



Factors associated with intention to receive vaccines for bacterial sexually transmitted infections among young HPV-vaccinated Canadian women

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Abstract

Objective The aim of this study was to explore the acceptability of bacterial STI vaccines among young HPV-vaccinated Canadian women to inform future vaccine program implementation.

Methods A 20-item cross-sectional questionnaire was administered from June 2019 to June 2020 to HPV-vaccinated participants of the pan-Canadian QUEST cohort. Multivariable logistic regression models assessed interest in chlamydia, syphilis, and gonorrhea vaccines using a priori variables and factors significant in bivariate analysis.

Results Of the 1092 respondents analyzed, 82% indicated interest in receiving one or more future STI vaccines. Respondents had a median age of 19.6 years (range 16.9–23.4), and 75% of respondents identified as white/European descent. In adjusted analyses, intent to engage in positive health behaviours was associated with vaccine interest for syphilis (OR = 5.76, 95% CI 4.03–8.27), chlamydia (OR = 5.27, 95% CI 3.66–7.63), and gonorrhea (OR = 5.96, 95% CI 4.15–8.60). Willingness to pay for an STI vaccine was also associated with vaccine interest for syphilis (OR = 2.02, 95% CI 1.29–3.19), chlamydia (OR = 2.41, 95% CI 1.50–3.90), and gonorrhea (OR = 2.29, 95% CI 1.44–3.63). Ever having sexual intercourse and identifying as LGBTQ were significantly associated with vaccine interest for all infections, while age and ever being immunosuppressed were not significant in any adjusted models.

Conclusion Findings indicate over 80% of participants in a cohort of young HPV-vaccinated Canadian women are interested in receiving future bacterial STI vaccines. Further exploration of STI vaccine acceptability among diverse populations is required to inform future bacterial STI vaccine program implementation.

Résumé

Objectif Cette étude visait à explorer l'acceptabilité des vaccins contre les ITS bactériennes chez les jeunes Canadiennes vaccinées contre le VPH pour éclairer la mise en œuvre de futurs programmes de vaccination.

Méthode Un questionnaire transversal de 20 questions a été administré entre juin 2019 et juin 2020 aux participantes de la cohorte QUEST pancanadienne ayant été vaccinées contre le VPH. Des modèles de régression logistique multivariée ont permis d'analyser l'intérêt pour les vaccins contre la chlamydia, la syphilis et la gonorrhée à l'aide de variables a priori et des facteurs significatifs dans l'analyse bivariée.

Résultats Sur les 1 092 répondantes analysées, 82 % ont manifesté l'intérêt de recevoir un ou plusieurs futurs vaccins contre les ITS. L'âge médian des répondantes était de 19,6 ans (intervalle 16,9–23,4), et 75 % s'identifiaient comme étant blanches/

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d'ascendance européenne. Dans les analyses ajustées, l'intention de s'adonner à des comportements de santé positifs était associée à l'intérêt pour les vaccins contre la syphilis (RC = 5,76, IC de 95 % 4,03–8,27), la chlamydia (RC = 5,27, IC de 95 % 3,66–7,63) et la gonorrhée (RC = 5,96, IC de 95 % 4,15–8,60). La volonté de payer pour un vaccin contre les ITS était aussi associée à l'intérêt pour les vaccins contre la syphilis (RC = 2,02, IC de 95 % 1,29–3,19), la chlamydia (RC = 2,41, IC de 95 % 1,50–3,90) et la gonorrhée (RC = 2,29, IC de 95 % 1,44–3,63). Le fait d'avoir déjà eu des rapports sexuels et le fait de s'identifier comme une personne LGBTQ présentaient une corrélation significative avec l'intérêt pour les vaccins contre toutes les infections, mais l'âge et le fait d'avoir déjà subi un traitement immunodépresseur n'étaient des facteurs significatifs dans aucun des modèles ajustés.

Conclusion Selon nos constatations, plus de 80 % des participantes d'une cohorte de jeunes Canadiennes vaccinées contre les VPH sont intéressées à recevoir de futurs vaccins contre les ITS bactériennes. Une exploration plus poussée de l'acceptabilité des vaccins contre les ITS dans des populations à forte mixité est nécessaire pour éclairer la mise en œuvre de futurs programmes de vaccination contre les ITS bactériennes.

