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Coverage of the influenza and pneumococcal vaccinations among immigrant and non-immigrant older adults in Canada: a cross-sectional analysis of data from the Canadian Longitudinal Study on Aging (CLSA)

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Abstract

Background Influenza and pneumococcal vaccination coverage in older adults fall below the target of 80%. Being an immigrant may be associated with lower coverage of both vaccinations, but limited efforts have been made in the Canadian context to explore such disparities. Therefore, we examined the association between immigrant status and coverage of influenza and pneumococcal vaccinations among older adults as well as the relative importance of immigrant status in predicting coverage of both vaccinations.

Methods We conducted a cross-sectional secondary analysis of the Canadian Longitudinal Study on Aging data. We descriptively analyzed coverage of both vaccinations by immigrant status and used Poisson regression models with robust standard errors to estimate the associations of immigrant status and other key equity stratifiers with vaccination. Importance of various determinants, including immigrant status, in predicting both vaccinations were assessed using random forest algorithms.

Results Immigrant participants reported lower coverage of influenza vaccination in the past 12 months (63.8% [95% CI: 60.9–66.7%] vs. 66.9% [95% CI: 65.5–68.3%]) and pneumococcal vaccination ever (48.7% [95% CI: 45.6–51.8%] vs. 55.8% [95% CI: 54.3–57.3%]). Prevalence of influenza and pneumococcal vaccinations were both lower among immigrant participants compared to non-immigrant participants. Immigrant status was among the 10 most important predictors of pneumococcal vaccination, but among the less important predictors of influenza vaccination.

Conclusions Overall, we found disparities in influenza and pneumococcal vaccination by immigrant status among older adults in Canada. Further studies on vaccination coverage and decision-making among marginalized communities, including immigrants, are warranted to equitably improve vaccine uptake.

Keywords Vaccination coverage, Immigrant health, Vaccine equity, Health equity, Influenza, Pneumococcal disease, The Canadian Longitudinal Study on Aging (CLSA)

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Background

Influenza and pneumonia rank among the top 10 leading causes of death in Canada [1]. Older age is a risk factor for the incidence and severity of influenza and pneumococcal disease [2]. Currently, in Canada, adults aged 65 years and older are recommended by the National Advisory Committee on Immunization (NACI) to receive an influenza vaccination every influenza season, particularly high-dose, adjuvanted, or recombinant influenza vaccines [3]. Those aged 65 years and older are also recommended to receive a dose of either the 20-valent or the 21-valent pneumococcal vaccine regardless of their previous pneumococcal vaccination history [4]. Notably, recommendations for influenza and pneumococcal vaccinations have changed over time. For instance, adults aged 65 years and older were recommended to receive a dose of the 23-valent pneumococcal vaccine since October 2014 and either the 20-valent or 21-valent pneumococcal vaccine since April 2025 [5]. Influenza and pneumococcal vaccinations are publicly funded in all jurisdictions in Canada for adults aged 65 years and older [6].

Despite these recommendations for and public funding of vaccinations, results from the 2023 Adult National Immunization Coverage Survey suggest that the national coverage of influenza and pneumococcal vaccines in adults aged 65 years and older was estimated to be 70.2% and 54.7%, respectively [7], well below the target of 80% [8]. Furthermore, the survey results on vaccination intentions indicate that 37.8% and 20.9% of participants reported being somewhat or very unlikely to receive the influenza and pneumococcal vaccines, respectively [7], and results from the 2021–2021 Seasonal Influenza Vaccination Coverage Survey suggest that the lack of awareness about pneumococcal vaccines is among the top three reasons for non-vaccination [9]. These findings of low coverage, intention, and awareness about recommended vaccinations warrant further research and public health efforts to improve vaccine uptake.

Increasing vaccine uptake to meet the vaccination coverage goals requires better understanding of populations and factors associated with lower vaccination coverage. Immigrants encounter unique personal, social, and physical challenges in becoming vaccinated and being an immigrant may be associated with lower uptake of influenza and pneumococcal vaccines [10–16]. However, there is limited evidence in the Canadian context regarding the disparities in coverage of both vaccinations among immigrants – commonly defined in literature by whether one is foreign-born or not [16–19]. Given that immigrants represent almost one in four individuals in Canada [20], this knowledge is critical to inform strategies to improve vaccine uptake and work toward achieving health equity.

Our study objectives were to: 1) estimate and compare coverage of both vaccinations by immigrant status, 2) quantify the association between immigrant status and vaccination, and 3) evaluate the relative importance of immigrant status in predicting the coverage of each vaccination in comparison to other determinants of vaccine uptake.

Methods

Study design

We conducted a cross-sectional secondary analysis of data from the Canadian Longitudinal Study on Aging (CLSA) Tracking and Comprehensive cohorts collected at baseline (2011–2015) and follow up 1 (FU1; 2015–2018). We analyzed data from FU1, which is the most recent data set available with vaccination information collected from all study participants, unless data were only available from the baseline survey (e.g., immigrant status).

Data source and study population

The CLSA is a national longitudinal cohort study on adult development and aging composed of 2 cohorts – Tracking and Comprehensive – followed every 3 years. Individuals unable to respond in English or French were excluded [21]. Details about the CLSA study have been published [21–23] and are available on the CLSA website (clsa-elcv.ca).

Eligibility criteria for this study were: participation in FU1; aged 65 years or older at FU1; availability of data on self-reported influenza vaccine uptake in the previous 12 months, pneumococcal vaccine uptake ever, and immigrant status; residence in one of 10 provinces at FU1 (Tracking cohort) or in one of 7 provinces at which data collection sites are situated (Comprehensive cohort).

Influenza and pneumococcal vaccination status

Outcomes were self-reported influenza and pneumococcal vaccination status. During FU1, participants were asked, "Have you had [a] flu shot in the last 12 months" and "… [a] pneumonia shot (pneumococcal vaccination) in your life". We defined those who answered "yes" as vaccinated, those who answered "no" as unvaccinated, and those who answered "don't know" or refused to answer as missing, consistent with previous literature [24, 25].

Immigrant status

During the baseline survey, participants were asked "In what country were you born?" and "In what year did you first come to Canada to live?". As defined by the CLSA and previous literature [17, 18], we categorized those who were born outside of Canada as immigrant, those who were born in Canada as non-immigrant, and those who did not answer as missing.

Covariates

Based on previous literature and content expertise [24–33], the following groups of covariates obtained at FU1 were analyzed: sociodemographics, health status/access to healthcare, lifestyle or health behaviour, social support and activities, and environmental [34–36]. We also included sex at birth, race and ethnocultural background, highest level of education, religion, and language most spoken at home, which were measured at baseline (Table S1). Categories with largest sample sizes were chosen as the reference category for nominal variables with three or more categories.

