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Research Article

The COVID-19 Pandemic Negatively Impacted Vaccine Attitudes within University of Saskatchewan Students

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Abstract

While vaccines play a critical role in minimizing the impact of infectious diseases, their utility is negatively impacted by vaccine hesitancy. The COVID-19 pandemic brought infectious diseases and vaccines to the forefront of public attention, and likely impacted how vaccines are perceived. We performed a repeated cross-sectional study to quantify opinions on various aspects of vaccine attitudes, based on the 5C Psychological Construct model, within students at the University of Saskatchewan. These surveys, conducted over three time periods: pre-COVID-19 (November to December 2019; N=389), epidemic COVID-19 (January to April 2020; N=257), and pandemic COVID-19 (November to December 2021; N=396), allowed us to examine the extent to which, and the sub-populations in which, vaccine attitudes changed due to pandemic experience. Within our subject group, the course of the COVID-19 pandemic was associated with an overall negative shift in vaccine attitudes for the confidence and constraints constructs with negative changes in participant vaccine trust, efficacy, knowledge, trust in media presentation, and health benefits. The highest rates of vaccine hesitancy, and most dramatic shifts in vaccine attitudes, were identified in participants self-identifying as male and unvaccinated for COVID-19. This study describes negative alterations in vaccine attitudes within individuals experiencing the COVID-19 pandemic and highlights the need for enhanced vaccine education and improved vaccine rollout protocols to restore more positive vaccine opinions and increase vaccine compliance.

Keywords: COVID-19; Pandemic; Vaccine; Immunology; WHO

Introduction

Vaccine hesitancy, the delay or refusal of accessible vaccination, has persisted to varying degrees and consequences over the history of vaccines [1,2]. This impacts the susceptibility of unvaccinated individuals, but also that of the population by compromising herd immunity [3]. Just prior to COVID-19, the World Health Organization listed vaccine hesitancy in the top ten threats to human health. Vaccine hesitancy can be understood following the 5C Psychological Construct model, which proposes confidence, complacency, constraints, calculation, and collective responsibility as psychological antecedents to vaccination [4]. Confidence is trust in vaccine efficacy and safety, while complacency considers perceptions of disease threat and vaccine necessity.

Constraints are barriers to vaccination, including availability and financial restraints. Calculation is information seeking and lastly, collective responsibility is the willingness to protect others through contribution to herd immunity. Vaccine hesitancy correlates with low perceived vaccine efficacy, limited education, financial instability, marginalized groups, and conspiracy suspicions and is more prevalent within females, minority groups, and those with high social media reliance [5,6]. Individuals with strong religious beliefs also demonstrate increased vaccine hesitancy [7]. Occupation and education interact with vaccine opinions whereby healthcare workers and students who demonstrate more vaccine compliant actions [8].

While vaccine hesitancy has been omnipresent, specific events impact the extents and specifics of these beliefs with corresponding consequences to public health [2]. The emergence of COVID-19 in late 2019 is a defining event in human infectious disease history. Caused by the SARS-CoV-2 virus which rapidly reached pandemic status by March 2020 causing, as of November 2023, nearly 800 million infections and 7 million deaths (https://covid19.who.int/). While several effective vaccines received emergency approval shortly after the declaration of the pandemic, the resistance of some to receive these vaccinations resulted in increasingly stringent mandates, including in Canada, that limited employment, travel, education, and other opportunities.

The extent to which COVID-19 has contributed to vaccine hesitant attitudes is contested [9-12]. Interpretation of these studies is challenged by the absence of data representing the pre-pandemic opinions, they are limited to post-hoc analysis rather than direct assessment of how vaccine attitudes shifted due to pandemic experiences. Serendipitously, we initiated a survey of vaccine opinions in the months preceding emergence of SARS-CoV-2 (November to December 2019) as well as the months corresponding to the epidemic phase (January to March 2020). Recognizing the value of these data, the survey was repeated during the pandemic phase (November to December 2021). University students represent a priority population at increased risk of exposure due to living in confined university residences and having wide social networks [13,14].

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With a baseline dataset of vaccination attitudes collected from USask students immediately prior to emergence of SARS-CoV-2, the present study addressed whether COVID-19 experiences in the epidemic and pandemic phases impacted vaccine beliefs. The study also examined if sex, religious affiliation, or vaccination status correlated with changes in vaccine beliefs.

Materials and Methods

Participants

Subjects were recruited through USask's personalized web environment, PAWS. The study procedure consisted of providing potential participants with a letter of invitation, written consent form, and vaccine and demographic questionnaires concerning self-reported trust in vaccines, perceived efficacy, religious and cultural views towards vaccines, vaccine accessibility, general vaccine knowledge. The first survey, distributed from November 27th to December 31st 2019, resulting in 389 respondents (pre-COVID-19 dataset) and again from January 1st to April 30th 2020 for another 257 completed responses (epidemic phase). The last data collection period for the second survey ran from November 24th to December 31st 2021 (pandemic phase) generated 396 completed responses. The demographics for each dataset may be found below (Table 1).

Table 1: Demographic composition of the pre-, epidemic, and pandemic COVID-19 datasets.

