April and November 2021 among 1,496 South Asian adults from Ontario and British Columbia. A quantitative survey was used to collect demographic characteristics, and vaccine attitudes were measured by the Vaccine Attitudes Examination (VAX) scale. Time since immigration, marital status, prior COVID-19 infection, age, multigenerational household status, education, and employment status were found to be related to vaccine hesitancy. Future research is needed to better understand the broader influences of vaccine hesitancy in this population to develop programs and policies suited to their needs to improve vaccine uptake.

Abstract

Background: South Asians represent the largest non-white ethnic group in Canada and were disproportionately impacted by COVID-19. We sought to determine the factors associated with vaccine hesitancy in South Asian Canadians.

Methods: We conducted a cross-sectional analysis of vaccine hesitancy using data collected at the baseline assessment of a prospective cohort study, COVID CommUNITY South Asian. Participants (18 + years) were recruited from the Greater Toronto and Hamilton Area in Ontario (ON) and the Greater Vancouver Area in British Columbia (BC) between April and November 2021. Demographic characteristics and vaccine attitudes measured by the Vaccine Attitudes Examination (VAX) scale were collected. Each item is scored on a 6-point Likert scale, and higher scores reflect greater hesitancy. A multivariable linear mixed effects model was used to identify sociodemographic factors associated with vaccine hesitancy, adjusting for multiple covariates.

Results: A total of 1496 self-identified South Asians (52% female) were analyzed (mean age = 38.5 years; standard deviation (SD): 15.3). The mean VAX score was 3.2, SD: 0.8 [range: 1.0–6.0]. Factors associated with vaccine hesitancy included: time since immigration ($p = 0.04$), previous COVID-19 infection ($p < 0.001$), marital status ($p < 0.001$), living in a multigenerational household ($p = 0.03$), age ($p = 0.02$), education ($p < 0.001$), and employment status ($p = 0.001$).

Conclusion: Among predominantly vaccinated South Asians living in ON and BC, time since immigration, prior COVID-19 infection, marital status, living in a multigenerational household, age, education, and employment status were associated with vaccine

hesitancy. This information can be used to address vaccine hesitancy in the South Asian population in future COVID-19 waves or pandemics. Future research is needed to explore vaccine hesitancy across various population groups to understand diverse perspectives and develop equitable interventions.

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Preface

This thesis follows the format of a "sandwich thesis". The first chapter serves as an introduction to the study, and the second chapter is a literature review. The third chapter consists of a manuscript that includes the introduction, methods, results, and discussion. The manuscript was published in the Canadian Journal of Public Health on May 7, 2024. The fourth and final chapter concludes the thesis with a summary of the findings, implications for public health, and future directions.

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List of Abbreviations

BC – British Columbia

CCHS – Canadian Community Health Survey

CFA – Confirmatory Factor Analysis

CFI – Comparative Fit Index

COVID-19 – Coronavirus disease 2019

GTHA – Greater Toronto Hamilton Area

GVA – Greater Vancouver Area

RMSEA – Root Mean Squared Error of Approximation

SAGE – Strategic Advisory Group of Experts

SAY-VAC – South Asian Youth as Vaccine Agents of Change

TLI – Tucker Lewis Index

VAX – Vaccine Attitudes Examination

WHO – World Health Organization

Declaration of Academic Achievement

I, Baanu Manoharan, declare that this thesis document is my original work. I conducted the literature review, performed the data analyses, wrote the results, and summarized the findings in this document. My supervisor, Dr. Sonia Anand, and committee members, Dr. Russell de Souza and Dr. Gita Wahi, contributed to conceptualization of the research project, supervised the data analysis, and provided feedback for all pieces of this final document. Additional authors for the manuscript have been credited.

Chapter 3: This chapter consists of a manuscript that has been published in the Canadian Journal of Public Health. I conducted data analysis and wrote the first draft of the manuscript. My supervisor and committee members contributed to the conceptualization of the research project and provided feedback throughout the process. All co-authors provided feedback and comments on the manuscript and approved the manuscript before submission.

Chapter 1: Introduction

Background

Vaccines are one of the most effective public health interventions for preventing infectious diseases and their associated mortality and morbidity.[1] In 2019, the WHO identified vaccine hesitancy as one of the top ten threats to global health,[2,3] with declining vaccine coverage rates and increasing outbreaks of infectious and vaccine preventable diseases. WHO defines vaccine hesitancy as the "delay in acceptance or refusal of vaccines despite the availability of vaccine services".[1] Vaccine hesitancy is a highly complex, multi-faceted phenomenon that varies across different contexts, places, and times.[2] With the rollout of the COVID-19 vaccines, vaccine hesitancy was heightened due to its rapid development and the unprecedented impact of COVID-19, which has reshaped healthcare and public health indefinitely. Understanding vaccine hesitancy and factors affecting the uptake of vaccines will allow for the development of tailored programs and policies.

The COVID-19 pandemic has highlighted many of the existing health and socioeconomic inequities within Canada's health systems, including the strong link between race, ethnicity, and health outcomes.[4,5] Ethnic minority groups have unquestionably experienced a significant burden during the pandemic. Evidence from the United States, United Kingdom, and Canada demonstrated ethnic differences in COVID-19 risk and outcomes, with racialized groups experiencing higher rates of infection,

hospitalization, and mortality rates compared to the general population.[6,7] Previous studies have shown reports of vaccine hesitancy to be greater among racialized groups impacted by the COVID-19 pandemic.[8] However, vaccine hesitancy studies often report differences between racialized and non-racialized groups, but do not provide further disaggregated results to understand how vaccine hesitancy varies among different ethnic groups and subgroups.[8]

South Asians in Canada are a high-risk ethnic group that have been disproportionately impacted by COVID-19.[9] The COVID CommUNITY Study revealed that a sample of South Asians primarily living in the Peel Region of Ontario had a seropositivity of 23.6%, confirming the high burden of infection in this population during the third wave of the pandemic (April 14 to July 28, 2021).[10] In the CCHS conducted from September to mid-December 2020, 76.0% of Canadians (excluding those from the territories) indicated that they were "very willing" or "somewhat willing" to receive the COVID-19 vaccine.[11] 82.5% of South Asians in Canada reported that they were "very willing" or "somewhat willing" to receive the COVID-19 vaccine.[11] However, although vaccine coverage and estimated vaccine coverage is high among the sample of South Asian Canadians, vaccine hesitancy may still persist.[8,12,13] Additionally, there are limited studies on vaccine hesitancy within the South Asian diaspora in Canada, as well as among vaccinated individuals.[14] Understanding vaccine hesitancy in these groups is crucial to the development of equitable strategies to sufficiently address gaps and improve vaccine uptake.

Thesis Objectives

This thesis seeks to explore the sociodemographic factors associated with COVID-19 vaccine hesitancy in South Asian adults (18+ years) in Ontario and BC to contribute to a more comprehensive understanding of this phenomenon.

The primary objective of this thesis is to identify what sociodemographic factors (age, sex, education, employment status, marital status, time since immigration, and prior COVID-19 infection) are associated with vaccine hesitancy using the validated Vaccine Attitudes Examination (VAX) scale (domains: mistrust of vaccine benefit, worries about unforeseen future side effects, concerns about commercial profiteering, and preference for natural immunity) among the South Asian community in Canada. The secondary objective of this study is to evaluate the internal consistency and construct validity of the VAX scale in the South Asian population.

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Chapter 2: Literature Review

Vaccine Hesitancy

Definition

According to the SAGE working group established by WHO, vaccine hesitancy is a "delay in acceptance or refusal of vaccines despite availability of vaccination services".[1] It is "complex and context-specific, varying across time, place and vaccines".[1] In previous literature, vaccine hesitancy refers to the attitudes, behaviours, and beliefs toward vaccination.[1,2] Generally, vaccine hesitancy occurs along a continuum of attitudes ranging from those who accept all vaccines with confidence to those who refuse all with conviction.[3–5] It is also dynamic in nature as individuals can move across the continuum as time progresses.[5] Further, vaccine hesitancy is a multifactorial decision-making process influenced by socioeconomic, psychological, sociocultural, and political factors.[3,6,7]

Vaccine hesitancy is often used interchangeably with other terms such as "anti-vaccination attitudes" or "vaccine reluctance", which represents one end of the spectrum and typically carry a negative connotation. Vaccine hesitancy is also commonly equated with the act or behaviour of vaccination; however, it does not necessarily correspond with behaviour.[8] A few studies have categorized vaccine hesitant individuals based on their decision to get vaccinated or not get vaccinated.[9] However, previous research has demonstrated that some vaccinated individuals express vaccine hesitancy.[10–12]

The different terms used to describe vaccine hesitancy reiterate the complex nature of hesitancy as it is context-specific. Understanding vaccine hesitancy and the

heterogeneity of individuals who may be vaccine hesitant is important to understanding and establishing programs and policies aimed at addressing vaccine hesitancy. In this thesis, we define vaccine hesitancy as a continuum of attitudes.

Vaccine Hesitancy and the COVID-19 Pandemic

With the onset of the COVID-19 pandemic, vaccine hesitancy has been brought to the forefront, presenting significant challenges to public health efforts despite the rapid development of COVID-19 vaccines, and highlighted pre-existing inequities and barriers in healthcare.[13] The pandemic also presented unprecedented challenges with social media, creating an "infodemic" and resulting in the spread of misinformation, further contributing to vaccine hesitancy.[14] Additionally, the emergence of new variants, development of new vaccine formulations, and frequent updates to guidelines have further complicated public health messaging and hesitancy.[15] Therefore, addressing these complexities through an iterative and multifaceted approach will improve vaccine uptake.