Keywords STIs · Vaccination · Young women · Acceptability · Interest

Mots-clés ITS · vaccination · jeunes femmes · acceptabilité des soins de santé · intérêt

Introduction

An estimated one million new sexually transmitted infections (STIs) are acquired globally each day, with chlamydia, gonorrhea, syphilis, and trichomoniasis contributing a significant burden of disease to individuals and healthcare systems (Plotnikoff et al., 2021). The most frequently reported STI in Canada is chlamydia, with women aged 15–24 years old reporting the highest rates of infection (PHAC, 2019). Global incidence of STIs is rising for a variety of reasons, which include increased access to testing, changing sexual attitudes and behaviours, and decreased condom use (Hughes & Field, 2015). Adolescent women have greater susceptibility to STIs than men due to biological factors such as increased cervical ectopy, and experience an overall disproportionate burden of sequelae from STIs (Shannon & Klausner, 2018). Confidentiality concerns and lack of access to health services may further pose barriers to STI screening for adolescents (Shannon & Klausner, 2018). Despite extensive school-based educational programs, risk-reduction counselling, and other preventive efforts, STIs remain on the rise among youth in Canada (Gottlieb et al., 2014).

STIs are often asymptomatic, are highly transmissible, and may be accompanied by negative psychosocial health consequences, including feelings of embarrassment or anger (Gottlieb & Johnston, 2017). Bacterial STIs such as gonorrhea and chlamydia may lead to pelvic inflammatory disease, adverse maternal health outcomes, and infertility (Tsevat et al., 2017). Existing interventions for bacterial STIs have significant limitations. Antimicrobial treatments for bacterial STIs do not protect against recurring infections, and antimicrobial resistance (AMR) poses a growing threat, specifically for *Neisseria gonorrhoeae* (Bodie et al., 2019). The majority of chlamydia infections are asymptomatic, which leads to undiagnosed or untreated infections, and results in individual and

economic health burdens exceeding those of clinically apparent infections (Tuite et al., 2012). In most settings, STI case management is typically sought by those who are symptomatic (Gottlieb et al., 2014). Given the challenges and limitations of available treatments, development of vaccines against bacterial STIs is a priority for sustainable STI control (Gottlieb et al., 2014).

Mathematical modelling indicates that STI vaccine programs that provide primary prevention could play an important cost-effective role in reducing the healthcare burden associated with STIs (Garnett, 2014). There are currently two vaccines against viral STIs, protecting against hepatitis B virus (HBV) and human papillomavirus (HPV) (Garnett, 2014). These vaccines have led to reductions of approximately 90% of HPV 6/11/16/18 infection, and a 70–90% decrease in chronic HBV carrier rates (Garland et al., 2016; Gerlich, 2015). While there are no approved vaccines against bacterial STIs, vaccine candidates for syphilis and gonorrhea are in preclinical development, and phase I clinical trials of chlamydia vaccine candidates are underway (Gottlieb & Johnston, 2017).

In 2014, the World Health Organization (WHO) published a comprehensive roadmap for the development of new vaccines against STIs, which includes the priority action area: 'plan for vaccine introduction in advance' (Gottlieb et al., 2016). A gap exists in current evidence on the acceptability of future bacterial STI vaccines among priority populations. Understanding acceptability and preferences for vaccine program delivery prior to implementation among those who will be a priority group in future bacterial STI vaccine programs is critical for informing the design of effective vaccine distribution and messaging. Issues with initial vaccine program implementation have the potential for lasting unintended negative consequences for public confidence in vaccines (Simms et al., 2020). Building on prior research exploring

acceptability of STI vaccines among STI clinic attendees, the primary objective of this study was to determine interest in, and factors associated with, vaccination against bacterial STIs among young HPV-vaccinated Canadian women who are enrolled in an HPV vaccine evaluation study (Plotnikoff et al., 2020). Secondary objectives included assessing preferences for key aspects of STI vaccine programming, including location, information sources, and cost.

Methods

Setting and population

The cross-sectional survey was offered to 2315 participants of the Quadrivalent HPV Vaccine Evaluation Study (QUEST) cohort, which aims to evaluate the long-term effectiveness of the HPV vaccination program after 2 or 3 doses of quadrivalent HPV vaccine (Donken, 2017). QUEST includes over 5800 girls recruited between ages 14 and 19 years old. QUEST cohort participants were enrolled between 2012 and 2018 from British Columbia, Alberta, Quebec, Nova Scotia, and Prince Edward Island.