Statistical analyses

We described the coverage of both vaccinations and key characteristics of the study population by immigrant status using proportions and 95% confidence intervals (CI). Poisson regression models with robust standard errors were used to examine the associations of immigrant status and other key equity stratifiers with influenza and pneumococcal vaccination and estimate prevalence ratios (PR) and adjusted prevalence ratios (aPR) [37]. Survey weights developed by the CLSA were applied [38]. R packages survey and gtsummary were used [39, 40].

For objective 3 (importance of immigrant status compared to other variables in predicting the coverage of each vaccination), we used random forest classification, a non-parametric machine learning technique that predicts outcomes by constructing multiple decision trees, each trained on random subsets of data and variables [41]. This analysis complements traditional regression analyses; variable importance measures that quantify the predictive power of each variable included in the model can be generated without making the assumptions required for regression models. The final prediction was determined by aggregating the majority vote from the decision trees and importance was defined by the degree to which a variable contributed to predicting the outcome [41, 42]. Participants were split 80:20 into training and testing data sets, respectively, using stratified random sampling on variables sexual orientation and language most spoken at home. Using the training data, a random forest algorithm was developed by tenfold cross-validation. Random forest hyperparameters were tuned to maximize the discrimination performance of the model (Table S2). We analyzed the association between covariates and vaccination using two methods. First, we measured the mean decrease in accuracy (i.e. the accuracy with which the model decreases when values of a particular feature are permuted) [41, 43]. Second, we calculated Shapley additive explanations (SHAP) values [44, 45]. SHAP is a method used to explain the decisions of machine learning models by showing how much each variable contributes to a specific prediction [46]. The contributions of each variable to individual predictions, quantified by absolute SHAP values, were weighted using CLSA analytic survey weights and averaged to generate global variable importance measures [38, 46]. Model performance metrics were evaluated using the test dataset. Analyses were conducted in R (version 4.3.3) with caret, randomForest, and fastshap packages [44, 47, 48].

Sample size and missing data

Objective 1 included all eligible participants (influenza vaccination $n = 23{,}214$; pneumococcal vaccination $n = 22{,}235$). For objective 2, we conducted complete case analyses as the total proportion of missingness was less than 10% among covariates included (i.e., age, sex at birth, race and ethnocultural background, highest level of education, total household income, province of residence, urbanicity of residence) (influenza vaccination $n = 21{,}108$; pneumococcal vaccination $n = 20{,}230$) [49]. For objective 3, as the proportion of missingness among all covariates analyzed exceeded 10%, random forest imputation technique was used to impute missing data among eligible participants. We used R package missForest for imputation [50].

Sensitivity analyses

First, we analyzed coverage of influenza and pneumococcal vaccinations stratified by region of birth and years lived in Canada to examine heterogeneities within immigrants. Second, we repeated objective 2 using imputed data from objective 3, and conversely repeated objective 3 using complete data only. Lastly, we repeated objective 3 after removing correlated predictors which may influence variable importance measures. We assessed correlation between covariates using Cramer's V. After identifying three variable pairs with Cramer's V of 0.5 or higher, we removed one variable from each pair guided by previous literature and clinical expertise.

Results

Study population

A total of 23,214 participants were eligible for influenza vaccination analyses (18,776 non-immigrants and 4,438 immigrants) and 22,235 participants for pneumococcal vaccination analyses (18,013 non-immigrants and 4,222 immigrants). Differences in immigrant and non-immigrant participants' sociodemographic characteristics included the distribution of race and ethnocultural background, highest level of education, total household income, language most spoken at home, province, and urbanicity (Tables S3 and S4).

Influenza and pneumococcal vaccination coverage

Coverage of influenza vaccination in the past 12 months was lower among immigrant participants (63.8%, 95%

CI: 60.9–66.7%) compared to non-immigrant participants (66.9%, 95% CI: 65.5–68.3%) (Table 1). Overall, the proportion of those who had ever received a pneumococcal vaccine was lower than the proportion of those who received an influenza vaccine within the previous 12 months, regardless of immigrant status (Table 2). Coverage of a pneumococcal vaccination was also lower among immigrant participants (48.7%, 95% CI: 45.6–51.8%) compared to non-immigrant participants (55.8%, 95% CI: 54.3–57.3%), and the difference in coverage between the two groups was greater for pneumococcal vaccination than for influenza vaccination.

Association between immigrant status and vaccination coverage

Table 3 presents the results of the robust Poisson regression models. Prevalence of influenza vaccination was lower among immigrant compared to non-immigrant participants (aPR: 0.92, 95% CI: 0.89–0.95). Age, total household income, province, and urbanicity were associated with influenza vaccination. Residents of Quebec reported lowest vaccination rates, followed by Newfoundland, Saskatchewan, and British Columbia, while residents of Nova Scotia reported the highest influenza vaccination coverage.

Prevalence of pneumococcal vaccination was also lower among immigrant compared to non-immigrant participants (aPR: 0.87, 95% CI: 0.83–0.91). Age, sex at birth, total household income, and province were associated with vaccination. While provincial variations in uptake remained, residents of Newfoundland reported lowest coverage, followed by Prince Edward Island and New Brunswick, whereas residents of Alberta, Manitoba, and Quebec reported the highest pneumococcal vaccination coverage.

Ranking of determinants of vaccination coverage using random forest algorithms

Figure 1 shows the ranking of determinants of influenza vaccination. Based on variables' values of MDA, contact with a family doctor in the past 12 month was the most important predictor of influenza vaccination coverage (MDA: 67.4), suggesting that if values of this variable were permuted, then the model's accuracy would decrease by 67.4 percentage points (pp) on average. Variables' mean absolute SHAP values indicate that age group was the most important predictor of influenza vaccination coverage (SHAP: 0.030), suggesting that on average, age group contributed to 0.030 (3.0 pp) change in predicted probability of influenza vaccination for each participant. While there were differences in results based on the importance measure used (i.e., MDA or SHAP), the results indicated that the most important predictors of influenza vaccination coverage included age (MDA: 43.6; SHAP: 0.030), province (MDA: 40.3; SHAP: 0.018), language most spoken at home (MDA: 42.8; SHAP: 0.014), presence of chronic medical conditions (MDA: 29.7; SHAP: 0.016), and contact with a family doctor (MDA: 67.4; SHAP: 0.012) and medical specialist (MDA: 23.3; SHAP: 0.016) in the previous 12 months.