Factors Influencing Vaccine Hesitancy

The vaccine hesitancy determinants matrix, developed by the SAGE working group, categorizes the determinants of vaccine hesitancy into three broader groups: individual and group influences; vaccine/vaccination-specific influences; and contextual influences.[1]

Multiple individual and group factors influence vaccine hesitancy, which combined can present a challenge to public health initiatives aimed at addressing vaccine hesitancy. Personal experiences play a critical role in shaping one's attitude toward vaccines.[1] Dubé et al. found that previous negative experiences (i.e., unpleasant

encounters with healthcare providers, fear of needles, and adverse reactions) to prior vaccination can affect an individual's outlook on vaccines.[16] Knowledge and awareness of vaccines, their benefits, efficacy, and safety are also determinants of hesitancy. During the COVID-19 pandemic, misinformation through various forms of media contributed to hesitancy and doubt in public health guidelines. According to Statistics Canada, the "infodemic" made it difficult for communities to determine what was factual and reliable during the pandemic.[17] 96% of Canadians reported seeing inaccurate or misleading COVID-19 information.[17] This misinformation can undermine public health efforts, contributing to vaccine hesitancy. Additionally, social norms surrounding vaccines can affect an individual's decision to get vaccinated. Social norms that promote vaccination as a communal responsibility have been shown to improve vaccine acceptance, while misinformation has been shown to decrease trust and increase hesitancy towards COVID-19 vaccines.[16]

Vaccine/vaccination-specific influences are directly related to the vaccine and the vaccination process, such as scientific evidence in support of vaccines and the reliability of the vaccine. Scientific evidence has demonstrated the benefit of vaccination as they reduce the risk of illness, hospitalization, and death; while side effects were a known risk, these were often minimal compared to the benefits of the vaccine.[18] However, when comparing different vaccines, individuals often favoured those with less controversy. A study comparing the AstraZeneca, Johnson & Johnson, Pfizer, and Moderna vaccines in Canada showed considerable preference towards the Pfizer and Moderna vaccines.[19] Despite all of the vaccines being considered effective by the Canadian government, there

was hesitancy towards the AstraZeneca and Johnson & Johnson vaccines after reports of some rare but serious adverse reactions. The authors assessed brand-based differences in perceived safety and effectiveness in a cross-sectional survey. Respondents reported being willing to wait months for their preferred vaccines, rather than receiving the AstraZeneca or Johnson & Johnson vaccine.[19]

Finally, contextual influences are broader societal and environmental factors that influence vaccine hesitancy. For example, media communication, historical influences, and the perception of the pharmaceutical industry affect willingness to accept the COVID-19 vaccine.[16,20] Historical influences also play a large role in vaccine acceptance by the public. Past medical abuse and misuse of power have led to skepticism among marginalized communities. Many Indigenous Peoples in Canada raised concerns when the COVID-19 vaccines were introduced in Canada, as historically they have been experimented on without consent.[21] Many Indigenous Peoples continue to face racism and medical abuse in the healthcare system, perpetuating their fear and lack of trust in the medical system. This fear in the medical system, particularly the pharmaceutical industry, is far-reaching for many communities. The motives of the pharmaceutical industry are often questioned as being profit-driven, which fosters greater hesitancy towards vaccines.[22]

Overall, vaccine hesitancy is driven by the complex interplay of individual and group influences, vaccine/vaccination-specific influences, and contextual influences. This highlights the diversity of factors that contribute to vaccine hesitancy, as well as its

complexities. Incorporating these influences in the development of interventions will ensure that public health efforts effectively address a variety of specific concerns.

Sociodemographic Factors Influencing Vaccine Hesitancy

Several sociodemographic factors have been identified to contribute to COVID-19 vaccine hesitancy across several countries. A retrospective analysis of global trends in vaccine confidence between 2015 and 2019 across 149 countries investigating the link between socioeconomic and non-socioeconomic determinants prior to the COVID-19 pandemic found that women and younger age groups were associated with improved vaccine uptake.[23] A global scoping review on the predictors of COVID-1 9 vaccine hesitancy found that associations of vaccine acceptance was seen in males, older adults, individuals with higher educational attainment, and high income groups .[24] A systematic review and meta-analysis of studies with 28 nationally representative samples from high-income countries found that females, those with lower income, those with lower educational attainment, and those from ethnic minorities had greater hesitancy towards the COVID-19 vaccine.[25] Overall, previous literature across several countries have generally found that education level, sex, ethnicity, age, and income were found to be significant predictors of COVID-19 vaccine acceptance, while lower educational attainment, being female, belonging to an ethnic minority, younger age, and lower income levels were associated with lower chances of COVID-19 vaccine uptake.[23-28] Of note, vaccine hesitancy has been increasingly observed in ethnic minorities who have been disproportionately impacted by the COVID-19 pandemic.[29,30]

In the Canadian context, there are few studies on COVID-19 vaccine hesitancy in ethnic minorities regarding sociodemographic factors in the adult population. A systematic review and meta-analysis of the prevalence and factors associated with vaccine hesitancy in Canada reported that, in parallel with global studies, vaccine hesitancy was higher in females compared to males (19.9% vs. 13.6%), non-white individuals compared to white individuals (21.7% vs. 14.8%), and those with lower educational attainment compared to those with higher education (24.2% vs. 15.9%).[32] A study on national trends in COVID-19 vaccine hesitancy among Canadians investigated the determinants of vaccine hesitancy and concluded that individuals who were non-white, among other predictors, were more likely to be vaccine hesitant.[33] However, no information on the specific ethnic groups that participated were available. Similarly, another Canadian study assessing inequalities in COVID-19 vaccination uptake and intent in adults with CCHS data from June to August 2021 identified that visible minorities compared to those who are not part of a visible minority group were more likely to receive the COVID-19 vaccine because the number of participants were insufficient to analyze separately.[34] Several studies have identified this as a limitation;[35] however, few studies have examined vaccine hesitancy differences and factors by racial or ethnic group.[36,37]

COVID-19 Vaccine Hesitancy in the South Asian Diaspora

South Asian Diaspora Definition

South Asians are defined as those who originate from the Indian subcontinent (India, Pakistan, Bangladesh, Sri Lanka, and Nepal) and those with South Asian ancestry

who have immigrated from Fiji, Mauritius, Guyana, Uganda, among others.[37] It is currently one of the world's largest diasporas and the largest non-white ethnic group in Canada, accounting for over one-fourth of the total visible minority population and about 7% or 2.6 million people of the Canadian population in 2021.[38] In Ontario, South Asians accounted for 10.8% of its population and in British Columbia, 9.6% of its population.[38]

While there may be some similarities in the cultural, geographic, and demographic characteristics, it is important to distinguish that the South Asian diaspora is diverse. It is often identified as one group when the diaspora consists of communities that vary culturally, linguistically, and religiously. The overlook is primarily due to the lack in knowledge or exposure to diversity, leading to the generalization and perception of homogeneity. There have been criticisms of homogenizing diverse communities and the use of one broad term without acknowledging the heterogeneity between ethnic subgroups.[39] As a result, many subgroups are not adequately represented in research. It is important to recognize and acknowledge that South Asians are a heterogeneous group as it is the key to the applicability of research findings and the creation of tailored interventions.

Vaccine Hesitancy Rates and Comparisons with Other Groups

COVID-19 vaccine hesitancy has been described in the South Asian diaspora in the United States, United Kingdom, and Canada.[40] COVID-19 vaccine hesitancy studies largely present aggregate ethnicity data and South Asians are grouped into the broader Asian American group in the United States. In a national sample of adults in the United States, the prevalence of vaccine hesitancy was lower among Asian Americans (46.6%)

compared to White respondents (55.5%).[41] Asian Americans also had a lower odds of COVID-19 vaccine hesitancy compared to White respondents.[41] However, the broad classification of Asian Americans suppresses any differences between ethnic groups and overlooks the diversity within Asian Americans. In the United Kingdom, it was observed that COVID-19 vaccine hesitancy was higher among South Asian communities, particularly in the Pakistani and Bangladeshi communities compared to South Asians of Indian origin and their British counterparts.[42,43] In Canada, there are few reports of COVID-19 vaccine hesitancy among South Asians. COVID-19 vaccine coverage reports from 2021 to 2022 reveal higher coverage (96%) among a sample of South Asians than among those who are neither visible minorities or Indigenous (93%).[44]

While vaccine uptake is high in some South Asian communities, this does not imply low vaccine hesitancy levels, as it can persist after vaccination. Higher vaccine uptake may be attributed to the implementation of vaccine mandates by the government, re-opening initiatives, and the efforts of local organizations in culturally tailoring public health messaging and advocating for culturally sensitive testing and vaccination centers.[45,46]

Sociocultural Factors Influencing Vaccine Hesitancy

Sociocultural factors significantly influence health behaviours, thereby shaping attitudes towards vaccination and impacting vaccine hesitancy within the South Asian diaspora. These factors include health beliefs and practices, religion, family and community influences, language, immigration, and acculturation, amongst others.

