PHARMACISTS AS IMMUNIZERS IN NOVA SCOTIA, CANADA: IDENTIFYING IMMUNIZATION PRESCRIBING TRENDS AND PATIENT CHARACTERISTICS

by

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Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.

Dedication

For my loving companion, Tofu. I miss you everyday.

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Abstract

The objectives of the study were 1.) To describe patterns in the age, sex, geographic location, and relative deprivation of individuals who are receiving immunizations prescribed by community pharmacists in Nova Scotia, to compare the characteristics of these individuals between the pre-COVID-19 and during COVID-19 time periods, and to compare the characteristics of these individuals to the general provincial population, and 2.) To describe immunization prescribing activity (both influenza and non-influenza vaccines, excluding COVID-19 vaccines) of pharmacists in the community pharmacy setting in Nova Scotia and to compare this activity between the pre-COVID-19 and during COVID-19 periods.

A retrospective study using existing administrative health databases was conducted. Eligible persons were defined as all community-dwelling Nova Scotia residents aged 2 years and older who received any immunization dispensed at a community pharmacy within the province from April 1, 2018, to March 31, 2022, with a pharmacist indicated as the prescriber. Descriptive statistics and multivariable negative binomial regression models were used to characterize the study population and pharmacist immunization prescribing activity. All analyses were performed using Stata MP 15.

A total of 531,780 immunizations were prescribed to the 274,081 individuals included in the study. The mean age was 53 years with nearly two-thirds (64%) of the population having been aged 50 years or older. 56% were female, 64% resided in an urban area, and 40% resided in Halifax Regional Municipality. 95% of all vaccines prescribed were influenza vaccines. The top 3 prescribed non-influenza immunizations were varicella zoster, hepatitis, and cholera vaccines. Prescribing of hepatitis and cholera vaccines decreased following the onset of the COVID-19 pandemic, whereas prescribing of varicella zoster vaccines remained relatively unchanged. The influenza multivariable regression model demonstrated associations between the rate of pharmacist influenza immunization prescribing and sex (female IRR 1.164, 95% confidence interval (CI) [1.151, 1.177]), rurality (urban IRR 1.181, 95% CI [1.167, 1.194]), and month (October IRR 1.073, 95% CI [1.059, 1.087]), as well as an interaction effect between age and fiscal year whereby incidence of influenza immunization prescribing was highest among those 65-79 years during the 2020-2021 fiscal year (IRR 10.707, 95% CI [8.652, 13.250]). The non-influenza multivariable regression model demonstrated statistically significant associations between the rate of pharmacist non-influenza immunization prescribing and rurality (urban IRR 1.074, 95% CI [1.047, 1.101]), age (5-19 IRR 1.146, 95% CI [1.095, 1.198; 20-34 IRR 1.103, 95% CI [1.060, 1.148]; 35-49 IRR 1.093, 95% CI [1.051, 1.137]; 65-79 IRR 0.937, 95% CI [0.910, 0.966]; 80+ IRR 0.859, 95% CI [0.805, 0.915]), month (May IRR 0.935, 95% CI [0.875, 0.998]; August IRR 0.934, 95% CI [0.880, 0.992), and fiscal year (2019-2020 IRR 1.060, 95% CI [1.027, 1.093]; 2020-2021 IRR 0.959, 95% CI [0.924, 0.995]).

This study describes for stakeholders the current state of community pharmacy-based immunization prescribing activity and characteristics of service users. The results may serve to inform future planning of pharmacy-based immunization service models. Based on the study results, further research on this topic is also warranted, particularly on further sociodemographic characteristics of the study population as well as barriers to and facilitators of non-influenza immunization prescribing in community pharmacies.

List of Abbreviations

Anatomic Therapeutic Chemical	ATC
Confidence Interval	CI
Canadian Institute of Health Information	CIHI
Canadian Index of Multiple Deprivation	CIMD
Dissemination Area	DA
Defined Daily Dose	DDD
Department of Health and Wellness	DHW
Forward Sortation Area	FSA
Health Data Nova Scotia	HDNS
High-Dose Quadrivalent Inactivated Influenza Vaccine	HD-QIIV
Live Attenuated Influenza Vaccine	LAIV
Heat-Labile Toxin-Producing Enterotoxigenic E. Coli	LT-ETEC
Live Zoster Vaccine	LZV
Measles, Mumps, and Rubella	MMR
Medical Services Insurance	MSI
Medically Underserved Area	MUA
Nova Scotia Drug Information System	NSDIS
Postal Code Conversion File	PCCF+
Quadrivalent Inactivated Influenza Vaccine	QIIV
Recombinant Zoster Vaccine	RZV
Secure Health Access Record	SHARE
Tetanus, Diphtheria and Pertussis	Tdap
Trivalent Inactivated Influenza Vaccine	TIIV
Varicella Zoster	VZ

1.0 – Introduction

1.1 – Rationale for pharmacists as immunizers

Pharmacists are one of the most accessible healthcare providers in Canada (1). With pharmacies available in nearly every community across the country and with greater than 42,000 pharmacists actively practicing in Canada, community pharmacists are often the first point of contact that a patient has with the Canadian healthcare system (2). As medication experts who routinely act as liaisons between different facets of the healthcare system, pharmacists have numerous roles they can fulfill with respect to providing immunization-related care, including acting as an educator for patients and their caregivers, acting as a facilitator by hosting other immunizers in their spaces to provide vaccines to pharmacy patients, as well as acting as immunizers themselves (3).

With Nova Scotia experiencing an ongoing family physician and nurse practitioner shortage, more Nova Scotians may rely on other primary care providers, such as pharmacists, to help bridge the gap in healthcare. As of July 1, 2023, the Nova Scotia Health Authority reported that 152,001 Nova Scotians, or 15.3% of the population, were on the Need a Family Practice Registry (4). In reality, the number of Nova Scotians lacking a primary care provider may be even larger than this given that patients without a provider are not automatically added to this registry (i.e., patients or their caregivers must register themselves) (5). Given the widespread difficulty in accessing primary care, it is crucial that pharmacists in Nova Scotia are practicing to full scope, which includes the provision of immunization services, in order to provide the best care possible to patients.

Additionally, the presence of community pharmacies in or near most residential areas as well as their integration into other businesses (i.e., grocery stores, department stores, shopping malls) makes the pharmacy an accessible setting in which to provide and receive immunization services. A 2011 study found that 63.6%, 84.6%, and 90.7% of Ontario residents live within walking distance, 2-km driving distance, and 5-km driving distance of one or more community pharmacies, respectively (6). A subsequent 2013 study found that 40.3%, 62.6%, and 78.8% of Nova Scotia residents live within walking distance, 2-km driving distance, and 5-km driving distance of one or more community pharmacies, respectively, although there were marked differences in accessibility in urban areas as compared to rural areas (7). Accessible locations coupled with extended hours of operation in pharmacies, which are typically open longer than most clinics and physicians' offices, make convenience a key factor in patients choosing to access immunization services at the pharmacy.

Pharmacists are also in an advantageous position for providing immunizations in terms of being able to interact with some hard-to-reach populations that may not interface as frequently with other parts of the healthcare system (3), such as those who otherwise do not have a primary care provider (8). These individuals are still likely to interact with pharmacists for the purpose of obtaining prescription and/or over-the-counter medications, which may provide an opportunity to also discuss immunization services.

Community pharmacists are commonly regarded as being well-trusted and important to the healthcare system by the general public—the Canadian Pharmacists Association reports that 96% of Canadians have a positive impression of pharmacists and that 94% of Canadians believe that pharmacists play either an important or an essential role in the Canadian healthcare system (9). In Nova Scotia, patients were more likely to visit a pharmacist for a variety of health services compared to the national average according to a 2016 survey (10). In terms of factors contributing to public trust in pharmacists, a 2021 study which conducted semi-structured interviews with community pharmacy patients found that trust-enhancing factors, i.e., factors which were associated with positive experiences with pharmacists, included accessibility, affability, respect, and acknowledgement of lived experience (11). Furthermore, prior research has found that over half of Canadians frequent their community pharmacy on a weekly basis and see their community pharmacists up to ten times more often than their family physician (12). Given this position of good standing with patients and frequent contact with the general public, pharmacists have an opportunity to make a positive impact with respect to immunization education and uptake.

Thus, considering the accessibility and convenience of community pharmacies, the potential for pharmacists to bridge gaps in primary care access, the public's trust in the profession, and the frequent interactions pharmacists have with much of the public, a case can be made for better understanding the role of pharmacists in providing immunizations in Nova Scotia, and the accessibility of their services, based on a description of the sociodemographic characteristics of pharmacy users compared to the general provincial population.

1.2 – Pharmacists as immunizers in Canada

Many jurisdictions in Canada have legislated both immunization prescribing and administration authority to pharmacists. Alberta and British Columbia became the first provinces to permit pharmacist-administered immunizations in 2009 (13,14) and since then, many other provinces have followed suit. As of July 2023, the Canadian Pharmacists Association reported that 11 of 13 provinces and territories have granted both influenza vaccine injection authority and general vaccine injection authority to pharmacists, and that 10 of 13 provinces and territories have granted pharmacists the authority to administer any drug or vaccine (15).

Despite the majority of jurisdictions in Canada legislating the role of pharmacists as immunizers, few of the immunizations that pharmacists are authorized to provide are publicly funded. In the 11 provinces and territories which permit pharmacist-administered immunizations, pharmacists are able to administer and be remunerated for the publicly funded influenza vaccine, although who is eligible for this publicly funded vaccine varies between jurisdictions, and the COVID-19 vaccines. With respect to other vaccines, only British Columbia, Alberta, and Manitoba remunerate pharmacist administration of publicly funded vaccines other than the seasonal influenza vaccine and COVID-19 vaccines (16).

Specifically, pharmacists in British Columbia can access and administer publicly funded pneumococcal, meningococcal, measles, mumps, rubella, and varicella (MMR-V), tetanus, diphtheria, and pertussis (Tdap), varicella zoster, human papillomavirus, and polio vaccines. In Alberta, pharmacists can access and administer publicly funded pneumococcal and Tdap vaccines. Finally, pharmacists in Manitoba can access and administer publicly funded pneumococcal, Tdap, and human papillomavirus vaccines (17). However, access to publicly funded vaccines through pharmacies is growing in Nova Scotia where pharmacists at select pharmacies participating in the provincial Community Pharmacy Primary Care Clinic pilot project may prescribe publicly funded Mpox vaccines in addition to influenza and COVID-19 vaccines (18). See Appendix A for a graphic comparing pharmacist vaccine and injection administration authority across provinces and territories in Canada.

1.3 – Pharmacists as immunizers during the COVID-19 pandemic

Amidst the COVID-19 pandemic, pharmacists have played an integral role in the delivery of COVID-19 immunizations across Canada. As of July 2023, the Canadian Pharmacists Association reported that pharmacists were involved with the rollout of COVID-19 immunizations in all provinces and territories save for the Northwest Territories and Nunavut (15). In New Brunswick, by December 2021, over 50% of all COVID-19 vaccines had been administered by pharmacists (19). In Nova Scotia, nearly 60% of all COVID-19 vaccines have been delivered by community pharmacies (20).

Pharmacists have also played a vital role in delivering other non-COVID-19 vaccines during the pandemic. A 2023 cross-sectional study utilizing mixed-mode surveys of community pharmacists practicing in rural areas of the southeastern United States found that the proportion of pharmacies offering a given type of vaccine did not significantly change between 2019 and 2020 irrespective of age group (adults, adolescents, and children) and type of vaccine (12 non-COVID-19 vaccine types were examined in total), with the exception of MMR vaccine provision in adults, which increased from 2019 to 2020 (21). The authors also found that the way in which pharmacists were delivering immunization services did not change between 2019 and 2020 for the majority of respondents. The findings of this study highlight the importance of pharmacists as vaccine providers during the COVID-19 pandemic in that the types of vaccines provided and the delivery process remained consistent amidst a public health emergency.

1.4 – Pharmacists as immunizers in Nova Scotia

Since August 2013, pharmacists in Nova Scotia have had the authority to administer immunizations (22). Initially, pharmacists were permitted to immunize those 5 years of age and older, although this changed to 2 years of age and older in March 2021 (23) and in April 2022, was further reduced for influenza and COVID-19 vaccines. Pharmacists with additional training may now administer influenza and COVID-19 vaccines to individuals 6 months to 2 years of age (24). Currently, pharmacists in Nova Scotia are permitted to provide COVID-19, herpes zoster, human papillomavirus, hepatitis A and B, typhoid fever, varicella, meningococcal, pneumococcal, influenza, measles, mumps, rubella, and varicella (MMR-V), tetanus, diphtheria, and pertussis (Tdap), yellow fever, rabies, and Japanese encephalitis vaccines, with the latter three requiring an additional certification in travel health (25).

Presently, the only immunizations provided by any pharmacist in Nova Scotia which are publicly remunerated are the seasonal influenza vaccine and COVID-19 vaccines, and, as stated above, Mpox vaccines may be prescribed by pharmacists working at provincial Community Pharmacy Primary Care Clinics; several other vaccines, such as MMR-V, Tdap, select meningococcal vaccines, etc. are publicly remunerated when provided by a different practitioner such as a physician or nurse, but are not funded publicly when prescribed or administered by a pharmacist (22). Multiple studies have been conducted on the impact of pharmacists as immunizers in Nova Scotia, particularly regarding their impact on influenza vaccination coverage, which are discussed below.

A 2016 retrospective analysis of physician billings, pharmacist billings, and public health data in Nova Scotia found that influenza immunization coverage increased in the province during the 2013-2014 influenza season following the implementation of pharmacists as immunizers in late 2013 as compared to the 2010-2011, 2011-2012, and 2012-2013 seasons, particularly in adults over 65 years of age, suggesting that the addition of pharmacists as immunization providers was associated with an overall increase in influenza immunization coverage (26). Another 2016 retrospective analysis of provincial census data and aggregate immunization data from 2010 to 2015 found that the initial increase observed in influenza immunization rates during the 2013-2014 influenza season following the implementation of pharmacists as immunizers in 2013 was sustained into the second year of the program during the 2014-2015 influenza season, with this study also finding the greatest impact on vaccination coverage in those over 65 years of age (27).

A 2018 retrospective analysis of provincial census data and aggregate immunization data from 2006 to 2016 (excluding the 2009-2010 due to the lack of influenza immunization data collected during the H1N1 pandemic) found that both the addition of universal influenza immunization policy during the 2010-2011 season and the addition of pharmacists as immunizers in the 2013-2014 season led to an increase in immunization coverage in the following seasons (28). However, in contrast with the results of the two previous studies, this study found that the effect of the addition of pharmacists as immunizers was not sustained into the third influenza season following this policy change (2015-2016), with immunization coverage declining for unknown reasons, although with a notable slower decline compared to previous influenza seasons prior to the addition of pharmacists as immunizers.

Beyond examining the impact of pharmacists as immunizers in a traditional community pharmacy setting, research has also been conducted to evaluate the impact of pharmacists as immunizers in offsite community-based settings in rural Nova Scotia. The CO-OPP Phase 1 study examined the fiscal feasibility, patient and site partner satisfaction, and impact on number of administered vaccines of pharmacist-led immunization clinics in non-pharmacy community-based sites. Immunization clinics offering publicly funded seasonal influenza vaccines were hosted at 7 different partner sites during the 2014-2015 and 2015-2016 influenza seasons with quality assurance surveys being administered to both patients and community partners following the clinics. Overall, the study found that pharmacist-led influenza immunization clinics hosted at community partner sites were financially feasible, convenient for both the site and patients attending the clinic, and increased the total number of immunizations provided by the pharmacy. Due to the small scale of the project, analysis of change in immunization rates within the areas were not within the scope of the study (29).

Several studies analyzing patient perspectives on pharmacists as immunizers in Nova Scotia have also been conducted. A 2018 descriptive study found that the majority of patients seeking influenza immunization at a community pharmacy reported positive experiences (30). Analysis of quality assurance questionnaires completed by over 6,500 immunization recipients during the 2013-2014 influenza season in Nova Scotia found that the convenience of receiving the vaccine at a pharmacy was an important influencing factor for many patients. Greater than 90% of survey respondents reported that the immunization service received at the pharmacy was as good or better than that previously received from other immunization providers. Respondents also reported the pharmacy environment to be a positive one, one they perceived as less stressful and with reduced risk of exposure to people who are ill compared to other waiting areas. In addition, respondents generally reported positive sentiments regarding pharmacists' knowledge, competency, and abilities as immunization providers. Areas of improvement identified by the questionnaire included documentation requirements (i.e., patients needing to fill out consent forms) and wait times being too long.

A 2021 cross-sectional study found that residents of four Nova Scotia and New Brunswick communities were generally supportive of the role of pharmacists as immunizers. A quantitative survey was used to assess the knowledge, attitudes, beliefs, and behaviors of community-dwelling adults regarding pharmacists as immunizers, with 985 members of the public having responded to the survey between February and November 2017. Of those who responded, 86.3% reported being aware that pharmacists were permitted to immunize, 76.8% agreed that pharmacists had received enough training to immunize, 75% reported that they were comfortable being immunized by a pharmacist, 70.7% reported that it was convenient for them to be immunized by a pharmacist, however, only 39% had reported being previously immunized by a pharmacist. Increasing number of pharmacy visits per year and prior immunization by a pharmacist were both predictive of feeling comfortable being immunized by a pharmacist and believing it is convenient to be immunized by a pharmacist (31).

