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A cross-sectional study assessing Pro-VC-Be short-form questionnaire in Canada; measuring psychosocial determinants of vaccination behavior in Canadian healthcare professionals

Arnaud Gagneur[a,b], David Roy[b], Catherine Pelletier[c], Marie-Eve Trottier[d], Samuel Lemaire-Paquette[b], Marina Rousseau[b], Ève Dubé[c,d], and Pierre Verger[e]

[a]Département de Pédiatrie, Université de Sherbrooke, Sherbrooke, Québec, Canada; [b]Département de Pédiaterie, Centre de Recherche du Centre Hospitalier Universitaire de Sherbrooke, Sherbrooke, Québec, Canada; [c]Département d'anthropologie, Université Laval, Québec City, Québec, Canada; [d]Direction des Risques Biologiques et de la Santé au Travail, Institut national de santé publique du Québec, Québec City, Québec, Canada; [e]Faculté des sciences médicales et paramédicales, ORS PACA, Southeastern Health Regional Observatory, Marseille, France

ABSTRACT

Vaccine hesitancy poses a significant challenge to worldwide public health and has been exacerbated by the COVID-19 pandemic, leading to heightened polarization and the spread of misinformation. Addressing vaccine hesitancy requires multifaceted strategies in which healthcare professionals (HCPs) play a critical role. Nonetheless, HCPs may also be hesitant toward vaccination. The 31-item original Pro-VC-Be tool, designed to measure the psychosocial determinants of vaccine attitudes in HCPs, was first validated in France, French-speaking Belgian regions, and Quebec (Canada). The validity of a short-form version was evaluated and found to be comparable to that of the long-form. Given differing vaccination recommendations and the changing pandemic context, assessing the tool's stability among diverse Canadian HCPs is crucial. Relying on the original short version of the Pro-VC-Be tool, a cross-sectional online survey was conducted among various Canadian HCPs ($N = 544$) to explore the psychosocial determinants that impact vaccination-related behaviors (frequency of general vaccination activity, vaccine recommendations activity, and willingness to recommend vaccines). The findings underscore three crucial dimensions – vaccine confidence, proactive efficacy, and trust in authorities – as robust predictors of positive professional practice and attitudes, and thus globally support the results obtained in previous studies using the Pro-VC-Be tool. HCPs with higher vaccine confidence, high proactive efficacy, and higher trust in authorities were 80% and 180% more likely to recommend vaccines to their patients and 80% more likely to have received a COVID-19 vaccine than other HCPs, respectively. By identifying the root causes of vaccine hesitancy among HCPs, adapted strategies can be developed.

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Introduction

Vaccine hesitancy – a motivational state of ambivalence that may lead to vaccine refusal or delays – remains a growing concern and a serious threat to public health worldwide.[1] During the COVID-19 pandemic, an exponential growth in misinformation was observed, in addition to growing polarization of perceptions on vaccination, which could contribute to decreased confidence in healthcare professionals and the healthcare system.[2] Even before the pandemic, the reluctance to accept vaccines was identified as a barrier in the efforts to curb the spread of preventable diseases, compromising the achievement of herd immunity and putting unnecessary pressure on the healthcare system. Tackling vaccine hesitancy requires a multifaceted approach that includes various strategies, such as restoring public confidence in the healthcare system and vaccines, decreasing barriers to accessing vaccination services, deploying educational campaigns, and implementing strategies to combat misinformation.[3,4] Notably, healthcare professionals (HCPs) play a crucial role in educating patients, eliminating false beliefs and building a foundation of trust to combat hesitancy and promote vaccine acceptance. However, for various reasons, including their ambivalence about vaccination, some HCPs may be reluctant to recommend vaccines to their patients.[5]

To develop adapted strategies to mitigate the impact of vaccine hesitancy, it is essential to understand the complexity of vaccine behaviors and their underlying factors among HCPs. The decision to recommend vaccination or not is closely linked to a series of psychosocial factors that influence an individual's attitudes and behavior, as well as their perception of the importance of vaccines.[6,7] Recently, the Pro-VC-Be (Health Professionals Vaccine Confidence and Behaviors) tool was developed to measure various psychosocial factors likely to influence vaccine behaviors for different types of HCPs.[7]

In 2020, the initial study validated the Pro-VC-Be tool's effectiveness with general practitioners in France and the French-speaking regions of Belgium (Brussels and Wallonia)

CONTACT Arnaud Gagneur Arnaud.Gagneur@USherbrooke.ca Department of Pediatrics, Neonatology, CIUSSS de l'Estrie – CHUS, 12ième Avenue Nord, SHERBROOKE, QC 3001, Canada.
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and among nurses in Quebec (Canada).[7] More recently, the original 31-item long-form questionnaire was adapted and validated into a short 10-item version to make it more accessible to HCPs. The short-form demonstrated good construct and criterion validity, similar to the long-form questionnaire.[8] Finally, a third study performed in 2022, the International Professionals' Vaccine Confidence and Behaviors (I-Pro-VC-Be), slightly adapted some items of the short-form questionnaire to measure the psychosocial determinants of HCPs' vaccine confidence and their associations with vaccination behavior in European countries (Germany, Finland, France, and Portugal).[9]