Health beliefs and practices have a significant impact on vaccine attitudes. For example, many South Asians may prefer alternative forms of medicine and health options, which may be attributed to negative perceptions of vaccine safety and effectiveness.[47,48] As well, as evidenced in COVID-19 vaccine hesitancy studies in South Asian countries, some may prefer natural immunity as they believe it provides greater protection than the vaccine.[49]

Religious beliefs are also another factor that impact vaccine attitudes as concerns about the vaccine may vary between religious groups. For example, some Muslim communities and other religious groups were concerned about the ingredients in the COVID-19.[50] They were also hesitant to receive the vaccine during Ramadan due to concerns of side effects and potentially breaking their fast to receive the vaccine.[51]

Further, family and community dynamics also influence attitudes toward vaccination. Studies exploring factors influencing COVID-19 vaccine hesitancy among South Asians in the UK and Canada found that family and community influences impacted their perceptions of the vaccine due to their collectivist nature.[52,53] As many South Asians live in multi-generational households, it is not uncommon for healthcare decisions to be a collective decision by the entire family. Trusted community leaders, religious leaders, or healthcare professionals from the community are highly influential and effective in addressing vaccine hesitancy, as described by South Asian community organizations in Canada.[53,54]

Additionally, language and communication barriers can contribute to vaccine hesitancy as it limits their access to information about the vaccines. As a result, they may

seek out different sources of information and engage in peer-to peer-knowledge sharing.[53,55] However, in some contexts, this may have resulted in the spread of misinformation and disinformation, possibly contributing to vaccine hesitancy.[53,55,56] Public health messaging in various languages and culturally tailored are essential to improving vaccine uptake, as several community organizations have demonstrated during the pandemic.[53,55]

Immigration is also another factor that can influence vaccine hesitancy as recent immigrants may experience difficulties accessing and navigating an unfamiliar healthcare system due to cultural and linguistic barriers.[13,57,58]

There is a paucity of literature on factors influencing vaccine hesitancy in the South Asian community in the Canadian context, as well as on sociodemographic factors in this context. These factors have been extensively described in aggregate group of ethnic minorities in comparison to non-racialized or White groups. However, the effects of sociodemographic factors can vary across population subgroups due to intersecting social identities.[5] Therefore, more research is needed to characterize vaccine hesitancy in the South Asian diaspora and its ethnic subgroups to reveal any variations in vaccine hesitancy and identify factors contributing to vaccine hesitancy. This will ensure the development of evidence-based interventions to effectively address vaccine hesitancy within the South Asian community.

Strategies to Address COVID-19 Vaccine Hesitancy in the South Asian Diaspora

Vaccine hesitancy is a multifaceted phenomenon that is specific to context and time, thereby requiring a nuanced understanding to ensure the development of effective and equitable strategies to address vaccine hesitancy across various population subgroups. Studies on the South Asian community in Canada highlighted that community engagement is a significant factor in improving confidence in public health, building trust, and improving vaccine uptake.[53,54] A qualitative study of public health community engagement in Asian populations in BC emphasized the importance of using a culture-centered approach and collaborating with trusted community leaders to provide health services during the pandemic.[54] The authors also highlighted that community engagement should recognize the strengths and assets of specific groups, rather than concentrating on vulnerabilities in public health emergencies.[54] The COVID CommUNITY qualitative study conducted in South Asians across Ontario and BC, involving community members and leaders, revealed similar sentiments regarding community engagement and partnerships as effective strategies to increase vaccine uptake and education through traditional and non-traditional media sources.[53] Bhalla et al. further highlighted that that community leaders, non-profit organizations, local and grassroots organizations in Ontario contributed to the development of initiatives to improve public health messaging during the pandemic.[55] The authors noted that South Asian community members developed a culture of self-advocacy in response to inadequate support from the government and health services.[55]

A common theme in studies on South Asians from Ontario and BC was the significance of public health messaging and its cultural and linguistic relevance.[53,55,59] Bhalla et al. found that South Asians in Ontario felt that there was a lack of effective public health messaging that was culturally or linguistically relevant, which resulted in the spread of misinformation.[55] The COVID CommUNITY qualitative study also echoed the importance of incorporating language and cultural context into vaccine provision and education.[53] The SAY-VAC program, a community health promotion campaign, in the GTHA of Ontario was developed to combat COVID-19 vaccine misinformation using youth as agents of change.[59] They created and disseminated video products about the COVID-19 vaccine through multisectoral partnerships, highlighting the importance of collaboration in developing and disseminating culturally relevant health communication.

Overall, the importance of building trust and fostering meaningful connections with the community was a significant finding from studies involving community members, organizations, and public health staff. Several studies among South Asians and ethnic minorities emphasized the necessity of structural changes within the government to allow for meaningful community engagement and personalized communication to improve health communications and meet community needs.[54,55]

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Chapter 3: Manuscript – "Sociodemographic factors associated with vaccine hesitancy in South Asian community in Canada"

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Sociodemographic factors associated with vaccine hesitancy in the South Asian community in Canada

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Introduction

Vaccine hesitancy is defined by the World Health Organization (WHO) as the "delay in acceptance or refusal of vaccines despite the availability of vaccine services", and reflects a continuum of attitudes from those who accept all vaccines with confidence and those who refuse all vaccines with conviction.[1] WHO identified vaccine hesitancy as one of the top ten threats to global health in 2019; its relevance is heightened by the global COVID-19 pandemic.[1] Vaccine hesitancy can also be viewed as a multifactorial decision-making process that is highly intersectional and influenced by various scientific, socioeconomic, psychological, sociocultural, and political factors.[2] Due to the complex intersection of factors, vaccine hesitancy varies across different contexts, time periods, and populations.[1] Reasons for vaccine hesitancy may include vaccine safety concerns, the perception that vaccines were developed too rapidly to be safe, and concern over potential long-term side effects. Vaccine hesitancy has been shown to vary by sociodemographic factors including age, gender, education, income, and ethnicity, among others.[3,4]

In Canada, 80% of adults received at least two COVID-19 vaccine doses.[5] Despite the high estimated vaccine coverage, vaccine hesitancy may exist among those who choose to get vaccinated, illustrating the complexities of vaccine hesitancy.[6] Existing literature on COVID-19 vaccine hesitancy in Canada is consistent with that of general vaccines. One consistent finding was that vaccine hesitancy was higher among racialized populations.[4] However, few studies in Canada present disaggregated results by racial or ethnic group, as these characteristics are not collected routinely in healthcare administrative datasets, or as a result of limitations in sample size, therefore preventing a

nuanced understanding of vaccine hesitancy among ethnically diverse communities in Canada.

There is little literature on COVID-19 vaccine hesitancy in individual ethnic groups in Canada, including the South Asian community. South Asians are people who originate from the Indian subcontinent. They are the largest non-white ethnic group in Canada, representing more than one third of visible minorities in Ontario, and more than one quarter of visible minorities in British Columbia (BC).[7] South Asians were overrepresented among COVID-19 cases in Ontario, accounting for over 16% of COVID-19 cases from 26 June 2020 to 21 April 2021, yet made up only 8.6% of the population.[8] In the Canadian Community Health Survey (June 2021 through February 2022), 96% of South Asians received at least 1 dose of the COVID-19 vaccine compared to 93% of those who were not visible minorities.[5] This likely reflects the outreach work done across Canada during this unprecedented vaccine rollout.[9]

There are few reports of vaccine hesitancy among South Asians in Canada and those who choose to get vaccinated.[6,10] Understanding the factors associated with COVID-19 vaccine hesitancy is a necessary step towards the development of tailored strategies to improve vaccine uptake for future doses of the COVID-19 vaccines in this high-risk group, and for future waves of COVID-19 or other pandemics.

This study aimed to identify factors associated with vaccine hesitancy in the South Asian community in the Greater Toronto Hamilton Area (GTHA) and Greater Vancouver Area (GVA) in Canada.

Methods

A cross-sectional analysis of COVID CommUNITY South Asian, a prospective cohort study of South Asian adults in the GTHA in Ontario and GVA in BC was performed. The purpose of the study was to investigate vaccine access, immunogenicity, effectiveness, safety, and hesitancy among high-risk populations, including South Asians. The study was approved by the Hamilton Integrated Research Ethics Board (13323 — March 24, 2021) and the British Columbia Research Ethics Board (H21-00866—June 18, 2021).

Participants

Adults (18 + years) of self-identified South Asian ethnicity and having provided informed consent were eligible for the study (see screening form, available in ESM-1). Self-reported South Asian ethnicity was defined by parental South Asian ancestry from the Indian subcontinent, Africa, Caribbean, and/or Guyana. Recruitment primarily occurred from vaccine centres after receiving the vaccine, with a smaller proportion from places of worship, word of mouth/social media, and invitation of South Asian participants from existing cohort studies. In Ontario, recruitment spanned from 14 April to 30 October 2021, and in BC, from 21 June to 23 November 2021. Participants who completed the Vaccine Attitudes Examination (VAX) scale within 12 months of recruitment were included in this analysis (Figure 1).

Setting

In Ontario and BC, COVID-19 vaccine rollout occurred in a phased approach beginning in December 2020, prioritizing high-risk populations (e.g., long-term care residents, healthcare workers). Vaccines were available to the general adult population from May 2021 onwards, with COVID-19 vaccination mandates implemented by the federal government for international travel in October 2021, by both provincial governments for entering public settings or workplaces, and by individual employers, requiring mandatory vaccination starting from September 2021.

Data collection

At enrolment, research personnel collected sociodemographic information and vaccination status. Participants were encouraged to complete an in-person or online questionnaire (see ESM-2) via an emailed link. The questionnaire collected additional information regarding employment type, health history, prior SARS-CoV-2 infection, and general vaccine attitudes. If participants did not complete the questionnaire online, study staff contacted participants, asking them to complete the questionnaire and administering a subset of questions by telephone (first visit short questionnaire, available in ESM-2). Although the questionnaires were provided in English, research personnel, many of whom were of South Asian origin and spoke multiple South Asian languages, provided translation in participants' preferred language upon request.

Measures

Sociodemographic factors collected included age, sex at birth, median household income (2015) based on forward sortation area (FSA), highest level of education completed, employment status, marital status, time since immigration, multigenerational household, previous self-reported COVID-19 infection, and past medical history. The median household income was based on the FSA of the participant using 2015 Census tract data for classification by income status at the neighbourhood level.