1.5 – Impact of pharmacists as immunizers on access to immunizations

While many studies examining pharmacists as immunizers commonly focus on impact on immunization rates or immunization coverage, some previous literature has specifically examined pharmacists' impact on patient access to immunizations. A retrospective analysis of seasonal influenza vaccine administration records from a national pharmacy chain in the United States found that these community pharmacies provided a significant number of vaccines in medically underserved areas (MUAs). MUAs were defined according to criteria published by the Health Resources and Services Administration (HRSA) of the United States Department of Health & Human Services. MUAs are designated by the HRSA as areas having too few primary care providers, high infant mortality, or a high poverty and/or high elderly population (32). The authors examined all seasonal influenza vaccine administration records between September 2009 to February 2010 from all pharmacies belonging to this chain in all 50 states and found that of the 43% of Americans living in medically underserved areas (MUAs), this chain of pharmacies served nearly half of this population and nationally, over one-third of influenza vaccines were administered by this pharmacy chain in MUAs. Additionally, the percentage of immunizations provided by these pharmacies in MUAs was as high as 77.1% in states with the largest proportions of their residents residing in MUAs (33). These results would suggest that pharmacists positively impact immunization accessibility, particularly in areas with otherwise low access to healthcare.

Another retrospective analysis of data for all immunizations provided at a different national pharmacy chain in the United States between August 2011 and July 2012 found that during the study period, pharmacists administered over 6.25 million immunizations, with nearly one-third of immunizations having been provided during 'off-clinic' hours, which included evenings, weekends, and holidays (34). In particular, younger, healthy, working-aged adults under the age of 65 were found to have accessed a variety of immunizations at the pharmacy during off-clinic hours. These findings suggest that the extended hours of operation associated with community pharmacies may be an important factor in opportunities for immunization service convenience and access, particularly amongst working age young adults.

In addition, a 2020 systematic review of 25 studies, including randomized controlled trials, quasi-experimental studies, cohort studies, cross-sectional studies, and case-control studies found that pharmacists had an overall positive influence on older adults' access to vaccines, with the most common vaccines being influenza and pneumococcal (35). In particular, 21 included studies (84%) found that pharmacists had a positive effect on immunization access. Two studies (8%) found a mixed effect (i.e., improvement in some aspects of access but not all, such as increased uptake with some vaccine types but not others) and two additional studies (8%) found no effect. None of the included studies reported a negative effect of pharmacists on older adults' access to immunizations.

1.6 – Characteristics of patients immunized by pharmacists

One approach to assessing the accessibility of pharmacy-based immunization services is to characterize the patient population using these services. By understanding the characteristics of the patients using pharmacy-based immunization services and comparing them to the characteristics of the general population in a given location, one can determine if some populations are under- or over-represented. Previous research from both the United States and Canada has aimed to characterize the patient populations vaccinated by pharmacists for this purpose, which is discussed below.

A cross-sectional survey of 1,730 adult vaccine recipients from the United States immunized in pharmacies between October 1 and December 31, 1998, found that 60% of recipients were women, 97% were white, the mean age was 54.2 +/- 15.2 years with 28% of recipients being 65 years of age or older, and 45% of recipients reported chronic use of medication. Most recipients reported having received an influenza vaccine in previous years, with 61% and 75% having received the vaccine in 1996 and 1997, respectively (36). This study is limited by the self-reported nature of the data, low response rate (21% of vaccine recipients responded), lack of patient comparator group, and its use of a convenience sample of pharmacies in just 10 states (Alabama, Arkansas, Idaho, Iowa, Mississippi, Nebraska, Tennessee, Texas, Virginia, and Wisconsin).

A 2017 cross-sectional study of 28,954 adults from 8 states in the United States and Puerto Rico who had reported receiving an influenza immunization in the past year via the 2014 Behavioural Risk Factor Surveillance System found that pharmacy-based immunization locations were the second most commonly used following physicians' offices. In addition, it was also found that residents of states that were early adopters of pharmacists as immunizers (i.e., implemented policies enabling pharmacists as immunizers prior to 1999) were 31% more likely to be immunized in a pharmacy as compared to a physician's office or other setting. This study also found several patient-level characteristics which were associated with influenza immunization in a pharmacy setting as compared to a physician's office. Individuals over the age of 65 years were more likely to choose a pharmacy over a physician's office. Black respondents were less likely to use pharmacy-based immunization compared to non-Hispanic white respondents. Having a college degree was associated with increased odds of pharmacy-based immunization whereas having health insurance was associated with lower odds of immunization at a pharmacy as compared to a physician's office. Both poor health status and having a high-risk condition were associated with lower odds of being immunized at a pharmacy (37).

A 2019 cross-sectional study of Ontario residents who had record of receiving an influenza vaccine between October and March of the 2013-2014 and 2015-2016 influenza seasons (2 and 4 years after the implementation of pharmacists as immunizers in the province, respectively) found that characteristics associated with receiving an influenza vaccine in a pharmacy setting as compared to a physician's office were: living in non-urban areas, living in higher income neighbourhoods, not identifying as an immigrant, not having a diagnosis of hypertension or diabetes, and having received another pharmacist service (e.g., a medication review) on the same day as their vaccination (38). In patients 66 years of age and above, those who had been admitted to the hospital in the last year were more likely to be vaccinated in a pharmacy versus a physician's office. Whereas having received a pharmacist service on the same day as one's vaccination was found to be a strong predictor for pharmacist administration of the influenza immunization, having received a pharmacist service in the past year was found to be only a weak predictor of the same.

A 2021 cross-sectional study of 26,173 United States residents found that among those who reported previously receiving a vaccine at a pharmacy, 51.3% of recipients were 70 years of age or older, 71.2% were female, and 30.9% were white. When compared to respondents who reported they did not use pharmacy-based immunization services, use of pharmacy-based immunization services was significantly associated with advancing age, higher level of education, identifying as 'non-white', and higher number of chronic diseases. Conversely, geographic location, gender, and income were all found to be weak predictors of use of pharmacy immunization services. Surprisingly, users of mail order pharmacies were found to have the highest use of pharmacy immunization services as compared to independent, chain, supermarket or mass merchandise pharmacies—this was attributed to the consistent use of patient reminders and other patient communications at these pharmacies, findings from prior research indicating that mail order pharmacies are more commonly frequented by older patients with chronic diseases, and the fact that mail order pharmacies in the United States are commonly situated within Health Maintenance Organization clinics or hospitals (39).

A 2023 cross-sectional study of 364 patients from 14 community pharmacies in New Zealand used self-administered questionnaires provided to individuals after receiving a pharmacist-administered influenza vaccine to assess characteristics and experiences of this population. The authors found that 60.7% of respondents identified as female, 76.9% were of European ethnicity, and 43.4% were between 45 and 64 years of age. Additionally, accessibility and convenience were the most cited reasons among respondents for having chosen a community pharmacy for immunization services and greater than 90% of respondents were satisfied with the services received (40).

2.0 – Objectives

2.1 – Research questions

The overarching research questions for this project are: (i) what are the characteristics of the population receiving immunizations prescribed by community pharmacists in Nova Scotia; (ii) what are the different types and amounts of immunizations prescribed by community pharmacists in Nova Scotia; and (iii) how do these vary across time? The following two objectives aim to address these research questions.

2.2 – Objective and hypothesis #1

The first objective of this study was to describe patterns in the age, sex, geographic location, and relative deprivation (as defined by the Canadian Index of Multiple Deprivation) of individuals who are receiving immunizations prescribed by community pharmacists in Nova Scotia, to compare the characteristics of these individuals between the pre-COVID-19 (April 1, 2018, to March 21, 2020) and during COVID-19 (March 22, 2020, to March 31, 2022) time periods, and to compare the characteristics of the study population to the general provincial population as described by the provincial census.

It was anticipated that those over 65 years of age would account for much of the study population based on previous literature. Additionally, while it was anticipated that much of the population would be located in urban areas due to the overall greater population density, it was hypothesized that a significant proportion of individuals accessing these services would be located in rural areas since there is less access to family physicians and nurse practitioners in rural Nova Scotia (41) and thus, possible increased reliance on other immunization providers, such as pharmacists. It was also hypothesized that those accessing prescribing services at a pharmacy for non-influenza immunizations might have been of lesser deprivation, particularly in regard to economic dependency, due to the out of pocket fees that accompany some immunization prescribing assessments and vaccine cost.

2.3 – Objective and hypothesis #2

The second objective of this study was to describe immunization prescribing activity (both influenza and non-influenza vaccines, excluding COVID-19 vaccines) of pharmacists in the community pharmacy setting in Nova Scotia and to compare this activity between the pre-COVID-19 and during COVID-19 periods. Of note, COVID-19 vaccines were excluded as these vaccines are not documented within the Nova Scotia Drug Information System (NSDIS) and thus, this data was not accessible for the study.

It was hypothesized that the seasonal influenza vaccine would account for the majority of immunization prescriptions in the NSDIS based on prior research on the provision of influenza vaccines by pharmacists in Nova Scotia (26,27). It was also anticipated that certain travel-related vaccines (e.g., hepatitis vaccines, the oral cholera vaccine) would be commonly prescribed by Nova Scotia pharmacists due to recently expanded travel medicine services in several chain pharmacies (42), and that this varied over time due to restricted out-of-province travel during the pandemic.

Additionally, it was hypothesized that the total number of immunizations prescribed by pharmacists decreased during the COVID-19 pandemic due to lockdowns, social distancing restrictions, and temporary closures of private counselling rooms in pharmacies. Based on media reports, it was hypothesized that the number of influenza immunizations provided by pharmacists increased in the 2020/2021 and 2021/2022 influenza seasons as compared to the 2018/2019 and 2019/2020 influenza seasons (43).

3.0 – Study Methodology

3.1 – Study population

The population of interest for this study was Nova Scotians two years of age and older, residing in the community, that received at least one immunization prescribed by a community pharmacist from April 1, 2018, to March 31, 2022. The population was restricted to those 2 years of age and older as this was the youngest age pharmacists were permitted to immunize during the study period. This population largely excluded those that reside in a long-term care facility or similar institution as not all long-term care facilities in the province are serviced by community pharmacies (44) and thus, not all immunizations provided would be captured in the NSDIS, although due to the nature of the available data, it is possible that some long-term care residents were included in the study sample; this is discussed further in the limitations section.

3.2 – Data sources

3.2.1. Nova Scotia Drug Information System

The primary source of data for this study was the Nova Scotia Drug Information System (NSDIS). The NSDIS is part of the provincial electronic health record system, SHARE (abbreviated from Secure Health Access Record) (45). The data from the NSDIS is sourced from the Nova Scotia Department of Health and Wellness (DHW) and is housed at Health Data Nova Scotia (HDNS) for research purposes. Since October 2016, all community pharmacies in Nova Scotia have been required to submit prescription dispensing data to the NSDIS (46), therefore, it is a comprehensive data source on all recent community pharmacy-based prescription dispensing activity. Data not captured within the

NSDIS includes prescriptions dispensed in hospital pharmacies for inpatients, outpatients, or hospital-based clinics; prescriptions for long-term care facilities, correctional facilities, and penitentiaries not serviced by a community pharmacy; prescriptions dispensed by Canadian Forces Base pharmacies; and medications or products which do not require a prescription (e.g., over the counter medications, natural health products, medication samples, certain medical supplies and devices) (47).

This study examined immunization dispensing records from the NSDIS from April 1, 2018, to March 31, 2022. The study period spans four fiscal years, with each fiscal year spanning from April 1 to March 31. Fiscal years were chosen as opposed to calendar years as fiscal years align well with the annual influenza season (i.e., the new fiscal year begins as influenza season is ending) and due to the timing of the COVID-19 pandemic, using fiscal years allowed a nearly equal divide of the study period into 'pre-COVID-19' and 'during COVID-19' time periods. Specifically, this study period provided approximately 2 years of data for both prior to and during the COVID-19 pandemic. The 'pre-COVID-19' and 'during COVID-19' time periods were defined as April 1, 2018 to March 21, 2020, and March 22, 2020 to March 31, 2022, respectively. March 22, 2020 was chosen as the cut-off point to mark the beginning of the COVID-19 period as the provincial state of emergency was declared on this date (48).

Immunization dispensing records were distinguished from other medication dispensing records within the NSDIS by the recorded drug identification number (DIN). All included DINs are listed in Appendix B and were identified using the World Health Organization (WHO) Anatomic Therapeutic Chemical/Defined Daily Dose (ATC/DDD) Index (49) and the Health Canada Drug Product Database (50). Data obtained from these dispensing records included the immunization DIN, immunization ATC code, dispensing date, provider ID, and pharmacy ID. Records from the NSDIS were then linked to two other databases housed at HDNS, the Insured Patient Registry (MASTER) and the Licensed Provider Registry (DOCTORS).

3.2.2. MASTER registry

The MASTER registry contains demographic and geographic information on the entire population of insured healthcare beneficiaries in Nova Scotia (i.e., registered beneficiaries of Medical Services Insurance (MSI) services). NSDIS records were linked to MASTER via provincial health card number to obtain patient sex, month and year of birth, and postal code. Health card number was only used for linkage and was not provided to the authors by HDNS, only de-identified data were included in the study dataset. Patient gender was also explored as a possible covariable, but was not available in the existing administrative health data, therefore, only patient sex was included. Month and year of birth were included provide information on patient age at the time of receiving an immunization prescription.

3.2.3. DOCTORS registry

The DOCTORS registry contains demographic information on health services providers in the province, including pharmacists. NSDIS records were linked to DOCTORS via provider ID to verify the status of the immunization prescriber as a pharmacist via their license number.

3.2.4. PCCF+ and census data

The Postal Code Conversion File (PCCF+) was used to probabilistically map the 6-digit patient postal codes obtained from MASTER to Statistics Canada census divisions and dissemination areas (DA). Census divisions in Nova Scotia correspond with the 18 historical counties in the province. DA is a small, relatively stable geographic unit typically comprised of 400 to 700 persons and is the smallest geographic area for which census data is disseminated (51). Mapping postal codes to census divisions and DAs allowed for examination of immunization prescribing by county and linkage to the Canadian Multiple Deprivation Index, respectively. The forward sortation area (FSA) from the postal code was also retained for the analysis to define rurality.

3.2.5. The Canadian Index of Multiple Deprivation

The Canadian Index of Multiple Deprivation (CIMD) is a geographically based index of deprivation and marginalization developed using microdata from the 2016 Census of Population (52). The four domains of deprivation in the CIMD are: residential instability, economic dependency, ethnocultural composition, and situational vulnerability. Residential instability describes the tendency for residents of neighbourhoods to fluctuate over time, considering both familial and housing characteristics. Economic dependency describes reliance on sources of income other than employment income. Ethnocultural composition describes the community make-up of immigrant populations. Situational vulnerability describes variations in sociodemographic conditions with respect to housing and education (52). Quintiles of scores for each of these four domains were linked to the study dataset using patient DA obtained via the PCCF+. These were represented within the dataset as categorical variables with values of 1 through 5, with a value of 1 corresponding to DAs that were the least deprived for that domain, and a value of 5 corresponding to DAs that were the most deprived. This provided information on the relative residential instability, economic dependency, ethnocultural composition, and situational vulnerability of those seeking immunization prescribing services at community pharmacies in Nova Scotia.

3.2.6. Final linked dataset variables

The variables in the final linked and de-identified dataset included individual study ID, product DIN, product ATC code, dispensing date, pharmacist ID, pharmacy ID, patient month and year of birth, patient sex, patient FSA, patient census division, patient DA, residential instability quintile, economic dependency quintile, ethnocultural composition quintile, and situational vulnerability quintile. Additional derived variables included time period (pre- or during COVID-19) and a binary urban/rural variable derived from the FSA. See Appendix C for a table of variables and the associated data sources from which they were derived and Appendix D for a data linkage diagram.

3.3 – Data analysis

Objective 1. To describe patterns in the age, sex, geographic location, and relative deprivation (as defined by the Canadian Index of Multiple Deprivation) of individuals who are receiving immunizations prescribed by community pharmacists in Nova Scotia, to compare the characteristics of these individuals between the pre-COVID-19 (April 1, 2018, to March 21, 2020) and during COVID-19 (March 22, 2020, to March 31, 2022) time periods, and to compare the characteristics of the study population to the general provincial population as described by the provincial census.

Descriptive statistics were calculated to determine the demographic characteristics of the patient cohort, including age, sex, geography, and relative deprivation. The descriptive statistics calculated and tabulated were:

- Mean age and standard deviation
- Number and percentage of population by broad age groups
- Number and percentage of males and females (defined by patient sex as gender was not available)
- Number and percentage of population by geographic region (i.e., by urban and rural areas and by census division)
- Number and percentage of population by quintile for each of the four domains of the CIMD

Cumulative immunization counts and corresponding percentages were then calculated and stratified by both patient demographics and time period (pre- or during the COVID-19 pandemic). Age, sex, geography, and relative deprivation of the study population were compared to the general provincial population using data from the 2021 census.

Objective 2. To describe immunization prescribing activity (both influenza and non-influenza vaccines, excluding COVID-19 vaccines) of pharmacists in the community pharmacy setting in Nova Scotia and to compare this activity between the pre-COVID-19 and during COVID-19 periods.

Descriptive statistics on types and amounts of immunizations prescribed were calculated, specifically counts of immunizations stratified by ATC classification over time.

The unit of time varied for different immunizations, either immunization prescription counts by month or year depending on the number of immunizations prescribed. Any cell counts less than 5 were rounded for privacy reasons. Using the time period variable derived from the date a given prescription was dispensed, these immunization counts were also stratified by pandemic, either pre-COVID-19 or during COVID-19, and differences in counts during compared to before the COVID-19 pandemic were also calculated.

Negative binomial regression models were built to characterize immunization prescribing activity over time. Negative binomial regression was chosen to model the data as the study dataset was comprised of count data and there was overdispersion present in the data (e.g., the variance of the dependent count variable was significantly greater than the mean). The outcome variable for each model was the number of immunizations prescribed per prescriber, grouped by month and year, as well as patient sex, age, and/or rurality depending on the univariable or multivariable model in question. The models included time-varying covariates to incorporate the effect of time, both as a linear function from April 1, 2018, and from the denoted onset of COVID-19 on March 22, 2020. All prescribed immunizations were categorized as either influenza or non-influenza and regression analyses were then conducted on these two groups separately. Univariable models were created for three non-time-related covariables: patient sex, patient age group, and patient rural/urban status. Multivariable models were subsequently built incorporating all three non-time-related covariables. Collinearity diagnostics were performed to check for multicollinearity among predictor variables. Interactions between covariables were investigated using margins and margins plots and then incorporated into the multivariable models if deemed significant.