Figure 2 shows the ranking of determinants of pneumococcal vaccination. Both measures of importance (i.e., MDA and SHAP) indicated that the most important predictor of pneumococcal vaccination was influenza vaccination in the previous 12 months (MDA: 265; SHAP: 0.119), suggesting that on average, if values of this variable were permuted, then the models' accuracy would decrease by 265 pp, and that the variable contributed to 0.119 (11.9 pp) change in predicted probability of pneumococcal vaccination for each participant. The second and third most important predictors were province (MDA: 75.7; SHAP: 0.036) and age (MDA: 45.8; SHAP: 0.027), respectively. In contrast to its relatively low ranking among determinants of influenza vaccination coverage (MDA: 4.85; SHAP: 0.005), immigrant status was among the 10 most important predictors of pneumococcal vaccination coverage (MDA: 19.2; SHAP: 0.007). Random forest model performance metrics are presented in Table S5.

Sensitivity analyses

Analyses using participants' region of birth revealed heterogeneities in influenza and pneumococcal vaccination coverage among immigrants. In comparison to non-immigrants, participants born in other regions reported lower influenza and pneumococcal vaccination coverage, except those born in other North American countries for influenza vaccination (Figure S1). Influenza and pneumococcal vaccination coverage were generally positively associated with number of years lived in Canada among immigrants; immigrants who lived in Canada for 61 years or more reported comparable coverage of both vaccines to non-immigrants (Figure S2). Results of other sensitivity analyses were similar to those of the main analyses (Figures S3-S6 and Table S6).

Discussion

In our cross-sectional analysis of 2015–2018 CLSA data, we found that self-reported influenza and pneumococcal vaccination coverage were lower among immigrants compared to non-immigrants, and that the difference was greater for pneumococcal vaccination. Immigrant status was among the least important predictors of influenza vaccination, but among the most important predictors of pneumococcal vaccination.

Our findings of lower vaccination coverage in immigrant compared to non-immigrant older adults are consistent with the limited literature on influenza and

Table 1 Key characteristics and self-reported influenza vaccination in the past 12 months of the Canadian Longitudinal Study on Aging (CLSA) participants at follow up 1 (2015-2018) by immigrant status

	Influenza vaccination in the past 12 months					
	Total		Non-immigrant		Immigrant	
Characteristic	N[a]	%[b] (95% CI[c])	N[a]	%[b] (95% CI[c])	N[a]	%[b] (95% CI[c])
Overall	**23214**		**18776**	**81.8 (80.8, 82.7)[f]**	**4438**	**18.2 (17.3, 19.2)[f]**
Influenza vaccination in the past 12 months						
No	6847	33.6 (32.4, 34.9)	5471	33.1 (31.7, 34.5)	1376	36.2 (33.3, 39.1)
Yes	16367	66.4 (65.1, 67.6)	13305	66.9 (65.5, 68.3)	3062	63.8 (60.9, 66.7)
Age						
65-74	13192	62.4 (61.1, 63.6)	10806	62.6 (61.1, 63.9)	2386	61.5 (58.7, 64.3)
75-84	8259	30.9 (29.7, 32.1)	6565	30.8 (29.5, 32.1)	1694	31.6 (28.9, 34.3)
85+	1763	6.7 (6.2, 7.3)	1405	6.7 (6.1, 7.3)	358	6.9 (5.8, 8.3)
Sex at birth						
Female	11650	53.3 (51.9, 54.6)	9616	53.9 (52.5, 55.4)	2034	50.2 (47.2, 53.2)
Male	11564	46.7 (45.4, 48.1)	9160	46.1 (44.6, 47.5)	2404	49.8 (46.8, 52.8)
Current marital/partner status						
Married/common-law	14502	66.4 (65.2, 67.6)	11616	65.7 (64.3, 67.0)	2886	69.6 (66.9, 72.2)
Divorced/separated	2862	10.4 (9.7, 11.2)	2308	10.5 (9.7, 11.4)	554	10.1 (8.6, 11.8)