Attitudes towards vaccines were measured using the VAX scale.[11] The VAX scale was developed to assess attitudes towards vaccines in general. It consists of 12 items categorized into 4 subscales: 1) mistrust of vaccine benefit, 2) worries about unforeseen future side effects, 3) concerns about commercial profiteering, and 4) preference for natural immunity.[11] These items are scored on a 6-point Likert scale with 1 indicating strongly disagree and 6 indicating strongly agree. Higher scores are interpreted as more vaccine hesitant. The VAX scale has been validated in the Italian, French, Spanish, Romanian, and Turkish populations within the COVID-19 context.[12–16] The original VAX scale has reported good internal consistency and sufficient convergent validity, and construct validity.[11]

Statistical Analysis

Standard descriptive statistics were calculated for sociodemographic variables and VAX scores. Cronbach's alpha values were calculated to assess the internal consistency of the VAX subscales with the overall scale. Confirmatory factor analysis (CFA) using SPSS Amos (v26) was performed to evaluate the construct validity of the VAX scale.

Model fit was evaluated using the Comparative Fit Index (CFI) (≥0.95), Tucker-Lewis Index (TLI) (≥0.95), and Root Mean Square Error of Approximation (RMSEA) (≤0.006).[17]

Non-responders to the VAX scale were compared with responders by age, sex, education, and income. Those who selected "prefer not to answer" for the time since immigration, employment, and marital status were compared to those who provided responses with respect to age, sex, education, and income.

A multivariable linear mixed effects model was constructed to identify sociodemographic factors associated with vaccine hesitancy and included a random effect for household to account for the correlation among multiple respondents within the same household. Variables were included in the multivariable models if the univariable relationship between sociodemographic factors and the mean VAX score had a p-value ≤ 0.20. Listwise deletion was used to handle missing data for variables missing less than 5% data. Where 5% or more of data were missing for a question, i.e., for time since immigration (13%), we included a "missing indicator" category. In the multivariable linear mixed effects model, variables with a p value of < 0.05 were considered statistically significant. Statistical analysis was conducted using SPSS v28 (2021).

Results

Between April and November 2021, a total of 2040 participants were enrolled into the COVID CommUNITY study, of whom 1910 participants were active and had complete data, and 1496 participants (73%) provided complete responses to the VAX scale and were included in the analysis (Figure 1). There were 1339 unique households with 1194

households having a single respondent. 71.1% (n = 1064) of participants were from Ontario and 28.9% (n = 432) of participants were from BC. Participants were recruited from vaccine centres (78%), places of worship (3%), social media and word of mouth (6%), and existing cohort studies (7%). Participants who did not complete the VAX scale were more likely to be male, be from Ontario, and have higher income levels. No important differences in age and education were observed (Supplementary Table 1).

The Cronbach's α for the 12-item VAX scale was 0.85, indicating good internal consistency. The Cronbach's alpha across the four subscales ranged from 0.78 to 0.90 (, Supplementary Table 2). The CFA demonstrated that the model was a good fit [CFI= 0.97; TLI= 0.96; RMSEA= 0.06, 90% CI= (0.05, 0.06)] (Supplementary Figure 1).

Demographic characteristics

The mean age of participants was 38.5 ± 15.3 years and 52.2% were female (Table 1). The most common mother tongue languages reported were Punjabi (49.3%), Hindi (10.9%), and Urdu (9.8%). The study participants were highly educated with over half of participants (59.1%) reporting having a university degree. Approximately two thirds of participants (64.6%) were employed, while 68.4% had a median neighbourhood household income of over $80,000. About half of participants (51.9%) were born in Canada or had lived in Canada for more than 10 years. Most participants reported not living in a multigenerational household (74.5%) and having no previous COVID-19 infection (82.3%). Nearly all (99.2%) participants received at least one dose of the COVID-19 vaccine.

The mean overall VAX score was 3.2 ± 0.8 points [range: 1.0–6.0] (Table 2). Greater vaccine hesitancy is indicated by higher VAX scores. The highest mean VAX score was in the "worries about unforeseen future effects" subscale with a score of 4.1 ± 1.1 points, followed by the "preference for natural immunity" subscale with a score of 3.5 ± 1.3 points. Lower scores reflecting less hesitancy were observed in the "concerns about commercial profiteering" subscale (2.9 ± 1.2 points), with the least hesitancy regarding the "mistrust of vaccine benefit" subscale (2.2 ± 1.1 points). No important differences in VAX scores between South Asians living in Ontario and those living in BC were observed, except for the "mistrust of vaccine benefit" subscale, which reflected greater mistrust among BC participants.

Multivariable analysis

The associations of sociodemographic factors with vaccine hesitancy measured by the VAX scale and adjusted mean VAX scores of sociodemographic factors are shown in Table 3 and Figure 2. Time since immigration ($p = 0.04$), previous COVID-19 infection ($p < 0.001$), marital status ($p < 0.001$), living in a multigenerational household ($p = 0.03$), age ($p = 0.02$), education ($p < 0.001$), and employment status ($p = 0.001$) were each associated with VAX scores (Table 3).

Overall, immigrants to Canada were more hesitant compared to those born in Canada, with lower vaccine hesitancy associated with longer duration of life in Canada (Figure 2). Compared to those born in Canada, immigrants who lived in Canada < 5 years, 5–10 years, or > 10 years scored progressively lower vaccine hesitancy points (0.22, 0.19, and 0.16, respectively). Participants reporting previous COVID-19 infection scored 0.2

points higher (95% CI: 0.1, 0.3) than those who did not report previous COVID-19 infection. Married or common-law participants scored 0.3 points higher (95% CI: 0.2, 0.4) and previously married (divorced/separated/widowed) participants scored 0.5 points higher (95% CI: 0.3, 0.7) compared to those who were never married. Participants living in a multigenerational household scored 0.1 points lower (95% CI: -0.2, 0.02) than those who reported not living in a multigenerational household. For every 10-year increase in age, there was a 0.05-point decrease (-0.1, -0.01) in the mean VAX score. For education, there was a lower vaccine hesitancy with a higher level of education completed. Those with a university degree scored 0.1 points lower (95% CI: -0.2, -0.02) and those with non-academic or vocational education and training scored 0.2 points higher (95% CI: 0.02, 0.3) than those who were high school graduates or less. Participants who were employed scored 0.07 points higher (95% CI: -0.04, 0.2) and participants who were retired scored 0.2 points lower (95% CI: -0.4, 0.01) than those who were unemployed.

Participants who selected "prefer not to answer" for time since immigration, employment status, and marital status scored higher on the VAX scale compared to those born in Canada, those unemployed, and those never married ($p = 0.01$, $p = 0.007$, and $p < 0.001$, respectively). Those selecting "prefer not to answer" at least once across these variables were younger, with no important differences observed in sex, income, and education (Supplementary Table 3).

Recruitment spanned seven months across both provinces, during which risk perceptions may have shifted with increased vaccine uptake due to vaccine mandates. In a sensitivity analysis, we examined differences in VAX scores before (14 April–31 August

2021) and after (1 September–23 November 2021) vaccine mandates. We observed that time period was associated with increased vaccine hesitancy in the second time period compared to the first, while other estimates showed minimal changes (Supplementary Table 4).

Discussion

Among South Asians from Ontario and BC, we identified that time since immigration, marital status, prior COVID-19 infection, age, multigenerational household status, education, and employment status were independently associated with vaccine hesitancy.

We observed that newer immigrants are more hesitant than settled immigrants or South Asians born in Canada, which may reflect lower familiarity with the healthcare system and less trust of public health advice.[18] This aligns with data indicating that immigrants face barriers accessing healthcare and health information due to economic and language barriers and cultural differences, which may contribute to greater hesitancy.[18] This is consistent with Canadian studies, which also demonstrated that immigrants were more likely to be hesitant.[19,20]

We observed that married/common-law individuals were more vaccine hesitant. This may reflect vaccine safety concerns at the time, including possible future effects on fertility, pregnancy, and breastfeeding.[21] Previous COVID-19 vaccine hesitancy studies found varying results regarding the effect of marital status on vaccine hesitancy. In a global scoping review, some studies demonstrated that unmarried individuals were more hesitant, and that being married was associated with higher vaccine acceptance.[22] Our

findings are consistent with other studies conducted in Canada and the United States, which demonstrate that married individuals were more vaccine hesitant.[6,23] Further, previously married individuals may have been more hesitant due to a lack of social support.

Individuals with prior COVID-19 infection were more vaccine hesitant than those who did not report prior infection, which may be due to their preference for infection-induced immunity, colloquially referred to as "natural" immunity. This includes beliefs that natural immunity may be better than vaccination and provide greater protection, which is consistent with other COVID-19 vaccine hesitancy studies in South Asian countries.[24] Alternatively, those with prior COVID-19 infection may have also been more hesitant due to breakthrough infections and vaccine effectiveness concerns.