All models included a prescriber random effect to control for individual variation in prescribing activity. It was anticipated that building models with both pharmacist and pharmacy random effects would be possible however, due to unavailability of pharmacy ID as a variable for a significant portion of the study period, only pharmacist ID was utilized in the final analyses. All analyses were performed using Stata MP 15 statistical software. See Appendix E for a table of study analyses as they relate to each objective.

4.0 – Results

4.1 – Descriptive summary of the study population

A total of 274,081 unique individuals were prescribed 531,780 influenza and non-influenza immunizations (excluding COVID-19 immunizations) by community pharmacists in Nova Scotia between April 1, 2018, and March 31, 2022. The mean number of immunizations prescribed per person during the study period was 2.57 immunizations (range 1-18, standard deviation 1.27, median 2). The mean age of the study population was 53 years (measured as age at the time the first immunization prescription was dispensed), with age ranging from 2 to 110 years. More than half the study population was female (56%). Of the study population, 64% resided in an urban area and 40% resided within Halifax Regional Municipality (HRM). In comparison to the provincial population, the study population was older on average (53 years vs. 44.2 years), had a higher proportion of females (56% vs. 51%), and a lower proportion of both urban residents (64% vs. 69%) and HRM residents (40% vs. 45%).

Of the population studied, 23% were categorized in the fifth quintile of the residential instability domain (i.e., highest level of residential instability), 24% in the first quintile of the economic dependency domain (i.e., lowest level of economic dependence), 27% in the fifth quintile of the ethnocultural composition domain (i.e., most ethnoculturally diverse), and 27% in the first quintile of the situational vulnerability domain (i.e., least situationally vulnerable). The percentages of the study population per quintile across the four CIMD domains largely aligned with those of the provincial population, although the study population percentages were slightly lower than the provincial percentages for the fifth residential instability quintile (23% vs. 28%), the first economic dependency quintile (24% vs. 27%), and the fifth ethnocultural composition quintile (27% vs. 30%).

Table 1 summarizes the study population's age, sex, rurality, and census division composition in comparison to the provincial population, as well as the proportions of the study population within each quintile of the four CIMD domains.

Table 1 – Individual-level descriptive characteristics of the study population (n = 274,081) compared to the provincial population (N = 969,380, as described by the 2021 Census)

Average age	**Mean age (standard deviation) of study population**	**Mean age (standard deviation) of provincial population[1]**
Mean age at first dispense date	53 (22)	44.2 (N/A)
Age group	**Number and percentage of study population**	**Number and percentage of provincial population[1]**
2-4	2,112 (1%)	20,170 (2%)
5-19	28,296 (10%)	144,550 (15%)
20-34	29,077 (11%)	178,010 (19%)
35-49	40,503 (15%)	173,375 (18%)
50-64	76,727 (28%)	217,790 (22%)
65-79	75,748 (28%)	167,155 (17%)
80+	21,618 (8%)	71,200 (7%)
Sex	**Number and percentage of study population**	**Number and percentage of provincial population[1]**
Female	152,829 (56%)	497,650 (51%)
Male	121,252 (44%)	471,730 (49%)
Rurality	**Number and percentage of study population**	**Number and percentage of provincial population[2]**
Urban	175,816 (64%)	671,500 (69%)
Rural	89,178 (33%)	297,880 (31%)
Unknown	9,087 (3%)	N/A
Census division	**Number and percentage of study population**	**Number and percentage of**

		provincial population[2]
Shelburne	4,197 (2%)	13,704 (1%)
Yarmouth	7,226 (3%)	24,947 (3%)
Digby	5,027 (2%)	17,062 (2%)
Queens	3,297 (1%)	10,501 (1%)
Annapolis	6,745 (2%)	21,252 (2%)
Lunenburg	15,155 (6%)	48,599 (5%)
Kings	16,993 (6%)	62,914 (6%)
Hants	13,365 (5%)	45,140 (5%)
Halifax	108,546 (40%)	440,069 (45%)
Colchester	16,482 (6%)	51,476 (5%)
Cumberland	9,126 (3%)	30,538 (3%)
Pictou	16,537 (6%)	43,657 (6%)
Guysborough	2,338 (1%)	7,373 (<1%)
Antigonish	5,523 (2%)	20,129 (2%)
Inverness	5,307 (2%)	17,346 (2%)
Richmond	2,645 (1%)	8,914 (<1%)
Cape Breton	24,598 (9%)	98,318 (10%)
Victoria	1,887 (1%)	7,441 (<1%)
Unknown	9,087 (3%)	N/A
CIMD residential instability quintile[3]	**Number and percentage of study population**	**Percentage of provincial population[4]**
1 (least residential instability)	48,736 (18%)	16.95%
2	50,498 (18%)	17.62%
3	50,526 (18%)	18.53%
4	51,846 (19%)	19.15%
5 (most residential instability)	62,939 (23%)	27.76%
Unknown	9,536 (3%)	-
CIMD economic dependency quintile[5]	**Number and percentage of study population**	**Percentage of provincial population[4]**
1 (least economically dependent)	66,856 (24%)	27.09%
2	51,058 (19%)	19.90%
3	53,573 (20%)	19.95%
4	48,937 (18%)	18.17%
5 (most economically dependent)	44,121 (16%)	14.88%
Unknown	9,536 (3%)	-
CIMD ethnocultural composition quintile[6]	**Number and percentage of study population**	**Percentage of provincial population[4]**
1 (least ethnoculturally diverse)	26,341 (10%)	10.05%
2	37,634 (14%)	13.78%

3	54,662 (20%)	20.11%
4	72,103 (26%)	25.98%
5 (most ethnoculturally diverse)	73,805 (27%)	30.07%
Unknown	9,536 (3%)	-
CIMD situational vulnerability quintile[7]	**Number and percentage of study population**	**Percentage of provincial population[4]**
1 (least situationally vulnerable)	75,293 (27%)	26.68%
2	57,619 (21%)	22.20%
3	49,514 (18%)	18.09%
4	47,043 (17%)	17.83%
5 (most situationally vulnerable)	35,076 (13%)	15.19%
Unknown	9,536 (3%)	-

[1]Statistics Canada. 2023. (table). *Census Profile*. 2021 Census of Population. Statistics Canada Catalogue no. 98-316-X2021001. Ottawa. Released March 29, 2023 (53).

[2]Statistics Canada. 2023. (table). *Focus on Geography Series*. 2021 Census of Population. Statistics Canada Catalogue no. 98-404-X2021001. Ottawa. Released November 30, 2022 (54).

[3]Statistics Canada description: "Residential instability speaks to the tendency of neighbourhood inhabitants to fluctuate over time, taking into consideration both housing and familial characteristics. The indicators in this dimension at the Atlantic-level measure concepts such as the proportion of persons living alone, the proportion of dwellings that are owned, the proportion of dwellings that are apartment buildings, the proportion of population that is married or common-law, and proportion of the population who moved within the past five years" (55).

[4]Percentages of the provincial population per CIMD quintile were calculated from the Atlantic region CIMD file using frequency weighting.

[5]Statistics Canada description: "Economic dependency relates to reliance on the workforce, or a dependence on sources of income other than employment income. Indicators included in this dimension at the Atlantic-level measure concepts such as the proportion of population aged 65 and older, the proportion of population participating in labour force (aged 15 and older), the dependency ratio (population aged 0-14 and aged 65 and older divided by population aged 15-64), the ratio of employment to population, and the proportion of population receiving government transfer payments" (55).

[6]Statistics Canada description: "Ethno-cultural composition refers to the community make-up of immigrant populations, and at the Atlantic-level takes into consideration factors such as the proportion of population who are recent immigrants (arrived in five years prior to Census), the proportion of population with no knowledge of either official language (linguistic isolation), the proportion of population that is foreign-born, and the proportion of population who self-identify as visible minority" (55).

[7]Statistics Canada description: "Situational vulnerability speaks to variations in socio-demographic conditions in the areas of housing and education, while taking into account other demographic characteristics. The indicators in this dimension at the Atlantic-level measure concepts such as the proportion of population that identifies as Aboriginal, the proportion of dwellings needing major repairs, and the proportion of population aged 25-64 without a high school diploma" (55).

The descriptive characteristics of the study population changed minimally before versus during the COVID-19 pandemic. Table 2 summarizes immunization-level study population characteristics before and during the COVID-19 pandemic as well as absolute differences in immunization prescription counts during as compared to before the pandemic. Percentages denoted pertain to the specific time period the counts correlate to (i.e., percentage of before COVID-19 immunization prescriptions, percentage of during

COVID-19 immunization prescriptions, or percentage of total immunization prescriptions). In regard to age, a greater proportion of immunizations were prescribed to those 65-79 years of age during the COVID-19 pandemic (33%) as compared to before (29%). Conversely, a smaller proportion of immunizations were prescribed to those 5-19 (8% during COVID-19 vs. 10% before), 20-34 (7% during COVID-19 vs. 10% before), and 35-49 years of age (12% during COVID-19 vs. 15% before).

Table 2 – Immunization-level descriptive characteristics of the study population compared before and during the COVID-19 pandemic

	Immunizations Before COVID-19	**Immunizations During COVID-19**	**Difference During vs. Before COVID-19**	**Total number of immunizations**
Number of immunizations	232,264	299,516	67,252	531,780
Mean Age (SD)	54 (21)	56 (21)	-	55 (21)
Frequency (%) by age group				
2-4	99 (<1%)	2,313 (1%)	2,214	2,412 (<1%)
5-19	23,336 (10%)	24,928 (8%)	1,592	48,264 (9%)
20-34	22,947 (10%)	22,287 (7%)	-660	45,234 (9%)
35-49	33,861 (15%)	37,370 (12%)	3,509	71,231 (13%)
50-64	67,024 (29%)	85,830 (29%)	18,806	152,854 (29%)
65-79	66,250 (29%)	99,838 (33%)	33,588	166,088 (31%)
80+	18,747 (8%)	26,950 (9%)	8,203	45,697 (9%)
Frequency (%) by sex				
Female	130,410 (56%)	166,804 (56%)	36,394	297,214 (56%)
Male	101,854 (44%)	132,712 (44%)	30,858	234,566 (44%)
Frequency (%) by rurality				
Urban	146,696 (63%)	184,827 (62%)	38,131	331,523 (62%)
Rural	84,926 (37%)	105,361 (35%)	20,435	190,287 (36%)
Unknown	642 (0%)	9,328 (3%)	8,686	9,970 (2%)
Frequency (%) by census division				
Shelburne	4,175 (2%)	5,342 (2%)	1,167	9,517 (2%)
Yarmouth	7,727 (3%)	8,217 (3%)	490	15,944 (3%)
Digby	4,940 (2%)	5,808 (2%)	868	10,748 (2%)
Queens	3,134 (1%)	3,744 (1%)	610	6,878 (1%)
Annapolis	6,359 (3%)	8,296 (3%)	1,937	14,655 (3%)
Lunenburg	14,282 (6%)	16,777 (6%)	2,495	31,059 (6%)

Kings	15,913 (7%)	17,789 (6%)	1,876	33,702 (6%)
Hants	10,788 (5%)	15,200 (5%)	4,412	25,988 (5%)
Halifax	87,620 (38%)	112,320 (38%)	24,700	199,940 (38%)
Colchester	15,344 (7%)	18,335 (6%)	2,991	33,679 (6%)
Cumberland	8,595 (4%)	10,920 (4%)	2,325	19,515 (4%)
Pictou	17,444 (8%)	21,075 (7%)	3,631	38,519 (7%)
Guysborough	2,112 (1%)	2,907 (1%)	795	5,019 (1%)
Antigonish	4,152 (2%)	6,390 (2%)	2,238	10,542 (2%)
Inverness	5,077 (2%)	6,617 (2%)	1,540	11,694 (2%)
Richmond	2,415 (1%)	3,137 (1%)	722	5,552 (1%)
Cape Breton	20,048 (9%)	25,215 (8%)	5,167	45,263 (9%)
Victoria	1,497 (1%)	2,099 (1%)	602	3,596 (1%)
Unknown	642 (<1%)	9,328 (3%)	8,686	9,970 (2%)
Frequency (%) by residential instability quintile[1]				
1 (least residential instability)	42,789 (18%)	54,312 (18%)	11,523	97,101 (18%)
2	44,578 (19%)	56,145 (19%)	11,567	100,723 (19%)
3	44,805 (19%)	56,560 (19%)	11,755	101,365 (19%)
4	46,041 (20%)	57,323 (19%)	11,282	103,364 (19%)
5 (most residential instability)	53,031 (23%)	65,354 (22%)	12,323	118,385 (22%)
Unknown	1,020 (<1%)	9,822 (3%)	8,802	10,842 (2%)
Frequency (%) by economic dependency quintile[2]				
1 (least economically dependent)	54,404 (23%)	70,273 (23%)	15,869	124,677 (23%)
2	43,899 (19%)	54,275 (18%)	10,376	98,174 (18%)
3	47,736 (21%)	59,350 (20%)	11,614	107,086 (20%)
4	43,732 (19%)	54,881 (18%)	11,149	98,613 (19%)
5 (most economically dependent)	41,473 (18%)	50,915 (17%)	9,442	92,388 (17%)
unknown	1,020 (<1%)	9,822 (3%)	8,802	10,842 (2%)
Frequency (%) by ethnocultural composition quintile[3]				
1 (least ethnoculturally diverse)	23,965 (10%)	30,044 (10%)	6,079	54,009 (10%)
2	34,199 (15%)	42,437 (14%)	8,238	76,636 (14%)
3	48,742 (21%)	60,170 (20%)	11,428	108,912 (20%)
4	63,806 (27%)	80,468 (27%)	16,662	144,274 (27%)
5 (most ethnoculturally diverse)	60,532 (26%)	76,575 (26%)	16,043	137,107 (26%)

Unknown	1,020 (<1%)	9,822 (3%)	8,802	10,842 (2%)
Frequency (%) by situational vulnerability quintile[4]				
1 (least situationally vulnerable)	63,384 (27%)	80,702 (27%)	17,318	144,086 (27%)
2	48,957 (21%)	62,368 (21%)	13,411	111,325 (21%)
3	43,898 (19%)	55,061 (18%)	11,163	98,959 (19%)
4	42,962 (18%)	52,884 (18%)	9,922	95,846 (18%)
5 (most situationally vulnerable)	32,043 (14%)	38,679 (13%)	6,636	70,722 (13%)
Unknown	1,020 (<1%)	9,822 (3%)	8,802	10,842 (2%)

[1]Statistics Canada description: "Residential instability speaks to the tendency of neighbourhood inhabitants to fluctuate over time, taking into consideration both housing and familial characteristics. The indicators in this dimension at the Atlantic-level measure concepts such as the proportion of persons living alone, the proportion of dwellings that are owned, the proportion of dwellings that are apartment buildings, the proportion of population that is married or common-law, and proportion of the population who moved within the past five years" (55).

[2]Statistics Canada description: "Economic dependency relates to reliance on the workforce, or a dependence on sources of income other than employment income. Indicators included in this dimension at the Atlantic-level measure concepts such as the proportion of population aged 65 and older, the proportion of population participating in labour force (aged 15 and older), the dependency ratio (population aged 0-14 and aged 65 and older divided by population aged 15-64), the ratio of employment to population, and the proportion of population receiving government transfer payments" (55).

[3]Statistics Canada description: "Ethno-cultural composition refers to the community make-up of immigrant populations, and at the Atlantic-level takes into consideration factors such as the proportion of population who are recent immigrants (arrived in five years prior to Census), the proportion of population with no knowledge of either official language (linguistic isolation), the proportion of population that is foreign-born, and the proportion of population who self-identify as visible minority" (55).

[4]Statistics Canada description: "Situational vulnerability speaks to variations in socio-demographic conditions in the areas of housing and education, while taking into account other demographic characteristics. The indicators in this dimension at the Atlantic-level measure concepts such as the proportion of population that identifies as Aboriginal, the proportion of dwellings needing major repairs, and the proportion of population aged 25-64 without a high school diploma" (55).

Table 3 summarizes the number and percentage of individuals by the number of pharmacist-prescribed immunizations received during the study period. Nearly half of the individuals included in the study population received one pharmacist-prescribed immunization during the four fiscal year study period, with <1% of individuals having received >5 pharmacist-prescribed immunizations during the same period.

Table 3 – Number and percentage of individuals by number of pharmacist-prescribed immunizations received during the study period

Number of immunizations	Number of individuals	Percentage (%)
1	129,458	47.23
2	69,282	25.28
3	43,904	16.02
4	27,562	10.06
5	2,103	0.77

6	1,355	0.49
7	277	0.10
8	84	0.03
9	37	0.01
10	9	<0.01
>10	10	<0.01
Total	**274,081**	**100.00**

4.2 – Descriptive summary of the immunizations prescribed

During the study period from April 1, 2018, to March 31, 2022, there were 531,780 immunizations prescribed by community pharmacists in Nova Scotia (excluding COVID-19 vaccines), with a greater proportion of vaccines having been prescribed in the during COVID-19 period (March 22, 2020, to March 31, 2022). Table 4 summarizes the number of immunizations prescribed stratified by ATC code and before or during the COVID-19 pandemic. Influenza vaccines comprised 95% (n = 503,789) of immunizations prescribed. Among the other 5% of vaccines, varicella zoster (ATC J07BK—13,383 vaccines prescribed) and two travel vaccines: hepatitis (ATC J07BC—8,710 vaccines prescribed) and cholera vaccines (ATC J07AE—1,960 vaccines prescribed) were most commonly prescribed. The proportions of influenza, hepatitis, meningococcal, and pertussis immunizations prescribed increased following the onset of the pandemic, whereas proportions of other immunizations prescribed either decreased or remained relatively unchanged following the onset of the pandemic.