Vaccine hesitancy and underlying psychosocial determinants in Canada and Europe vary due to social, cultural, and political factors.[10] In Canada, the National Advisory Committee on Immunization (NACI) provides recommendations on the timing and administration of vaccines. However, provinces can establish their own recommendations and oversee the implementation of vaccination programs, resulting in only three Canadian provinces and territories having mandatory childhood vaccination. In contrast, since 2017, France has expanded mandatory vaccination to include 11 vaccines for children under 2 years old.[10,11] Consequently, the implementation of these country-specific public policies, including (or not) coercive measures,[12] can impact vaccine confidence, particularly regarding trust in the healthcare system and policymakers.[11,13] Furthermore, health education systems and healthcare structures vary,[14] with nurses playing a central role in Canada's immunization programs, while in Europe, this responsibility often falls to general practitioners or is shared among various HCPs.[15] Additionally, several studies demonstrated an association between the prevalence of vaccine hesitancy among HCPs and their type of profession, the duration of their studies, their role in population vaccination, or their satisfaction at work.[16–18]

Although the Pro-VC-Be short-form questionnaire was validated among French-speaking nurses in Quebec and HCPs in Europe in the early COVID-19 pandemic,[8] the surge of vaccine misinformation, hesitancy and distrust in authorities caused by the COVID-19 vaccination campaign has greatly changed the current context. Additionally, Canadian provinces can establish their own vaccination recommendations, highlighting the need to verify the stability of the instrument's construct in the current context and across a diversified sample of HCPs throughout Canadian provinces. The data will provide a comprehensive understanding of the psychosocial determinants that influence HCPs' vaccination practices and self-vaccination behaviors. This work allowed to analyze vaccination behavior according to sociodemographic characteristics and professions to identify any significant associations with self-vaccination behavior and shed light on patterns across different HCP groups. Furthermore, an immunization score was determined as a method for appraising HCPs' confidence in vaccination and their dedication to advocating vaccination within their patient population.

Materials and methods

Study population

An initial cross-sectional online survey was conducted from July to September 2022 among Canadian healthcare professionals: general practitioners, medical specialists (pediatricians and gynecologists), nurses, midwives, and pharmacists. The online survey was conducted using the Voxco platform. The survey was available in both English and French. The Canadian HCPs were recruited via a contact list retrieved from BookYourData's database. Briefly, this database contains over 25,000 contacts for Canadian HCPs. However, the recruitment list used for the survey included 703 medical specialists, 1,015 pharmacists, 1,500 nurses, and 1,500 general practitioners/family physicians. Quebec nurses were recruited from a list of nurses who had agreed to receive surveys from the *Ordre des infirmières et infirmiers du Québec* (OIIQ). The majority of HCPs were contacted by e-mail, with three follow-ups at approximately two-week intervals. Midwives were solicited five times via the Canadian Association of Midwives (CAM) newsletter. The survey participants received no monetary compensation for their participation. The research protocol and questionnaire were approved by the Ethics Review Board of the CHU de Québec-Université Laval. Participants gave their consent to take part in the study via a form at the beginning of the survey. The demographic characteristics of survey respondents were collected.

Outcomes

The Pro-VC-Be tool is based on three theoretical frames/models (Theoretical Domain Framework,[19] Health Belief Model,[20] and the 5C[21] to establish a set of 10 dimensions of vaccine confidence and vaccination behavior.[7] Four dimensions – perceived risks associated with vaccines, complacency, perceived risk/benefit balance, and perceived collective responsibility – represent core determinants of vaccine confidence. In contrast, 'perceived constraints' and 'trust in authority' represent core determinants of contextual factors. The intermediary factors are represented by the last four dimensions: self-efficacy, commitment to vaccination, reluctant trust, and openness to patients.

As described in the short-form Pro-VC-Be questionnaire,[8] five measures of HCPs' vaccination behavior were used as outcome criteria to assess the extent to which psychosocial determinants (study variables) were associated with these measures. These measures were adapted from the short-form, as shown in Table 1, to better reflect the Canadian context and the COVID-19 pandemic situation. For example, the original short-form question regarding self-vaccination against COVID-19 was: "If a vaccine were available, would you recommend it to your patients, and would you agree to vaccinate yourself?" In the current Canadian context, this question has been modified to: "Have you been vaccinated against COVID-19?" Briefly, measures associated with behaviors were assessed by **(1)** the frequency of HCPs' general vaccination activity based on questions relating to vaccination practices in general, **(2)** the frequency of HCPs' recommendations in four specific vaccine-related situations, and **(3)** a section on HCPs' measure (i.e., willingness) to recommend the same vaccines. Questions on HCPs' behavior were collected on 4-point Likert scales (from 1 = "Never" to 4 = "Always") with three other options, i.e. "I don't know," "I prefer not to answer," and "Not applicable." In addition, **(4–5)** self-vaccination behavior was measured with a question on COVID-19 self-vaccination ("Yes,"

Table 1. A set of items adapted to the Canadian context that were used in the Pro-VC-Be questionnaire to assess vaccination behaviors among HCPs.