Younger individuals were more vaccine hesitant than older individuals, which may reflect their perceptions of being healthier and feeling greater confidence of being able to "fight off the infection". Older individuals may be less hesitant due to their increased vulnerability to COVID-19 and consequences as a result of chronic illnesses or other conditions. This may be attributed to public perceptions of risk, given that more severe and mortal outcomes during the pandemic were experienced by older individuals. A systematic review and meta-analysis found that Canadian studies demonstrated varying effects of age on COVID-19 vaccine hesitancy. Most studies, consistent with our findings, have demonstrated that vaccine hesitancy among younger age groups was likely due to lower COVID-19 risk perception.[4]

We observed that individuals living in a multigenerational household were less vaccine hesitant than those who reported not living in a multigenerational household. Although individual perspectives within a household vary, less hesitancy may be attributed to increased social support, an increased awareness of health risks affecting high-risk individuals in the family, and perceptions being informed by the community due to the collectivist nature of South Asian cultures.[25,26]

Individuals with a university degree were observed to be less vaccine hesitant and individuals with a non-academic or vocational education and training were observed to be more hesitant compared to high school graduates or less. This non-linear relationship has also been observed in other studies.[27] Individuals may be more or less hesitant across different education levels because of the risks and side effects of the vaccine, lack of knowledge, or lack of trust in the vaccine.[28]

We also observed that employed individuals were more vaccine hesitant, while retired individuals were less hesitant, compared to individuals who were unemployed. Employed individuals may be more hesitant due to concerns about potential side effects of the vaccine interfering with their ability to work.[29] Retired individuals' lower vaccine hesitancy may be in part due to older age and their increased vulnerability to COVID-19, as previously mentioned.

Previous research in Canada indicates higher COVID-19 vaccine hesitancy among those who are younger, female, married, immigrants, or racialized, or have a lower educational level.[4] Reasons for COVID-19 vaccine hesitancy among racialized people may include institutional mistrust, vaccine development concerns, lack of reliable

information, and vaccine safety and effectiveness concerns.[10] This is consistent with other research conducted in the South Asian context. A study conducted among South Asians in Ontario that aimed to identify areas for improvement in public health communication found that the lack of accessible and culturally relevant information resulted in the spread of misinformation and contributed to vaccine hesitancy.[30] This study reveals the complexities of vaccine hesitancy, with sociodemographic factors having varying effects across different populations. This highlights the importance of disaggregated data by ethnicity and by those who choose to be vaccinated, as hesitancy may persist, particularly with booster doses. A nuanced understanding of vaccine hesitancy and a collaborative approach involving healthcare professionals, policymakers, and community leaders are essential to address the complex intersection of factors driving hesitancy. One such model emerged during the COVID-19 pandemic in Peel Region in Ontario, where the local public health unit partnered with a South Asian Taskforce that assisted with both communications and outreach as well as delivery of vaccinations in a specialized, culturally congruent clinic targeted at the South Asian population.[31]

Strengths and limitations of the study

The strengths of our study included its large size, inclusion of South Asians in Canada from Ontario and BC and particularly in "hot-spot" regions in those two provinces, and our direct measure of ethnicity, as all study participants self-identified as South Asian. The limitations of our analysis include the non-random study sample, given that over 78% of participants were recruited from vaccine centres and > 99% were vaccinated with at least one dose of the COVID-19 vaccine, limiting the generalizability

of our results to a broader population. This was due to our study being part of a larger research project with a primary objective of assessing seropositivity through the collection of dried blood spots. As a result, participants were primarily recruited in-person at vaccination centres, contributing to the high vaccination rate observed in our study sample.

Our estimates of vaccine hesitancy are likely an underestimate, as those who refused or delayed the vaccine at the time and those who were not as likely to present to a vaccine centre were not included. Therefore, our findings may not be representative of the entire South Asian population in Canada. However, COVID-19 vaccine mandates implemented in Ontario and BC during our study recruitment period may have captured highly hesitant individuals getting vaccinated due to vaccine mandates as shown in our sensitivity analysis. It showed that overall vaccine hesitancy in the second time period compared to the first increased, which is correlated with the timing of vaccine mandates starting in September 2021 (Supplementary Table 4). The VAX scale was designed to assess general vaccine attitudes; however, the questionnaire was administered during the COVID-19 pandemic, and participant responses may be reflective of their attitudes toward COVID-19 vaccines rather than toward vaccines in general. While it may be considered a limitation that participants who selected "prefer not to answer" were included in this analysis, we analyzed the characteristics of this group. The significant association of "prefer not to answer" and higher VAX scores highlights the influence of non-response in our findings as such participants may have chosen not to provide certain demographic information due to the sensitivity of the topic, stigma, or complexities of

their immigrant status. Participants who chose "prefer not to answer" for time since immigration, employment status, and marital status had higher VAX scores and were younger but did not differ in other characteristics from responders. While our study provides insights into the South Asian population from two regions in the country, the findings have limited generalizability to other ethnic populations in Canada. Further, causality cannot be established due to the cross-sectional nature of this analysis.

Conclusion

Among South Asians from two regions in Canada (the provinces of Ontario and British Columbia), time since immigration, marital status, prior COVID-19 infection, age, multigenerational household status, education, and employment status were each independently associated with vaccine hesitancy. This information highlights the importance of understanding the factors associated with vaccine hesitancy in non-white ethnic groups. A multi-faceted, tailored approach, including targeted messaging, building trust, and actively collaborating with community organizations with a focus on new immigrants, younger people, and other key sociodemographic factors is required to effectively address vaccine hesitancy and enhance vaccine uptake in the future.

Contributions to knowledge

What does this study add to existing knowledge?

- This study provides insights into the sociodemographic factors associated with vaccine hesitancy among a sample of South Asians and vaccinated individuals in

Canada, contributing to a limited knowledge base on vaccine hesitancy in this ethnic group.

- Results from our study demonstrate that factors associated with hesitancy include time since immigration, marital status, prior COVID-19 infection, age, multigenerational household status, education, and employment status.

What are the key implications for public health interventions, practice, or policy?

- This study conducted in a high-risk community offers valuable insights into the complexities of vaccine hesitancy. The study underscores the importance of developing and implementing tailored public health communication strategies in collaboration with communities to address unique sociodemographic factors, including a focus on new immigrants, younger people, those who are married, and those who live in multigenerational households.
- Such communication and health promotion strategies may be useful to promote vaccine uptake in the South Asian population for future COVID-19 waves or pandemics.

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Tables and Figures

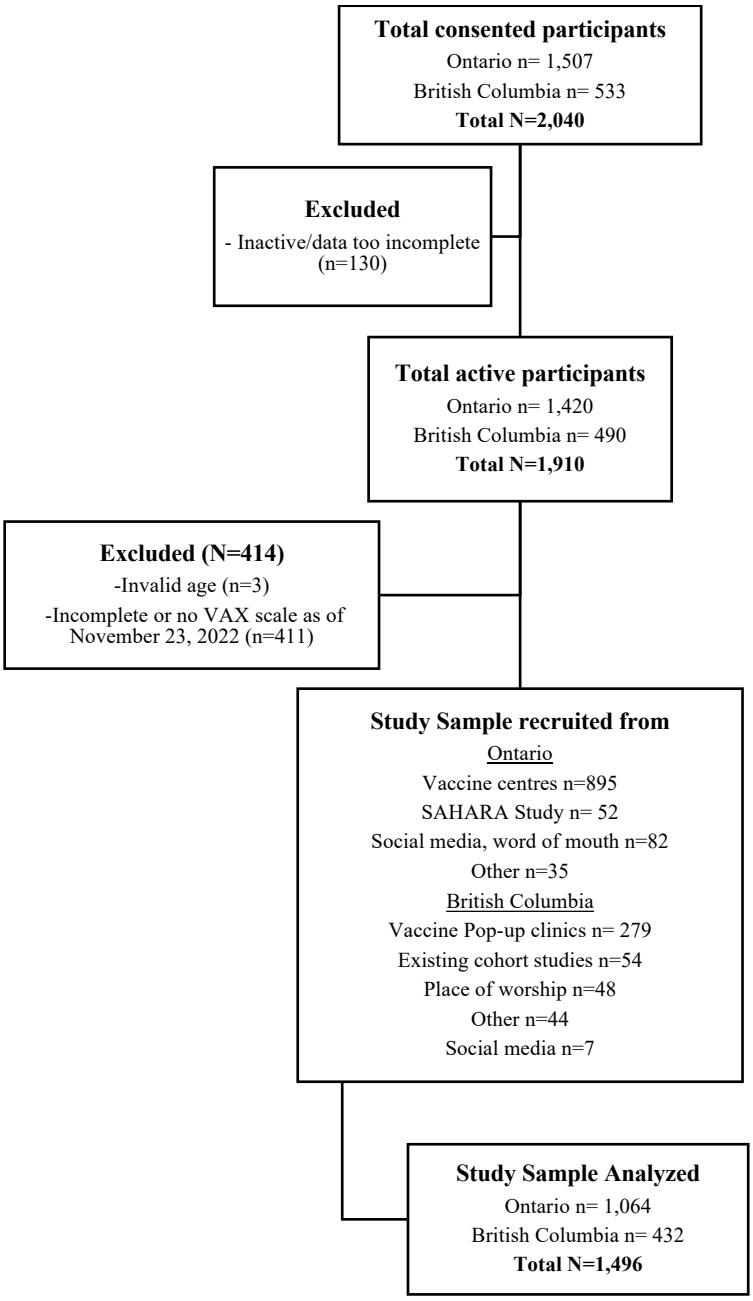


Figure 1: CONSORT diagram

Table 1: Demographic characteristics of study participants (N=1496)

Demographic Factors	N (%)
Age	
18-24	308 (20.6%)
25-34	413 (27.6%)
35-44	309 (20.7%)
45-54	211 (14.1%)
55-64	134 (9.0%)
65+	117 (7.8%)
Missing	4 (0.3%)
Sex	
Male	701 (46.9%)
Female	781 (52.2%)
Prefer to self-describe	3 (0.2%)
Prefer not to answer	8 (0.5%)
Missing	3 (0.2%)
Mother Tongue	
Punjabi	738 (49.3%)
Hindi	163 (10.9%)
Urdu	147 (9.8%)
English	140 (9.4%)
Gujarati	130 (8.7%)
Tamil	77 (5.1%)
Bengali	29 (1.9%)
Other South Asian languages	118 (7.9%)
Prefer not to answer	8 (0.5%)
Highest level of education completed	
Less than high school graduation	32 (2.1%)