Table 4 – Number and percentage of immunizations prescribed by ATC code and time period (before or during the COVID-19 pandemic)

	Before COVID-19	**During COVID-19**	**Difference During vs. Before COVID-19**	**Total (2018-2022)**
Number of Immunization Prescriptions	n = 232,264	n = 299,516	n = 67,252	n = 531,780
ATC Classification				
J07BB (influenza)	215,873 (93%)	287,916 (96%)	72,043	503,789 (95%)
J07BK (varicella zoster)	5,858 (3%)	7,525 (3%)	1,667	13,383 (3%)
J07BC (hepatitis)	6,750 (3%)	1,960 (1%)	-4,790	8,710 (2%)
J07AE (cholera)	1,762 (1%)	198 (<1%)	-1,564	1,960 (<1%)
J07AP (typhoid)	863 (<1%)	103 (<1%)	-760	966 (<1%)
J07AL (pneumococcal)	284 (<1%)	665 (<1%)	381	949 (<1%)
J07BM (papillomavirus)	290 (<1%)	403 (<1%)	113	693 (<1%)
J07AH (meningococcal)	90 (<1%)	393 (<1%)	303	483 (<1%)
J07BL (yellow fever)	182 (<1%)	91 (<1%)	-91	273 (<1%)
J07AJ (pertussis)	52 (<1%)	119 (<1%)	67	171 (<1%)
J07BG (rabies)	104 (<1%)	49 (<1%)	-55	153 (<1%)
J07BD (measles)	63 (<1%)	31 (<1%)	-32	94 (<1%)
J07BA (encephalitis)	61 (<1%)	29 (<1%)	-32	90 (<1%)
J07AM (tetanus)	32 (<1%)	34 (<1%)	2	66 (<1%)

Tables 5 and 6 summarize counts of prescribed influenza and non-influenza vaccines, respectively, before and during the COVID-19 pandemic by product name and drug identification number (DIN). The majority of prescribed influenza vaccines were publicly funded inactivated quadrivalent vaccines. The three most commonly prescribed non-influenza vaccines were Shingrix®, Twinrix®, and Dukoral®.

Table 5 – Number of influenza immunizations prescribed by type before and during the COVID-19 pandemic

Influenza Vaccine Type	Immunization Count Before COVID-19	Immunization Count During COVID-19	Total Immunization Count (2018-2022)
Quadrivalent inactivated influenza vaccine (QIIV)	213,885	284,077	497,962
High dose quadrivalent inactivated influenza vaccine (HD-QIIV)	1,737	3,156	4,893
Live attenuated intranasal influenza vaccine (LAIV)	209	663	872
Trivalent inactivated influenza vaccine (TIIV)	46	23	69
Total	**215,877**	**287,919**	**503,796**

Table 6 – Number of non-influenza immunizations prescribed by DIN and product name before and during the COVID-19 pandemic

ATC	DIN(s)	Product	Disease Prevented	Count Before COVID-19	Count During COVID-19	Total Count (2018-2022)
J07BK	02468425	Shingrix®	Herpes zoster	5,798	7,479	13,277
J07BC	02230578	Twinrix®	Hepatitis A and B	4,247	1,348	5,595
J07AE	02247208	Dukoral®	Cholera and LT-ETEC diarrhea	1,762	198	1,960
J07BC	02187078	Havrix 1440®	Hepatitis A	864	200	1,064
J07AL	02335204	Prevnar 13®	Pneumococcal	228	512	740
J07BM	02437058	Gardasil 9®	Human papillomavirus	290	403	693
J07BC	02231056	Havrix 720 Junior®	Hepatitis A	516	103	619
J07BC	02237548	Twinrix Junior®	Hepatitis A and B	506	84	590
J07AP	00885975	Vivotif®	Typhoid	499	7	506

J07BC	01919431, 02296454, 02487020, 02487039	Engerix-B®	Hepatitis B	265	213	478
J07AP	02130955	Typhim VI®	Typhoid	363	96	459
J07BC	02237792	Avaxim®	Hepatitis A	276	7	283
J07BL	00428833	VF-Vax®	Yellow fever	182	91	273
J07AL	00431648, 02436442	Pneumovax 23	Pneumococcal	56	153	209
J07AH	02417030	Bexsero®	Meningococcal group B	10	176	186
J07AJ	02240255	Adacel®	Tetanus, diphtheria, and pertussis	52	119	171
J07AH	02468751	Trumenba®	Meningococcal group B	0	135	135
J07BG	02267667	Rabavert®	Rabies	62	49	111
J07AH	02279924	Menactra®	Meningococcal groups ACYW-135	71	33	104
J07BA	02333279	Ixiaro®	Japanese encephalitis	61	29	90
J07BD	00466085	MMR II®	Measles, mumps, and rubella	48	31	79
J07BC	02243741	Avaxim Pediatric®	Hepatitis A	67	5*	72*
J07BK	02246081	Varivax III®	Varicella zoster	23	43	66
J07AM	00514462	Td Adsorbed®	Tetanus and diphtheria	32	34	66
J07AH	02402904	Nimenrix®	Meningococcal groups ACYW-135	6	46	52
J07BG	01908286	Imovax Rabies®	Rabies	42	0	42
J07BK	02375516	Zostavax II®	Herpes zoster	37	5*	42*

J07BD	02239208	Priorix®	Measles, mumps, and rubella	15	0	15
J07BC	02243676	Recombivax HB®	Hepatitis B	9	5*	14*
J07AH	02347393	Menveo®	Meningococcal groups ACYW-135	5*	5*	10*
J07AH	02440709	Menjugate®	Meningococcal group C	5*	0	5*
J07AP	02242727	Typherix®	Typhoid	5*	0	5*
J07BK	02241047	Varilrix®	Varicella zoster	0	5*	5*
Total	**-**	**-**	**-**	**16,402***	**11,614***	**28,016***

*cell value influenced due to rounding (any cell values originally <5 were rounded to 5)

Table 7 and Figure 1 summarize the number of influenza immunizations prescribed by month and fiscal year. October and November encompassed most of the influenza vaccine prescribing each fiscal year, with December accounting for most of the rest, although the month with the highest prescribing incidence varied year to year. An increase in pharmacist-prescribed influenza vaccines was observed in the 2020-2021 and 2021-2022 fiscal years as compared to the 2018-2019 and 2019-2022 fiscal years.

Table 7 – Number of influenza immunizations prescribed by month and fiscal year

Month and Fiscal Year	2018-2019	2019-2020	2020-2021	2021-2022	Total (2018-2022)
April to September	87	19	231	13	**350**
October	47,462	44,292	77,862	45,899	**215,515**
November	42,371	48,989	49,123	76,871	**217,354**
December	7,748	9,261	12,877	16,678	**46,564**
January	7,169	4,739	3,223	2765	**17,896**
February	922	1,694	487	1123	**4,226**
March	311	872	221	480	**1,884**
Total	**106,070**	**109,866**	**144,024**	**143,829**	**503,789**

Figure 1 – Bar graph of number of influenza immunizations prescribed by month and fiscal year

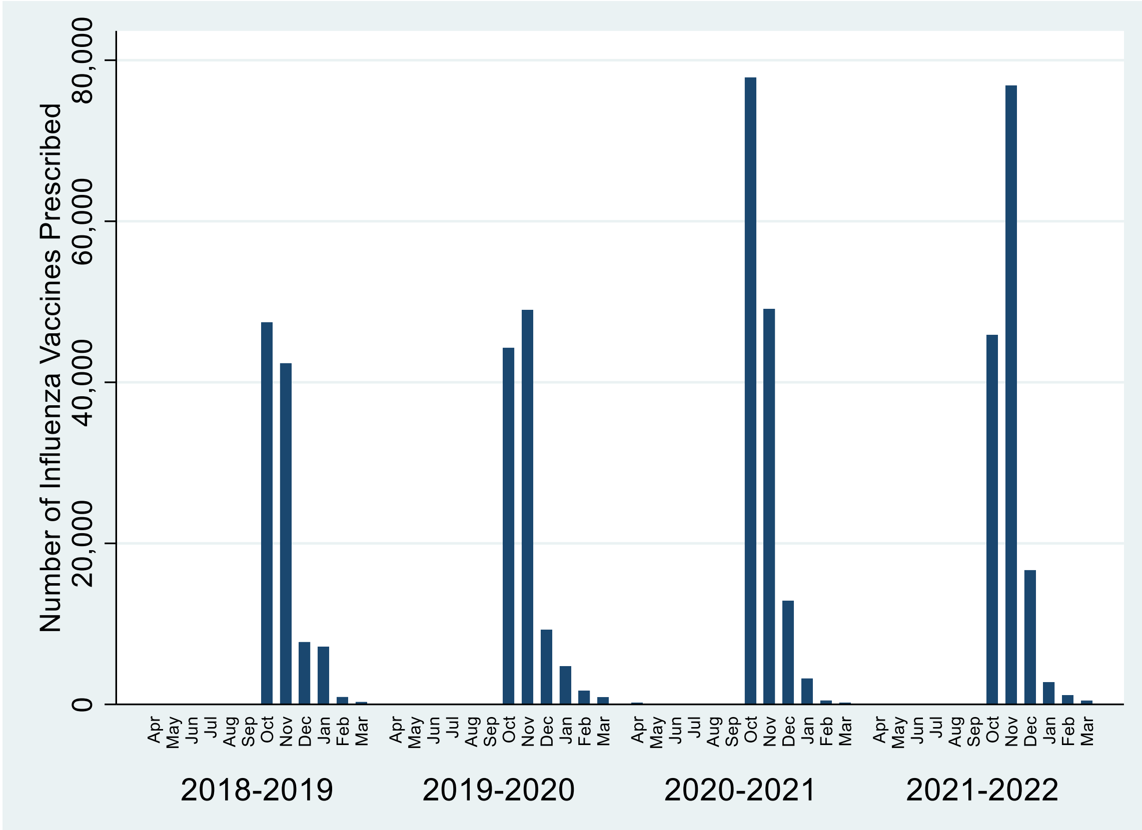


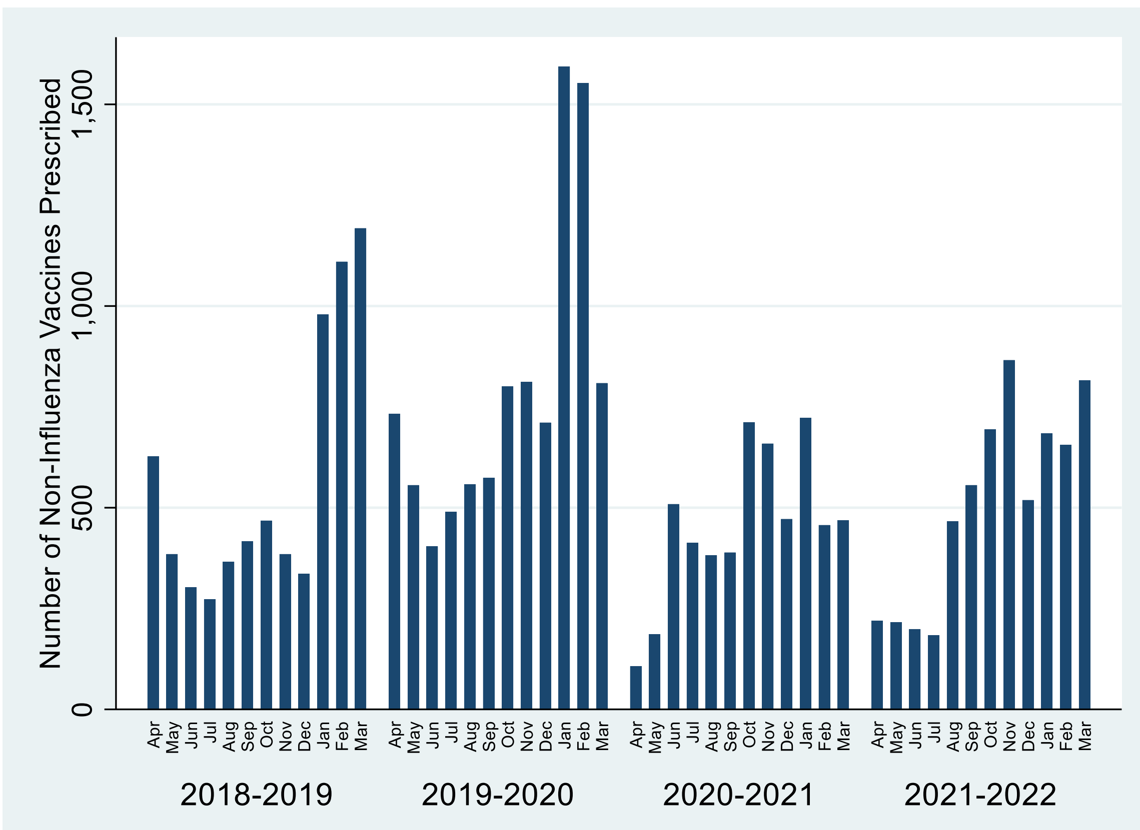
Table 8 and Figure 2 summarize the number of non-influenza immunizations prescribed by month and fiscal year. Non-influenza immunization prescribing activity reached its peak during the 2019-2020 fiscal year and then dropped below that of the 2018-2019 fiscal year following the onset of the COVID-19 pandemic. The highest numbers of non-influenza immunizations prescribed per month pre-COVID-19 pandemic were in January, February, and March. In comparison, during the COVID-19 pandemic, non-influenza immunization prescribing activity during these months was diminished.

Table 8 – Number of non-influenza immunizations prescribed by month and fiscal year

Month and Fiscal Year	2018-2019	2019-2020	2020-2021	2021-2022	Total (2018-2022)
April	627	733	107	220	**1,687**
May	385	556	186	216	**1,343**

June	303	404	509	199	**1,415**
July	273	490	413	184	**1,360**
August	366	558	382	466	**1,772**
September	417	574	389	556	**1,936**
October	468	801	712	694	**2,675**
November	385	812	659	866	**2,722**
December	336	711	472	519	**2,038**
January	979	1,594	723	684	**3,980**
February	1,110	1,553	457	656	**3,776**
March	1,193	809	469	816	**3,287**
Total	**6,842**	**9,595**	**5,478**	**6,076**	**27,991**

Figure 2 – Bar graph of number of non-influenza immunizations prescribed by month and fiscal year



Tables 9 to 11 and Figures 3 to 5 summarize trends in the top three most commonly prescribed non-influenza vaccines. The decision to look in depth at only these non-influenza vaccines was made as all other non-influenza vaccine types had approximately

1,000 vaccines or less prescribed over the four-year study period and many of the less commonly prescribed vaccine types were not able to be fully tabulated over time due to limitations with small cell sizes.

Table 9 and Figure 3 summarize the number of varicella zoster (VZ) immunizations (ATC J07BK) prescribed by month and fiscal year. Where ATC J07BK comprises both varicella (chickenpox) and herpes zoster (shingles) vaccines, it is important to note that almost all prescribed VZ vaccines were for herpes zoster. In particular, the recombinant adjuvanted zoster vaccine (RZV, i.e., Shingrix®) accounted for 13,277 of the 13,383 prescribed varicella zoster vaccines. In comparison, the live attenuated zoster vaccine (LZV, i.e., Zostavax II®) accounted for less than 42 of the 13,383 prescribed varicella zoster vaccines.

The seasonal variation in prescribing that is observed with some of the other immunizations is not observed with VZ vaccines. VZ immunization prescribing remained fairly consistent in the pre-COVID-19 and during COVID-19 periods, with the exception of April and May 2020, which had lower numbers of VZ vaccine prescriptions than prior years. April 2020 had the lowest prescription count per month over the 4-year study period at 58 vaccines prescribed. The onset of the COVID-19 pandemic, however, did not seem to significantly impact varicella zoster vaccine prescribing beyond this period.

Table 9 – Number of varicella zoster immunizations prescribed by month and fiscal year

Month and Fiscal Year	**2018-2019**	**2019-2020**	**2020-2021**	**2021-2022**	**Total (2018-2022)**
April	174	263	58	151	646
May	198	263	138	168	767
June	160	206	339	121	826
July	143	246	248	101	738
August	164	205	203	253	825

September	153	265	240	343	1,001
October	240	386	448	437	1,511
November	214	368	439	591	1,612
December	117	281	348	294	1,040
January	211	491	552	453	1,707
February	192	409	348	412	1,361
March	316	212	388	433	1,349
Total	**2,282**	**3,595**	**3,749**	**3,757**	**13,383**

Figure 3 – Bar graph of number of varicella zoster immunizations prescribed by month and fiscal year

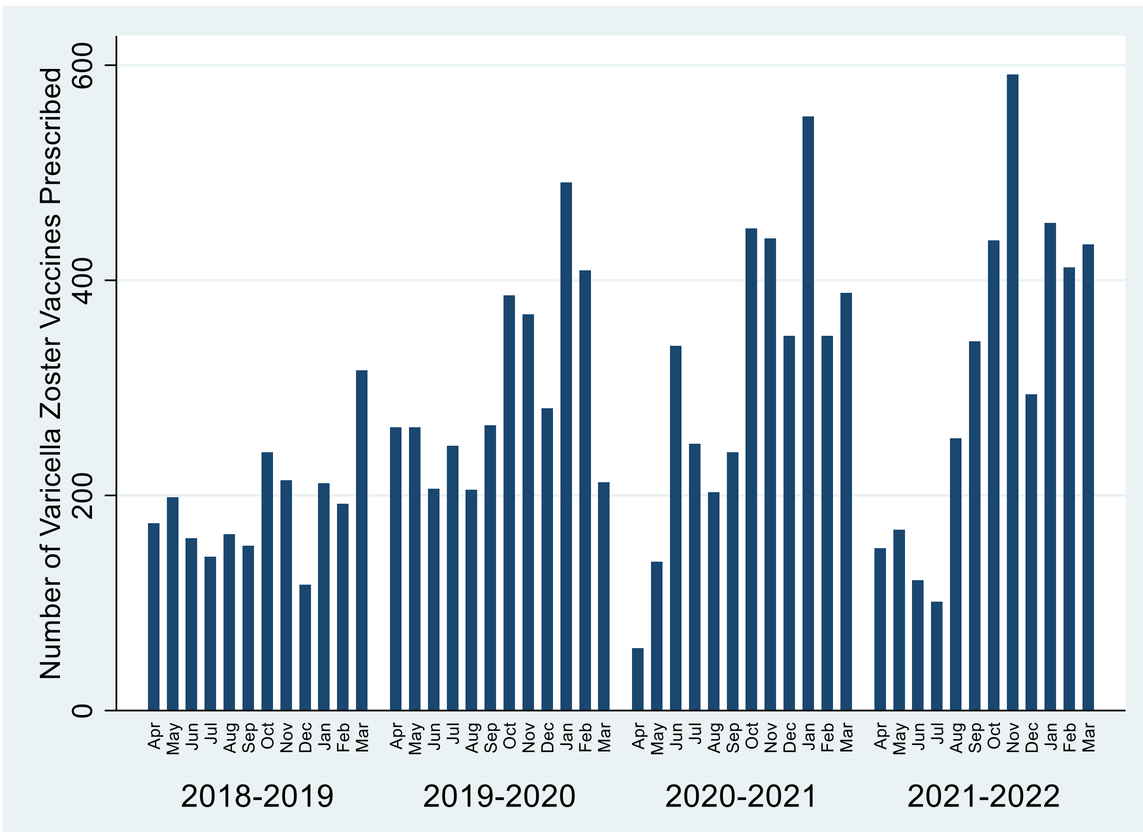


Table 10 and Figure 4 summarize the number of hepatitis immunizations prescribed by month and fiscal year. The combined hepatitis A and B vaccine (Twinrix®) was the most commonly prescribed hepatitis vaccine, comprising 5,595 of the 8,710 hepatitis vaccines, with Twinrix Junior® accounting for another 590 hepatitis vaccines. During the pre-pandemic years, January, February, and March were the months with the highest hepatitis immunization prescribing activity. However, hepatitis immunization prescribing decreased significantly during the COVID-19 pandemic as compared to the pre-pandemic years.