Procedures

QUEST participants were offered a 20-item online questionnaire between June 2019 and June 2020 on opinions and beliefs about future STI vaccines. The survey was adapted from a previous study conducted at an STI clinic in Vancouver, BC (Plotnikoff et al., 2020). The survey instrument was developed based on the theoretical framework of the Health Belief Model (Champion & Skinner, 2008). Survey responses were captured using the secure Research Electronic Data Capture (REDCap) application for online surveys (Patridge & Bardin, 2018). Ethics approval was obtained from the UBC Children's and Women's Research Ethics Board (H12-01246).

Survey items

The survey collected demographic information, STI history, general interest in STI vaccines, and barriers and facilitators to STI vaccine interest. The full survey is available in Supplementary appendix 1.

Sample size

The optional STI vaccine questions were included at the end of the annual QUEST study survey, and as such, all QUEST participants were eligible to complete the STI vaccine questions. Using an estimated STI vaccine acceptability proportion of 82% based on prior research, the

minimum sample size was calculated to be 227 with a 5% margin of error (95% CI 79.5–84.5) (Plotnikoff et al., 2020). Fifteen percent was added to this value to obtain a sample size of $N=261$, to account for missing or declined responses to the primary outcome question or covariates of interest.

Statistical analysis

A complete case analysis was conducted and only surveys that did not have missing data on primary outcome variables or covariates of interest were included. Demographic characteristics and categorical data were assessed using descriptive statistics. The relationship between potential correlates and interest in vaccines for chlamydia, syphilis, and gonorrhea was assessed using bivariate analyses. Separate bivariate analyses were completed for each STI to assess for potential differences in interest in receiving a vaccine specific to each infection. Interest in STI vaccines was dichotomized by 5-point Likert scales (very interested to very uninterested). 'Neutral' responses on Likert scale items were coded as 'not interested' to obtain a more conservative estimate of vaccine interest. Variables identified as highly correlated during bivariate analysis were linearly combined, and inter-item reliability was assessed using Cronbach's alpha. Factors significant at $p \leq 0.05$ as determined by the Wald test were included in a multivariable logistic regression (MLR) model for each of the three bacterial STI vaccines explored. MLR model fit was assessed using the Bayesian Information Criterion (BIC). The three MLR models were adjusted for a priori clinically relevant variables (age, ever having had sexual intercourse, and sexual orientation). Variables identified as relevant based on current STI vaccine literature (e.g., willingness to pay) were also included in bivariate analyses (Plotnikoff et al., 2020). Data were analyzed using R software (version 4.0.2).

Results

Between June 2019 and June 2020, 2315 surveys were distributed to the QUEST cohort. A total of 1613 surveys were returned for a 69.7% response rate. After excluding 457 respondents due to missing data to a primary outcome variable or covariate of interest, and 64 additional respondents for declining to provide an answer to these items, a total of 1092 surveys were included in analysis (Fig. 1). Missingness was assessed for each of the outcome variables based on available sociodemographic variables including age, province of residence, and sexual orientation, which were non-significantly different ($p > 0.05$). Continuous data were compared with a Kruskal–Wallis test, and discrete data were compared with a chi-squared test.

Descriptive statistics

The median age of respondents was 19.6 years old (range 16.9–23.4), and 85.2% (930/1092) of participants resided in British Columbia (Table 1). Most respondents (70.7%, 772/1092) reported ever having had sexual intercourse, and were white or of European descent (75.4%, 823/1092).

Most respondents (81.8%, 893/1092) agreed or strongly agreed that they would be interested in receiving a vaccine to prevent syphilis, chlamydia, and/or gonorrhea. When asked to identify one main reason for interest in an STI vaccine, most participants reported a desire to protect oneself (81.2%, 887/1092). When respondents were able to select their reason(s) for interest in an STI vaccine, 96.9% (1059/1092) indicated protecting oneself as a motivating reason, and 83.9% (917/1092) reported wanting to protect a partner from an undiagnosed STI. When asked to identify one main barrier to interest in an STI vaccine, the top reason selected was the ability to pay if there was a high cost associated with receiving the vaccine (20.2%, 221/1092). When respondents were able to

select multiple reasons for being uninterested in an STI vaccine, half of respondents (50.9%, 556/1092) indicated concern about potential long-term side effects of an STI vaccine, and 50.2% (548/1092) indicated that high cost would be a factor for not being interested in an STI vaccine.