High school graduate	281 (18.8%)
Trade certificate, vocational school, or apprenticeship training	32 (2.1%)
Non-university certificate or diploma from a community college, CEGEP	180 (12.0%)
University bachelor's degree	515 (34.4%)
University graduate degree (e.g., masters or doctorate)	370 (24.7%)
Prefer not to answer	78 (5.2%)
Missing	8 (0.5%)
Marital Status	
Never Married	448 (29.9%)
Common law/Living with partner	39 (2.6%)
Currently married	856 (57.2%)
Divorced/Separated	47 (3.1%)
Widowed	23 (1.5%)
Prefer not to answer	75 (5.0%)
Missing	8 (0.5%)
Employment Status	
Employed	967 (64.6%)
Unemployed	200 (13.4%)
Retired	98 (6.6%)
Temporarily laid off due to COVID-19	29 (1.9%)
Permanently laid off due to COVID-19	9 (0.6%)
Prefer not to answer	185 (12.4%)
Missing	8 (0.5%)
Median neighbourhood household income	
$0-$39,999	0
$40,000-$59,999	49 (3.3%)
$60,000-$79,999	415 (27.7%)

$80,000-$99,999	775 (51.8%)
$100,000+	248 (16.6%)
Missing	9 (0.6%)
Time since immigration	
Born in Canada	199 (13.3%)
10 years or more	578 (38.6%)
5 – 10 years	147 (9.8%)
< 5 years	324 (21.7%)
Prefer not to answer	58 (3.9%)
Missing	190 (12.7%)
Multigenerational household	
Yes	202 (13.5%)
No	1114 (74.5%)
Prefer not to answer	166 (11.1%)
Missing	14 (0.9%)
Any recorded infection of COVID-19	
Yes	246 (16.4%)
No	1231 (82.3%)
Prefer not to answer	15 (1.0%)
Missing	4 (0.3%)
Medical history of cardiovascular disease (myocardial infarction, angioplasty, or stroke)	
Yes	40 (2.7%)
No	1449 (96.9%)
Missing	7 (0.5%)
Chronic medical conditions requiring medication	
Diabetes	
Yes	93 (6.2%)
No	1376 (92.0%)

Missing	27 (1.8%)
Hypertension	
Yes	102 (6.8%)
No	1367 (91.4%)
Missing	27 (1.8 %)
Heart disease or Stroke	
Yes	19 (1.3%)
No	1450 (96.9%)
Missing	27 (1.8%)
Arthritis	
Yes	22 (1.5%)
No	1447 (96.7%)
Missing	27 (1.8%)
Chronic Lung Disease	
Yes	3 (0.2%)
No	1466 (98.0%)
Missing	27 (1.8%)
Vaccinated against COVID-19	
No	9 (0.6%)
Yes, one or more doses*	1,484 (99.2%)
Prefer not to answer	1 (0.1%)
Missing	4 (0.3%)

*78% of participants were recruited at vaccine centres.

Table 2: VAX scale characteristics of participants (N=1496)

	Mean VAX Score (SD)		
	Overall (N=1496)	**Ontario (n=1064)**	**British Columbia (n=432)**
Overall VAX Score	3.2 (0.8)	3.2 (0.8)	3.2 (0.9)
Mistrust of vaccine benefit subscale	2.2 (1.1)	2.1 (1.0)	2.4 (1.2)
Worries about unforeseen future effects subscale	4.1 (1.1)	4.1 (1.1)	4.1 (1.1)
Concerns about commercial profiteering subscale	2.9 (1.2)	2.9 (1.2)	3.0 (1.3)
Preference for natural immunity subscale	3.5 (1.3)	3.5 (1.3)	3.5 (1.3)

Table 3: Multivariable linear mixed effects model of sociodemographic factors associated with vaccine hesitancy measured by VAX Score

Factor	**Parameter Estimate**	**95% Confidence Interval**	**P-Value**
Time since immigration			0.04
Born in Canada (Reference group)			
>10 years in Canada	0.16	(0.01, 0.30)	
5-10 years in Canada	0.19	(0.01, 0.37)	
<5 years in Canada	0.22	(0.07, 0.37)	
Prefer not to answer	0.33	(0.08, 0.58)	
Missing	0.20	(0.03, 0.37)	
Previous COVID-19 infection			<0.001
No (Reference group)			
Yes	0.22	(0.11, 0.34)	
Prefer not to answer	0.03	(-0.38, 0.43)	
Marital Status			<0.001
Never married (Reference group)			
Currently married/Common law/Living with partner	0.28	(0.16, 0.40)	
Previously married	0.50	(0.28,0.73)	
Prefer not to answer	0.44	(0.21, 0.68)	
Multigenerational household			0.03
No (Reference group)			
Yes	-0.11	(-0.23, 0.02)	
Prefer not to answer	0.13	(-0.01, 0.27)	
Sex at birth			0.40
Male (Reference group)			

Female	-0.04	(-0.12, 0.04)	
Prefer not to answer	-0.30	(-0.87, 0.27)	
Age (per 10 years)	-0.05	(-0.1, -0.01)	0.02
Highest Level of Education Completed			<0.001
High school graduate or less (Reference group)			
Non-academic or vocational education and training	0.16	(0.02, 0.31)	
University bachelor's or graduate degree	-0.13	(-0.23, -0.02)	
Prefer not to answer	0.02	(0.21, 0.25)	
Employment Status			0.001
Unemployed (Reference group)			
Retired	-0.21	(-0.43, 0.01)	
Employed	0.07	(-0.04, 0.19)	
Prefer not to answer	0.23	(0.06, 0.40)	

Intraclass correlation coefficient of 0.45.

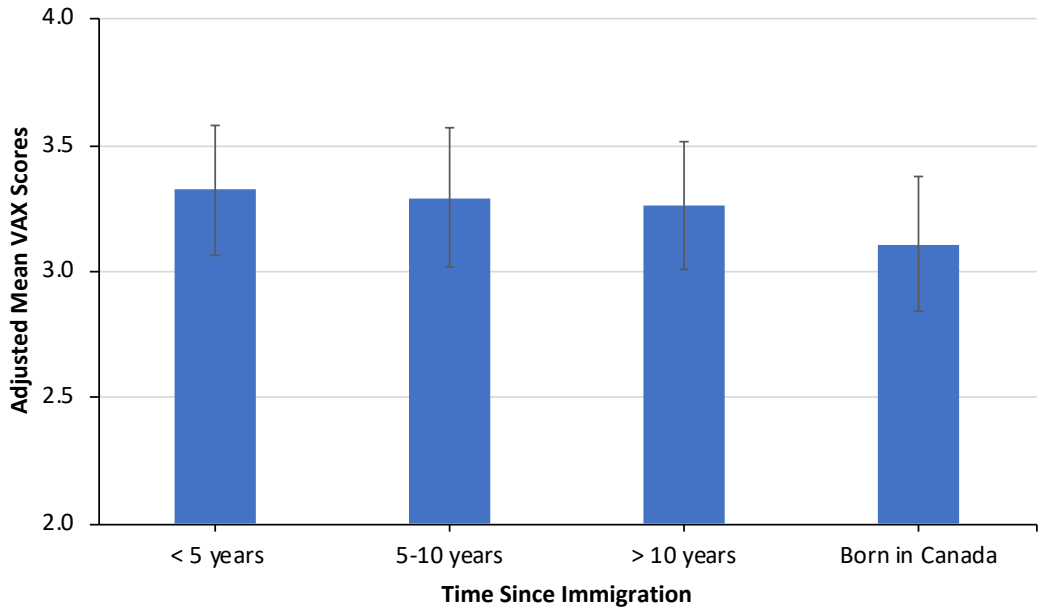


Figure 2: Adjusted Mean VAX Scores and 95% Confidence Intervals by Time Since Immigration

Appendices

Appendix A: Screening Form

COVID CommUNITY - South Asian screening

Welcome and thank you for your interest in the COVID CommUNITY study.

This is an online consent form that you will need to complete to continue with the COVID CommUNITY study. Please read each section carefully.

A study team member should be with you to discuss the consent with you and answer any questions you may have.

Thank you and please do not hesitate to contact the study team if you have any questions.

CONTACT INFORMATION	
TODAY	_____
[name_text]	_____
Name question text.	_____
Are you at least 18 years old?	◯ Yes ◯ No
Do you self-identify as South Asian?	◯ Yes ◯ No
Email address	_____
OPTIONAL: Email address of Witness (Translator) If you would like to have someone you know and trust read the consent form with you to make sure you fully understand it before signing, please enter their email address here. This email address will only be used to send them the consent form to read and sign as a witness.	_____
Where did you find out about us?	◯ Brampton soccer centre immunization clinic ◯ Embassy Grand Convention Centre immunization clinic ◯ Embassy Grand Convention Centre Testing Site ◯ Through another study ◯ Social Media ◯ Word of mouth (friend or family) ◯ Pharmacy ◯ Other, specify: _____
Where did you find out about us?	◯ BC pop up clinics ◯ Through another study ◯ Social Media ◯ Place of Worship ◯ Other, please specify: _____

Please specify which social media platform you were on when you heard about us:	◯ Facebook ◯ Instagram ◯ Twitter ◯ WhatsApp ◯ Other, please specify: _____
Is this your final COVID-19 vaccine dose?	◯ Yes ◯ No
Which study are you already a part of?	◯ SAHARA ◯ START ◯ RICH Legacy ◯ Canadian Alliance for Healthy Hearts and Minds (CAHHM)
Which study are you already a part of?	◯ SAHARA ◯ MCHAT ◯ RICH Legacy
DAG	_____
Study ID	_____
Parent Cohort Referral number	_____

Sorry, you are not eligible to participate in this study.
Thank you for your interest.