Single, never married/lived with a partner	1531	5.9 (5.4, 6.6)	1308	6.3 (5.6, 7.0)	223	4.4 (3.4, 5.6)
Widowed	4305	17.2 (16.2, 18.2)	3531	17.5 (16.4, 18.6)	774	15.9 (13.8, 18.2)
Missing	14	<0.1 (0.0, 0.1)	13	<0.1 (0.0, 0.1)	1	<0.1 (0.0, 0.2)
Race and ethnocultural background[d]						
White	22370	96.4 (95.8, 96.8)	18488	98.2 (97.8, 98.6)	3882	87.9 (85.9, 89.7)
East Asian	115	0.4 (0.3, 0.6)	41	0.2 (0.1, 0.3)	74	1.5 (1.0, 2.4)
Southeast Asian	51	0.2 (0.1, 0.3)	1	<0.1 (0.0, 0.1)	50	1.0 (0.6, 1.6)
South Asian	164	0.6 (0.4, 0.8)	0	0.0 (0.0, 0.0)	164	3.0 (2.2, 4.2)
Middle Eastern	28	<0.1 (0.0, 0.1)	4	<0.1 (0.0, 0.0)	24	0.4 (0.2, 0.6)
Black	116	0.7 (0.5, 1.1)	15	0.2 (0.1, 0.8)	101	2.9 (2.0, 4.1)
Other	345	1.5 (1.2, 1.9)	213	1.2 (1.0, 1.6)	132	2.8 (1.9, 4.2)
Missing	25	0.1 (0.1, 0.3)	14	<0.1 (0.0, 0.1)	11	0.4 (0.2, 1.3)
Highest level of education						
Post-secondary degree/diploma	16662	52.7 (51.4, 54.1)	13139	50.5 (49.0, 52.0)	3523	62.7 (59.4, 65.8)
Some post-secondary education	1851	10.5 (9.7, 11.3)	1522	10.5 (9.7, 11.3)	329	10.5 (8.8, 12.4)
Secondary school graduation	2641	15.8 (14.9, 16.8)	2261	16.2 (15.2, 17.3)	380	14.0 (12.0, 16.3)
Less than secondary school graduation	1987	20.7 (19.3, 22.1)	1806	22.6 (21.0, 24.2)	181	12.1 (9.5, 15.4)
Missing	73	0.4 (0.2, 0.6)	48	0.3 (0.2, 0.5)	25	0.7 (0.3, 1.6)
Total household income						
Less than $20,000	1299	6.9 (6.1, 7.6)	1108	7.4 (6.6, 8.4)	191	4.2 (3.2, 5.6)
$20,000 - <$50,000	7055	35.3 (34.0, 36.6)	5801	36.0 (34.6, 37.4)	1254	32.2 (29.4, 35.1)
$50,000 - <$100,000	8555	34.5 (33.2, 35.8)	6917	33.9 (32.5, 35.3)	1638	37.1 (34.2, 40.1)
$100,000 - <$150,000	2860	9.9 (9.2, 10.6)	2235	9.4 (8.7, 10.2)	625	11.9 (10.3, 13.8)
$150,000+	1450	4.7 (4.3, 5.2)	1091	4.5 (4.0, 5.0)	359	5.7 (4.7, 6.9)
Missing	1995	8.8 (8.0, 9.6)	1624	8.7 (8.0, 9.6)	371	8.9 (7.2, 10.9)
Language most spoken at home						
English	18620	73.7 (72.7, 74.6)	14735	71.4 (70.3, 72.4)	3885	83.9 (81.6, 86.1)
French	4224	24.4 (23.5, 25.3)	3998	28.4 (27.3, 29.4)	226	6.8 (5.4, 8.5)
Other	347	1.8 (1.5, 2.2)	28	0.2 (0.1, 0.4)	319	9.0 (7.4, 11.0)
Missing	23	0.1 (0.1, 0.2)	15	<0.1 (0.0, 0.2)	8	0.3 (0.1, 0.6)
Province of residence						
Ontario	5165	33.6 (32.7, 34.6)	3776	31.3 (30.1, 32.5)	1389	44.3 (41.4, 47.2)
Newfoundland	1462	1.8 (1.7, 1.9)	1347	2.1 (1.9, 2.2)	115	0.5 (0.4, 0.7)
Prince Edward Island	507	0.4 (0.3, 0.4)	449	0.4 (0.4, 0.4)	58	0.2 (0.2, 0.3)
Nova Scotia	2096	3.2 (3.1, 3.4)	1801	3.5 (3.3, 3.7)	295	1.8 (1.5, 2.3)
New Brunswick	566	2.0 (1.8, 2.1)	523	2.2 (2.1, 2.4)	43	0.8 (0.6, 1.2)
Quebec	4316	26.6 (25.8, 27.4)	3920	29.4 (28.4, 30.4)	396	13.9 (12.0, 16.0)
Manitoba	2042	4.1 (3.9, 4.3)	1713	4.3 (4.1, 4.6)	329	2.9 (2.4, 3.4)
Saskatchewan	544	2.2 (2.0, 2.3)	504	2.5 (2.3, 2.7)	40	0.6 (0.4, 0.9)
Alberta	2243	8.6 (8.2, 8.9)	1764	8.6 (8.2, 9.1)	479	8.2 (7.0, 9.5)
British Columbia	4273	17.7 (17.1, 18.3)	2979	15.7 (15.0, 16.4)	1294	26.7 (24.6, 29.0)
Urbanicity of residence[e]						
Urban	19858	83.6 (82.6, 84.5)	15886	82.7 (81.6, 83.8)	3972	87.7 (85.6, 89.5)
Rural	3334	16.2 (15.3, 17.1)	2870	17.1 (16.0, 18.2)	464	12.3 (10.4, 14.4)
Missing	22	0.2 (0.1, 0.4)	20	0.2 (0.1, 0.5)	2	<0.1 (0.0, 0.2)
Presence of chronic medical conditions						
No CMC	4951	21.8 (20.8, 22.9)	3947	21.6 (20.4, 22.8)	1004	23.0 (20.7, 25.5)
1+ CMC	17591	77.2 (76.1, 78.2)	14302	77.5 (76.3, 78.7)	3289	75.5 (73.0, 77.8)
Missing	672	1.0 (0.9, 1.2)	527	0.9 (0.8, 1.0)	145	1.5 (1.0, 2.2)
Contact with family doctor in past 12 months						
No	1277	6.2 (5.6, 6.9)	1022	6.3 (5.6, 7.1)	255	5.7 (4.6, 6.9)
Yes	21922	93.7 (93.1, 94.4)	17743	93.6 (92.8, 94.3)	4179	94.3 (93.1, 95.3)
Missing	15	<0.1 (0.0, 0.1)	11	<0.1 (0.0, 0.1)	4	<0.1 (0.0, 0.1)