Factors associated with interest in STI vaccination

Seven highly correlated Likert scale items were identified during bivariate analysis in the MLR model-building process. All items had an acceptable inter-item reliability with a Cronbach's alpha of $\alpha=0.73$. Scores on these items were combined into a single 'intent to engage in future positive health behaviours' variable. Items included agreement with continuing condom use if STI vaccines were available; receiving a vaccine to reduce personal STI risk; continuing to receive STI testing following STI vaccination; encouraging partner(s) or friends to receive an STI vaccine if available; interest in receiving an STI vaccine to protect a future child; belief that

Table 1 Characteristics of survey participants

Characteristic	Frequency (%)
	<i>N</i> = 1092
Median age (range)	19.6 (16.9–23.4)
Sexual orientation	
	Heterosexual 756 (69.2%)
	Bisexual 206 (18.9%)
	Not sure or questioning 43 (3.9%)
	Pansexual 32 (2.9%)
	Lesbian 26 (2.4%)
	Queer 19 (1.7%)
	Asexual 10 (0.9%)
Current region of residence	
	British Columbia 930 (85.2%)
	Alberta and Saskatchewan 137 (12.5%)
	Eastern Canada 15 (1.4%)
	Other, international 10 (0.9%)
Ethnicity*	
	White, European descent 823 (75.4%)
	Asian descent 195 (17.9%)
	Indigenous/First Nations 62 (5.7%)
	Central or South American 23 (2.1%)
	African descent 18 (1.6%)
	Australian or Pacific Islander 17 (1.5%)
	Other 64 (5.9%)
Ever had sexual intercourse	772 (70.7%)
Ever had an STI	64 (5.9%)
Ever been pregnant	22 (2.0%)
Currently immunosuppressed**	51 (4.7%)
Willing to pay out of pocket for an STI vaccine	390 (35.7%)

*Respondents could select more than one response

**Participants were questioned whether they were currently taking any medications or had any medical conditions that affected the immune system (e.g., cortisone pills, monoclonal antibodies (Humira, Reicade, Rituxen), diabetes, JRA, lupus)

vaccines are an effective way to prevent STIs; and belief that others should be allowed to receive an STI vaccine.

Syphilis

If available today, 78.2% (95% CI 75.6–80.6) of respondents indicated they would be interested or very interested in receiving a syphilis vaccine (Fig. 2). In unadjusted regression analysis, intent to engage in future positive health behaviours, identifying as LGBTQ, ever having had sexual intercourse, and willingness to pay were significantly associated with interest in receiving a syphilis vaccine (Table 2).

In the adjusted model, willingness to pay (OR=2.02, 95% CI 1.29–3.19, $p=0.002$), intent to engage in future positive health behaviours (OR=5.76, 95% CI 4.03–8.27, $p<0.0001$), identifying as LGBTQ (OR=1.58, 95% CI 1.03–2.47, $p=0.03$), and ever having had sexual intercourse (OR=1.86, 95% CI 1.32–2.61, $p=0.0004$) remained significantly associated with interest in a syphilis vaccine (Table 2).

Chlamydia

If available today, 80.3% (95% CI 77.8–82.6) of respondents indicated they would be interested or very interested in receiving a chlamydia vaccine (Fig. 2). Unadjusted regression analysis found that ever having had sexual intercourse, willingness to pay, identifying as LGBTQ, and intent to engage in future

positive health behaviours were significantly associated with increased interest in receiving a chlamydia vaccine (Table 2).

In the adjusted model, willingness to pay (OR=2.41, 95% CI 1.50–3.90, $p=0.0003$), intent to engage in future positive health behaviours (OR=5.27, 95% CI 3.66–7.63, $p<0.0001$), identifying as LGBTQ (OR=1.72, 95% CI 1.16–2.59, $p=0.008$), and ever having had sexual intercourse (OR=2.21, 95% CI 1.56–3.15, $p<0.0001$) remained significant factors associated with chlamydia vaccine interest (Table 2).

Gonorrhea

If available today, 78.3% (95% CI 75.7–80.7) of respondents indicated they would be interested or very interested in receiving a gonorrhea vaccine (Fig. 2). Unadjusted regression analysis found ever having had sexual intercourse, identifying as LGBTQ, willingness to pay, and intent to engage in future positive health behaviours were significantly associated with interest in receiving a gonorrhea vaccine (Table 2).