Appendix B: First visit short questionnaire

First Visit Short Questionnaire

This is an abbreviated survey, with the essential questions that you have not yet completed. It should take somewhere between < 1 and 10 minutes to complete.

If you have any questions about this survey or any other aspects of the study, please contact the study team at [studyemail].

Vaccination status

Date of Phone Survey

Person completing phone survey

Have you been vaccinated against the coronavirus (COVID-19)?

◯ Yes, fully
◯ Yes, first dose and await second dose
◯ No
◯ Prefer not to answer

Has the vaccine been offered to you?

◯ Yes
◯ No, please explain: ------
◯ Prefer not to answer

Which vaccine did you receive?

◯ Pfizer
◯ Moderna
◯ Astra Zeneca
◯ Johnson & Johnson
◯ I don't know
◯ Other, specify: ------

Date of first vaccine

Date of second vaccine ------ ------

Original date of the second vaccine

Has the date for your second COVID-19 vaccine changed? ◯ Yes ◯ No
Your original scheduled vaccine date was [psoldt]

When is your new appointment for the second dose?

Have you received a booster shot for the COVID-19 vaccine?

◯ Yes
◯ No
◯ Prefer not to answer

Which vaccine did you receive for your booster shot?

◯ Pfizer
◯ Moderna

Date of booster vaccine

Did you experience an adverse event(s) from the vaccine for which you sought medical attention?

◯ Yes ◯ No ◯ Prefer not to answer

Vaccine Confidence

For the next set of questions, please indicate how strongly you agree or disagree with each statement.

Domain 1: Mistrust of vaccine benefit

	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly Agree
I feel safe after being vaccinated.	○	○	○	○	○	○
I can rely on vaccines to stop serious infectious diseases.	○	○	○	○	○	○
I feel protected after getting vaccinated.	○	○	○	○	○	○

Domain 2: Worries about unforeseen future events

	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly Agree
Although most vaccines appear to be safe, there may be problems that we have not yet discovered.	○	○	○	○	○	○
Vaccines can cause unforeseen problems in children.	○	○	○	○	○	○
I worry about the unknown effects of vaccines in the future.	○	○	○	○	○	○

Domain 3: Concerns about commercial profiteering

	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly Agree
Vaccines make a lot of money for pharmaceutical companies, but do not do much for regular people.	○	○	○	○	○	○
Authorities promote vaccination for financial gain not for people's health	○	○	○	○	○	○
Vaccination programs are a big con.	○	○	○	○	○	○

Domain 4: Preference for natural immunity						
	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly Agree
Natural immunity lasts longer than a vaccination.	○	○	○	○	○	○
Natural exposure to viruses and germs gives the safest protection.	○	○	○	○	○	○
Being exposed to diseases naturally is safer for the immune system than being exposed through vaccination.	○	○	○	○	○	○

COVID-19 history

Do you think you have had COVID-19?

◯ Yes
◯ No
◯ Prefer not to answer

How do you know you had COVID-19?

☐ Online Symptom review
☐ I had symptoms of COVID-19
☐ Positive COVID-19 Nasal/throat test result
☐ Positive COVID-19 Blood test
☐ A Health care provider told me
☐ I was in contact with a confirmed case of COVID-19
☐ Other, please specify: ------
☐ Prefer not to answer

What was the date you were diagnosed?

What treatment did you receive?

☐ Self-isolation (Quarantine) at home or at an isolation facility
☐ Hospitalized ------
☐ Prefer not to answer

Other health history

Have you ever...

Had a heart attack?	◯ Yes	◯ No	◯ Unsure
Had angioplasty, stent in your heart, or heart bypass surgery?	◯ Yes	◯ No	◯ Unsure
Suffered a stroke?	◯ Yes	◯ No	◯ Unsure
Been diagnosed with cancer?	◯ Yes	◯ No	◯ Unsure
Do you have a chronic medical condition that requires you to take medication(s) everyday?	◯ Yes	◯ No	◯ Prefer not to answer

Please specify which condition(s) require you to take medication everyday.

☐ Diabetes
☐ High blood pressure
☐ Heart disease or Stroke
☐ Arthritis
☐ Chronic Lung Disease
☐ Cancer
☐ Other, specify: ------

Demographics & other contextual information

What is your mother tongue?

☐ Bengali
☐ English
☐ Gujarati
☐ Hindi
☐ Punjabi
☐ Tamil
☐ Urdu
☐ Other, specify: ------
☐ Prefer not to answer

What is your religious affiliation?

☐ Buddhism
☐ Christianity
☐ Hinduism
☐ Islam
☐ Jainism
☐ Sikhism
☐ Other, specify: ------
☐ Prefer not to answer

Were you born in Canada?

◯ Yes
◯ No
◯ Prefer not to answer

What is the highest level of education you have completed?

◯ Less than high school graduation
◯ High school graduate
◯ Trade certificate, vocational school, or apprenticeship training
◯ Non-university certificate or diploma from a community college, CEFEP
◯ University bachelor's degree
◯ University graduate degree (e.g. masters or doctorate)
◯ Prefer not to answer

What is your marital status?

◯ Never Married
◯ Common law/Living with partner
◯ Currently married
◯ Divorced/Separated
◯ Widowed
◯ Prefer not to answer

What is your current employment status?

◯ Employed, please specify where you work: ------
◯ Unemployed
◯ Retired
◯ Temporarily laid off due to COVID-19
◯ Permanently laid off due to COVID-19
◯ Prefer not to answer

What is your best estimate of the total income of ALL household members from ALL sources in the past 12 months (before taxes)?

◯ $0 - 19,999
◯ $20,000 - 39,999
◯ $40,000 - 59,999
◯ $60,000 - 79,999
◯ $80,000 - 99,999
◯ $100,000 and above
◯ Prefer not to answer

What is your country of birth?

◯ India
◯ Pakistan
◯ Sri Lanka
◯ Bangladesh
◯ Guyana
◯ Trinidad
◯ Uganda
◯ Tanzania
◯ South Africa
◯ United Arab Emirates
◯ Other, specify: ------
◯ Prefer not to answer

How many years have you lived in Canada?

◯ < 5 years
◯ 5 - 10 years
◯ > 10 years
◯ Prefer not to answer

How many people reside in your immediate household, including yourself?

Children under 18 years old ------ ------
Adults 18 to 59 years old ------
Adults 60 to 69 years old ------
Adults 70 to 79 years old ------
Adults 80+ years old ------

Have you ever smoked any tobacco products (cigarettes)? ◯ Yes ◯ No

Have you smoked in the last 12 months? ◯ Yes ◯ No

What was your average smoking pattern over the last 12 months?

I smoked on average ------ cigarettes ------

Average number of cigarettes smoked in a day

Supplementary Tables and Figures

Supplementary Table 1: Demographics in responders versus non-responders for the VAX scale

		Completed VAX Scale	
	Overall	**Yes**	**No**
N	1910	1496	414
Female (%)	51.0	52.7	46.5
Age (SD)	38.6 (15.3)	38.5 (15.3)	39.1 (15.3)
Median neighbourhood household income >=$80,000 (%)	70.5	68.7	80.1
University degree (%)	62.9	63.5	55.6

Supplementary Table 2: Alpha reliabilities of subscales and overall mean VAX score

	Cronbach's Alpha
Mistrust of vaccine benefit subscale	0.90
Worries about unforeseen future effects subscale	0.78
Concerns about commercial profiteering	0.81
Preference for natural immunity	0.85
Overall VAX score	**0.85**

Supplementary Table 3: Demographics in responders versus at least one "prefer not to answer" response for time since immigration, marital status, and employment status

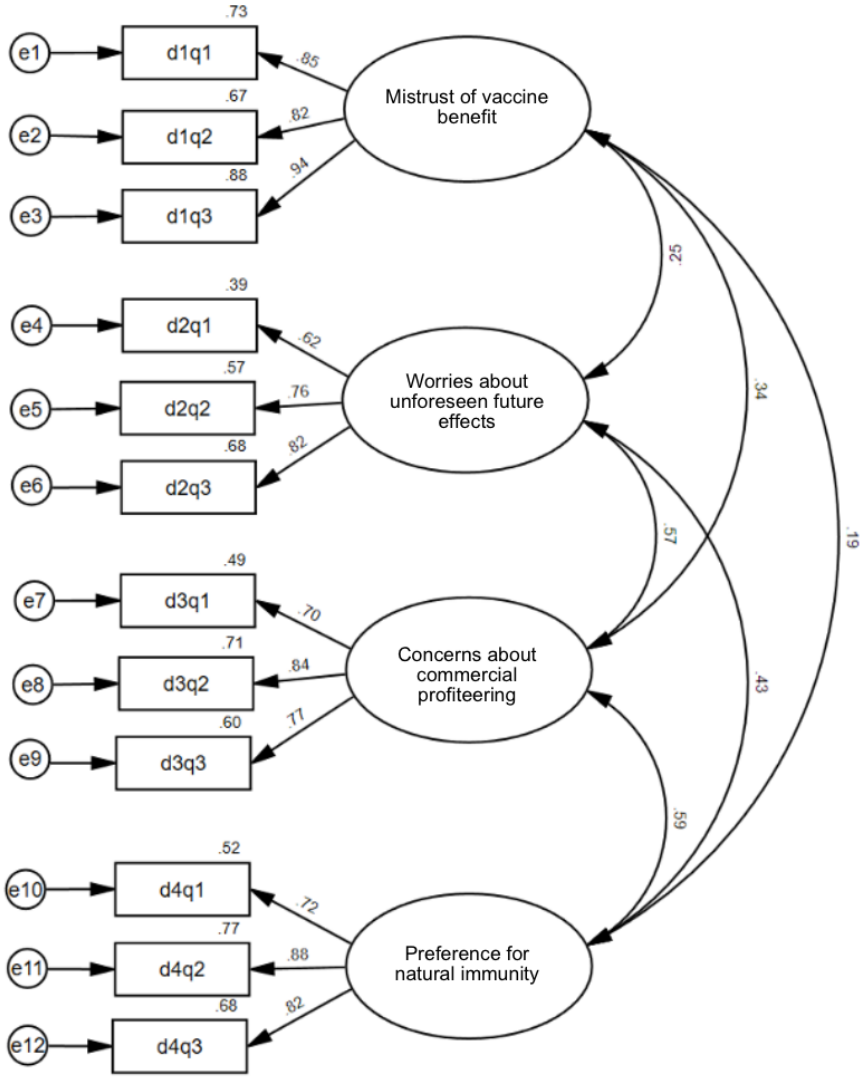
		At least 1 "prefer not to answer" response	
	Overall	**No**	**Yes**
N	1496	1257	239
Female (%)	52.7	53.1	50.4
Age (SD)	38.5 (15.3)	38.8 (15.5)	36.7 (14.0)
Median neighbourhood household income >=$80,000 (%)	68.8	68.9	68.4
University degree (%)	62.8	62.9	62.1