	Pre-COVID-19	Epidemic COVID-19	Pandemic COVID-19
Age (Years)			
Mean	22.46	22.77	22.65
Range	17 - 49	18 - 60	17 - 74
Sex (%)			
Male	25.91	25.39	31.39
Female	72.02	74.22	63.8
Other	2.07	0.39	4.81
Education (%)			
1st Year Undergraduate	21.09	31.91	19.29
2nd Year Undergraduate	31.77	22.96	34.77
3rd Year Undergraduate	23.96	19.07	17.26
4th Year Undergraduate	14.32	15.18	18.27
5th Year Undergraduate	3.91	4.67	3.81
Postgraduate +	3.39	5.45	5.33
Other	1.56	0.78	1.27
Religious Affiliation (%)			
Non-religious	49.61	44.14	48.72
Christian	37.66	41.8	33.16
Judaism	0.52	0.39	0.26
Hinduism	0.78	0.39	1.28
Buddhism	0.52	0	1.02
Islam	2.6	5.08	2.81
Sikhism	0.52	0.39	0.77
Other	7.79	7.81	11.99

Age (in years) was provided by participants to create a mean (average) age and age range (youngest and oldest participants). Remaining data are shown as weighted column percentage. Participants selected either male, female, or other for their sex, and either 1st, 2nd, 3rd, 4th, or 5th year of an Undergraduate Degree, a Postgraduate degree, or other for education level. Participants selected religion, if any, from a provided list.

Measures

The study procedure consisted of providing potential participants with a letter of invitation, consent form, and vaccine and demographic questionnaires concerning self-reported trust in vaccines, perceived efficacy, religious and cultural views towards vaccines, vaccine accessibility, general vaccine knowledge. Datasets were collected through SurveyMonkey (https://www.surveymonkey.com). Copies of the surveys and demographic questions can be found within the supplementary material. The survey consisted of multiple choice, multiple select, 5- point Likert Scales, and an open-ended question. The demographic questionnaire queried academic program, religion, age, sex, and immunization status. After completing or withdrawing from the study, participants were directed to the debriefing form.

Statistical analyses

Data analysis and visualization was performed on IBM SPSS Statistics 29 (Armonk, NY: IBM Corp; 2017), GraphPad Prism 9.3.1 (GraphPad Software, Inc., USA), and SurveyMonkey. Four independent reviewers sorted survey questions into the 5C Psychological Construct categories. Survey questions were included in one-way ANOVA analysis if with unanimous agreement on the appropriate placement within the 5C Psychological Construct. Cronbach's alpha was conducted for each construct category. Only the Confidence and Constraints categories with $\alpha>0.75$ (based on DeVellis' Scale Development [15] were analyzed by ANOVA and Tukey's multiple comparisons test (Table 2). Responses (1="strongly agree" to 5="strongly disagree") to the included survey questions were used to calculate a mean for each participant. Mean imputation was used to fill in blank responses. The confidence construct questions were positively coded where a low mean score, consisting of more "strongly agree" and "agree" responses, would suggest increased vaccine confidence. The constraints construct questions were negatively coded where a low mean score, consisting of "strongly agree" and "agree" responses, would show decreased vaccine compliance due to constraints. Secondary analyses involved a series of chi-square tests of homogeneity at a 95% confidence level to determine differences in the proportions of the grouped responses, "agree," "neither agree nor disagree," and "disagree" between the three data subsets. If the chi-square test result was significant (χ^2 or $p<0.05$), another chi-square analysis searched for differences in proportions for all five options within the 5-point Likert scale. Three chi-square analysis tests were then performed for each question to identify between which exact data subsets the differences were located. Crosstabulation was then used to compare several variables at once for a deeper understanding of categorical relationships. Subsequently, chi-square analysis was performed again based on the crosstabulation output tables to identify which demographics had more extreme shifts in vaccine attitudes. Lastly, descriptive statistics provided by the survey software were calculated individually for every survey item.

Results

Opinions within time periods

Vaccine attitudes were generally positive within each period with the majority of respondents agreeing that "vaccines are safe and efficacious", "vaccines are important" and "it is dangerous to not vaccinate" (Table 3). On concerns surrounding side effects included allergic reactions and injection site pain followed by muscle and joint pain, swelling, headaches, and a small percentage believing vaccines may cause the disease they are intended to protect against.

Participants accessed information through a similar assortment of sources including government sources (like Health Canada), Health Care professionals (doctors, pharmacists and nurses), friends and family, the internet (both searches and social media), as well as traditional news. Most participants were up to date on their vaccinations. Safety concerns, lack of trust with the government and

Table 2: Psychological Construct Categories.

	Confidence	Constraints	Complacency	Calculation	Collective Responsibility
Survey Items					
1	In general, I trust vaccines.	My religion disagrees with vaccines.	No questions were agreed upon	What are the most important factors you consider when making decisions about vaccines?	I understand what herd immunity is.
2	In general, vaccines are safe.	My culture disagrees with vaccines.		Which vaccines do you think are necessary?	Herd immunity is at risk in Canada.
3	Vaccines protect against infectious diseases.	My personal beliefs disagree with vaccines.		In your opinion, who do you think benefits the most from vaccines?	
4	It is important to follow the recommended vaccine schedule.	I am unsure about my beliefs towards vaccines.		We are vaccinating for too many things.	
5	I trust the companies that manufacture vaccines.			The risks of vaccines outweigh the benefits.	
6	I trust the doctors who recommend				
Cronbach's α (All Time Periods)					
α	0.89	0.78	N/A	0.46	0.45
95% CI	.88 to .90	.76 to .80		.39 to .52	.37 to .51

Four independent reviewers assigned every survey item to the most suitable 5C Psychological Construct Category – category definitions are described in the Introduction. Cronbach's alpha (α) was calculated to assess consistency for survey items with unanimous agreement; CI: Confidence Interval.

manufacturing companies, lack of personal choice, concerns over safety and questions over who benefitted most from vaccines, all contributed to a shift in increasing vaccine hesitancy as the pandemic progressed.