In the adjusted model, willingness to pay (OR=2.29, 95% CI 1.44–3.63, $p=0.0004$), intent to engage in future positive health behaviours (OR=5.96, 95% CI 4.15–8.60, $p<0.0001$), ever having had sexual intercourse (OR=2.25, 95% CI 1.60–3.17, $p<0.0001$), and identifying as LGBTQ (OR=1.76, 95% CI 1.20–2.62, $p=0.005$) remained significant factors associated with interest in a gonorrhea vaccine (Table 2).

Discussion

In a cohort of HPV-vaccinated young women who are enrolled in an HPV vaccine evaluation study, we found a high interest (>80%) in receiving future vaccinations against syphilis, chlamydia, and gonorrhea. Given that the highest rates of STIs in Canada occur in those aged 20–24 years old with females having higher rates than males, examining acceptability of future STI vaccines and preferences among young women is critical to effective planning for implementation of eventual STI vaccination programs (Haghir et al., 2018). Understanding the factors associated with bacterial STI vaccine acceptance is essential in planning strategies to increase vaccine acceptability before these vaccines become available. Rapid advancements in vaccine technology in recent years, particularly in response to the COVID-19 pandemic, have paved the way for development and implementation of other vaccines. The STI vaccine development pipeline includes initial phase I trial results, which support the safety and immunogenicity of chlamydia vaccines, and continued development is underway (Abraham et al., 2019). We found factors significantly associated with greater interest in receiving vaccines against syphilis, chlamydia, and gonorrhea included willingness to pay, intent to engage in future positive health behaviours, identifying as LGBTQ, and ever having had sexual intercourse. Our findings align with prior

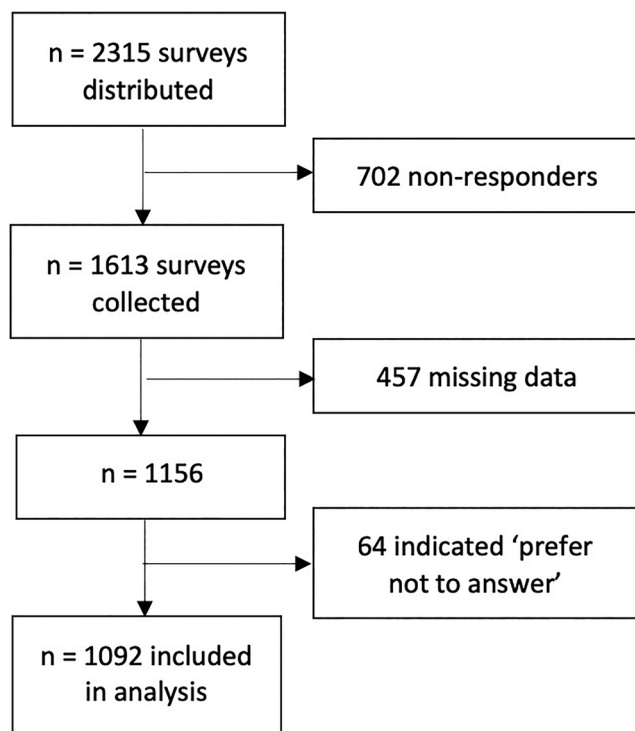
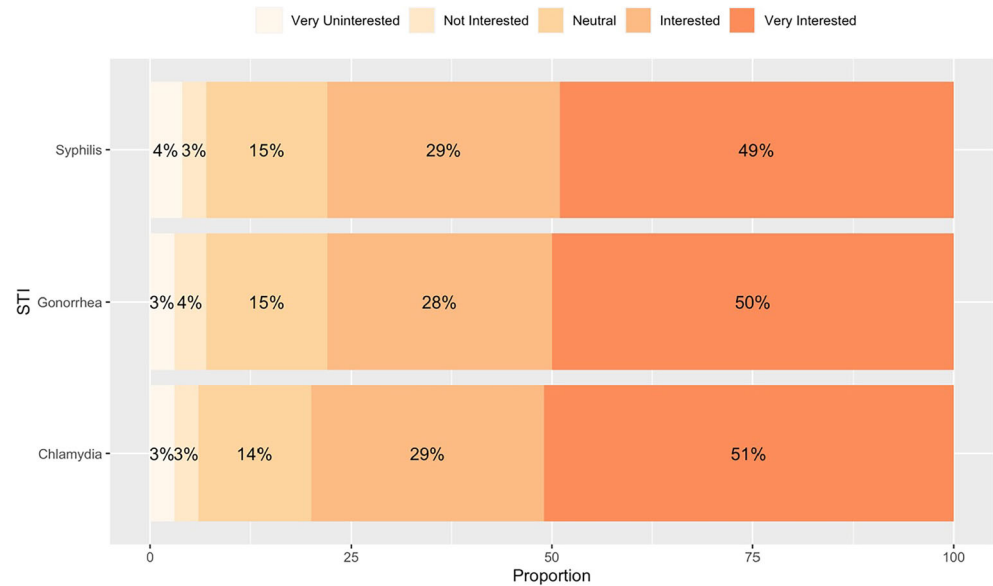