Note: Those who selected "prefer not to answer" at least once across the time since immigration, marital status, and employment status questions were slightly younger, while slightly more females provided responses.

Supplementary Table 4: Sensitivity analysis of sociodemographic factors associated with vaccine hesitancy measured by VAX score across different time periods based on VAX scale completion date

Factor	Parameter Estimate	95% Confidence Interval	P-Value
Time since immigration			0.10
Born in Canada (Reference group)			
>10 years in Canada	0.16	(0.01, 0.30)	
5-10 years in Canada	0.19	(0.01, 0.37)	
<5 years in Canada	0.19	(0.04, 0.33)	
Prefer not to answer	0.31	(0.06, 0.56)	
Missing	0.14	(-0.03, 0.31)	
Previous COVID-19 infection			0.002
No (Reference group)			
Yes	0.20	(0.09, 0.32)	
Prefer not to answer	0.02	(-0.38, 0.42)	
Marital Status			<0.001
Never married (Reference group)			
Currently married/Common law/Living with partner	0.27	(0.15, 0.39)	
Previously married	0.49	(0.26,0.71)	
Prefer not to answer	0.42	(0.19, 0.65)	
Multigenerational household			0.05
No (Reference group)			

Yes	-0.10	(-0.23, 0.02)	
Prefer not to answer	0.12	(-0.02, 0.25)	
Sex at birth			0.35
Male (Reference group)			
Female	-0.04	(-0.12, 0.04)	
Prefer not to answer	-0.33	(-0.89, 0.24)	
Age (per 10 years)	-0.04	(-0.09, 0.001)	0.06
Highest Level of Education Completed			<0.001
High school graduate or less (Reference group)			
Non-academic or vocational education and training	0.17	(0.03, 0.31)	
University bachelor's or graduate degree	-0.11	(-0.22, -0.01)	
Prefer not to answer	0.03	(0.20, 0.25)	
Employment Status			0.002
Unemployed (Reference group)			
Retired	-0.22	(-0.44, -0.001)	
Employed	0.06	(-0.06, 0.17)	
Prefer not to answer	0.23	(0.06, 0.40)	
Time period based on VAX scale completion			<0.001
Pre-vaccine mandates: April 14, 2021 to August 31, 2021 (Reference group)			
Post-vaccine mandates: September 1, 2021 to November 23, 2021	0.19	(0.11, 0.28)	



Supplementary Figure 1: Confirmatory factor analysis of VAX scale

Chapter 4: Conclusion

Summary of Findings

The purpose of this study was to identify the sociodemographic factors associated with vaccine hesitancy as measured by the VAX scale among a highly selected sample of

South Asian adults aged 18 years and older from the GTHA of Ontario and GVA of BC. A total of 1,496 participants reporting South Asian ethnicity were recruited between April and November 2021. Nearly all participants received at least one dose of the COVID-19 vaccine. During this time, COVID-19 vaccination mandates were implemented by the government limiting international travel or entering public settings; similar vaccine mandates were also implemented by workplaces with individual employers requiring mandatory vaccination of their employees.[1–3] Study participants were recruited from vaccine centres, places of worship, existing cohort studies, through word of mouth, and social media. A cross-sectional analysis of a prospective cohort study was performed using a multivariable linear mixed effects model to identify sociodemographic factors associated with vaccine hesitancy.

We identified that time since immigration, prior COVID-19 infection, marital status, residence in a multigenerational household, age, education, and employment status were independently associated with vaccine hesitancy. We observed that newer immigrants, married/common-law individuals, individuals with prior COVID-19 infection, younger individuals, employed individuals, and individuals with a non-academic or vocational education and training were more vaccine hesitant. In contrast, individuals living in a multigenerational household, individuals with a university degree, and retired individuals were less vaccine hesitant. Additionally, the VAX scale demonstrated good internal consistency (α=0.85) and a CFA demonstrated that the model was a good fit (CFI = 0.97; TLI = 0.96; RMSEA = 0.06, 90% CI = 0.05, 0.06). In a sensitivity analysis, we examined differences in VAX scores of vaccine attitudes before

and after the implementation of vaccine mandates. We found that vaccine hesitancy increased in the second time period, following the implementation of vaccine mandates, as compared to the period prior.

Implications for Public Health and Future Directions

This project provides insights into the sociodemographic factors associated with vaccine hesitancy in the South Asian population in Canada and is one of the very few studies that focus on vaccine hesitancy in this population. These findings can be used to develop public health programs that focus on vaccine hesitant groups such as new immigrants, younger people, married individuals, and individuals living in multigenerational households, along with other factors. Further research should extend beyond sociodemographic factors, such as individual and group influences; vaccine/vaccination-specific influences; and contextual influences as outlined in the SAGE vaccine hesitancy determinants matrix to gain a comprehensive understanding of hesitancy and develop effective interventions.

This study fills a gap in literature on vaccine hesitancy in the South Asian population and highlights the need for further exploration of this phenomenon. It also emphasizes the importance of further research needed within diverse subgroups of the South Asian population to gain a nuanced understanding of variations in vaccine hesitancy. Current evidence largely presents aggregate ethnicity data and results in reference to non-racialized groups due to a lack of ethnic diversity during recruitment and/or small sample sizes. This has an impact on the development of public health policies and programs to effectively address vaccine hesitancy. An evidence-based

approach to developing tailored, equitable, and culturally sensitive interventions is crucial to promote vaccine uptake. The importance of collaborating with communities to understand and address specific concerns and barriers has been clearly demonstrated throughout the pandemic.[4–7] As the landscape of COVID-19 evolves with newer variants and formulations of the vaccine, a contemporary approach is required to ensure interventions are reflective of changes in vaccine attitudes and constantly shifting knowledge.

Further research is needed on the diverse perspectives of the various South Asian subgroups to gain a deeper understanding of vaccine hesitancy and its trends. South Asians are one of the most diverse ethnic groups consisting of several subgroups that vary by culture, language, history, immigration patterns, acculturation, and demographic profiles. Recognizing the diversity of South Asians is essential as stratifying ethnic groups to understand variations that may exist between these subgroups will allow for tailored interventions, which are consistent with the needs of the community.

Furthermore, our study was limited to South Asians in predominantly urban areas of Ontario and BC. Future studies should explore the experiences of South Asians living in rural or remote areas across Canada to understand their unique perspectives. Additionally, our study demonstrated that vaccine hesitancy progressively decreased with increased time since immigration. Future research should explore the effects of immigrant categories (i.e., economic, refugee, etc.) as different immigrants have differing socioeconomic and demographic profiles and face unique challenges. Overall, representation and inclusion of South Asians by demographics and geographic location in

future studies would allow for a nuanced understanding of vaccine hesitancy and aid in the development of tailored interventions.

Similar to other studies, our study was limited to a cross-sectional analysis, which does not capture trends in vaccine hesitancy over time or the way vaccine hesitancy may evolve as perceptions and attitudes change with the political climate, economic factors, social media, and misinformation. As vaccine hesitancy is influenced by context and time, the generalizability of this project is limited to attitudes during a specific time period. Further research using longitudinal study designs are needed to understand the dynamics of vaccine hesitancy over a period of time. Additionally, future studies should validate existing vaccine hesitancy measurement tools across different populations to ensure that it accurately measures hesitancy and allows for meaningful comparisons.

Finally, further studies should investigate the interactions between sociodemographic factors to enhance our understanding of vaccine hesitancy, which is influenced by intersecting social identities. Overall, this study forms the foundation for future studies necessary to understand the factors contributing to vaccine hesitancy among South Asian communities in Canada.

Final remarks

This thesis investigated the sociodemographic factors associated with vaccine hesitancy among the South Asian community from two regions in Canada during the COVID-19 pandemic. It is one of the very few reports of COVID-19 vaccine hesitancy in the South Asian population in Canada and in vaccinated individuals, addressing a gap in the existing literature on this topic. It builds on previous research on the association of

sociodemographic factors with vaccine hesitancy, demonstrating similarities and variations compared to other populations. This study emphasizes the importance of disaggregated ethnicity data and the need for diverse recruitment to investigate this phenomenon within the South Asian population of Canada, who are widely heterogeneous. Further research on ethnic populations that may have been underrepresented in past studies is warranted to develop equitable public health strategies tailored to various subgroups to address vaccine hesitancy and improve vaccine uptake.

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