Table 10 – Number of hepatitis immunizations prescribed by month and fiscal year

Month and Fiscal Year	2018-2019	2019-2020	2020-2021	2021-2022	Total (2018-2022)
April	329	325	24	38	716
May	141	190	29	20	380
June	108	112	140	26	386
July	94	149	121	24	388
August	148	224	132	63	567
September	211	183	86	92	572
October	143	274	112	92	621
November	99	262	97	104	562
December	133	269	60	101	563
January	483	688	127	84	1,382
February	546	722	59	106	1,433
March	563	363	49	165	1,140
Total	**2,998**	**3,761**	**1,036**	**915**	**8,710**

Figure 4 – Bar graph of number of hepatitis immunizations prescribed by month and fiscal year

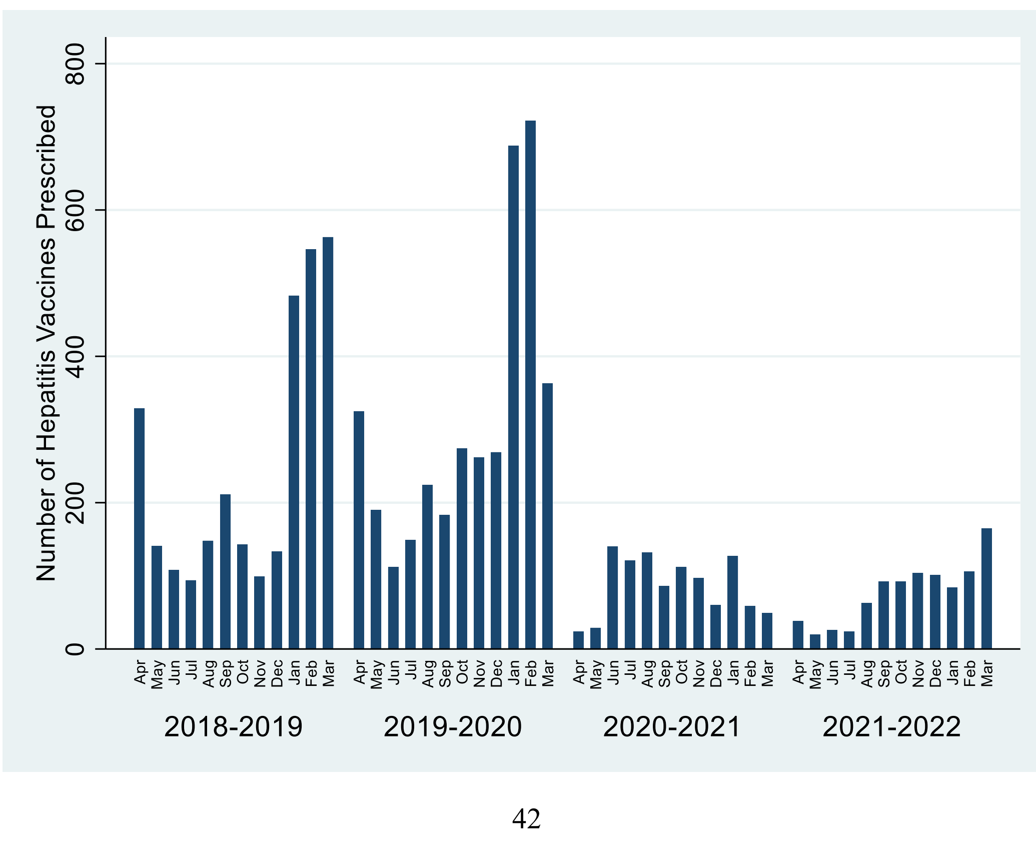


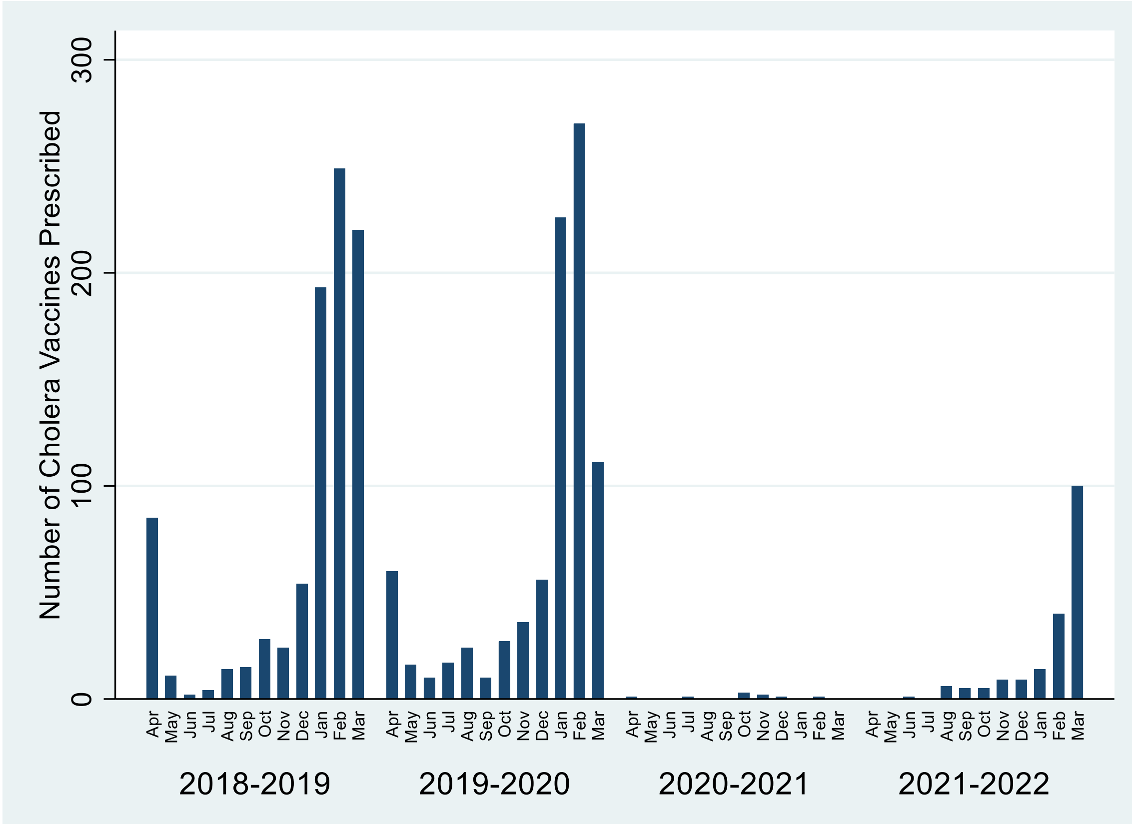
Table 11 and Figure 5 summarize the number of cholera immunizations prescribed by month and fiscal year. Similar to the hepatitis immunizations, during the pre-pandemic years, January, February, and March were the months with the highest cholera immunization prescribing activity. However, cholera immunization prescribing decreased during the COVID-19 pandemic as compared to the pre-pandemic years, with the number of cholera vaccines prescribed during the 2020-2021 fiscal year dropping to ~1% of that of the two prior fiscal years at 9 vaccines prescribed that year. During the 2021-2022 fiscal year, the cholera vaccine prescription count was 189 vaccines prescribed, approximately 21% and 22% of the 2018-2019 and 2019-2020 fiscal years, respectively.

Table 11 – Number of cholera immunizations prescribed by month and fiscal year

<table>
<tr><th></th><th colspan="5">Fiscal Year</th></tr>
<tr><th>Month</th><th>2018-2019</th><th>2019-2020</th><th>2020-2021</th><th colspan="2">2021-2022</th></tr>
<tr><td>April</td><td>85</td><td>60</td><td rowspan="12">9 (April to March)</td><td rowspan="5">April to August</td><td rowspan="5">7</td></tr>
<tr><td>May</td><td>11</td><td>16</td></tr>
<tr><td>June</td><td>5*</td><td>10</td></tr>
<tr><td>July</td><td>5*</td><td>17</td></tr>
<tr><td>August</td><td>14</td><td>24</td></tr>
<tr><td>September</td><td>15</td><td>10</td><td>September</td><td>5</td></tr>
<tr><td>October</td><td>28</td><td>27</td><td>October</td><td>5</td></tr>
<tr><td>November</td><td>24</td><td>36</td><td>November</td><td>9</td></tr>
<tr><td>December</td><td>54</td><td>56</td><td>December</td><td>9</td></tr>
<tr><td>January</td><td>193</td><td>226</td><td>January</td><td>14</td></tr>
<tr><td>February</td><td>249</td><td>270</td><td>February</td><td>40</td></tr>
<tr><td>March</td><td>220</td><td>111</td><td>March</td><td>100</td></tr>
<tr><td>Total</td><td>903*</td><td>863</td><td>9</td><td>-</td><td>189</td></tr>
</table>

*cell value influenced due to rounding (any cell values originally <5 were rounded to 5)

Figure 5 – Bar graph of number of cholera immunizations prescribed by month and fiscal year



4.3 – Analytic summary of the immunizations prescribed

Negative binomial regression models were built to characterize pharmacist immunization prescribing over time. All prescribed immunizations were categorized into two groups as either influenza vaccines (i.e., vaccines with an ATC code of J07BB) or non-influenza vaccines (i.e., all vaccines with ATC codes other than J07BB) and regression models were run separately for each group. The outcome variable was the number of immunizations prescribed per individual prescriber by month and year, as well as patient sex, age, and/or rurality dependent on the specific model. All models included a prescriber random effect to control for individual variation in prescribing activity. While a random effect of the individual receiving the vaccine(s) would make theoretical sense in these models, as Table 3 showed almost half of individuals only had a single prescription and over 70% only had 2, the random effect for individual vaccine recipients could not be included in any of the models. Interactions between model covariables were investigated for both influenza and non-influenza immunization models—there was a statistically significant interaction between year and age group for the multivariable influenza immunization model and therefore, this interaction term was incorporated into the model. The same interaction was not statistically significant for the multivariable non-influenza immunization model. All other interactions investigated were not found to be statistically significant.

Table 12 summarizes the results of the three univariable negative binomial regression models built to characterize pharmacist influenza immunization prescribing. All models include month and fiscal year, the first model was adjusted for patient sex, the second model was adjusted for patient age group, and the third model was adjusted for patient urban/rural status.

Table 12 – Univariable negative binomial regression models for number of influenza immunizations prescribed by month and year

Variable	**Univariable sex model – Incidence rate ratio (95% confidence interval)**	**Univariable age model – Incidence rate ratio (95% confidence interval)**	**Univariable rurality model – Incidence rate ratio (95% confidence interval)**
Fiscal year			
2018-2019	1.00 (reference)	1.00 (reference)	1.00 (reference)
2019-2020	1.038 (1.001, 1.076)*	1.045 (1.020, 1.070)*	1.030 (0.984, 1.078)
2020-2021	1.298 (1.251, 1.347)*	1.302 (1.272, 1.334)*	1.263 (1.206, 1.324)*
2021-2022	1.337 (1.289, 1.387)*	1.354 (1.321, 1.386)*	1.404 (1.339, 1.472)*
Month			
April	0.097 (0.076, 0.125)*	0.208 (0.167, 0.259)*	0.102 (0.075, 0.139)*
May	0.077 (0.049. 0.118)*	0.178 (0.121, 0.260)*	0.079 (0.047, 0.132)*
June	0.036 (0.017, 0.077)*	0.110 (0.053, 0.226)*	0.035 (0.015, 0.083)*
July	0.028 (0.006, 0.134)*	0.080 (0.017, 0.373)*	0.024 (0.004, 0.133)*
August	0.028 (0.004, 0.187)*	0.068 (0.010, 0.446)*	0.025 (0.003, 0.200)*
September	0.047 (0.008, 0.264)*	0.106 (0.020, 0.567)*	0.038 (0.005, 0.265)*

October	1.057 (1.021, 1.094)*	1.036 (1.015, 1.057)*	1.050 (1.007, 1.095)*
November	1.00 (reference)	1.00 (reference)	1.00 (reference)
December	0.262 (0.252, 0.272)*	0.338 (0.330, 0.346)*	0.307 (0.294, 0.321)*
January	0.143 (0.137, 0.149)*	0.222 (0.215, 0.229)*	0.175 (0.166, 0.184)*
February	0.085 (0.080, 0.091)*	0.179 (0.170, 0.189)*	0.099 (0.092, 0.107)*
March	0.088 (0.081, 0.097)*	0.194 (0.180, 0.210)*	0.098 (0.092, 0.107)*
Sex			
Male	1.00 (reference)	N/A	N/A
Female	1.228 (1.197, 1.260)*		
Age group			
2-4	N/A	0.109 (0.102, 0.117)*	N/A
5-19		0.464 (0.451, 0.477)*	
20-34		0.400 (0.389, 0.412)*	
35-49		0.583 (0.567, 0.599)*	
50-64		1.00 (reference)	
65-79		1.066 (1.039, 1.094)*	
80+		0.425 (0.413, 0.438)*	
Rurality			
Rural	N/A	N/A	1.00 (reference)
Urban			1.407 (1.360, 1.455)*
Unknown			0.157 (0.148, 0.167)*

*Values are statistically significant ($p < 0.05$)

Table 13 summarizes the results of the multivariable negative binomial regression model built to characterize pharmacist influenza immunization prescribing. In examining the interaction between age and fiscal year included within this model, 15 of 21 IRRs produced from this interaction were statistically significant, as described in the table below (see Figure 6 for the predictive margins plot), with the largest magnitude of effect observed for those 65-79 years of age during the 2020-2021 fiscal year (IRR 10.707, 95% CI [8.652, 13.250]). The incidence rate of pharmacist influenza immunizations prescribed per prescriber was 1.073 times higher in October as compared to the reference month of November (IRR 1.073, 95% CI [1.059, 1.087]) when controlling for age, sex, rurality, and year, whereas the incidence rate was significantly lower in all other months as compared to November, excluding August and September. The incidence rate of pharmacist influenza immunizations prescribed per prescriber was 1.164 times higher in female patients as compared to male patients (IRR 1.164, 95% CI [1.151, 1.177]) when controlling for age, rurality, month, and year. The incidence rate of pharmacist influenza immunizations prescribed per prescriber was 1.181 times higher in those residing in urban areas as compared to those residing in rural areas (IRR 1.181, 95% CI [1.167, 1.194]) when controlling for age, sex, month, and year, whereas the incidence rate was significantly lower in those with unknown rural/urban status as compared to those residing in rural areas (IRR 0.359, 95% CI [0.347, 0.370]).