Trends for vaccine opinions

Differences in confidence and constraints categories were identified between the three periods (Table 4). specifically, between the pre- and pandemic COVID-19 and the epidemic and pandemic COVID-19 periods, but not between pre- and epidemic COVID-19 (Table 5). In particular, pandemic COVID-19 responses showed decreased vaccine confidence and increased role of constraints on declining vaccine attitudes.

Vaccine knowledge changed between the three survey periods. Less people believed that children (10.5% pre-COVID-19, 2.8% pandemic) and everybody (84.8% pre-COVID-19, 78.3% pandemic data) benefit the most from vaccines with more people believing vaccine companies (3.1% pre-COVID-19, 13.1% pandemic data) benefit the most. In addition, a higher proportion of participants in the pandemic COVID-19 dataset responded that "vaccines have serious negative side effects" in comparison to the pre- and epidemic COVID-19 datasets (χ^2 (4)=119.90, p<0.001) (Figure 1). During the pandemic phase, more respondents agreed with the statement "society has been vaccinating for too many things", and while the majority of participants agreed it was "dangerous to not vaccinate" in pre- (89.5%) and epidemic (91.8%) COVID-19, only 78.5% of participants agreed with the statement in the pandemic COVID-19 dataset (χ^2 (4)=25.91, p<0.001) (Figure 2). More pandemic COVID-19 respondents (84.1%) reported they were "well informed about vaccines" relative to pre-COVID-19 (76.0%) and epidemic COVID-19 phases (79.8%) (χ^2 (4)=26.89, p<0.001), and less respondents agreed that "more information on vaccines should be available" (χ^2 (4)=17.13, p=0.002). Within the pandemic dataset, more respondents agreed they understood herd immunity (χ^2 (4)=21.51, p<0.001), and significantly less people believed that herd immunity is at risk in comparison to the pre-COVID-19 cohort (χ^2 (4)=45.19, p<0.001). These knowledge differences may have influenced media perceptions as more pre-COVID-19 and epidemic phase respondents

Table 3: Vaccine opinions within pre-, epidemic, and pandemic COVID-19 time periods.

	Pre-COVID-19	Epidemic COVID-19	Pandemic COVID-19
Vaccine Confidence			
Vaccines are Safe	96.9	97.3	92.4
Trust Vaccines	96.7	97.7	91.7
Vaccines are Efficacious	97.9	97.7	94.2
Vaccines are Important	96.9	98.05	93.9
Dangerous not to Vaccine	89.5	91.8	78.5
Who Benefits the Most from Vaccines			
Everyone	83	87.6	78.3
Children	11.8	8.6	2.8
Vaccine Companies	3.9	2	13.3
Sources of COVID-19 Vaccine Concerns			
Lack of Trust in Government	N/A	N/A	8.1
Lack of Trust in Vaccine Manufacturers	N/A	N/A	7.6
Lack of Personal Choice	N/A	N/A	6.6
Side Effects			
Allergic reactions	81.9	81.6	75.8
Injection Site Pain	82.7	78.2	72.5
Muscle and Joint Aches	66.1	60.3	68.9
Headaches	40.1	40.6	60.4
Swelling	47.2	41.5	52
Cause Disease	13.3	10.7	13.6
Sources of Information			
Doctors	84.8	87.2	76
Government	72.9	76.3	87.1
School	68.3	71.2	55.6
Pharmacists	N/A	N/A	53
Nurses	N/A	N/A	48.2
Family	41.8	47.9	45
Friends	27.6	28.4	33.6
Internet	35.3	46.3	48.5
News	25.2	34.6	45
Social media	17.3	23.7	28.3

Data are shown as weighted column percentage, rounded to one decimal place. "N/A" for answers that were not available on the Pre- and Epidemic COVID-19 surveys.

Table 4: ANOVA test results for Confidence and Constraints for the pre, epidemic, and pandemic COVID-19 time periods.

Construct	Time Period	Mean	SD	SS	DF	MS	*F*	*p*
Confidence	**Pre-COVID-19**	9.27	3.39					
	Epidemic COVID-19	9.17	3.29					
	Pandemic COVID-19	10.14	4.67					
	Treatment (between columns)			205.4	2	102.7	F (2, 1029)=6.73	0.0012*
Constraints	**Pre-COVID-19**	18.61	2.07					
	Epidemic COVID-19	18.58	2.18					
	Pandemic COVID-19	17.78	3.14					
	Treatment (between columns)			166	2	82.99	F (2, 1038)=12.73	<0.0001*
		Significant differences identified between the three time period datasets for both the confidence and constraints construct categories						

Individual means were created for each participant's responses to the Confidence and Constraints survey items (1="strongly agree" to 5="strongly disagree"). Mean imputation filled in blank responses. Next, a mean score from all participant data was calculated for the Confidence and Constraints categories for the pre-, epidemic, and pandemic COVID-19 time periods. The confidence construct questions were positively coded where a low mean score consisted of more "strongly agree" and "agree" responses. The constraints construct questions were negatively coded where a low mean score consisted of "strongly agree" and "agree" responses. Source, between columns; SD: Standard Deviation; SS: Sum of Squares; DF: Degrees of Freedom; MS: Mean Square; F: F statistic; p: p-value.