Fig. 1 Survey response and analysis flowchart. A total of 1092 respondents were included in this analysis

Fig. 2 Proportion of respondents based on STI vaccine interest per infection on a 5-item Likert scale from very uninterested to very interested



research conducted among STI clinic attendees in Vancouver, BC, which indicated a strong willingness to receive vaccination against bacterial STIs (Plotnikoff et al., 2020). As is reflected in recent COVID-19 vaccine acceptance literature, future bacterial STI vaccine campaigns should focus on translating the high levels of observed interest in receiving vaccines into vaccine uptake (Solís Arce et al., 2021).

Regarding the acceptable age for STI vaccine program initiation, 68.5% of respondents indicated that it would be acceptable to first offer STI vaccines during adolescence (defined as 13–19 years old). Across Canada, publicly funded, universal school-based immunization programs have been a successful platform for administering vaccines to prevent HPV for those 9–13 years of age and hepatitis B for those who did not receive the vaccine in infancy (Ogilvie et al., 2010). Existing literature supports STI vaccination in early adolescence, as STI vaccine programs would be most effective if started before sexual debut (Shannon & Klausner, 2018). Further research is needed to assess parental intentions to vaccinate their adolescent children against bacterial STIs. Factors associated with HPV vaccine acceptance by parents of adolescents include having a strong healthcare provider recommendation of the vaccine, recommending vaccination concurrently with other adolescent vaccines, addressing the benefits of vaccination, and use of a positive tone during discussion (Butterfield & Dhanani, 2021).

Most respondents indicated that they were either not sure (45.1%) or would not be willing (19.1%) to pay for an STI vaccine. Cost is an important barrier to vaccination, and uptake of HPV vaccination in Canada is significantly higher for publicly funded programs than when out-of-pocket expenditures are required (Bird et al., 2017). Vaccines that require multiple doses or boosters will also have greater financial implications for immunization program implementation and

public acceptance of out-of-pocket costs (Plotnikoff et al., 2020). The most frequently reported primary barrier to receiving an STI vaccine was ability to pay if a high cost was associated with receiving a vaccine (20.2%). However, 44.4% of those participants who were willing to pay out of pocket for an STI vaccine indicated that they would pay more than \$100 CAD. Prior research conducted among STI clinic patients also found that willingness to pay was a significant factor associated with syphilis vaccine interest (Plotnikoff et al., 2020).

Intent to engage in future positive health behaviours was identified as an important factor associated with STI vaccine interest for all three bacterial STIs, which is similar to findings from an STI clinic attendee population (Plotnikoff et al., 2020). While this suggests that those who already engage in positive health behaviours would also be more interested in STI vaccines, components of this variable, including continued condom use and STI screening after vaccination, may be modifiable by school-based educational public health interventions that encourage positive health behaviours following vaccination. Furthermore, evidence suggests that gender-specific prevention strategies may be important for effective public health campaigns beyond promoting STI knowledge to influence risk perceptions among those who are sexually active (Leval et al., 2011). Young women who have ever engaged in sexual intercourse expressed greater interest in receiving a future STI vaccine. This could be explained by a higher perceived risk of acquiring an STI, given that early sexual initiation is associated with increased STIs among adolescents (Epstein et al., 2014).