	Items adapted to the Canadian context (this study)[a]	Original short-form item
General immunization activity	For patients under your care: 1. How often do you bring up the subject of vaccination? 2. How often do you recommend the vaccines that are indicated for them? 3. **How often do you check that your patients have received the vaccines recommended for them**	For patients under your care: 1. How often do you bring up the subject of vaccination? 2. How often do you recommend the vaccines that are indicated for them? 3. **How often do you prescribe indicated vaccines to them?**
Vaccine recommendation frequency	How often do you recommend the following vaccines? 1. Pertussis vaccine in pregnancy 2. Human papillomavirus vaccine in young girls and boys 3. Seasonal flu vaccine for chronically ill adults 4. **COVID-19 vaccine for children aged 5–11 years**	How often do you recommend the following vaccines? 1. Pertussis vaccine in pregnancy (Quebec)/pertussis vaccine in mothers who have just given birth, if not vaccinated before pregnancy (France) 2. Human papillomavirus vaccine in young girls and boys aged 11 to 14 years old 3. Seasonal flu vaccine in adults under 65 years old with chronic illness 4. **Catch-up MMR for adolescents** **5. Meningitis C vaccine at 12 months of age** **6. Catch-up hepatitis B vaccine in adolescents**
Self-vaccination against COVID-19[b]	**1. Have you been vaccinated against COVID-19?**	If a COVID-19 vaccine were available (Oct- Nov 2020): 1. **Would you agree to recommend it to your patients?** **2. Would you agree to vaccinate yourself?**
Up-to-date with influenza immunization[c]	**1. How many times have you been vaccinated against seasonal flu in the last three years?**	1. **Were you vaccinated against seasonal influenza for the winter 2019–2020 season?** **2. For this coming winter (2020–2021), do you intend to be vaccinated against seasonal influenza? (France and Belgium only)** 3. Have you had a pertussis vaccination booster dose during your adult life in the past 20 years? (France only)

[a]Original outcomes that were adapted for the Canadian context in this study are shown in bold.
[b]In the original short-form version, this item was identified as 'Stated willingness to accept future COVID-19 vaccines' (i.e. strong acceptance of COVID-19 vaccine as vaccination outcome).
[c]In the original short-form version, this item was identified as 'Self-vaccination behavior' (i.e. up-to-date with personal vaccinations as vaccination outcome).

"No," and "I prefer not to answer") and a question on seasonal flu self-vaccination (i.e., number of influenza vaccines received in the last three years).

For each criterion, a score was calculated by adding the answers of HCPs to the corresponding items with no missing values and dividing the total by the number of elements. Scores were dichotomized for analysis. The first three behavioral scores were linearly transformed to produce scores ranging from 0 (no vaccination behavior) to 100 (systematic vaccination behavior); the 75% threshold was selected to represent HCPs with high immunization activity and vaccine recommendations. For self-immunization behavior, the COVID-19 vaccine uptake threshold was set at 4 (four doses) and dichotomized to identify favorable COVID-19 immunization behaviors. The criterion for flu self-vaccination was set at 3 (three doses in the last 3 years) to represent HCPs up-to-date with influenza immunization.

Pro-VC-Be short-form variables

As the aim of the article was to provide an analysis of the descriptive results and not revalidate the model, we used the same statistical approaches as in the initial validation studies.[7,8] Briefly, the same 10 dimensions – perceived risks, complacency, perceived risk/benefit balance, perceived collective responsibility, perceived constraints, trust in authority, self-efficacy, commitment to vaccination, reluctant trust, and openness to patient – were used as Pro-VC-Be variables. Six observed dimensions were combined into the same two latent dimensions described by Verger et al. (Table 2): vaccine confidence and proactive efficacy, considering the intercorrelation between some observed dimensions.[7] The latent dimension 'vaccine confidence' is composed of four dimensions: perceived risks, complacency, perceived risk/benefit balance, and perceived collective responsibility, while the latent dimension 'proactive efficacy' groups together the dimensions of self-efficacy and commitment to vaccination. Intercorrelations between Pro-VC-Be dimensions were assessed in the Canadian context beforehand using Spearman's correlation coefficients. When considered as explanatory variables in regressions, variables were dichotomized around their mean to determine the extent to which HCPs with above-average scores differed in their behaviors from those with below-average scores.

Poisson regression models

For each outcome, we looked at the strength of associations with the Pro-VC-Be dimensions using modified Poisson regression models with robust error measures while consistently correcting for age, gender, and profession. Due to the moderate intercorrelation of certain factors, Pro-VC-Be factors were first introduced separately as explanatory variables in models and then together in multifactorial models. For each block, the relative risk estimate was presented with its 95% confidence interval and *P*-value. Furthermore, the strength of associations between HCPs' self-vaccination behavior scores and socio-demographic characteristics was also assessed using modified Poisson regression models to identify potential disparities. Since nurses represented a majority of the sample, the analysis of self-vaccination behaviors was divided into nurses and other HCPs to obtain a more nuanced understanding of self-vaccination behaviors.

Immunization resources score

An immunization resources score was also calculated, as described by Verger et al. This score, calculated using the

Table 2. Pro-VC-Be short-form dimensions and items.

Latent dimension	Observed dimension[a]	Items
Vaccine confidence	Perceived risks of vaccines	Some vaccines can cause autoimmune diseases
	Complacency	Today, some vaccines recommended by authorities are not useful, because the diseases they prevent are not serious
	Perceived benefit/risk balance	The benefits of the vaccine against hepatitis B in infants (or as catch-up in adolescents) are much greater than its potential risks
	Perceived collective responsibility	I recommend the vaccines on the vaccination schedule to my patients because it's essential to contribute to the protection of the population (community immunity)
Proactive efficacy	Commitment to vaccination	I am committed to ensuring that my patients are vaccinated.
	Self-efficacy	I feel sufficiently trained on how to approach the question of vaccines with hesitant patients
	Trust in authorities	I trust the public health authorities (national and provincial) to establish the vaccination strategy.
	Openness to patient	I inform my patients about the benefits and risks of vaccines but I let them make their decision without trying to influence them
	Reluctant trust	I may sometimes recommend the vaccines on the official schedule even in cases where I have doubts about their safety.
	Perceived constraints	The cost of some vaccines is a problem for some patients and can keep me from prescribing them.