Table 5: Tukey's Multiple Comparisons Test Results for Confidence and Constraints Psychological Constructs data between the pre-, epidemic, and pandemic COVID-19 time periods.

Construct	Time Period	Mean Diff.	95% CI of Diff.	Adjusted *p* Value
Confidence	Pre- *vs.* Epidemic COVID-19	0.11	-0.63 to .84	.94
	Pre- *vs.* Pandemic COVID-19	-0.87	-1.52 to -0.21	.0053*
	Epidemic *vs.* Pandemic COVID-19	-0.97	-1.71 to -0.24	.0054*
Constraints	Pre- *vs.* Epidemic COVID-19	0.03	-0.45 to .51	.99
	Pre- *vs.* Pandemic COVID-19	0.83	.41 to 1.26	<.0001*
	Epidemic *vs.* Pandemic COVID-19	0.81	.33 to 1.29	.0003*

Mean Diff.: Mean Difference; 95% CI of Diff.: 95% Confidence Interval of the Difference

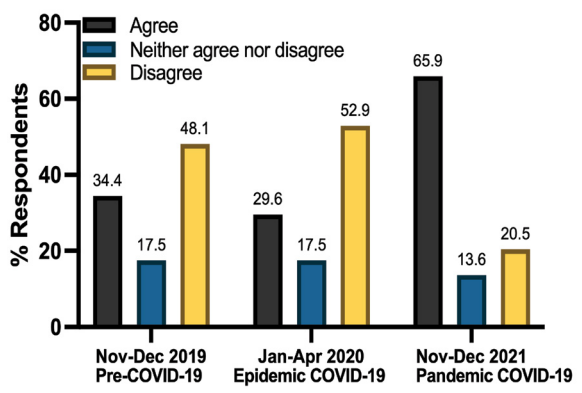

Figure 1: Vaccines and Negative Side Effects. Percentage of respondents is shown for the survey item, "In general, vaccines have serious negative side effects" for all three time periods (Pre-, Epidemic, or Pandemic COVID-19). The survey item consisted of a 5-point response scale and the data were converted to a 3-point scale for statistical analysis by consolidating responses in the two scales at each pole. Chi-squared test identified a significant difference between the first two time periods (Pre- and Epidemic COVID-19) and Pandemic COVID-19 responses (χ2 (4)=119.90, p<0.001).

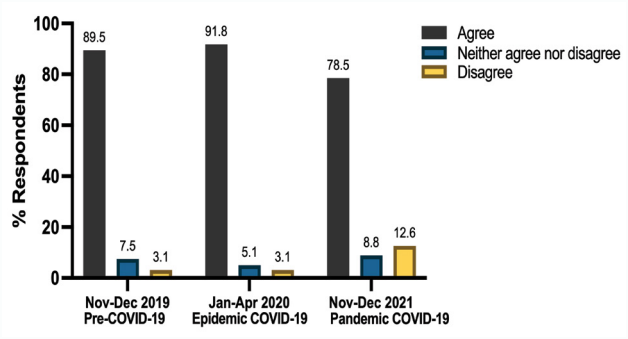

Figure 2: Vaccine Knowledge: Dangerous to Not Vaccinate. Percentage of respondents for the survey item, "It is dangerous to not vaccinate" is shown for all three time periods (Pre-, Epidemic, or Pandemic COVID-19). The survey item consisted of a 5-point response scale and the data was converted to a 3-point scale for statistical analysis by combining the responses in the two scales at each pole. Chi-squared test identified a significant difference between the first two time periods (Pre- and Epidemic COVID-19) and Pandemic COVID-19 responses (χ2 (4)=25.91, p<0.001).

agreed "the media exaggerates the risk of vaccines" than pandemic respondents (χ^2 (4)=31.53, p <0.001 (Figure 3). A greater number of respondents in the pandemic phase (38.6%) agreed that "vaccines do not prevent the disease they are intended to" compared to the pre- (16.2%) and epidemic (13.2%) phases suggesting greater concerns with vaccine efficacy (χ^2 (4)=77.61, p<0.001). This opinion might reflect the mistaken impression that COVID-19 provides sterilizing immunity rather than the reality of minimizing disease severity. Within these responses there is also evidence of polarization of vaccine beliefs within the pandemic phase with significantly less respondents selected the neutral option and more selected agree or disagree, relative to baseline respondents (χ^2 (4)=77.61, p<0.001) (Figure 4).