[a] N represents unweighted number of study participants
[b] % represents weighted proportions of study participants
[c] CI: Confidence intervals
[d] Categories of race and ethnocultural background were derived using the Canadian Institute for Health Information (CIHI) Guidance on the Use of Standards for Race-Based and Indigenous Identity Data Collection and Health Reporting in Canada (https://www.cihi.ca/sites/default/files/document/guidance-and-standards-for-race-based-and-indigenous-identity-data-en.pdf)
[e] Urbanicity categories were defined by the Canadian Longitudinal Study on Aging (https://www.clsa-elcv.ca/wp-content/uploads/2023/06/urbanrural_dsd_01_03_2018_final.pdf)
[f] % represents the weighted proportions of non-immigrant and immigrant participants among total number of participants

Table 2 Key characteristics and self-reported pneumococcal vaccination ever of CLSA participants at follow up 1 (2015-2018) by immigrant status

	Pneumococcal vaccination ever					
	Total		Non-immigrant		Immigrant	
Characteristic	N[a]	%[b] (95% CI[c])	N[a]	%[b] (95% CI[c])	N[a]	%[b] (95% CI[c])
Overall	**22235**		**18013**	**81.9 (80.9, 82.9)[f]**	**4222**	**18.1 (17.1, 19.1)[f]**
Pneumococcal vaccination ever						
No	10185	45.5 (44.2, 46.9)	8034	44.2 (42.7, 45.7)	2151	51.3 (48.2, 54.4)
Yes	12050	54.5 (53.1, 55.8)	9979	55.8 (54.3, 57.3)	2071	48.7 (45.6, 51.8)
Age						
65-74	12664	62.4 (61.1, 63.6)	10392	62.5 (61.1, 63.9)	2272	61.7 (58.8, 64.6)
75-84	7899	31.0 (29.8, 32.2)	6292	30.9 (29.6, 32.3)	1607	31.2 (28.5, 34.1)
85+	1672	6.7 (6.1, 7.3)	1329	6.6 (6.0, 7.2)	343	7.0 (5.8, 8.4)
Sex at birth						
Female	11362	54.0 (52.7, 55.4)	9401	54.8 (53.2, 56.2)	1961	50.7 (47.6, 53.8)
Male	10873	46.0 (44.6, 47.3)	8612	45.2 (43.8, 46.8)	2261	49.3 (46.2, 52.4)
Current marital/partner status						
Married/common-law	13874	66.5 (65.3, 67.8)	11132	65.9 (64.4, 67.3)	2742	69.6 (66.8, 72.2)
Divorced/separated	2729	10.3 (9.5, 11.1)	2198	10.3 (9.5, 11.2)	531	9.9 (8.5, 11.7)
Single, never married/lived with a partner	1473	5.9 (5.3, 6.6)	1261	6.3 (5.6, 7.0)	212	4.4 (3.4, 5.6)
Widowed	4146	17.2 (16.2, 18.3)	3410	17.5 (16.4, 18.6)	736	16.1 (14.0, 18.5)
Missing	13	<0.1 (0.0, 0.1)	12	<0.1 (0.0, 0.1)	1	<0.1 (0.0, 0.2)
Race and ethnocultural background[d]						
White	21428	96.4 (95.8, 96.8)	17735	98.2 (97.7, 98.6)	3693	87.9 (85.8, 89.8)
East Asian	109	0.4 (0.3, 0.6)	41	0.2 (0.1, 0.3)	68	1.6 (1.0, 2.4)
Southeast Asian	51	0.2 (0.1, 0.3)	1	<0.1 (0.0, 0.1)	50	1.1 (0.7, 1.7)
South Asian	156	0.6 (0.4, 0.8)	0	0.0 (0.0, 0.0)	156	3.1 (2.3, 4.3)
Middle Eastern	26	<0.1 (0.0, 0.1)	3	<0.1 (0.0, 0.0)	23	0.4 (0.2, 0.6)
Black	111	0.7 (0.5, 1.1)	15	0.3 (0.1, 0.8)	96	2.7 (1.9, 3.9)
Other	330	1.5 (1.2, 1.9)	204	1.2 (1.0, 1.6)	126	2.8 (1.8, 4.2)
Missing	24	0.1 (0.1, 0.3)	14	<0.1 (0.0, 0.1)	10	0.5 (0.2, 1.3)
Highest level of education						
Post-secondary degree/diploma	15973	52.7 (51.3, 54.0)	12619	50.5 (49.0, 52.0)	3354	62.5 (59.1, 65.7)
Some post-secondary education	1751	10.4 (9.6, 11.2)	1440	10.4 (9.6, 11.3)	311	10.4 (8.7, 12.4)
Secondary school graduation	2549	15.9 (14.9, 16.9)	2184	16.3 (15.2, 17.4)	365	14.0 (11.9, 16.4)
Less than secondary school graduation	1893	20.7 (19.3, 22.2)	1724	22.5 (20.9, 24.2)	169	12.5 (9.7, 15.9)
Missing	69	0.4 (0.2, 0.6)	46	0.3 (0.2, 0.5)	23	0.6 (0.3, 1.6)
Total household income						
Less than $20,000	1255	6.8 (6.1, 7.6)	1072	7.4 (6.6, 8.4)	183	4.2 (3.1, 5.5)
$20,000 - <$50,000	6787	35.3 (34.0, 36.6)	5591	36.0 (34.6, 37.5)	1196	32.0 (29.1, 35.0)
$50,000 - <$100,000	8198	34.6 (33.3, 35.9)	6640	34.0 (32.6, 35.4)	1558	37.1 (34.1, 40.2)
$100,000 - <$150,000	2727	9.9 (9.2, 10.7)	2136	9.4 (8.7, 10.3)	591	12.0 (10.4, 14.0)
$150,000+	1367	4.6 (4.1, 5.0)	1026	4.3 (3.8, 4.9)	341	5.7 (4.6, 6.9)
Missing	1901	8.8 (8.1, 9.6)	1548	8.8 (8.0, 9.7)	353	9.0 (7.3, 11.1)
Language most spoken at home						
English	17883	74.0 (73.1, 75.0)	14182	71.9 (70.7, 73.0)	3701	83.9 (81.4, 86.1)
French	4003	24.0 (23.1, 25.0)	3791	27.9 (26.8, 29.0)	212	6.7 (5.2, 8.4)
Other	327	1.8 (1.5, 2.2)	26	0.2 (0.1, 0.4)	301	9.2 (7.5, 11.2)
Missing	22	0.1 (0.1, 0.2)	14	<0.1 (0.0, 0.2)	8	0.3 (0.1, 0.6)
Province of residence						
Ontario	4913	33.8 (32.8, 34.7)	3601	31.4 (30.2, 32.7)	1312	44.3 (41.3, 47.3)
Newfoundland	1430	1.8 (1.7, 1.9)	1318	2.1 (2.0, 2.2)	112	0.5 (0.4, 0.7)
Prince Edward Island	490	0.4 (0.3, 0.4)	436	0.4 (0.4, 0.4)	54	0.2 (0.2, 0.3)
Nova Scotia	1976	3.2 (3.0, 3.3)	1705	3.5 (3.3, 3.7)	271	1.8 (1.4, 2.2)
New Brunswick	534	1.9 (1.8, 2.0)	493	2.2 (2.0, 2.3)	41	0.8 (0.6, 1.2)
Quebec	4113	26.3 (25.5, 27.1)	3737	29.0 (28.0, 30.1)	376	13.9 (12.0, 16.1)
Manitoba	1948	4.0 (3.8, 4.2)	1629	4.3 (4.0, 4.5)	319	2.9 (2.5, 3.5)
Saskatchewan	532	2.2 (2.1, 2.3)	491	2.5 (2.4, 2.7)	41	0.7 (0.5, 1.0)
Alberta	2186	8.7 (8.3, 9.1)	1726	8.8 (8.3, 9.3)	460	8.2 (7.0, 9.5)
British Columbia	4113	17.8 (17.2, 18.4)	2877	15.8 (15.0, 16.5)	1236	26.7 (24.5, 29.0)
Urbanicity of residence[e]						
Urban	19011	83.6 (82.6, 84.5)	15232	82.7 (81.6, 83.8)	3779	87.5 (85.3, 89.4)
Rural	3203	16.2 (15.3, 17.2)	2761	17.1 (16.0, 18.2)	442	12.5 (10.6, 14.7)
Missing	21	0.2 (0.1, 0.4)	20	0.2 (0.1, 0.5)	1	<0.1 (0.0, 0.3)
Presence of chronic medical conditions						
No CMC	4690	21.5 (20.4, 22.6)	3737	21.2 (20.0, 22.5)	953	22.7 (20.4, 25.2)
1+ CMC	16910	77.5 (76.4, 78.6)	13777	77.9 (76.6, 79.1)	3133	75.8 (73.3, 78.2)
Missing	635	1.0 (0.8, 1.1)	499	0.9 (0.8, 1.0)	136	1.4 (1.0, 2.1)
Contact with family doctor in past 12 months						
No	1216	6.1 (5.5, 6.8)	975	6.2 (5.5, 7.0)	241	5.6 (4.6, 6.9)
Yes	21007	93.9 (93.2, 94.5)	17030	93.8 (92.9, 94.5)	3977	94.3 (93.1, 95.4)
Missing	12	<0.1 (0.0, 0.1)	8	<0.1 (0.0, 0.1)	4	<0.1 (0.0, 0.1)