Table 13 – Multivariable regression model of influenza immunizations prescribed by month and year including age, sex, and rurality covariables and an interaction term between fiscal year and age

Variable	Incidence rate ratio (95% confidence interval)
Interaction between age and fiscal year	
2-4 years	
2018-2019	1.00 (reference)
2019-2020	0.785 (0.298, 2.067)
2020-2021	1.109 (0.606, 2.029)
2021-2022	3.639 (1.953, 6.779)*
5-19 years	
2018-2019	1.00 (reference)
2019-2020	1.057 (0.923, 1.210)
2020-2021	1.520 (1.321, 1.750)*
2021-2022	1.431 (1.238, 1.655)*
20-34 years	
2018-2019	1.00 (reference)
2019-2020	1.048 (0.933, 1.178)
2020-2021	0.975 (0.869, 1.093)
2021-2022	1.476 (1.303, 1.672)*
35-49 years	
2018-2019	1.00 (reference)
2019-2020	1.239 (1.083, 1.417)*
2020-2021	1.796 (1.561, 2.066)*
2021-2022	1.921 (1.667, 2.213)*
50-64 years	
2018-2019	1.00 (reference)
2019-2020	1.221 (1.036, 1.439)*
2020-2021	5.325 (4.416, 6.422)*
2021-2022	3.557 (2.979, 4.246)*
65-79 years	
2018-2019	1.00 (reference)
2019-2020	1.332 (1.114, 1.593)*

2020-2021	10.707 (8.652, 13.250)*
2021-2022	8.492 (6.967, 10.351)*
80+ years	
2018-2019	1.00 (reference)
2019-2020	1.105 (0.966, 1.265)
2020-2021	1.950 (1.691, 2.249)*
2021-2022	2.301 (1.996, 2.652)*
Month	
April	0.366 (0.304, 0.441)*
May	0.267 (0.194, 0.369)*
June	0.252 (0.127, 0.500)*
July	0.209 (0.049, 0.895)*
August	0.178 (0.030, 1.053)
September	0.257 (0.053, 1.258)
October	1.073 (1.059, 1.087)*
November	1.00 (reference)
December	0.461 (0.454, 0.469)*
January	0.350 (0.342, 0.359)*
February	0.342 (0.327, 0.358)*
March	0.376 (0.351, 0.402)*
Sex	
Male	1.00 (reference)
Female	1.164 (1.151, 1.177)*
Rurality	
Rural	1.00 (reference)
Urban	1.181 (1.167, 1.194)*
Unknown	0.359 (0.347, 0.370)*

*Values are statistically significant (p <0.05)

Figure 6 – Predictive margins for the interaction between age and fiscal year with 95% confidence intervals

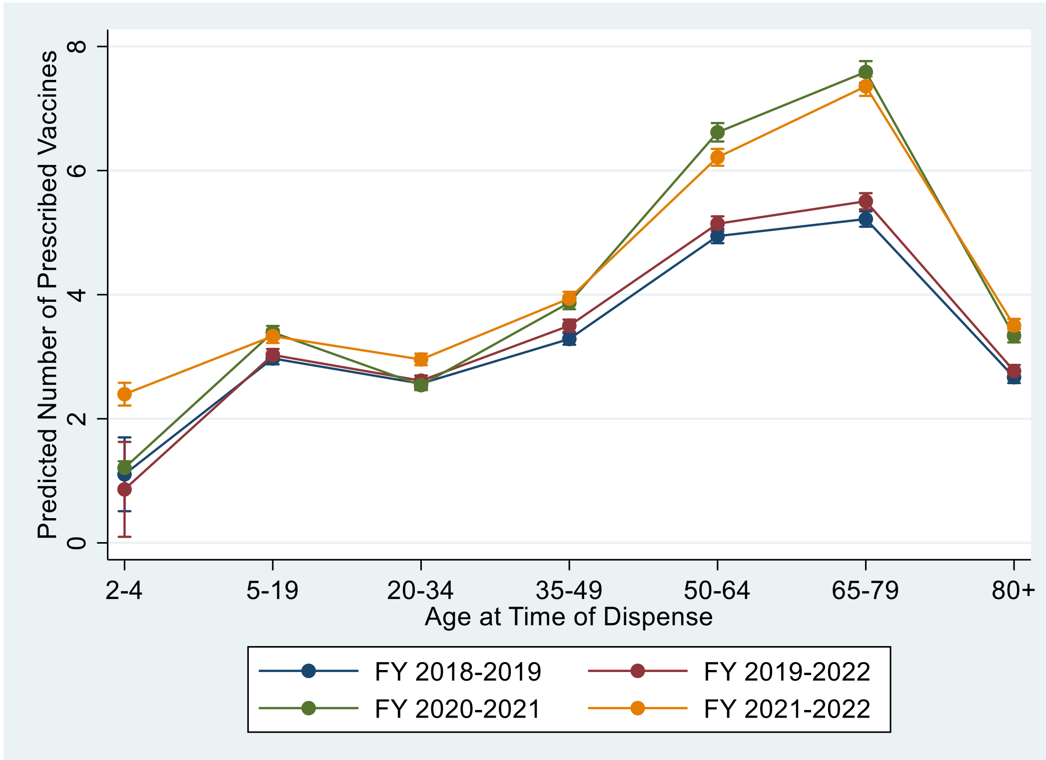


Table 14 summarizes the results of the three univariable negative binomial regression models built to characterize pharmacist non-influenza immunization prescribing. All models include month and fiscal year, the first model was adjusted for patient sex, the second model was adjusted for patient age group, and the third model was adjusted for patient urban/rural status.

Table 14 – Univariable regression models of non-influenza immunizations prescribed by month and year

Variable	**Univariable sex model – Incidence rate ratio (95% confidence interval)**	**Univariable age model – Incidence rate ratio (95% confidence interval)**	**Univariable rurality model – Incidence rate ratio (95% confidence interval)**
Fiscal year			
2018-2019	1.00 (reference)	1.00 (reference)	1.00 (reference)
2019-2020	1.125 (1.086, 1.166)*	1.074 (1.039, 1.110)*	1.120 (1.076, 1.165)*
2020-2021	0.849 (0.815, 0.884)*	0.925 (0.890, 0.961)*	0.838 (0.802, 0.876)*

2021-2022	0.896 (0.861, 0.932)*	0.958 (0.923, 0.994)*	0.857 (0.820, 0.896)*
Month			
April	0.882 (0.823, 0.945)*	0.883 (0.828, 0.942)*	0.869 (0.805, 0.938)*
May	0.855 (0.794, 0.921)*	0.878 (0.820, 0.940)*	0.829 (0.764, 0.899)*
June	0.920 (0.856, 0.990)*	0.928 (0.867, 0.993)*	0.890 (0.822, 0.964)*
July	0.870 (0.808, 0.936)*	0.905 (0.845, 0.969)*	0.833 (0.769, 0.903)*
August	0.912 (0.852, 0.976)*	0.894 (0.839, 0.952)*	0.879 (0.816, 0.947)*
September	0.982 (0.919, 1.056)	0.948 (0.892, 1.008)	0.926 (0.861, 0.996)*
October	0.995 (0.937, 1.058)	0.980 (0.926, 1.036)	0.984 (0.920, 1.052)
November	1.00 (reference)	1.00 (reference)	1.00 (reference)
December	0.945 (0.885, 1.008)	0.954 (0.898, 1.013)	0.924 (0.860, 0.993)*
January	1.148 (1.086, 1.215)*	1.070 (1.016, 1.126)*	1.149 (1.080, 1.223)*
February	1.136 (1.073, 1.202)*	1.018 (0.966, 1.073)	1.130 (1.061, 1.203)*
March	1.067 (1.007, 1.131)*	0.993 (0.941, 1.048)	1.050 (0.984, 1.120)
Sex			
Male	1.00 (reference)	N/A	N/A
Female	1.047 (1.019, 1.076)*		
Age group			
2-4	N/A	0.762 (0.619, 0.939)*	N/A
5-19		1.063 (1.014, 1.114)*	
20-34		1.007 (0.966, 1.050)	
35-49		1.041 (0.999, 1.085)	
50-64		1.00 (reference)	
65-79		0.918 (0.890, 0.947)*	
80+		0.738 (0.691, 0.789)*	
Rurality			
Rural	N/A	N/A	1.00 (reference)
Urban			1.112 (1.077, 1.147)*
Unknown			0.772 (0.699, 0.853)*

*Values are statistically significant (p <0.05)

Table 15 summarizes the results of the multivariable negative binomial regression model built to characterize pharmacist non-influenza immunization prescribing. The incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was slightly higher in 2019-2020 as compared to the reference year of 2018-2019 (IRR 1.060, 95% CI [1.027, 1.093]) when controlling for age, sex, rurality, and month, whereas the incidence rate was lower in 2020-2021 as compared to 2018-2019 (IRR 0.959, 95% CI [0.924, 0.995]). The incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was lower in May and August as compared to the reference month of November (May IRR 0.935, 95% CI [0.875, 0.998]; August IRR 0.934, 95% CI [0.880, 0.992]) when controlling for age, sex, rurality, and year; the incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was not significantly different for all other months as compared to November. The incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was 1.146, 1.103, and 1.093 times higher in those 5-19 years of age, 20-34 years of age, and 35-49 years of age, respectively, as compared to the reference group of 50-64 year olds (5-19 IRR 1.146, 95% CI [1.095, 1.198; 20-34 IRR 1.103, 95% CI [1.060, 1.148]; 35-49 IRR 1.093, 95% CI [1.051, 1.137]) when controlling for sex, rurality, month, and year. In contrast, the incidence rate was 1.067 and 1.164 times lower in those 65-79 and 80 years and above, respectively (65-79 IRR 0.937, 95% CI [0.910, 0.966]; 80+ IRR 0.859, 95% CI [0.805, 0.915]). There was a non-significant difference in the incidence rate of pharmacist non-influenza immunizations prescribed per prescriber between males and females. Lastly, the incidence rate of pharmacist non-influenza immunizations prescribed per prescriber for urban residents was 1.074 times higher than that of rural residents (IRR 1.074, 95% CI [1.047, 1.101]) when controlling for age, sex, month, and year.

Table 15 – Multivariable regression model of non-influenza immunizations prescribed by month and year including age, sex, and rurality

Variable	**Incidence rate ratio (95% confidence interval)**
Fiscal year	
2018-2019	1.00 (reference)
2019-2020	1.060 (1.027, 1.093)*
2020-2021	0.959 (0.924, 0.995)*
2021-2022	0.977 (0.943, 1.013)
Month	
April	0.941 (0.885, 1.000)
May	0.935 (0.875, 0.998)*
June	0.979 (0.917, 1.044)
July	0.941 (0.881, 1.004)
August	0.934 (0.880, 0.992)*
September	0.990 (0.934, 1.049)

October	0.990 (0.939, 1.044)
November	1.00 (reference)
December	0.966 (0.912, 1.023)
January	1.035 (0.985, 1.087)
February	1.009 (0.960, 1.061)
March	0.991 (0.942, 1.043)
Age group	
2-4	0.940 (0.769, 1.148)
5-19	1.146 (1.095, 1.198)*
20-34	1.103 (1.060, 1.148)*
35-49	1.093 (1.051, 1.137)*
50-64	1.00 (reference)
65-79	0.937 (0.910, 0.966)*
80+	0.859 (0.805, 0.915)*
Sex	
Male	1.00 (reference)
Female	0.998 (0.975, 1.022)
Rurality	
Rural	1.00 (reference)
Urban	1.074 (1.047, 1.101)*
Unknown	0.980 (0.900, 1.069)

*Values are statistically significant ($p < 0.05$)

5.0 – Discussion

5.1 – Summary of findings

This analysis described the characteristics of those receiving immunizations prescribed by community pharmacists in Nova Scotia and the types and numbers of immunizations prescribed by the same from April 1, 2018, to March 31, 2022, and changes in these from before and during the COVID-19 pandemic (defined by the cutoff date of March 22, 2020).

Analysis of the sociodemographic characteristics of 274,081 individuals accessing pharmacist immunization prescribing services found that the mean age was 53 years with nearly two-thirds (64%) of the study population having been aged 50 years or older at the time of the first immunization dispensing date, 56% of the population was female, 64% resided in an urban area, and 40% resided in Halifax Regional Municipality. In comparison to the provincial population, the study population was slightly older on average, had a higher proportion of females, a lower proportion of both urban residents and HRM residents, and similar proportions of individuals across the quintiles of the four CIMD domains. Population characteristics did not change significantly during the COVID-19 pandemic compared to before.

A total of 531,780 immunizations were prescribed to the 274,081 individuals included in the study, 95% of which were influenza immunizations. Pharmacist prescribing of influenza vaccines increased significantly following the onset of the COVID-19 pandemic. The three most commonly prescribed non-influenza immunizations were varicella zoster vaccines, hepatitis vaccines, and cholera vaccines. Pharmacist prescribing of hepatitis and cholera vaccines decreased significantly following the onset of the COVID-19 pandemic, whereas prescribing of varicella zoster (predominantly herpes zoster) vaccines remained relatively unchanged.

The incidence rate of pharmacist influenza immunizations prescribed per prescriber was higher in October and significantly lower in all other months excluding August and September as compared to the reference month of November, higher in females as compared to males, and higher in urban residents as compared to rural residents. Additionally, there was a significant interaction effect between age and fiscal year whereby the incidence rate of pharmacist influenza immunizations prescribed per prescriber was highest in those 65-79 years of age during the 2020-2021 fiscal year.

The incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was higher in 2019-2020 and lower in 2020-2021 as compared to the reference year of 2018-2019, higher in May and August as compared to the reference month of November, higher in those 5-19, 20-34, and 35-49 years of age and lower in those 65-79 and 80+ years of age as compared to the reference group of 50-64 year olds, and higher in urban residents as compared to rural residents.

5.2 – Patient characteristics

Individuals 50- to 64 years of age and 65- to 79 years of age made up the largest age groups in the study population, together making up approximately 56% of the study population. Compared to the provincial population, there was a smaller proportion of individuals under 50 years of age and a larger proportion of individuals 50 years and older. This aligns with prior research on pharmacists as immunizers where older adults are the most frequently immunized group by pharmacists (39). It is also known that older adults use more prescription medications than any other age group in Canada (56), so they would have more frequent contact with their local pharmacy and pharmacists and thus, a greater chance of accessing and/or being offered pharmacy-based immunization services.

Over half (56%) of the study population were female, which was somewhat higher than the percentage of female individuals in the provincial population (51%). The proportion of females observed in this study was also similar to prior studies on pharmacists as immunizers, such as Waite et al. 2019 (38). This higher proportion of females may also be accounted for by sex-based differences in vaccine uptake, with prior research having described higher vaccination rates in females as compared to males (57). As previously noted, only patient sex was available via the administrative health databases used and thus, is being used as a proxy for patient gender as well, which is known to influence individual healthcare use (58) and thus, may contribute to the observed higher proportion of females.

While the majority of the population (64%) resided in urban areas, the proportion of urban-dwelling individuals was lower in the study population as compared to the general provincial population (69%). Conversely, the proportion of rural-dwelling individuals was slightly higher in the study's population (33%) as compared to the provincial population (31%). The rural-urban status was unknown for 3% of the study population due to missing postal code. The largest proportion resided in Halifax county (40%), although the proportion of individuals within this census division was smaller in the study population as compared to the provincial population (45%). Conversely, slightly higher proportions of individuals residing in Shelburne, Lunenburg, Colchester, Guysborough, Richmond, and

Victoria counties in the study population as compared to the provincial population. With rural areas being disproportionately impacted by the current primary care crisis in Nova Scotia, particularly Northern and Eastern NSH zones (59), it is possible that people in these areas more heavily rely on pharmacists for primary care services such as immunization prescribing and administration due to low access to other primary care providers, such as physicians and nurse practitioners.

For the residential instability domain, the largest proportion of the study population fell under the fifth quintile, which correlates to DAs with the highest level of instability in residential living conditions, and which may relate to frequent fluctuation in neighbourhood residents, higher proportions of temporary housing situations, and other indicators of residential fluctuation. The distribution of individuals in the study population across the residential instability domain quintiles was quite similar to that of the provincial population, although there was a slightly higher proportion of individuals from the provincial population within the fifth quintile (28%) as compared to the study population (23%). Given the missingness of CIMD quintile data for 3% of the study population, it is difficult to discern whether this is a meaningful difference in residential instability indicators between the two populations or whether these proportions would be more similar if there was not missingness within this variable.

For the economic dependency domain, the largest proportion of the study population fell under the first quintile, which correlates to DAs with the lowest level of economic dependency, and which may relate to higher proportions of residents with higher degrees of financial self-sufficiency and lower reliance upon social assistance programs within these areas. The distribution of individuals in the study population across the economic dependency domain quintiles was quite similar to that of the provincial population, although there was a slightly higher proportion of individuals from the provincial population within the first quintile (27%) as compared to the study population (24%). It is difficult to discern whether this is a meaningful difference for similar reasons outlined above.

For the ethnocultural composition domain, the largest proportion of the study population fell under the fifth quintile, which correlates to DAs with the highest level of ethnocultural diversity, and which may relate to higher proportions of residents who are recent immigrants, those without knowledge of either official language, those that are foreign born, and those who self-identify as a visible minority. The distribution of individuals in the study population across the ethnocultural composition domain quintiles was quite similar to that of the provincial population, although there was a slightly higher proportion of individuals from the provincial population within the fifth quintile (30%) as compared to the study population (27%). It is difficult to discern whether this is a meaningful difference for similar reasons outlined above.

For the situational vulnerability domain, the largest proportion of the study population (27%) fell under the first quintile, which correlates to DAs with the lowest level of situational vulnerability, and which may relate to higher proportions of residents with favourable sociodemographic conditions with respect to education and housing who may be less vulnerable to adverse housing conditions, environmental hazards, etc. The distribution of individuals in the study population across the situational vulnerability domain quintiles was very similar to that of the provincial population with little appreciable differences.

The characteristics of the study population remained relatively stable during the four-year study period. Slight changes were seen in the increased age from before COVID-19 to during COVID-19 (mean, as well as proportion of older age groups). This may reflect the same group of people using pharmacist immunization services over the four-year study period and thus, aging within the study population cohort over time. This also may reflect the impact of public health messaging during 2020 to 2022 with respect to protecting older individuals from COVID-19, which may have transferred over to increased pursuit of other protective health measures recommended to this age group, such as influenza immunization.

Finally, with respect to the number of immunizations prescribed per individual, there was a large variation in the total number of prescribed immunizations received during the four-year study period ranging from one vaccine per person to 18 vaccines per person. Nearly half the study population only received one pharmacist-prescribed vaccine during the study period. This aligns somewhat with prior literature in that Waite et al. found that having received a pharmacy service in the prior year was a weak predictor of pharmacy-based influenza immunization (38). This finding may also reflect a large proportion of the population receiving vaccines from wherever and whomever was most convenient, especially during the COVID-19 pandemic where access to primary care became even more precarious.