Sub-group analysis

Sex, religious affiliation, and vaccination status had significant impact on vaccine attitudes (Table 6). In the pandemic dataset, relative to the pre and epidemic phases, Males demonstrated more vaccine hesitant attitudes and a greater shift in vaccine attitudes with significant declines in general trust in vaccines (p<0.001); belief that vaccines are safe (p<0.001) and prevent disease (p<0.001) as well as a decline in trust in the media regarding threats of infectious disease (p<0.05). In contrast, among female respondents, the only significant difference (p<0.05) within that time point comparison

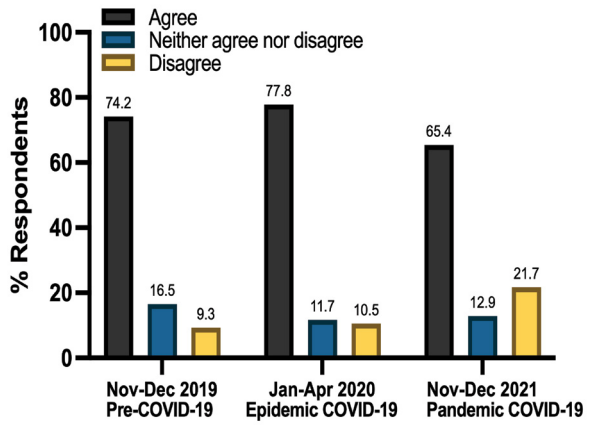

Figure 3: Media Perceptions Risk Portrayal of Vaccines. Percentage of respondents for the survey item, "the media exaggerates the risk of vaccines" are shown for all three time periods (Pre-, Epidemic, or Pandemic COVID-19). The survey item consisted of a 5-point response scale and the data was converted to a 3-point scale for statistical analysis by combining the responses in the two scales at each pole. Chi-squared test identified a significant difference between the first two time periods (Pre- and Epidemic COVID-19) and Pandemic COVID-19 responses ($\chi 2$ (4)=31.53, p<0.001).

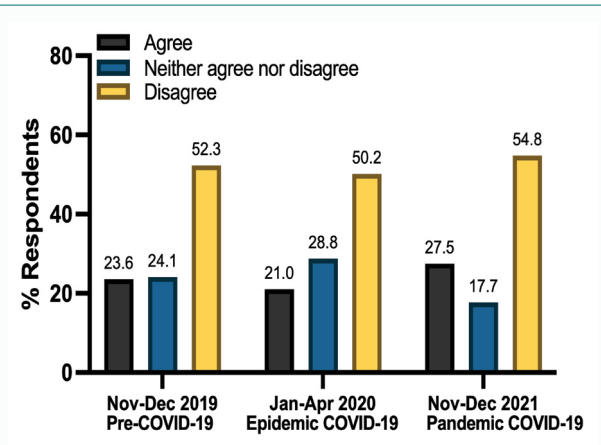

Figure 4: Concerns Vaccines Don't Prevent Disease. Percentage of respondents for the survey item, "I am concerned that the vaccine may not prevent the disease" are presented on the 3-point Likert scale for all three time periods (Pre-, Epidemic, or Pandemic COVID-19). Chi-squared test identified a significant difference between the first two time periods (Pre- and Epidemic COVID-19) and Pandemic COVID-19 responses ($\chi 2$ (4)=77.61, p<0.001).

was to the question of whether vaccines prevent disease, which, is an accurate reflection of the emerging data that the COVID vaccines served primarily to minimize disease severity rather than prevent infection (Table 6). While there were no differences in COVID-19 vaccination rates between males and females; however, this may not reflect vaccine with regards to religious affiliation, the sample size was only sufficient to analyze Christianity and non-religious groups with Christians holding more vaccine hesitant views for the survey items (A) "In general, I trust vaccines", and (B) "In general, Vaccines are safe" (Figure 5). There were also significant differences in vaccine opinions between those who reported being vaccinated for COVID-19 (91.9%) and those who remained unvaccinated (8.1%), although these results must be viewed cautiously due to limited sample size of unvaccinated participants.

Interestingly, regardless of COVID-19 vaccination status, participants agreed they were "well informed about vaccines." 91.4% of participants agreed they understood herd immunity, 52.0% believed that "herd immunity is at risk in Canada," and only 76.8% of the pandemic participants felt the COVID-19 vaccine was a societal responsibility. Among individuals unvaccinated for COVID-19, none felt vaccination was a societal responsibility in comparison to 85.2% of vaccinated individuals.

Discussion

This study analyzed vaccine attitudes within the USask student population. This study is unique in that opinions were collected at multiple time points to analyze belief shifts beyond vaccination intentions. This study compared how the experience of a pandemic, in which vaccines were paramount in overcoming the disease threat, impacted vaccine beliefs. Although the same participants were not tracked across the three periods, the survey was distributed through identical methods to achieve comparable representative samples. The pre-COVID-19 sample population demonstrated positive vaccine attitudes towards trust, safety, efficacy, and necessity. These beliefs were largely maintained within the epidemic phase of COVID-19. Within the pandemic sample population, vaccine hesitancy remained generally low with high rates of trust, safety, and perceived efficacy, although to a lower confidence level. Within that, there was a decrease in vaccine confidence, and a negative shift in attitudes regarding trust, perceived efficacy, knowledge, and media trust. This is congruent with other groups [9-11,16] who also found decreased vaccine receptivity and intentions throughout COVID-19. In contrast, this finding contradicts the results Gursoy et al. [17] which observed no changes in vaccine attitudes, and Siegler et al. [12] who found a decline in vaccine hesitancy. Our findings can best be understood with reference to the 5C Psychological Construct model which proposes confidence, complacency, constraints, calculation, and collective responsibility as the psychological antecedents to vaccination.