Barriers and facilitators to vaccination have important programming implications for STI vaccine dissemination and policy, specifically with regard to addressing potential vaccine hesitancy. The WHO has named vaccine hesitancy as one of the top ten threats to global health, and individuals may be more susceptible to anti-vaccine messaging

Table 2 Unadjusted and adjusted ORs for factors associated with STI vaccine interest

	Syphilis			Chlamydia			Gonorrhea					
	Unadjusted	Adjusted†		Unadjusted	Adjusted†		Unadjusted	Adjusted†				
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)			
Age (continuous)	1.07 (0.95–1.20)	0.27	0.97 (0.86–1.11)	0.67	1.06 (0.94–1.19)	0.36	0.95 (0.83–1.08)	0.44	1.12 (0.99–1.26)	0.06	1.01 (0.89–1.15)	0.87
Sexual orientation (Heterosexual: Ref)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
LGBTQ	1.57 (1.11–2.24)	0.01*	1.58 (1.03–2.47)	0.03*	1.72 (1.19–2.52)	0.004*	1.72 (1.16–2.59)	0.008*	1.76 (1.24–2.54)	0.002*	1.76 (1.20–2.62)	0.005*
Other	1.38 (0.66–3.24)	0.42	1.39 (0.63–3.40)	0.44	1.05 (0.52–2.38)	0.89	1.09 (0.51–2.56)	0.83	1.21 (0.59–2.72)	0.63	1.26 (0.59–2.98)	0.57
Intent to engage in future positive health behaviours	6.45 (4.61–9.06)	0.00**	5.76 (4.03–8.27)	0.00**	5.88 (4.18–8.28)	0.00**	5.27 (3.66–7.63)	0.00**	6.50 (4.64–9.14)	0.00**	5.96 (4.15–8.60)	0.00**
Currently immunosuppressed	0.69 (0.46–1.06)	0.08	0.74 (0.47–1.19)	0.21	0.76 (0.49–1.19)	0.22	0.82 (0.51–1.35)	0.42	0.87 (0.57–1.37)	0.54	0.98 (0.61–1.62)	0.93
Ever had sexual intercourse	1.51 (1.11–2.04)	0.008*	1.86 (1.32–2.61)	0.0004*	1.76 (1.29–2.4)	0.00**	2.21 (1.56–3.15)	0.00**	1.80 (1.33–2.42)	0.0001**	2.25 (1.60–3.17)	0.00**
Willingness to pay out of pocket (not willing to pay: Ref)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Willing to pay	3.51 (2.32–5.36)	0.00**	2.02 (1.29–3.19)	0.002*	4.06 (2.62–6.36)	0.00**	2.41 (1.50–3.90)	0.0003**	3.94 (2.60–6.05)	0.00**	2.29 (1.44–3.63)	0.0004**
Not sure	1.52 (1.06–2.16)	0.02*	1.22 (0.83–1.79)	0.31	1.55 (1.08–2.23)	0.02*	1.27 (0.86–1.88)	0.22	1.58 (1.11–2.25)	0.01*	1.30 (0.88–1.91)	0.18

Bold indicates statistical significance

*Significant at $p \leq 0.05$;

**Significant at $p \leq 0.001$

†Adjusted for all other variables listed

due to fear or lack of knowledge regarding vaccines (WHO, 2019). Addressing vaccine hesitancy requires ongoing strategies that proactively seek to understand and address underlying concerns and preferences, rather than a responsive or reactive approach (Dubé et al., 2016). The second most frequently reported barrier to receiving an STI vaccine was concern regarding potential unknown long-term side effects (50.9%). Potential unknown long-term side effects continue to be an important perceived barrier to HPV vaccination campaigns, despite extensive clinical evidence supporting their safety and efficacy (Garland et al., 2016). Given the high proportion of young women who indicated concerns related to potential unknown long-term sequelae, effective communication on vaccine safety and efficacy must be prioritized in future bacterial STI vaccination campaigns. Evidence-based communication campaigns, discussions with trusted medical providers, and leveraging social norms in support of vaccination may mitigate vaccine hesitancy (Chevallier et al., 2021).

Healthcare professionals (HCPs) are integral to the successful implementation of vaccine programs. Nearly half (43.1%) of respondents indicated that they would prefer in-person conversations with a HCP (physician, nurse, or public health nurse) at a clinic as their primary source of information regarding STI vaccines. Research conducted among Canadian parents indicate that recommendations in favour of HPV vaccination from HCPs, and by a physician in particular, were an important predictor of parental intention to have their daughters vaccinated against HPV (Ogilvie et al., 2007). The importance of the HCPs was also indicated by participant preferences for vaccine administration location, with 70.2% of respondents indicating that they would prefer to be vaccinated in a clinical setting (private doctor's clinic, 41.0%; walk-in clinic, 19.0%; STI clinic, 11.4%).