[a]Ten dimensions were used to evaluated HCPs psychosocial determinants of vaccination behaviors; (1) Perceived risks of vaccines assesses HCPs' perceptions of vaccination risks, including those associated with controversial vaccines, (2) Complacency measures HCPs' perceptions of the usefulness of vaccines, (3) Perceived benefit/risk balance helps to understand the adoption of prevention behaviors, (4) Perceived collective responsibility underscores the importance of collective commitment to vaccination, (5) Commitment to vaccination assessed willingness to adhere to favorable vaccination practices, (6) self-efficacy refer to HCP's belief in their own ability, in terms of knowledge and skills, to successfully address vaccination with their patients, (7) Trust in authorities evaluated the confidence and belief HCP have in the information, recommendations, and actions provided by authorities (pharmaceutical companies, experts, public health, government, etc.), (8) Openness to patient measures HCPs' attitudes toward vaccine-hesitant patients, (9) Reluctant trust assesses HCPs' trust in the vaccination system, taking into account their concerns about specific vaccines or the entire system, and (10) Perceived constraints evaluates how HCPs perceive external constraints on access to vaccines.

three constructive resources that HCPs can use to improve their immunization practices, provides information on overall immunization performance and helps identify areas that need to be improved or addressed. Briefly, the immunization resources score is calculated from the three dimensions showing the strongest associations with vaccination behaviors: vaccine confidence, proactive efficacy, and trust in authorities. The resources score ranges from 1 to 4, where a 1-point increase in the score is equivalent to a 33% increase in additional vaccination resources. The modified Poisson regression model, adjusted for age, gender, and profession, was used to estimate the relative risks of observing high vaccination behaviors (i.e., above 75%) when the immunization resources score was at its highest (i.e., 4).

Results

Demographic profile of healthcare professionals

A total of 825 questionnaires were collected during the data collection period, of which 544 (66%) were complete and kept in the analysis. The final sample included 262 questionnaires (48.2%) completed in French and 282 (51.8%) in English. As depicted in Table 3, the vast majority (84%) of respondents were female and were aged between 30 and 59 (74%). Nurses were the most represented professional category (61%), followed by pharmacists (8%), pediatricians (5%), and public health workers (5%), while physicians and midwives each accounted for 3% of respondents. Among nurses, a large majority (71%) were members of *Ordre des infirmières et infirmiers du Québec* (OIIQ), while 26% were located in other provinces, and 3% did not specify their affiliation. However, 12% of respondents claimed they worked in a professional category not specified in the survey. Importantly, most of the participants (78%) held a vaccination-related profession, while 22% of them did not discuss vaccination with their patients as part of their work.

Pro-VC-Be factors and vaccination behaviors

Because HCPs play a critical role in educating patients and building trust to curb hesitancy and promote vaccine benefits, understanding the underlying psychosocial determinants of certain vaccination behaviors (general immunization activity, vaccine recommendation frequency, and vaccine recommendation) among HCPs is crucial. Interestingly, similar trends were observed for associations between the three behavioral measurements mentioned above and Pro-VC-Be dimensions among Canadian HCPs. In separate models, all three practice-related vaccination behaviors were significantly associated with the same three Pro-VC-Be dimensions: vaccine confidence, proactive efficacy, and trust in authorities. As shown with relative risk (RR) values in Table 4, HCPs with high (> mean) vaccine confidence were more likely to report higher general immunization activity (+ 40%, $p > .01$), frequently recommend vaccines to their patients (+ 80%, $p < .001$), and were more willing to recommend vaccines to their patients (+ 60%, $p < .001$). HCPs with above-average trust in authorities showed similar patterns, having a greater chance of observing high (>75%) vaccination-related behaviors by + 50%, + 60%, and + 50% ($p < .001$) for general immunization activity, vaccine recommendation frequency, and vaccine recommendation measure, respectively. In addition, HCPs with high proactive efficacy were more likely to have high general immunization score (+ 140%, $p < .001$), high vaccine recommendation frequency score (+ 180%, $p < 0.001$), and were more inclined to propose vaccines to their patients (+ 80%, $p < .001$). While the global models showed the same trends as the separate models for general immunization activity, vaccine confidence and trust in authorities dimensions were not significantly associated with this behavior when all Pro-VC-Be factors were introduced in the same model. Trust in authorities also differed within the vaccine recommendation regression models, not being significantly associated with a higher score in the global model. Finally, Pro-VC-Be dimensions of

Table 3. Social-demographic characteristics of respondents.