Confidence

In the pandemic phase, most respondents trusted vaccines, but more than double the number of respondents reporting distrust with vaccination in comparison to pre-COVID-19. The study noted similar findings for perceived vaccine safety. Participants within the pandemic dataset also demonstrate greater concern surrounding vaccine side effects and vaccine efficacy, which could contribute to vaccine hesitancy [18,19]. Participant concern that "vaccines may not prevent the disease intended" demonstrates the public's expectation to achieve sterilizing immunity to prevent infection underscoring the need for better education on the role of vaccines in mitigating disease.

Complacency

Although our results do not directly analyze complacency shifts, the pandemic sample population showed more participants perceive lower risks of contracting vaccine preventable diseases. Muhajarine et al. [5] report strong connections between low complacency and vaccination, and the results of this project show the media's role in complacency through perceived vaccine and disease threat. Remarkably less people in the pandemic dataset felt the media exaggerated the risks associated with vaccines in comparison to the pre- and epidemic phase datasets, which suggests that people are more aware of vaccine risks. Also, more pandemic respondents felt the media exaggerated the risk of COVID-19, which implies

Table 6: Sex, Religious Affiliation, and Vaccination Status Impact on Vaccine Attitudes throughout COVID-19 Pandemic.

Subgroup Analysis	Time Period		In generaI, I trust vaccines (% strongly agree, χ2)	In general, vaccines are safe (% strongly agree)	The media exaggerates the threat of disease outbreaks (% strongly agree)	I am concerned that the vaccine may not prevent the disease (% strongly agree)	Have you been vaccinated for COVID-19? (% agree)	I view vaccines more positively since the COVID-19 pandemic began (% strongly disagree)
Sex	Pandemic COVID-19	Male	58.1	58.1	36.3	12.9	89.5	21
		Female	74.6	68.7	16.7	6.4	93.3	11.1
			p <.05*	p <.05*	p <.05*	p <.05*	p >.05*	p <.05*
	Pre- and Epidemic COVID-19 vs. Pandemic COVID-19	Male	χ^2 (2)=16.96, p < .001*	χ^2 (2)=10.33, p < .001*	χ^2 (2)=6.00, p < .050*	χ^2 (2)=34.55, p < .001*	N/A	N/A
		Female	χ^2 (2)=2.30, *p*=.316	χ^2 (2)=3.44, *p*=.179	χ^{22} (2)=1.92, *p*=.382	χ^2 (2)=38.19, *p* < .001*	N/A	N/A
Religious Affliation	Pandemic COVID-19	Christian	58.5	53.1	33.9	10	86.2	20
		Non-Religious	80.6	77.5	16.2	1.6	97.9	10
			p <.05*	*p* <.05*	*p* <.05*	*p* >.05*	*p* <.05*	*p* <.05*
Vaccination Status	Pandemic COVID-19	Up to Date on Vaccinations	78.7	74	18.5	5	98.4	8.5
		Not up to Date on Vaccinations	34.1	31.8	43.2	29.6	61.4	40.9
			p <.05*	*p* <.05*	*p* <.05*	*p* <.05*	*p* <.05*	*p* <.05*

Impacts of sex, religious affiliation, and vaccination status on responses to survey items, shown as weighted column percentage, rounded to one decimal place. Crosstabulations were used to determine differences in responses between sexes, religious affiliations, and vaccination statuses. Chi-squared tests were performed to determine sex-based differences in survey item responses from pre- and epidemic COVID-19 to pandemic COVID-19 time periods. Survey items consisted of 5-point response scales and the data was converted to 3-point scales for statistical analysis by combining the responses in the two scales at each pole. χ^2: Chi-squared test; p: p-value; N/A: Survey item question or answer not available at that time period.

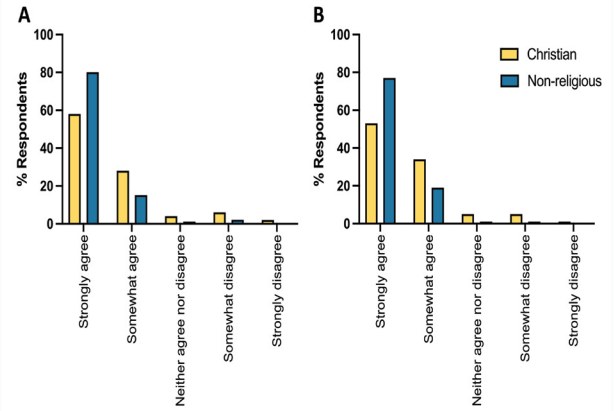

Figure 5: Religious Differences in Vaccine Beliefs. Pandemic COVID-19 dataset responses (shown as percentage of respondents) to the survey items (A) "In general, I trust vaccines," and (B) "In general, vaccines are safe" for participants identifying as non-religious (solid blue bars) or Christian (solid yellow bars). The survey item consisted of a 5-point response scale.

low risk perception that could impact vaccine decision. Individuals reported getting vaccinated to protect themselves and others, to return to normal life, and based on the recommendations of doctors and government policy. While most students also approved of the measures taken by USask and the government, lack of trust with the government and manufacturing companies, lack of personal choice, the speed of vaccine development, and safety concerns were reported.