Limitations

All participants in the QUEST cohort have received the HPV vaccine, and the high proportion of observed STI vaccine acceptance may have limited external validity as participants are enrolled in a vaccine study and have demonstrated a willingness to receive a prior STI vaccine. Participants enrolled and retained in the QUEST cohort are highly engaged and research-minded, and may be of higher socioeconomic status or more informed regarding STI vaccines than the general Canadian population. While our findings are not intended to be generalizable to the broader population, the QUEST cohort represents a critical segment of the population, young adolescent women, for whom future bacterial STI vaccine would be targeted. When bacterial STI vaccines become available, targeted vaccination programs will require insights on preferences and acceptability among young women to maximize the benefits of STI vaccination, including those who have already

received vaccines for other viral STIs. Caution may be required when interpreting 68.5% of respondents recommending the age of first offering STI vaccines during adolescence (13–19 years), as study participants are older adolescents and young adults (16.9–23.4 years) who have already received a vaccine for STI prevention and may have a different perspective on the utility of a vaccine than an adolescent vaccine recipient or the parent of same.

Approximately one third of the returned surveys were missing data on key variables. Missing data may lead to non-response bias, which can distort findings. However, there were no significant differences in the demographic distributions of participants who had missing data on interest in STI vaccines and those who responded to the survey. As there were <15% of missing responses to each of the main outcome variables or covariates of interest, a complete case analysis was conducted.

Conclusion

To our knowledge, this is the first study to investigate perceptions about bacterial STI vaccines among young women in Canada. Results from this study indicate that most young Canadian women previously vaccinated against HPV would be accepting of future STI vaccines. As vaccine candidates for bacterial STIs enter phase I clinical trials, the programmatic and STI vaccine acceptability considerations addressed in this study may act in parallel with advancing research and development to identify and implement effective vaccines for bacterial STIs. Our findings will be valuable to vaccine program planning for Canadian youth with respect to cost, preferred location of STI vaccine administration, preferred sources of information, and barriers and facilitators to future STI vaccine uptake. Minimizing or eliminating out-of-pocket expenditures associated with vaccination and prioritizing in-person conversations with HCPs to provide evidence-based vaccine information will be important aspects of future STI vaccine program implementation. Health policymakers and practitioners should ensure that planning for eventual bacterial STI vaccine program implementation addresses these factors to ensure optimal uptake.

Contributions to knowledge

What does this study add to existing knowledge?

- Vaccines for bacterial STIs are currently in development and present an important opportunity for primary prevention in the context of increasing STI rates globally. To our knowledge, this is the first study to assess acceptability, perceived barriers, and attitudes towards future bacterial STI vaccines among young Canadian women.

- In total, 82% of young HPV-vaccinated Canadian women surveyed agreed or strongly agreed they would be interested in receiving a vaccine to prevent syphilis, chlamydia, and/or gonorrhea.

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

- Factors associated with interest in bacterial STI vaccines are consistent with findings from research conducted among STI clinic attendees in Vancouver, suggesting that an important potential barrier to vaccine acceptance is cost associated with bacterial STI vaccines if not publicly funded. The second most frequently reported barrier to vaccine acceptance (50.9%) was potential unknown long-term side effects.
- STI vaccine programming results, including preferred location, information sources, and cost, will be informative to planning for implementation of future bacterial STI vaccine programs. The main preferred source for STI vaccine information was in-person conversations with a physician or nurse (43.1%), and most participants would prefer to receive vaccination for an STI in a clinical setting (70.2%).

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.17269/s41997-022-00648-2>.

Author contributions GSO conceived the project. KP, GSO, LS, and TG created the survey. ADW analyzed data and drafted the manuscript. CSR and RD contributed to analysis and data interpretation. All the authors reviewed, revised, and approved the manuscript.

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Data availability Data are available upon reasonable request.

Code availability Code is available upon reasonable request (R Version 4.0.3).

Declarations

Ethics approval Ethics approval was obtained from the UBC Children's and Women's Research Ethics Board (H12-01246).

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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