5.3 – Descriptive summary of immunization prescribing

From April 1, 2018, to March 31, 2022, community pharmacists in Nova Scotia prescribed 531,780 influenza and non-influenza vaccines (excluding COVID-19 vaccines) to 274,081 individuals. This represents approximately one-quarter of the provincial population having been prescribed at least one vaccine by a community pharmacist during this time period. The vast majority of the captured immunizations were for influenza; influenza vaccines counted for 503,796 (approximately 95%) of the pharmacist-prescribed vaccines. This aligns with prior research (60) and what was expected given that the only vaccines pharmacists can prescribe in Nova Scotia which are publicly funded for administration by pharmacists are influenza vaccines and COVID-19 vaccines (the latter of which were not included in this study due to unavailability of administrative health data on pharmacist COVID-19 vaccine provision).

The vast majority of prescribed influenza vaccines were the publicly funded quadrivalent inactivated influenza vaccines (QIIV). A small proportion of prescribed influenza vaccines were for the Fluzone High-Dose quadrivalent inactivated influenza vaccine (HD-QIIV), which is recommended for individuals 65 years of age and older but was not publicly funded for community-dwelling residents in Nova Scotia during the study period (61). Additionally, there was also a small proportion of a live attenuated influenza vaccine (LAIV) which is administered as a nasal spray (Flumist Quadrivalent); similar to HD-QIIV, it is not publicly funded by the provincial government in Nova Scotia (62). Low counts of HD-QIIV and LAIV were expected given the lack of public funding during the study period and prior evidence indicating that individuals are more willing to be vaccinated if it is funded (63).

A marked increase in volume of influenza immunizations prescribed was observed in the during COVID-19 period as compared to before the pandemic, likely reflecting increased demand from the public and larger numbers of doses ordered by Public Health in an attempt to avoid a ‘twindemic’ and the strain that concurrent COVID-19 and influenza outbreaks would place on the healthcare system (64). Interestingly, the month of highest influenza vaccine prescribing activity varied year to year: in 2018 and 2020, October saw the highest numbers of influenza vaccines prescribed, whereas in 2019 and 2021, it was November. Timing of peak influenza vaccine prescribing activity may be influenced by various factors, including timing of vaccine shipments from Public Health as well as public demand. In the case of this study, upon further examination of situational factors, there was high demand for influenza vaccines early in the 2020 flu season, resulting in marked shortages by early November (65). Comparatively, in 2021, influenza vaccines were not available in Nova Scotia until the end of October (66), which would likely account for the bulk of influenza vaccines having been prescribed in November this year.

Of the non-influenza vaccines, varicella zoster (ATC J07BK) was the most commonly prescribed. While ATC J07BK encompasses both vaccines to prevent varicella (chickenpox) and vaccines to prevent herpes zoster (shingles), the recombinant adjuvanted zoster vaccine (RZV, i.e., Shingrix) accounted for almost all (99.2%) of prescribed varicella zoster vaccines. The recombinant vaccine was approved by Health Canada in October 2017 (67) and by August 2018, the National Advisory Committee on Immunizations (NACI) had updated their recommendations on the use of herpes zoster vaccines to reflect the superior efficacy of RZV as compared to LZV (68). Herpes zoster vaccine prescribing during the study period likely reflects this shift from the live attenuated product to the recombinant vaccine.

In addition, the recombinant vaccine is recommended for nearly all patients over the age of 50 (68), a population that already commonly frequents community pharmacies (69). Because of the relatively straightforward eligibility criteria for this vaccine, this is also an easier and less time-consuming immunization assessment for pharmacists to complete. Several chain pharmacies have also launched marketing campaigns and materials aimed at advertising shingles vaccine prescribing and administration services (70,71). Additionally, this vaccine is not publicly funded in Nova Scotia for anyone, so that everyone receiving it will have to pay out of pocket or submit the prescription cost to their private drug insurance regardless of the type of provider who prescribes it. All of these factors may contribute to varicella zoster vaccines, specifically the recombinant adjuvanted zoster vaccine, being the most common non-influenza vaccine prescribed by community pharmacists in Nova Scotia.

Hepatitis vaccines were also commonly prescribed non-influenza vaccines. This aligns with prior literature; Grant et al. reported that both travel and non-travel vaccine prescribing were among the top 10 pharmacist prescribing services accessed in Nova Scotia from 2017 to 2020 and that travel vaccines were largely comprised of prescriptions for the combined hepatitis A and B vaccine (60). Although travel is a commonly cited indication for hepatitis immunization, it is possible that some of the prescribed hepatitis vaccines included in the study dataset were prescribed for other indications (e.g., pre-exposure prevention of hepatitis B infection in those with occupational risk for exposure, although these vaccines would typically be administered in the workplace and provided by the employer).

Prescribing of the cholera vaccine in this study aligns with prior literature in that it was one of the most commonly prescribed travel vaccines in Grant et al.'s study as well (60). Although the study data do not provide information on specific indication for immunization prescribing, it is commonly prescribed for prevention of travellers' diarrhea despite recommendations against routine administration for this purpose based on moderate quality data which demonstrated the vaccine was not effective in preventing travellers' diarrhea as compared to placebo (72). Given this was the third most commonly prescribed type of non-influenza vaccine in this study, further education for pharmacists in the province may be warranted to prevent unnecessary prescribing.

A significant reduction in prescribing of the oral inactivated cholera and heat-labile toxin producing enterotoxigenic *E. Coli* (LT-ETEC) vaccine was observed following the onset of the COVID-19 pandemic, likely due to subsequent federal restrictions on travelling given that it is a travel vaccine indicated for the prevention of and protection against cholera and diarrhea caused by LT-ETEC (73). A similar reduction in hepatitis vaccine prescribing was also observed across the same years, though to a lesser degree, likely due to similar reasons. Varicella zoster (VZ) vaccines, however, did not show this same decrease in prescribing frequency. The reasons for this are not clear, however, VZ vaccination is required regardless of travel whereas hepatitis and cholera vaccination are largely travel-specific. Additionally, organizations such as the United States Centers for Disease Control and Prevention (CDC) provided guidance indicating that shingles vaccination is an essential preventative healthcare service for older individuals that should not be delayed or stopped during the COVID-19 pandemic unless an individual is suspected to have an active COVID-19 infection (74), which would support the steady numbers of VZ vaccines prescribed during COVID-19 as compared to before the pandemic.

5.4 – Analytic summary of immunization prescribing

The multivariable negative regression model for influenza immunizations demonstrated significant associations between influenza immunization prescribing and all predictor variables, although not on all levels of each predictor variable, as well as a significant interaction between age and year. Regarding the interaction between age and fiscal year within this model, the largest magnitude of effect was observed for those 65-79 years of age during the 2020-2021 fiscal year whereby the incidence rate of pharmacist influenza immunizations prescribed per prescriber was 10.707 times higher in those 65-79 years of age during the 2020-2021 fiscal year as compared to the incidence rate within the same age group during the referent year of 2018-2019 when controlling for sex, rurality, and month.

The reason for this is not entirely clear, although prior literature demonstrated increased uptake of influenza vaccine during the 2020-2021 season among Canadian adults aged 50 and older, with both history of prior influenza immunization as well as concern regarding COVID-19 having been positively associated with odds of influenza immunization in this population during this season (75). Although influenza immunization does not protect against COVID-19, flu vaccination was part of broader public health strategy during this time to help flatten the curve of respiratory disease overall and preserve medical resources to be used for care of COVID-19 patients (76). Additionally, those 65 years of age and older are at significantly higher risk of flu-related morbidity and mortality as compared to their younger counterparts (77). Considering both of these factors in tandem, this may explain in part why this interaction between age and year was observed.

The rate of influenza immunizations prescribed per prescriber was 1.164 times higher for females as compared to males when controlling for age, rurality, month, and year. This aligns with prior research conducted with a similar population, as Waite et al. examined the population of individuals in Ontario who received an influenza vaccine from a community pharmacist during the 2013-2014 and 2015-2016 seasons and observed a larger proportion of female patients compared to males among those vaccinated against influenza by a pharmacist (54.5% to 54.9% females depending on age group and influenza season). Additionally, further literature on influenza vaccine uptake and sex indicates that females often have higher levels of influenza vaccine coverage as compared to males. A 2020 retrospective analysis examining sex-based differences in influenza vaccine uptake in the United States during the 2018-2019 influenza season found that odds of influenza immunization was higher in females compared to males in both unadjusted and adjusted analyses, although only among patients 75 years of age and younger; the association was not significant for patients over 75 years of age (57). Additionally, a 2022 literature review of 39 studies found that seasonal influenza vaccine coverage is highest in females, white individuals (race not specifically explored in this study, see limitations section), and older people (78).

In addition, the rate of influenza immunizations prescribed per prescriber was 1.181 times higher for urban residents as compared to rural residents when controlling for age, sex, month, and year, which may relate back to the large proportion of urban residents in the study population (64% as per Table 1). In regard to why urban residents may be more likely to receive a pharmacist-prescribed vaccine compared to a rural resident, several factors may influence this including access to and distance from a pharmacy, more limited modes of transportation in rural areas, hours of operation often being more limited in rural areas, and needing to take time off work to accommodate appointments and related travel (79).

Lastly, the incidence rate of pharmacist influenza immunizations prescribed per prescriber was 1.073 times higher in October as compared to the reference month of November when controlling for age, sex, rurality, and year, whereas the incidence rate was significantly lower in all other months as compared to the same referent, excluding August and September. This is reflective of when influenza vaccines are typically distributed and administered in the region, which is annually during fall and winter in the Northern hemisphere, often beginning in October.

In regard to the non-influenza model, there were notably less statistically significant differences found as compared to the influenza model. One factor potentially contributing to this may be the stark difference in sample size, with the influenza model encompassing data from greater than 503,000 immunizations whereas the non-influenza model only includes data on approximately 27,000 immunizations. Conversely, this may also mean that the influenza model was overpowered and may be detecting statistically significant differences that may or may not be clinically significant. Another reason may be due to combining many different vaccine types into one model—due to limitations with sample size for individual ATC code categories, it was not feasible to build individual models for individual non-influenza vaccine types and so they were pooled to create one single model.

The incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was 1.060 times higher in 2019-2020 and 1.043 times lower in 2020-2021 as compared to the reference year of 2018-2019 when controlling for age, sex, rurality, and month. A 2023 study by Grant et al. examining pharmacist prescribing activities over three fiscal years from 2018 to 2020 found that the average number of prescriptions by pharmacists increased from the first to the last year of the study (60), which would support the observed increase in non-influenza vaccine prescribing in the present study. Regarding the observed decrease, this is likely predominantly due to the onset of the COVID-19 pandemic in March 2020 given that a significant proportion of non-influenza vaccines captured in this study are indicated for travel, which was heavily restricted for much of this year, and that notable decreases in monthly counts for several of these vaccines, namely hepatitis and cholera, were observed following onset of the pandemic in the descriptive analysis of the study.

The incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was 1.070 and 1.071 times lower in May and August, respectively, as compared to the referent month of November when controlling for age, sex, rurality, and year. Although statistically significant, the potential clinical significance of this small difference is unclear. Unlike influenza immunization prescribing, there is not a strong temporal or seasonal relationship for general non-influenza immunization prescribing. Additionally, pooling many different types of non-influenza immunizations together for this model due to inherent sample size limitations could be negating any anticipated prescribing patterns for specific non-influenza vaccines which were more evident in the descriptive analyses (e.g., increased prescribing of travel immunizations such as hepatitis and cholera vaccines during the later winter months).

The incidence rate of pharmacist non-influenza immunizations prescribed per prescriber was 1.146, 1.103, and 1.093 times higher in those 5-19 years of age, 20-34 years of age, and 35-49 years of age, respectively, as compared to the reference group of 50-64 year olds when controlling for sex, rurality, month, and year. In contrast, the incidence rate was 1.070 and 1.071 times lower in those 65-79 and 80 years and above, respectively. The reasons for this are unclear, particularly given that a significant proportion of non-influenza immunizations observed in the study were for herpes zoster, which is indicated in older adults (i.e., those 50 years of age and older). One possible explanation is that younger individuals may be more likely to travel abroad to destinations warranting commonly prescribed travel immunizations (such as hepatitis and cholera vaccines) than older individuals, particularly those of advancing age. However, this remains unclear and is something that requires further investigation.

Lastly, similar to the influenza model, the incidence rate of pharmacist non-influenza immunizations prescribed per prescriber for urban residents was 1.074 times higher than that of rural residents when controlling for age, sex, month, and year. likely for reasons similar to those discussed above.

6.0 – Strengths and Limitations

6.1 – Strengths

There are several notable strengths of this study, one being the use of data from the NSDIS. As the NSDIS is mandated for use in all community pharmacies in Nova Scotia and has been for over 7 years, it contains complete and comprehensive dispensing data for the study timeframe and therefore, should provide an accurate depiction of community pharmacist immunization prescribing patterns during this period. In addition, the study had a large sample size comprised of over 274,000 individuals and over 531,000 immunization prescriptions.

Furthermore, given the timeframe of the study, it is possible to compare immunization prescribing patterns from before the COVID-19 pandemic to those during the COVID-19 pandemic, which has not been previously done. Given the immense impact of COVID-19 on pharmacy operations, altered provision of expanded scope services, decreased demand for travel vaccinations due to restrictions on non-essential travel, and increased demand for influenza vaccinations during this time, it is important to quantify the impact of the pandemic on the provision of immunization prescribing services in pharmacies to better inform planning for future pandemics.

Additionally, another strength of this study is the ability to link NSDIS dispensing records to other databases, like the MASTER registry and the CIMD, to discern important demographic characteristics of the patients accessing pharmacist immunization prescribing services. This study is the first to characterize this population in Nova Scotia and only the second to characterize this population in a Canadian setting, with Waite et al. having previously characterized the population of patients immunized against influenza by pharmacists in Ontario (38). This study is also the first in Canada to characterize the population accessing pharmacist non-influenza immunization prescribing. Learning more about the demographic characteristics of this population is an important first step in being able to assess the overall equity and accessibility of these services.

6.2 – Limitations

There are also several important limitations to be mindful of when interpreting the results of this study. Firstly, while the NSDIS captures all prescriptions dispensed in community pharmacies, including all medications prescribed by community pharmacists, it does not capture data on pharmacist immunization prescribing in non-community settings (i.e., hospital inpatient settings, hospital-based clinics, some long-term care facilities, and other institutions not serviced by a community pharmacy). This means that the findings of this study with respect to immunization prescribing trends may not be representative of pharmacists practicing outside of community pharmacy settings in the province and thus, the results may not be generalizable to these practitioners. Additionally, this may introduce selection bias into the study population as those in long-term care facilities, correctional facilities, and other similar institutions may differ significantly from those in the community.

In addition, while the NSDIS itself captures information on immunization prescribing, dispensing, and administration (as immunizations administered by community pharmacists must be recorded in the NSDIS immunization module), data on immunization administration is not currently available through the NSDIS database at HDNS and therefore, analysis of pharmacy-based immunization administration trends is outside the scope of the study. However, it is generally assumed that immunizations prescribed by a pharmacist are also administered within the pharmacy (i.e., by a pharmacist or pharmacy technician), so this lack of administration data is not likely a considerable limitation.

Another important limitation is that although the data is available to investigate pharmacist prescribing of immunizations, this study cannot determine what causes people to (a) get an immunization or (b) choose a pharmacist over a different healthcare professional for their immunization. A provincial immunization registry would provide insight into everyone that received an immunization prescribed, and although Nova Scotia is in the process of implementing software to capture such data, that information was not available for this study.

Additionally, another limitation in related to the availability of immunization data is the inability to study pharmacy-based provision of COVID-19 immunizations. Since March 2021, pharmacies in Nova Scotia have been providing COVID-19 immunizations; however, these immunizations are recorded in CANImmunize Clinic Flow rather than the NSDIS (80). Due to this, examination of pharmacy-based provision of COVID-19 vaccines is not within the scope of this project.

The inability to examine race and ethnicity when characterizing the patient population currently accessing immunization prescribing services in Nova Scotia is another limitation of this study. While the CIMD does include a domain on ethnocultural composition, information on race and ethnicity of each individual in the study population is not available. There is a current lack of race-based data in the healthcare sector in Canada and without this data, it is not possible to fully characterize the population of interest nor is it possible to fully measure inequities in access to pharmacy-based immunization services. The Canadian Institute for Health Information (CIHI) has recently proposed standards for race-based and Indigenous identity data collection and health reporting (81); if there is implementation of these standards in Canadian institutions, examination of immunization prescribing service use and access by different racial and ethnic patient populations will be an important research topic to address, especially given the fact that racial and ethnic disparities in the provision of immunizations, both in the greater community setting and specifically among pharmacy patients, have previously been described in the literature (82,83).

Similarly, this study is limited in its ability to meaningfully examine other important characteristics of the population of interest, such as gender and socioeconomic status. Despite the expansion of gender options for provincial identity documents in July 2019 (84), administrative health databases in the Nova Scotia are still largely only reflective of sex, including the MASTER Patient Registry, which unfortunately precludes the examination of gender in this study. In regard to socioeconomic status (SES), although the CIMD includes a domain on economic dependency which may be used to infer certain SES-related features based on the DA in which one resides, person-level information on SES is not available for the individuals included within the study, which limits the ability to examine this characteristic.

Additionally, while this project specifically aims to examine age, sex, geography, and relative deprivation of the population of interest, other information available via administrative health data such as medical comorbidities and use of other prescription medications, were not included in the objectives. While comorbidities and medication use are important influencing factors in immunization assessment and prescribing, examination of this information is outside the scope of this project due to the complexity of defining these additional variables with administrative data. This continues to represent an important direction for future research.

Another study limitation relates to the measurement of the different included variables. Because this project relies on the use of pharmacy dispensing data, it may be subject to misclassification bias secondary to coding or data entry errors in the adjudication and billing processes. However, this is not expected to significantly influence the results based on the volume of records included in the study and numerous processes in place to minimize medication dispensing errors in community pharmacies. Furthermore, as the means of collecting immunization prescribing data through the NSDIS did not change at all during the study period, this is not expected to have influenced the results either. Measurement-related issues may also extend to the CIMD component of this study—while the CIMD can be used as a proxy for individual-level information (52), as these scores are based off a composite of all individuals residing within a given DA, they may not be entirely reflective of a given individual's residential, economic, ethno-cultural, and situational vulnerability status.