		Frequency	%
Gender	Male	79	15
	Female	457	84
	Non-binary	3	1
	Prefers not to answer	4	1
	Missing	1	0.2
Total		**544**	**100**
Age range			
	18–29	42	8
	30–39	109	20
	40–49	151	28
	50–59	139	26
	60–64	52	10
	65+	51	9
Total		**544**	**100**
Number of children in care			
	1	78	14
	2	125	23
	3	37	7
	4+	17	3
	None	287	53
Total		**544**	**100**
Born in Canada			
	Yes	444	82
	No	94	17
	Prefers not to answer	6	1
Total		**544**	**100**
Profession			
	General Practitioner or Family Physician	18	3
	Pediatrician	26	5
	Gynecologist	12	2
	Nurse	334	61
	Quebec province	*236*	*71*[a]
	Rest of Canada	*87*	*26*[a]
	Unspecified	*11*	*3*[a]
	Midwife	17	3
	Pharmacist	45	8
	Public health worker	25	5
	Other	67	12
Total		**544**	**100**
Vaccination-related profession			
	Yes	426	78
	No	118	22
Total		**544**	**100**

openness to patients, reluctant trust, and perceived constraints were not significantly associated with vaccine-related behaviors in either model.

Pro-VC-Be dimensions and self-vaccination against COVID-19 and influenza

Concerning behaviors toward HCPs, self-vaccination, trust in authorities and proactive efficacy were the only Pro-VC-Be factors correlated with COVID-19 vaccination in the separate models. HCPs with a higher trust in authorities were 80% ($p < .01$) more likely to have received the COVID-19 vaccine compared to 60% ($p < .05$) when displaying high proactive efficacy. In addition, three Pro-VC-Be dimensions were positively associated with HCPs being up-to-date with their influenza vaccination in both models: vaccine confidence, proactive efficacy, and trust in authorities, whereas high (> mean) openness to patients was correlated with fewer flu doses in both separate (RR = 0.83 [0.72;0.95]) and global models (RR = 0.76 [0.66;0.89]).

Disparities in HCPs' self-vaccination behaviors

Association between vaccine-related behavioral scores and socio-demographic characteristics (Table 5) demonstrated that female HCPs were less likely (− 25%, $p < .001$) to be up-to-date with their influenza vaccination. Interestingly, nurses were less likely to have received the COVID-19 vaccine (− 90%, $p < .001$) and be up-to-date with influenza vaccination (− 30%, $p < .001$) than other HCPs. Further multivariable analysis (data not shown) shows that both predictors kept similar effects. When the analysis is broken down by profession, as shown in Table 6, it appears that among non-nursing professions, having an above-average trust in authorities increased the chances of being vaccinated against COVID-19 by 90% ($p < .05$) when factors were analyzed separately. In contrast, no Pro-VC-Be dimension was significantly associated with COVID-19 self-vaccination among nurses. However, strong vaccine confidence, proactive efficacy, and trust in authorities increased the chance of being up-to-date with influenza vaccination among HCPs in the separate model (+ 30% to + 60%), with some disparities with the global model.

Immunization resource score and immunization behaviors

HCPs with a full resource score (i.e., 4) were more likely to have more favorable self-vaccination behaviors toward the COVID-19 vaccine (+ 70%, $p < .05$) and influenza vaccine (+ 60%, $p < .001$). Greater associations were observed with practice-related immunization behaviors, while HCPs with a full resource score were 2.8, 3.6, and 2.6 times more likely to have high immunization activity, recommendation frequency, and recommendation measure, respectively.

Discussion

As highlighted by the COVID-19 pandemic,[22] vaccine hesitancy varies significantly between European countries and Canada. Overall, confidence in vaccines is lower in the European region than in other parts of the world, with France among the nations with the lowest level of confidence in vaccine safety.[23,24] Since the vaccination context, including vaccine hesitancy, psychosocial determinants, vaccination policies[10] and healthcare structures,[14] can vary between countries because of social, cultural, and political factors,[10] the slightly modified Pro-VC-Be short-form questionnaire was used to measure psychosocial determinants of Canadian HCPs' vaccination behavior with a particular emphasis on nurses from the province of Quebec.[8] However, original items associated with each Pro-VC-Be dimension of HCPs' psychosocial determinants of vaccination (see Table 2), which are generally associated with vaccine confidence and related behaviors, were conserved.[7] Spearman's correlation coefficients (Supplementary Figure S1) confirmed the intercorrelation of items in this study within the two latent dimensions – vaccine confidence and proactive efficacy- validating the six-dimensional Pro-VC-Be structure initially described in the original short-form questionnaire.[8]

Table 4. Associations between vaccination behavioral scores and Pro-VC-Be factors among Canadian HCPs ($n = 544$) using multiple modified Poisson regressions.