[a] N represents unweighted number of study participants
[b] % represents weighted proportions of study participants
[c] CI: Confidence intervals
[d] Categories of race and ethnocultural background were derived using the Canadian Institute for Health Information (CIHI) Guidance on the Use of Standards for Race-Based and Indigenous Identity Data Collection and Health Reporting in Canada (https://www.cihi.ca/sites/default/files/document/guidance-and-standards-for-race-based-and-indigenous-identity-data-en.pdf)
[e] Urbanicity categories were defined by the Canadian Longitudinal Study on Aging (https://www.clsa-elcv.ca/wp-content/uploads/2023/06/urbanrural_dsd_01_03_2018_final.pdf)
[f] % represents the weighted proportions of non-immigrant and immigrant participants among total number of participants

Table 3 Prevalence of influenza and pneumococcal vaccination in CLSA participants at follow up 1 (2015-2018)

	Influenza vaccination in the past 12 months		Pneumococcal vaccination ever	
	PR[a] (95% CI[b])	aPR[c] (95% CI[b])	PR[a] (95% CI[b])	aPR[c] (95% CI[b])
Immigrant status				
Non-immigrant	Ref	Ref	Ref	Ref
Immigrant	0.96 (0.93, 0.99)	0.92 (0.89, 0.95)	0.88 (0.84, 0.93)	0.87 (0.83, 0.91)
Age				
65-74	Ref	Ref	Ref	Ref
75-84	1.20 (1.17, 1.22)	1.21 (1.18, 1.24)	1.31 (1.27, 1.36)	1.33 (1.28, 1.38)
85 and over	1.25 (1.20, 1.29)	1.27 (1.22, 1.32)	1.32 (1.25, 1.41)	1.34 (1.26, 1.42)
Sex at birth				
Female	Ref	Ref	Ref	Ref
Male	1.01 (0.98, 1.03)	0.99 (0.97, 1.01)	0.89 (0.86, 0.92)	0.88 (0.85, 0.91)
Race and ethnocultural background[d]				
White	Ref	Ref	Ref	Ref
Racialized	0.90 (0.83, 0.97)	0.93 (0.87, 1.01)	0.85 (0.76, 0.95)	0.92 (0.83, 1.03)
Highest level of education				
Post-secondary degree/diploma	Ref	Ref	Ref	Ref
Some post-secondary education	0.99 (0.95, 1.03)	0.97 (0.93, 1.01)	0.99 (0.94, 1.05)	0.97 (0.92, 1.02)
Secondary school graduation	0.97 (0.93, 1.00)	0.97 (0.94, 1.00)	1.01 (0.96, 1.06)	0.98 (0.94, 1.03)
Less than secondary school graduation	0.97 (0.93, 1.01)	0.97 (0.93, 1.01)	1.04 (0.98, 1.10)	0.97 (0.91, 1.02)
Total household income				
Less than $20,000	Ref	Ref	Ref	Ref
$20,000 - <$50,000	1.12 (1.05, 1.19)	1.10 (1.04, 1.17)	1.00 (0.93, 1.08)	1.04 (0.97, 1.12)
$50,000 - <$100,000	1.21 (1.14, 1.29)	1.19 (1.12, 1.27)	1.05 (0.98, 1.13)	1.15 (1.06, 1.23)
$100,000 - <$150,000	1.25 (1.17, 1.34)	1.24 (1.16, 1.32)	1.07 (0.99, 1.16)	1.20 (1.10, 1.30)
$150,000+	1.21 (1.13, 1.30)	1.19 (1.11, 1.28)	0.99 (0.90, 1.08)	1.10 (1.00, 1.21)
Province of residence				
Ontario	Ref	Ref	Ref	Ref
Newfoundland	0.84 (0.79, 0.89)	0.84 (0.80, 0.89)	0.60 (0.54, 0.67)	0.60 (0.54, 0.66)
Prince Edward Island	0.98 (0.91, 1.06)	1.01 (0.94, 1.09)	0.79 (0.68, 0.91)	0.80 (0.70, 0.92)
Nova Scotia	1.09 (1.05, 1.13)	1.10 (1.06, 1.14)	0.96 (0.90, 1.03)	0.97 (0.91, 1.04)
New Brunswick	0.94 (0.87, 1.01)	0.98 (0.91, 1.05)	0.81 (0.71, 0.92)	0.82 (0.72, 0.94)
Quebec	0.77 (0.73, 0.80)	0.78 (0.75, 0.81)	1.08 (1.03, 1.14)	1.09 (1.03, 1.15)
Manitoba	0.95 (0.90, 0.99)	0.95 (0.91, 1.00)	1.12 (1.05, 1.19)	1.12 (1.05, 1.20)
Saskatchewan	0.92 (0.85, 0.99)	0.92 (0.85, 0.99)	1.04 (0.94, 1.16)	1.03 (0.93, 1.14)
Alberta	0.95 (0.91, 0.99)	0.95 (0.91, 1.00)	1.12 (1.06, 1.19)	1.13 (1.06, 1.20)
British Columbia	0.92 (0.89, 0.95)	0.92 (0.89, 0.95)	0.98 (0.93, 1.04)	0.99 (0.94, 1.04)
Urbanicity of residence[e]				
Urban	Ref	Ref	Ref	Ref
Rural	0.94 (0.90, 0.97)	0.94 (0.91, 0.98)	0.91 (0.87, 0.96)	0.97 (0.92, 1.02)

[a] PR: prevalence ratio
[b] CI: confidence interval
[c] aPR: adjusted prevalence ratio
[d] Categories of race and ethnocultural background were derived using the Canadian Institute for Health Information (CIHI) Guidance on the Use of Standards for Race-Based and Indigenous Identity Data Collection and Health Reporting in Canada (https://www.cihi.ca/sites/default/files/document/guidance-and-standards-for-race-based-and-indigenous-identity-data-en.pdf)
[e] Urbanicity categories were defined by the Canadian Longitudinal Study on Aging (https://www.clsa-elcv.ca/wp-content/uploads/2023/06/urbanrural_dsd_01_03_2018_final.pdf)

pneumococcal vaccination coverage in Canada [13, 14] and in the US [51], although the association between immigrant status and influenza and pneumococcal vaccination coverage remains inconclusive [27, 52]. Potential reasons for lower vaccination coverage among immigrants include personal thoughts, beliefs, and concerns about vaccines, as well as those rooted in historical and structural barriers that challenge vulnerable groups like older adult immigrants from accessing vaccinations. These include lack of vaccine information and awareness, mistrust in vaccines and the wider governance and healthcare system, language barriers, and racism [15, 16, 53, 54]. Cost and affordability of vaccinations are also commonly identified as barriers to vaccinations among immigrants [15, 16, 53], although this may be less applicable in our study as influenza and pneumococcal