Constraints

The pandemic dataset presents a larger proportion of participants claiming their religion, culture, and/or personal beliefs disagree with vaccines and impacts vaccine compliance in comparison to the pre- and epidemic phases. Pandemic participants express feeling that vaccine availability during COVID-19 was not an issue, but almost three-quarters of participants felt that more information on vaccines should be available.

Calculation

Although this study could not directly compare changes in calculation, several vaccine attitude changes relating to calculation were highlighted. In comparison to the pre-COVID-19 phase, the pandemic dataset had less participants understand the need to follow vaccine schedules and more participants agreed that society has been vaccinating excessively. Similarly, more respondents in the pandemic dataset no longer felt it was dangerous to forgo vaccination. These findings may originate from the sources used to obtain information; significantly less individuals in the pandemic dataset report relying on doctor recommendations. Individuals in the pandemic dataset also felt more confident in their vaccine knowledge than in the pre-COVID-19 and epidemic phases. This overconfidence in self-knowledge could add barriers to disseminating future vaccine information.

Collective responsibility

Despite the study's limitation in directly measuring collective responsibility changes interesting shifts after experiencing the pandemic are worth noting. Within the pandemic dataset, more participants stated they understood herd immunity; however, less participants believed herd immunity was at risk in Canada and less felt COVID-19 vaccination was a societal responsibility. Herd immunity depends upon collective vaccination so knowledge beliefs that do not value social responsibility are detrimental to vaccine efficacy.

Demographic changes

Within the pandemic phase dataset, sex had the greatest influence over transitioning vaccine attitudes. Males showed increased vaccine

hesitancy in comparison to females. This finding is contradictory to Allington et al. [20] and Muhajarine and team [5] who reported females as more vulnerable to vaccine hesitancy. However, in the university environment, females manifest less vaccine hesitancy relative to males [8]. This suggests that attending university adds another dimension when considering sex-based differences in vaccine hesitancy.

Furthermore, our study uniquely finds that males experience more severe vaccine attitude changes than females. While we did not find sex-based differences in COVID-19 vaccination rates, which is one measure to determine vaccine hesitant attitudes, they still cohered to vaccination behaviours. However, as COVID-19 vaccination was required for students of USask such that absolute vaccine refusal would have excluded them from the study. Most likely, is that a higher percentage of male students were unwilling vaccine recipients.

Lastly, the study highlights the polarization of vaccine beliefs over the pandemic; participants are more likely to agree or disagree with vaccine concepts than to remain neutral. Respondents were also more inclined to "strongly" agree or disagree with vaccine statements than "somewhat" agree or disagree. This confidence could enhance difficulties converting vaccine hesitant opinions.

Limitations

The sample group is not representative, nor is it designed to represent the attitudes of public. University students were prioritized based on unique characteristics of their shared experiences that may influence their risks to infectious diseases as well as their perceptions of vaccines [13,14]. Within this population it is important to note that the mandatory vaccination program implemented at USask may have caused vaccine hesitant students to withdraw from the university. If so, this would suggest that the trends we observed towards greater vaccine hesitancy over the pandemic underestimate increased negative perceptions of vaccines.

Additionally, although the same measures were used to distribute the survey to participants in the pre-, epidemic, and pandemic COVID-19 phases, there were sex differences between the datasets (Table 1). This demographic difference results in increased demonstration of male-centric attitudes and could account for some of the vaccine attitude changes. However, all datasets were collected in attempt to represent the same population and data analysis was completed on three platforms and some methodology was completed after data collection. Some investigations of the impacts of COVID-19 on vaccine opinions have reported distinctions with respect to childhood and seasonal vaccines [21-23], although it is unclear to what extent these changes reflect increased vaccine hesitancy or reluctance and/or difficulties to visit healthcare facilities during the pandemic. Our study was designed to investigate more general beliefs on vaccine safety and efficacy as opposed to opinions of specific vaccines. With that, we are unable to further dissect the basis of the shifts in vaccine opinion or offer informed assessment on how these changes in beliefs may manifest with respect to decisions to receive specific vaccines for themselves or their children. The current cohort of datasets is also unable to offer insight into the extent to which the observed changes in vaccine opinion will persist as we move past the pandemic. Nevertheless, the study captures changes in vaccine opinion within the critical moment in history.

Conclusions and Future Directions

COVID-19 has caused a decrease in vaccine confidence an increase in vaccine hesitant attitudes within the USask population especially in participants self-identifying as male and unvaccinated for COVID-19. Vaccine promotional programs and more effective strategies for vaccine education is critical in ensuring vaccine uptake and protecting public health. Overestimated vaccine knowledge can be a barrier to receiving vaccine information, so creating culturally inclusive promotional programs with easy-to-understand language or making vaccine education more accessible would be beneficial.