Pro-VC-Be factors	Separately[a]	Global[b]
Self-reported very frequent (>75%) general immunization activity score		
Vaccine confidence > mean (ref. No)	**1.4 [1.1;1.8]**	1.12 [0.84;1.5]
Proactive efficacy > mean (ref. No)	**2.4 [1.8;3.2]**	**1.92 [1.37;2.7]**
Trust in authorities > mean (ref. No)	**1.6 [1.2;2.1]**	1.24 [0.89;1.7]
Openness to patients > mean (ref. No)	1.12 [0.88;1.41]	0.97 [0.75;1.3]
Reluctant trust > mean (ref. No)	0.88 [0.68;1.13]	0.99 [0.74;1.3]
Perceived constraints > mean (ref. No)	1.14 [0.89;1.46]	1.16 [0.89;1.5]
Self-reported very frequent (>75%) vaccine recommendation frequency score		
Vaccine confidence > mean (ref. No)	**1.8 [1.5;2.3]**	**1.5 [1.17;1.9]**
Proactive efficacy > mean (ref. No)	**2.8 [2.2;3.7]**	**2.4 [1.78;3.1]**
Trust in authorities > mean (ref. No)	**1.5 [1.2;1.9]**	0.9 [0.72;1.1]
Openness to patients > mean (ref. No)	1.06 [0.87;1.30]	1.0 [0.87;1.3]
Reluctant trust > mean (ref. No)	0.93 [0.75;1.14]	1.2 [0.94;1.4]
Perceived constraints > mean (ref. No)	1.07 [0.88;1.31]	1.1 [0.90;1.3]
Self-reported very frequent (>75%) vaccine recommendation measure score		
Vaccine confidence > mean (ref. No)	**1.6 [1.3;1.8]**	**1.33 [1.13;1.6]**
Proactive efficacy > mean (ref. No)	**1.8 [1.6;2.2]**	**1.51 [1.28;1.8]**
Trust in authorities > mean (ref. No)	**1.6 [1.4;1.9]**	**1.25 [1.05;1.5]**
Openness to patients > mean (ref. No)	1.02 [0.89;1.16]	0.97 [0.85;1.1]
Reluctant trust > mean (ref. No)	0.86 [0.74;1.00]	0.95 [0.82;1.1]
Perceived constraints > mean (ref. No)	1.00 [0.88;1.15]	1.04 [0.91;1.2]
Self-vaccination against COVID-19		
Vaccine confidence > mean (ref. No)	1.04 [0.77;1.42]	0.82 [0.58;1.2]
Proactive efficacy > mean (ref. No)	**1.6 [1.1;2.4]**	1.20 [0.79;1.8]
Trust in authorities > mean (ref. No)	**1.8 [1.2;2.6]**	**1.78 [1.09;2.9]**
Openness to patients > mean (ref. No)	0.99 [0.71;1.38]	0.90 [0.63;1.3]
Reluctant trust > mean (ref. No)	0.82 [0.56;1.21]	0.88 [0.58;1.3]
Perceived constraints > mean (ref. No)	1.23 [0.89;1.71]	1.41 [0.98;2.0]
Up-to-date with influenza immunization		
Vaccine confidence > mean (ref. No)	**1.4 [1.2;1.6]**	**1.26 [1.07;1.48]**
Proactive efficacy > mean (ref. No)	**1.4 [1.2;1.6]**	**1.48 [1.24;1.77]**
Trust in authorities > mean (ref. No)	**1.4 [1.2;1.6]**	**1.31 [1.09;1.57]**
Openness to patients > mean (ref. No)	**0.83 [0.72;0.95]**	**0.76 [0.66;0.89]**
Reluctant trust > mean (ref. No)	1.01 [0.88;1.16]	1.15 [0.99;1.35]
Perceived constraints > mean (ref. No)	0.99 [0.86;1.15]	1.04 [0.89;1.22]

[a]Pro-VC-Be factors introduced separately as explanatory variables in models, adjusted for gender, age, and profession.
[b]All Pro-VC-Be factors were introduced in the same model, adjusted for gender, age, and profession.
Bold characters mean statistically significant differences.

Table 5. Association between vaccination behavioral scores and socio-demographic characteristics ($n = 544$) using modified Poisson regressions (univariate model).

	General immunization activity	Recommendation frequency	Recommendation measure	Self-vaccination against COVID-19	Up-to-date with influenza immunization
Age[a]	0.88 [0.50;1.57]	1.04 [0.62;1.74]	0.89 [0.68;1.16]	1.17 [0.33;4.10]	1.14 [0.79;1.63]
Gender (ref. male)	1.08 [0.76;1.53]	0.97 [0.74;1.28]	1.09 [0.89;1.33]	0.74 [0.48;1.12]	**0.75 [0.66;0.86]**
Profession (ref. nurse)	0.98 [0.77;1.25]	1.03 [0.84;1.26]	1.00 [0.87;1.14]	**1.9 [1.3;2.6]**	**1.3 [1.2;1.5]**

[a]for each additional unit.
Bold characters mean statistically significant differences.

One of the main findings of this study is that the same three Pro-VC-Be dimensions (i.e., vaccine confidence, trust in authorities, and proactive efficacy) identified in the previous validation studies of the Pro-VC-Be were also linked with high vaccination activity and high vaccine recommendation behaviors among Canadian HCPs.[7–9] It's important to emphasize that 7 out of 10 dimensions make up these 3 Pro-VC-Be factors (see Table 2), of which 5 of them are among the core determinants of vaccination behaviors as described by Verger et al.[7] Proactive efficacy, representing intermediary factors, was the dimension most strongly associated with vaccination behaviors, consistent with the short-form validation study.[8] Overall, this study supported data obtained in previous studies[7–9] by observing the consistency of results between three Pro-VC-Be factors (vaccine confidence, trust in authorities, and proactive efficacy) and vaccination behaviors amongst HCPs in different countries, suggesting that these factors form universal constructive psychosocial resources in HCPs and influence positive behavior and attitudes toward vaccination. Furthermore, the dimensions that constitute low vaccine confidence and distrust in authorities have been identified as effective predictors of vaccine hesitancy within the population, supporting the connections between these Pro-VC-Be variables and immunization outcomes.[21]

Interestingly, the item 'perceived constraints,' the last core determinant of vaccination behavior, was not significantly associated with any vaccinal behaviors in this study. This finding contrasts with the results from the short-form validation study conducted in French-speaking countries (including the province of Quebec, Canada), where the perceived constraints dimension was a barrier to positive vaccination activity and recommendation behavior.[8] In support of this study's

Table 6. Associations between self-vaccination scores and Pro-VC-Be factors between nurses and other HCPs ($n = 544$) using multiple modified Poisson regressions.