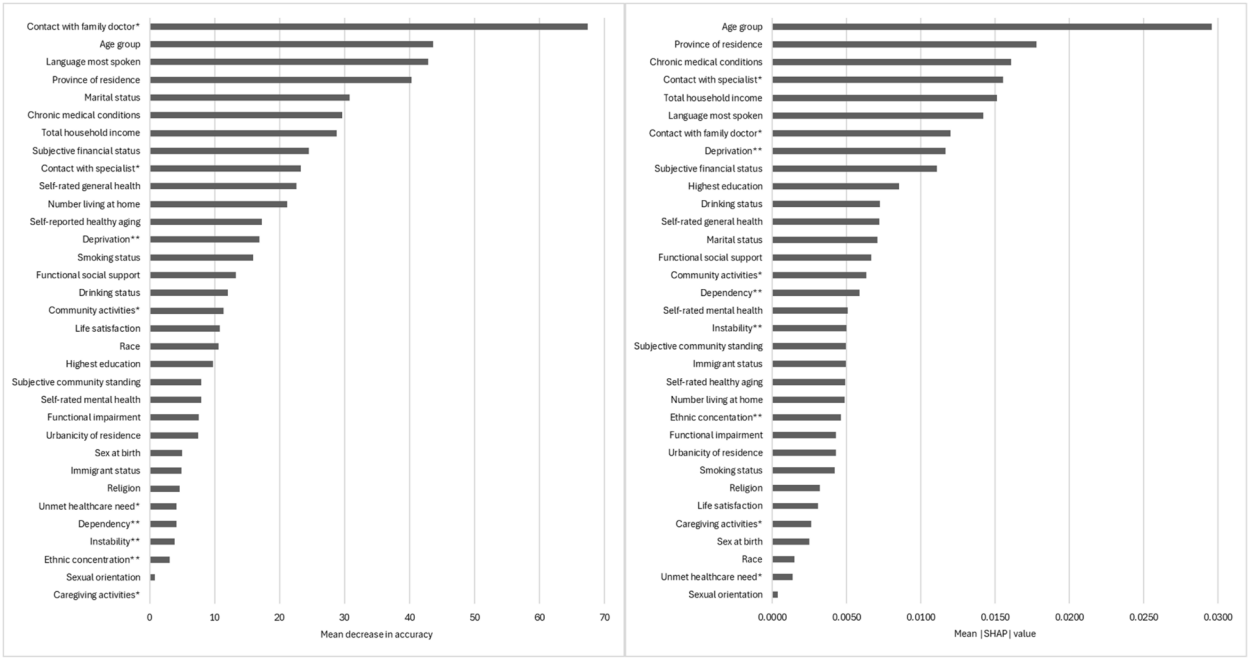

Fig. 1 Ranking of determinants of CLSA participants' self-reported influenza vaccination in the past 12 months at follow up 1 by mean decrease in accuracy (MDA; left) and mean absolute SHapley Additive exPlanations (SHAP; right) values. MDA values represent the mean extent (in percentage points) to which the model's accuracy decreases when values of a feature are permuted, and range between 0 and 100. SHAP values represent the weighted mean absolute change in predicted probability of outcome, expressed as the average magnitude of the contribution that a variable makes to individual predictions, and range between 0 and 1. * In the past 12 months. ** Dimensions of the Canadian Marginalization Index (i.e., quintile of dependency/deprivation/ethnic concentration/instability)

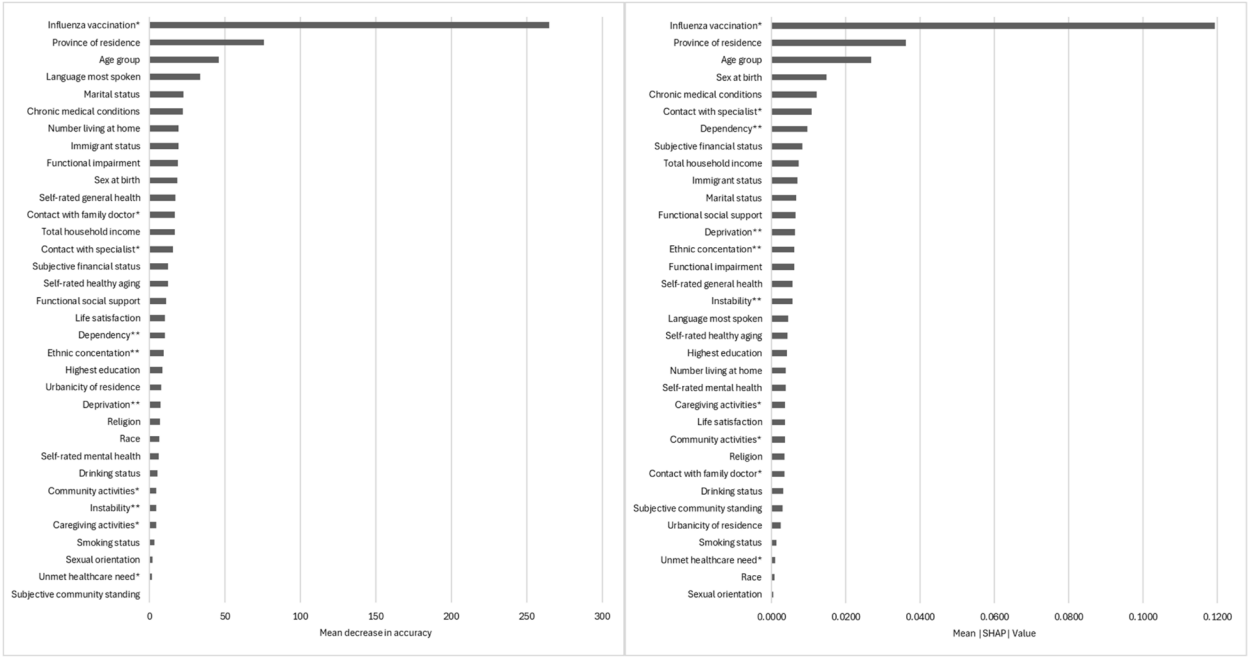

Fig. 2 Ranking of determinants of CLSA participants' self-reported pneumococcal vaccination ever at follow up 1 by mean decrease in accuracy (MDA; left) and mean absolute SHapley Additive exPlanations (SHAP; right) values. MDA values represent the mean extent (in percentage points) to which the model's accuracy decreases when values of a feature are permuted, and range between 0 and 100. SHAP values represent the weighted mean absolute change in predicted probability of outcome, expressed as the average magnitude of the contribution that a variable makes to individual predictions, and range between 0 and 1. * In the past 12 months. ** Dimensions of the Canadian Marginalization Index (i.e., quintile of dependency/deprivation/ethnic concentration/instability)

vaccinations are publicly funded for adults aged 65 years and older in all jurisdictions in Canada [6, 55]. The discrepancies in public funding of vaccinations may contribute to inconclusive associations between immigrant status and vaccination coverage reported in literature [27, 52].