Finally, several limitations arose during the data analysis phase of this study that are important to consider. Given the age range of the population (2 to 110 years) captured in the study dataset, it is likely that some long-term care facility residents who receive services from community pharmacies (as some do in the province) were included in the population, however, as information on long-term care residence was not available within the databases accessed for the study, the proportion of the study population who are not truly community-dwelling cannot be determined. Additionally, there was some missingness in the patient postal codes used during the data linkage process which carried over to missingness in the census division, dissemination area, and CIMD quintile variables. Furthermore, while pharmacist ID was able to be incorporated into the regression models to account for prescriber random effects, pharmacy ID was not available for the entire study period and so this variable had to be excluded from the models. Finally, despite the large sample size of the study, where the samples of various types of non-influenza immunizations were relatively small, regression models were not able to be built for individual types of non-influenza immunizations.

7.0 – Conclusion

This study found that individuals accessing immunization prescribing services in community pharmacies in Nova Scotia between 2018 and 2022 were predominantly female, urban residents, and aged 50 years or older. Influenza immunizations made up 95% of all prescribed vaccines and the three most commonly prescribed non-influenza vaccines were varicella zoster, hepatitis, and cholera. Multivariable regression models found significant associations between the rate of pharmacist influenza immunization prescribing per prescriber and female sex, urban residence, and month, in addition to an interaction effect between age and fiscal year (highest incidence among those 65-79 years of age during 2020-2021), as well as significant associations between the rate of pharmacist non-influenza immunization prescribing per prescriber and age, urban residence, month, and fiscal year (increased incidence in 2019-2020 and decreased incidence in 2020-2021).

The overarching goal of the study was to gain a deeper understanding of current pharmacist immunization prescribing practices in order to improve these services and expand pharmacy-based immunization access. By characterizing both the trends in pharmacist immunization prescribing patterns and the population currently accessing these prescribing services, information from this study may be used to inform practice and policy changes in order to improve immunization services in community pharmacies—this may include, but is not limited to, focusing more resources (e.g., more pharmacist hours and overlap to allow increased provision of clinical services) in rural community pharmacies to potentially improve service use in these areas, implementing methods to improve engagement and interest in pharmacist immunization services among males and younger individuals (e.g., marketing targeted at these groups), and increased screening of pharmacy patients as appropriate to identify those who may benefit from pharmacist prescribing services (e.g., offering herpes zoster vaccine prescribing to those inquiring about herpes zoster antiviral medication prescribing or offering pneumococcal vaccines to those filling medications for chronic lung diseases, such as asthma and chronic obstructive pulmonary disease [COPD]).

The results of this study may also serve to generate additional hypotheses to inform direction for future research—given the study's findings, further research is warranted on the population's sociodemographic characteristics, particularly characteristics we were not able to precisely measure (e.g., gender, race, income) or measure at all (e.g., health status, comorbidities). Additionally, research into barriers and facilitators of non-influenza immunization is also warranted, particularly barriers preventing pharmacist prescribing of some of the commonly recommended non-influenza immunizations that were not frequently prescribed in this study (e.g., pneumococcal vaccines).

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Appendix A – Pharmacist Vaccine and Injection Authority Across Canada

INJECTION AUTHORITY AND VACCINE ADMINISTRATION IN PHARMACIES ACROSS CANADA

✓ Authority | ✓ (temporary) Temporary authority under an emergency order | V Vaccines | D/V Drugs and vaccines | X No authority

	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	YT	NWT	NU
Pharmacist Injection Authority and Prescribing													
Scope of injection authority[1]	D/V	D/V	D/V	D/V	D/V	V [A]	D/V	D/V	D/V	D/V	D/V	X	X
Pharmacists authorized to prescribe vaccines[2]	X [B]	✓ [C]	✓ [D,E]	X [F]	X [G]	✓	✓ [D,E]	✓ [D,E,H]	✓ [D]	✓ [D]	✓ [D]	X	X
Pharmacist Administration of Vaccines[3,4]													
Influenza	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	X	X
COVID-19	✓ *$	✓ *$	✓ *$	✓ *$	✓ (temporary) *$	✓ *$	✓ *$	✓ *$	✓ *$	✓ *$	✓	X	X
Pneumococcal	✓ *$	✓ *$	✓	✓ *$ [I]	✓	✓ *$	✓	✓	✓	✓	✓	X	X
Meningococcal	✓ *$	✓	✓	✓	✓	✓ *$	✓	✓	✓	✓	✓	X	X
Haemophilus influenza B	✓ *$	✓	✓	✓	✓	✓ *$	✓	✓	✓	✓	✓	X	X
Hepatitis A	✓ *$	✓	✓	✓	✓	✓ *$	✓	✓	✓	✓	✓	X	X
Hepatitis B	✓ *$	✓	✓	✓	✓	✓ *$	✓	✓	✓	✓	✓	X	X
Measles, mumps, rubella	✓ *$	✓	✓	✓	X	✓ *$	✓	✓	✓	✓	✓	X	X
Diphtheria, tetanus (with/without pertussis)	✓ *$	✓ *$	✓	✓ *$	X	✓ *$	✓	✓	✓	✓	✓	X	X
Varicella zoster (chickenpox)	✓ *$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X
Herpes zoster (shingles)	✓	✓	✓	✓	✓	✓	✓	✓ *$	✓ *$	✓	✓ *$	X	X
Human papillomavirus	✓ *$	✓	✓	✓ *$	✓	✓ *$	✓	✓	✓	✓	✓ *$	X	X
Polio	✓ *$ [J]	✓	✓	✓	X	✓ *$	✓	✓	✓	✓	✓	X	X

General:

* Pharmacists may access and administer publicly-funded vaccine; note that for each infectious disease, the individual vaccine product(s) included in public programs through pharmacies may vary by jurisdiction. (Otherwise, patients requiring these vaccines can access the publicly-funded supply through physicians or public health clinics at no charge or can pay the cost of privately acquired product through the pharmacy, except in QC where an eligible patient must obtain a publicly-funded vaccine.) Patient eligibility may vary by jurisdiction.

$ Remuneration is provided by P/T government for publicly-funded vaccine administration or assessment/prescribing of vaccine. Patient eligibility may vary by jurisdiction.

1. Authority excludes injectable cosmetic treatments (except in AB)
2. Prescribing authority is subject to additional training and/or regulatory requirements. Regulations vary by jurisdiction.
3. Injection training, CPR, and application to regulatory authority required, along with other training depending on jurisdiction.
4. This is not a comprehensive list of all vaccines pharmacists may administer by injection.
5. Under supervision of a pharmacist with injection authority.
6. Scope of injection authority varies by jurisdiction.
7. Authority is limited to the technical functions of drug/vaccine administration.

Jurisdictional:

A. May administer other drugs for patient education/demonstration and in an emergency.
B. No prescription required for most vaccines, incl. influenza, COVID-19, and any vaccine part of a routine immunization program.
C. Pharmacists with Additional Prescribing Authority may prescribe vaccines.
D. Pharmacists may prescribe for a list of preventable and/or travel related diseases approved by the provincial regulator.
E. Prescribing for certain travel-related diseases (SK, NB) or providing comprehensive travel health services (NS) requires additional training in travel medicine.
F. Five vaccines can be administered without a prescription only if the patient is eligible for the publicly funded vaccine (HPV, Tdap, diphtheria, tetanus, pneumcoccal and influenza).
G. Influenza, herpes zoster and COVID-19 are the only vaccines that can be administered without a prescription.
H. No prescription required for any vaccine under the provincial immunization program.
I. Pneumococcal authority in MB only includes polysaccharide-containing vaccines.
J. For travel indications.
K. No age limit for COVID-19 vaccine if engaged by an organization in agreement with the Minister of Health.
L. Under emergency order, there are no age restrictions for the administration of influenza and COVID-19 vaccines.

Adapted with permission from Fonseca J, Sharpe JP, Houle SKD, Waite NM. Time for harmonization: pharmacists as immunizers across Canadian jurisdictions. *Can Pharm J* (Ott) 2019; 152:395-400.

Canadian Pharmacists Association | Association des pharmaciens du Canada

Reference: Canadian Pharmacists Association. Canadian Pharmacists Association. 2023 [cited 2023 Aug 25]. INJECTION AUTHORITY AND VACCINE ADMINISTRATION IN PHARMACIES ACROSS CANADA. Available from: https://www.pharmacists.ca/cpha-ca/assets/File/cpha-on-the-issues/InjectionVaccineScan_July2023_EN.pdf

Appendix B – Immunization DINs

ATC code and classification	Vaccine type(s) and trade name	Drug identification number(s)
CHOLERA VACCINES (J07AE)	Oral inactivated cholera and LT-ETEC (Dukoral)	02247208
MENINGOCOCCAL VACCINES (J07AH)	Meningococcal group B (Bexsero, Trumenba), meningococcal group C (Menjugate, NeisVac-C), and meningococcal groups ACYW-135 (Menactra, MenQuadfi, Menveo, Nimenrix)	02417030 02279924 02243820 02440709 02507161 02347393 02245057 02402904 02468751
PERTUSSIS VACCINES (J07AJ)	Tetanus, diphtheria, and acellular pertussis (Adacel, Tripacel)	02240255 02230273
PNEUMOCOCCAL VACCINES (J07AL)	Polyvalent pneumococcal (Pneumovax 23), 7-valent pneumococcal (Prevnar), 13-valent pneumococcal (Prevnar 13), 10-valent pneumococcal (Synflorix), and 15-valent pneumococcal (Vaxneuvance)	00431648 02436442 02244081 02335204 02320541 02522403
TETANUS VACCINES (J07AM)	Tetanus and diphtheria (Td Adsorbed)	00514462
TYPHOID VACCINES (J07AP)	Salmonella typhi capsular polysaccharide (Typherix, Typhim Vi) and live oral attenuated typhoid (Vivotif)	02242727 02130955 00885975
ENCEPHALITIS VACCINES (J07BA)	Japanese encephalitis (Ixiaro)	02333279
INFLUENZA VACCINES (J07BB)	Quadrivalent inactivated influenza (Afluria Tetra, Agriflu, Flucelvax Quad, Flulaval Tetra, Fluzone Quadrivalent), adjuvanted H5N1 influenza (Arepanrix H5N1, Foclivia), trivalent inactivated influenza	02473283 02473313 02346850 02428881 02401886 02362384 02434881 02494248 02494256 02420783 02478978 02426544 02420686 02445646 02420643 02432730

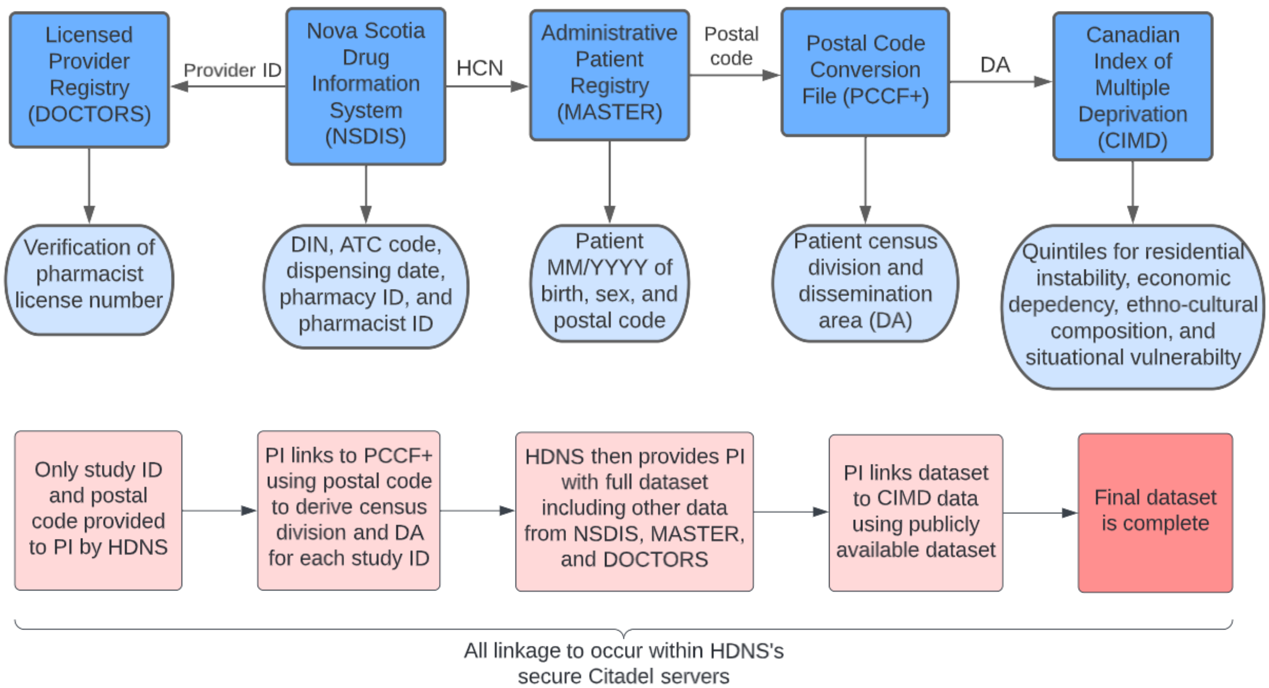
	(Fluad, Fluad Pediatric, Fluviral, Influvac, Vaxigrip), live attenuated influenza nasal spray (Flumist), high dose inactivated trivalent influenza (Fluzone High-Dose), high dose inactivated quadrivalent influenza (Fluzone High-Dose Quadrivalent), and quadrivalent recombinant inactivated influenza (Supemtek)	02484854 02401886 02494256 02478978 02500523 02420635 02420651 02510561 02510588 02510936 02269562 02223929 02367718 02510561 02510588
HEPATITIS VACCINES (J07BC)	Inactivated hepatitis A (Avaxim, Avaxim Pediatric, Havrix, Havrix Junior, Vaqta), recombinant hepatitis B (Engerix-B, Recombivax HB), combined hepatitis A/hepatitis B (Twinrix, Twinrix Junior)	02237792 02243741 02243750 01919431 02296454 02487020 02487039 02187078 02231056 02243676 02245977 02230578 02237548 02229702
MEASLES VACCINES (J07BD)	Live attenuated measles, mumps, and rubella (MMR II, Priorix, Priorix-Tetra, ProQuad)	00466085 02239208 02297884 02399229
RABIES VACCINES (J07BG)	Inactivated whole virus rabies (Imovax Rabies, Rabavert)	01908286 02267667
VARICELLA ZOSTER VACCINES (J07BK)	Recombinant adjuvanted herpes zoster (Shingrix), live attenuated varicella (Varilix, Varivax III), and live attenuated herpes zoster (Zostavax II)	02468425 02241047 02246081 02375516
YELLOW FEVER VACCINES (J07BL)	Live attenuated yellow fever (YF-Vax)	00428833
PAPILLOMAVIRUS VACCINES (J07BM)	Recombinant adjuvanted human papillomavirus types 16 and 18 (Cervarix), recombinant 9-valent human papillomavirus (Gardasil 9), and recombinant	02342227 02283190 02437058

	quadrivalent human papillomavirus (Gardasil)	

Appendix C – Variables and Associated Data Sources

Variable	**Data Source**
Product DIN	NSDIS
Product ATC code	NSDIS
Dispensing date	NSDIS
Pharmacist ID	NSDIS/DOCTORS
Pharmacy ID	NSDIS
Patient age (via month and year of birth)	NSDIS/MASTER
Patient sex	MASTER
Patient FSA	MASTER
Patient census division	MASTER/PCCF+
Patient dissemination area	MASTER/PCCF+
Patient residential instability quintile	PCCF+/CIMD
Patient economic dependency quintile	PCCF+/CIMD
Patient ethno-cultural composition quintile	PCCF+/CIMD
Patient situational vulnerability quintile	PCCF+/CIMD
Time period	NSDIS (inferred from dispensing date)
Urban/rural flag	MASTER (inferred from FSA)

Appendix D – Data Linkage Diagrams



Appendix E – Objectives and Associated Analyses

Objective	Analysis
Describe patterns in the age, sex, geographic location, and relative deprivation (as defined by the Canadian Index of Multiple Deprivation) of individuals who are receiving immunizations prescribed by community pharmacists in Nova Scotia, to compare the characteristics of these individuals between the pre-COVID-19 (April 1, 2018, to March 21, 2020) and during COVID-19 (March 22, 2020, to March 31, 2022) time periods, and to compare the characteristics of the study population to the general provincial population as described by the provincial census.	• Calculation of descriptive statistics in regard to patient demographics (e.g., mean age, percentage of population by broad age groups, percentage of males and females, percentage of population by geographic region, percentage of population by quintile of each of the four CIMD domains). • Immunization counts stratified by patient demographics and by pandemic (before or during COVID-19). • Descriptive comparison of study population demographics to the general provincial population using census data.
Describe immunization prescribing activity (both influenza and non-influenza vaccines, excluding COVID-19 vaccines) of pharmacists in the community pharmacy setting in Nova Scotia and to compare this activity between the pre-COVID-19 and during COVID-19 periods.	• Immunization counts stratified by ATC classification over time, by month and/or year. • Immunization counts stratified by ATC classification and by pandemic (before or during COVID-19). • Multivariable negative binomial regression model using time-varying covariates with the number of influenza immunizations prescribed per prescriber by month, year, sex, age, and rurality as the outcome variable. • Multivariable negative binomial regression model using time-varying covariates with the number of non-influenza immunizations prescribed per prescriber by month, year, sex, age, and rurality as the outcome variable.

Appendix F – Data Declaration

Portions of the data used in this study were made available by Health Data Nova Scotia of Dalhousie University. Although this research analysis is based on data obtained from the Nova Scotia Department of Health and Wellness, the observations and opinions expressed are those of the authors and do not represent those of either Health Data Nova Scotia or the Department of Health and Wellness.