	Self-vaccination against COVID-19				*Up-to-date with influenza immunization*			
	Nurse ($n = 334$)		Health professional ($n = 210$)		Nurse ($n = 334$)		Health professional ($n = 210$)	
Pro-VC-Be factors	Separately[a]	Global[b]	Separately[a]	Global[b]	Separately[a]	Global[b]	Separately[a]	Global[b]
Vaccine confidence > mean (ref. No)	1.09 [0.67;1.77]	0.91 [0.46;1.8]	1.11 [0.75;1.65]	0.83 [0.53;1.3]	**1.4 [1.1;1.7]**	1.31 [0.97;1.77]	**1.5 [1.2;1.8]**	**1.24 [1.05;1.46]**
Proactive efficacy > mean (ref. No)	1.52 [0.87;2.65]	1.30 [0.71;2.4]	1.59 [0.93;2.70]	1.15 [0.64;2.1]	**1.4 [1.2;1.7]**	**1.60 [1.20;2.13]**	**1.5 [1.2;1.8]**	**1.45 [1.18;1.78]**
Trust in authorities > mean (ref. No)	1.61 [0.91;2.84]	1.16 [0.58;2.3]	**1.9 [1.1;3.3]**	**2.73 [1.41;5.3]**	**1.3 [1.1;1.7]**	1.20 [0.88;1.63]	**1.6 [1.3;1.9]**	**1.44 [1.17;1.78]**
Openness to patients > mean (ref. No)	1.28 [0.79;2.08]	1.25 [0.71;2.2]	0.62 [0.36;1.07]	0.61 [0.35;1.1]	0.83 [0.68;1.00]	**0.68 [0.53;0.86]**	**0.81 [0.67;0.99]**	**0.83 [0.69;0.99]**
Reluctant trust > mean (ref. No)	0.97 [0.58;1.64]	1.04 [0.54;2.0]	0.93 [0.59;1.48]	1.11 [0.65;1.9]	0.97 [0.78;1.21]	1.16 [0.90;1.49]	0.98 [0.82;1.16]	1.05 [0.88;1.24]
Perceived constraints > mean (ref. No)	1.45 [0.87;2.43]	1.56 [0.86;2.8]	1.20 [0.78;1.84]	1.57 [0.97;2.5]	0.99 [0.78;1.25]	0.98 [0.77;1.25]	1.13 [0.95;1.33]	**1.31 [1.11;1.55]**

[a]Pro-VC-Be **Note**: factors introduced separately as explanatory variables in models, adjusted for gender, age, and profession.
[b]All Pro-VC-Be factors were introduced in the same model, adjusted for gender, age, and profession.
Bold characters mean a statistically significant difference.

findings, there was no association between 'perceived constraints' and vaccination behaviors in the I-Pro-VC-Be short-form.[9] As mentioned by Garrison et al., this dimension could be more sensitive to contextual factors, and thus, it's not surprising to observe some disparities given the differences in vaccination systems and vaccine accessibility between countries.[9] In Quebec's public health system, vaccination services are often accessible free of charge and widely promoted by public health authorities, resulting in reduced financial barriers, facilitated access to vaccination, and minimized perceived constraints. Furthermore, this study confirmed for the first time that vaccine confidence, trust in authorities, and self-efficacy factors are strongly associated with vaccine recommendation measures (ie. willingness of HCPs to recommend vaccines). It is well established that HCPs' vaccine confidence, knowledge, and attitudes are strong determinants of vaccine acceptance and good predictors of the willingness of HCPs to recommend vaccines, including Canadian HCPs.[25–27]

Trust in the authorities is a key factor influencing vaccine acceptance in HCPs,[27,28] including the COVID-19 vaccine,[25,29] and consequently, it's not surprising that this psychosocial determinant was associated with self-immunization behaviors among Canadian HCPs.[8] In particular, mistrust in authorities was an important factor among Canadian HCPs who refused to be vaccinated against COVID-19 during the early pandemic.[30] It is important to note that the pandemic context differs between the validation study of the short-form questionnaire (when COVID-19 vaccines were still waiting to be marketed) and this study (self-vaccination against COVID-19). Therefore, COVID-19 vaccine policies, such as coercive measures, can negatively influence vaccine confidence over time.[31] The withering of vaccine confidence during the pandemic may partly explain why, in this study, the vaccine confidence dimension was not associated with vaccination against COVID-19 among Canadian HCPs. Confidence about COVID-19 vaccine safety was the strongest factor associated with vaccine acceptance in a study conducted at the beginning of the 2020 pandemic among HCPs in Canada (Quebec), France, and Belgium.[32] However, we cannot rule out the possibility of other factors, such as social, cultural, or individual factors, being involved, as the four dimensions underlying vaccine confidence (safety, complacency, benefit/risk balance, and collective responsibility) were shown to be associated with self-vaccination against COVID-19 in the I-Pro-VC-Be, which took place in 2022.[22]