We found that the association between immigrant status and vaccination differed between influenza and pneumococcal vaccines. Disparities were larger for pneumococcal vaccination and immigrant status was a more important predictor for pneumococcal vaccination than for influenza vaccination. One reason for these differences may be availability and accessibility of vaccinations (i.e., how readily available and accessible vaccinations are to those wishing to become vaccinated). In Canada, depending on the province and/or territory of residence, influenza vaccines are available for free in various settings (i.e., doctors' offices, pharmacies, and public health sites), whereas pneumococcal vaccines are not as widely available [56]. Research suggests that over 50% of adults who received an influenza vaccine during the 2023–2024 influenza season received their vaccinations at pharmacies [57], and that administration of influenza vaccines by pharmacists increased vaccination coverage by improving availability, proximity, and accommodation of vaccinations [58]. This suggests that expanding availability of vaccines with low coverage, such as pneumococcal vaccinations, for administration in various settings, including pharmacies, may improve vaccination coverage and disparities. Furthermore, these differences in accessibility/availability of vaccinations at different settings, as well as differences in vaccination programs (particularly for pneumococcal) may contribute to the large provincial differences observed in influenza and pneumococcal vaccination coverage. For example, unlike influenza vaccinations which are consistently publicly funded for all adults aged 65 years and older in all provinces and territories, pneumococcal vaccination schedules differ by the type of vaccine offered and eligibility (e.g., whether one has previously received a pneumococcal vaccine or not) across jurisdictions. Another reason for the differences may be awareness of vaccines. A 2021 survey among Canadian adults aged 65 years and older reported that the "doctor did not mention it" or that they "never heard of this vaccine" as the leading reasons for pneumococcal non-vaccination [9]. The importance of influenza vaccines are promoted through annual vaccination campaigns and numerous advocacy efforts [59]. As such, disparities in coverage by immigrant status may be smaller for influenza vaccination compared to pneumococcal vaccination due to heightened efforts to improve accessibility and awareness of influenza vaccinations, which are barriers to vaccinations experienced by immigrant communities. Thus, public health efforts to increase awareness of and accessibility to vaccines may be effective in increasing vaccine uptake in the population, but a "one size fits all" approach may not be appropriate for the complex and diverse needs of diverse older adults [15].

The importance of a variable in predicting an outcome reflects its predictive ability, which is influenced by how the variable is defined. The low relative ranking of immigrant status in predicting influenza vaccination coverage may suggest that the study's definition of this variable cannot sufficiently capture important heterogeneities within immigrant communities by factors such as recency of immigration, immigration category, region of birth, and generation, that influence immigrants' influenza vaccination decisions [19, 60, 61]. In fact, our sensitivity analyses revealed that coverage of both vaccinations differed considerably among immigrants by region of birth and time since immigration.

Overall, our findings reveal disparities in influenza and pneumococcal vaccination coverage among older immigrant adults living in Canada, likely driven by both individual and structural barriers. Further research on vaccination coverage using more disaggregated definitions and categorizations of immigrants is warranted. Furthermore, immigrant health is determined simultaneously by the interaction of various social positions and dimensions of inequalities [62, 63]. Therefore, future studies should consider how intersecting social factors, historical inequities, and vaccine-specific issues influence decision-making, particularly among immigrants, to better address these compounded barriers and improve vaccine uptake equitably in Canada [64, 65].

Limitations

The characteristics of the CLSA cohort may limit generalizability of results, because of overrepresentation of individuals born in Canada and with higher socioeconomic status, education, and better health compared to the general older adult population in Canada [21, 22]. Further, vaccination coverage reported by previous studies on influenza and pneumococcal vaccination using CLSA data indicate that coverage of both vaccinations among study participants are higher than those of older adults in Canada overall [24, 25, 66]. Our definition of immigrant status may have masked important heterogeneities within immigrant communities. Sensitivity analyses by region of birth and years lived in Canada were conducted, but analyses were limited due to small sample sizes. We analyzed data from the first follow-up, which was collected before the COVID-19 pandemic. It is unknown whether the association between immigrant status and vaccination coverage has changed during the pandemic, during which there were extensive campaigns to promote vaccination awareness and accessibility [67, 68]. Vaccination data were self-reported, which

may not be accurate. However, previous analyses using self-reported influenza and pneumococcal vaccination data suggest that this would have minimal impact [24, 69, 70]. Lastly, we lacked data on reasons for vaccination or non-vaccination, which limited our ability to explore decision-making factors that differ between immigrants and non-immigrants.

Conclusions

We found lower self-reported coverage of an influenza vaccination in the previous 12 months and pneumococcal vaccination ever among immigrants compared to non-immigrants. The disparities in coverage were greater for pneumococcal vaccination than for influenza vaccination. Immigrant status was also found to be an important predictor of pneumococcal vaccination, while not of influenza vaccination. Future studies should investigate the coverage of and reasons for uptake of various vaccines in immigrants using more disaggregated definitions and categorizations and accounting for intersecting vulnerabilities to gain a deeper understanding of the heterogeneous vaccination experiences within immigrant communities.

Abbreviations

aPR	Adjusted prevalence ratio
CI	Confidence intervals
CLSA	The Canadian Longitudinal Study on Aging
FU1	Follow-up 1
NACI	National Advisory Committee on Immunization
pp	Percentage points
PR	Prevalence ratio
SHAP	Shapley additive explanations

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-25005-z.

Supplementary Material 1.

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Authors' contributions

JK and PL planned the study and acquired the data. JK, GS, AR, AB, and PL contributed to the initial data analysis plan. JK conducted the analysis and all authors (JK, GS, AR, SY, JP, AB, and PL) contributed to data analysis and interpretation. JK drafted the manuscript and all authors (JK, GS, AR, SY, JP, AB, and PL) reviewed and revised the manuscript. All authors (JK, GS, AR, SY, JP, AB, and PL) read and approved the final manuscript. AB and PL are co-senior authors of this manuscript.

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Data availability

Data analyzed in the current study are available from the Canadian Longitudinal Study on Aging for approved researchers who meet the criteria for access. The datasets are not publicly available and users must sign an agreement that prohibits sharing of the data beyond the approved research team. Further information about data access and application can be found at [www.clsa-elcv.ca] (http:/www.clsa-elcv.ca).

Declarations

Ethics approval and consent to participate

The CLSA study has been approved by McMaster University Health Integrated Research Ethics Board and by research ethics boards at all collaborating institutions. All participants of the CLSA provided informed written consent during data collection. As this study is a secondary analysis of fully de-identified data provided by the CLSA, additional consent was not required. Ethics approval for the current study was obtained from the McGill University Institutional Research Board (A04-M19-23A (23–04-012)). All study procedures were performed in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

JP reports personal fees from Enanta and participation in clinical trials funded by Merck and MedImmune.

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