References

1. MacDonald NE. Vaccine hesitancy: Definition, scope and determinants. Vaccine. 2015;33(34):4161-4.
2. Poland GA, Jacobson RM. The age-old struggle against the antivaccinationists. N Engl J Med. 2011;364(2):97-9.
3. Olivera Mesa D, Hogan AB, Watson OJ, Charles GD, Hauck K, Ghani AC, et al. Modelling the impact of vaccine hesitancy in prolonging the need for Non-Pharmaceutical Interventions to control the COVID-19 pandemic. Commun Med (Lond). 2022;2:14.
4. Betsch C, Schmid P, Heinemeier D, Korn L, Holtmann C, Bohm R. Beyond confidence: Development of a measure assessing the 5C psychological antecedents of vaccination. PLoS One. 2018;13(12):e0208601.
5. Muhajarine N, Adeyinka DA, McCutcheon J, Green KL, Fahlman M, Kallio N. COVID-19 vaccine hesitancy and refusal and associated factors in an adult population in Saskatchewan, Canada: Evidence from predictive modelling. PLoS One. 2021;16(11):e0259513.
6. Johnson KD, Akingbola O, Anderson J, Hart J, Chapple A, Woods C, et al. Combatting a "Twin-demic": A quantitative assessment of COVID-19 and influenza vaccine hesitancy in primary care patients. Health Promot Perspect. 2021;11(2):179-85.
7. Kibongani Volet A, Scavone C, Catalan-Matamoros D, Capuano A. Vaccine Hesitancy Among Religious Groups: Reasons Underlying This Phenomenon and Communication Strategies to Rebuild Trust. Front Public Health. 2022;10:824560.
8. Tavolacci MP, Dechelotte P, Ladner J. COVID-19 Vaccine Acceptance, Hesitancy, and Resistancy among University Students in France. Vaccines (Basel). 2021;9(6):654.
9. Lin C, Tu P, Beitsch LM. Confidence and Receptivity for COVID-19 Vaccines: A Rapid Systematic Review. Vaccines (Basel). 2020;9(1):16.
10. Fridman A, Gershon R, Gneezy A. COVID-19 and vaccine hesitancy: A longitudinal study. PLoS One. 2021;16(4):e0250123.
11. de Albuquerque Veloso Machado M, Roberts B, Wong BLH, van Kessel R, Mossialos E. The Relationship Between the COVID-19 Pandemic and Vaccine Hesitancy: A Scoping Review of Literature Until August 2021. Front Public Health. 2021;9:747787.
12. Siegler AJ, Luisi N, Hall EW, Bradley H, Sanchez T, Lopman BA, et al. Trajectory of COVID-19 Vaccine Hesitancy Over Time and Association of Initial Vaccine Hesitancy with Subsequent Vaccination. JAMA Netw Open. 2021;4(9):e2126882.
13. Sharma M, Davis RE, Wilkerson AH. COVID-19 Vaccine Acceptance among College Students: A Theory-Based Analysis. Int J Environ Res Public Health. 2021;18(9):4617.
14. Wermers R, Ostroski T, Hagler D. Health care provider use of motivational interviewing to address vaccine hesitancy in college students. J Am Assoc Nurse Pract. 2021;33(1):86-93.
15. DeVellis RF. Scale development: Theory and applications (2nd Ed). Thousand Oaks, CA: Sage Publications; 2003.
16. Wang K, Wong EL, Ho KF, Cheung AW, Yau PS, Dong D, et al. Change of Willingness to Accept COVID-19 Vaccine and Reasons of Vaccine Hesitancy of Working People at Different Waves of Local Epidemic in Hong Kong, China: Repeated Cross-Sectional Surveys. Vaccines (Basel). 2021;9(1):62.
17. Gursoy D, Can AS, Williams N, Ekinci Y. Evolving impacts of COVID-19 vaccination intentions on travel intentions. Serv Ind J. 2021;41(11-12):719-33.
18. Cerda AA, Garcia LY. Hesitation and Refusal Factors in Individuals' Decision-Making Processes Regarding a Coronavirus Disease 2019 Vaccination. Front Public Health.

2021;9:626852.

19. Shen SC, Dubey V. Addressing vaccine hesitancy: Clinical guidance for primary care physicians working with parents. Can Fam Physician. 2019;65(3):175-81.

20. Allington D, McAndrew S, Moxham-Hall V, Duffy B. Coronavirus conspiracy suspicions, general vaccine attitudes, trust and coronavirus information source as predictors of vaccine hesitancy among UK residents during the COVID-19 pandemic. Psychol Med. 2023;53(1):236-47.

21. Kiely M, Mansour T, Brousseau N, Rafferty E, Paudel YR, Sadarangani M, et al. COVID-19 pandemic impact on childhood vaccination coverage in Quebec, Canada. Hum Vaccin Immunother. 2022;18(1):2007707.

22. MacDonald SE, Paudel YR, Kiely M, Rafferty E, Sadarangani M, Robinson JL, et al. Impact of the COVID-19 pandemic on vaccine coverage for early childhood vaccines in Alberta, Canada: a population-based retrospective cohort study. BMJ Open. 2022;12(1):e055968.

23. Kiely M, Tadount F, Lo E, Sadarangani M, Wei SQ, Rafferty E, et al. Sex differences in adverse events following seasonal influenza vaccines: a meta-analysis of randomised controlled trials. J Epidemiol Community Health. 2023;77(12):791-801.