As for practice-related vaccination behaviors, the same three Pro-VC-Be dimensions were good predictors of HCPs' influenza vaccine uptake. However, it was surprising that the dimension 'openness to patients' was, to a certain extent, negatively associated with flu vaccination among HCPs (Table 6). This result suggests that Canadian HCPs, particularly non-nursing HCPs, were somewhat influenced by their patients' concerns regarding seasonal flu vaccines. This phenomenon has already been documented for other vaccines, suggesting that some professionals attach importance to the concerns and opinions of their patients.[33,34] For instance, a study by Bruno et al. reported that caregivers who are more open to unusual ideas are less likely to get vaccinated against COVID-19. Additionally, hesitant HCPs may be more open to questions from hesitant patients and, consequently, be more influenced than other HCPs by patients' negative experiences with vaccines.[34,35]

Overall, no association was observed between the dimensions of 'reluctant trust' and 'perceived constraints' and the different outcomes tested in the Canadian context. In validation studies, the impact of these two dimensions seems to be more subtle on vaccination behaviors and self-vaccination. As previously mentioned, the 'perceived constraints' dimension seemed to negatively influence general vaccination activities in the original short-form. The lack of association in this study is likely due to contextual factors and may vary according to country. On the other hand, the 'reluctant trust' dimension seemed to have a greater downward influence on the frequency of recommendations by general practitioners (GP) – but not

for nurses – in the long-form validation study (separate model). However, in the long-form global model, as well as both the separate and global models in the original short-form validation study, there was no association between 'reluctant trust' and the 'frequency of recommendation,' supporting our findings. Therefore, these two dimensions provide additional resources for understanding specific aspects of vaccination determinants in a particular profession or context not observed in this study.

Finally, although the results confirmed that the immunization resources score is an excellent predictor of recommended behaviors and attitudes in HCPs, the strength of some associations seemed weaker than those obtained in the validation study of the short form of the questionnaire,[8] particularly concerning COVID-19 vaccine attitudes. The difference may be attributed to the pandemic context between the original short-form and the present short-form validation studies since perceptions toward the COVID-19 vaccine have evolved due to misinformation. Nonetheless, the immunization resources score represents an interesting measure for future intervention studies.

Strengths and limitations

One of the study's strengths is that we found the same factor structure and criterion validity results as in the previous validation study, which supports using this tool in Canada. Indeed, it confirmed the feasibility of contextualizing certain outcomes while maintaining the power of association between psychosocial determinants and vaccination-related behaviors among HCPs. Furthermore, it is worth noting that the initial validation process carried out by Verger et al. in 2020 included cognitive validation and was conducted with nurses in Quebec, confirming its applicability to this francophone province. On the other hand, a limitation of the study is that the sample consists of volunteers, as for all studies of this type, potentially creating a response bias since HCPs more engaged with vaccination were more likely to participate. For the same reason, the sample size is somewhat limited due to challenges in recruiting various types of HCPs. Nonetheless, having the vast majority of respondents involved in vaccination tasks reinforces the conclusions of the article. Additionally, to reduce the likelihood of sample bias due to the overrepresentation of nurses and female HCPs, underrepresentation of GPs, and a majority of participants in a vaccination-related field, all models were adjusted for age, gender, and profession. Although an advantage of the Pro-VC-Be tool is that it can be used to measure vaccine perceptions and attitudes in different contexts, a limitation is that some vaccine-related topics could vary according to the current context, for example, during a pandemic. Therefore, comparisons between studies carried out in different contexts must be interpreted with caution.

Conclusion

This study confirmed that three main factors – vaccine confidence, proactive efficacy, and trust in authorities – were primarily associated with good vaccination behaviors among Canadian HCPs. Overall, these results were in line with those previously published in France, Belgium, and Quebec and support the validity of the Pro-VC-Be questionnaire in measuring the psychosocial determinants of HCPs' vaccination behavior for themselves and their patients in the Canadian context. Thus, the Pro-VC-Be short-form questionnaire is an accessible and cost-effective tool that could prove helpful in identifying the underlying causes of HCPs' vaccination behaviors with the goal of developing more adapted strategies to mitigate vaccine hesitancy in Canada.

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Notes on contributor

Dr Arnaud Gagneur is a pediatric neonatologist trained at the University of Brest in France, where he also obtained his PhD in virology. Dr Gagneur is a full professor at the Faculty of Medicine and Health Sciences of the University of Sherbrooke and is affiliated with the Centre de Recherche du Centre Hospitalier Universitaire de Sherbrooke (CRCHUS). He specializes in developing strategies to curb vaccine hesitancy in the population. He developed and validated the PromoVac strategy, i.e. the concept of promoting vaccination in maternity units using the motivational interviewing (MI) approach. In collaboration with the Quebec Ministry of Health, he co-directed the implementation of the PromoVac strategy as a provincial public health program, the EMMIE program, and carried out its evaluation. In addition, Dr. Gagneur's research team developed a training program in MI that was applied to vaccination for healthcare professionals, as well as its evaluation tool. In collaboration with UNICEF and the US Centers for Disease Control and Prevention (CDC), he is developing a training course on the MI approach to immunization for health professionals.

ORCID

Arnaud Gagneur http://orcid.org/0000-0002-2119-2799

Authors contributions

E.D., A.G., and P.V. were involved in the study design and conception. C. P. and M-E.T. coordinated, ensured the study's progress and collected the data. S.L-P. performed statistical analyses, interpreted the data alongside D.R. and A.G. A.G. and D.R. wrote the manuscript draft and contributed to the revision process. E.D., S.L-P., and P.V. critically revised and brought expertise insight to the paper. M.R. revised and formatted the article. A.G. approved the final manuscript to be published. All authors agree to be accountable for all aspects of the work.

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