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Perceived threat and coping responses during the COVID-19 pandemic: Prospective associations with vaccine hesitancy

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ABSTRACT

Background: The COVID-19 pandemic has brought to light the importance of identifying factors associated with vaccine hesitancy. Disease threat and coping responses are central to health behavior engagement and present potential alterable targets for intervention.
Purpose: To examine the roles of perceived threat of COVID-19 and coping in vaccine hesitancy, we examined how coping strategies involving approach and avoidance interact with perceived threat of COVID-19 to predict vaccine hesitancy.
Methods: We used data from 1570 North American participants who reported their vaccine hesitancy as part of a longitudinal study assessing psychosocial responses to the pandemic. We used logistic regression models and mean scores of perceived threat of COVID-19, approach coping, and avoidance coping from prior timepoints to predict vaccine hesitancy in December 2020, when COVID-19 vaccines were first being approved for use in North America.
Results: Low perceived threat of COVID-19 was associated with greater likelihood of being vaccine hesitant. However, approach coping moderated this association, such that people who engaged in more approach coping were less likely to be vaccine hesitant even when they did not feel personally threatened by COVID-19. In contrast, avoidance coping was associated with greater likelihood of vaccine hesitancy regardless of perceived threat of COVID-19.
Conclusions: Our results illustrate the contributions of approach and avoidance coping to vaccine hesitancy and in doing so, provide preliminary evidence for coping behavior to serve as a target for intervention to reduce vaccine hesitancy.

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1. Introduction

Vaccination is a cornerstone of public health and has protected countless lives. However, despite widespread agreement among scientists and medical professionals of their importance and general high levels of public uptake, non-vaccination remains a major threat to public health [1,2]. The attitudes and beliefs underlying the continuum of behaviors ranging from the delay of individual vaccines to the outright refusal of all vaccinations are collectively referred to as vaccine hesitancy [3]. Although not a new phenomenon, the COVID-19 pandemic has laid bare the public health impact of vaccine hesitancy and brought to light the importance of identifying associated risk factors. One such risk factor associated with vaccine hesitancy is low perceived threat of illness [1,4,5]. However, it is also crucial to examine the role of coping responses that characterize different ways of interacting with the perceived threat of illness [6,7]. By examining both perceived threat of COVID-19 and coping responses, we can increase understanding of the dynamic interplay of cognitions and behaviors associated with being vaccine hesitant.

Perceived threat of illness is a key contributor to preventive health behavior engagement, including vaccination [1,4,5]. In the case of childhood vaccination, low perceived threat posed by vaccine preventable diseases has long been a contributor to vaccine hesitancy among parents [2,8,9]. In the context of the COVID-19 pandemic, perceived threat posed by the SARS-CoV-2 virus to one's own health and that of loved ones has been associated with increased willingness to be vaccinated [10–15]. This replicates findings from research conducted during prior infectious disease outbreaks such as H1N1, Ebola, and SARS [16–18]. The findings align with prominent models of health behavior such as the health belief model and protection motivation theory which posit that heightened perceived threat of disease generally increases one's willingness to take preventive action [19]. Such models view threat appraisal as it is depicted by the transactional model; specifically,

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as an iterative process, occurring in tandem with how one copes with the perceived threat to influence subsequent behavior [20–22]. As such, coping responses must also be examined when considering the role that threat perception plays in vaccine hesitancy.

In considering the role of coping in health beliefs and behaviors, a dominant paradigm that is often used involves distinguishing between coping responses that involve attending to the threat and those that involve turning one's attention elsewhere [7,23,24]. Referred to as approach and avoidance coping respectively, this categorization aligns with the fundamental motivations theorized to underlie many responses and behaviors [24,25], and has been useful in predicting a wide range of psychological and behavioral outcomes [7,23,24]. Approach coping encompasses a range of responses from information- and help-seeking behaviors to engagement in behaviors that mitigate the impact of the perceived threat. In contrast, avoidant coping involves attempts to forget about a given threat or deny its existence. While no coping strategy is inherently adaptive or maladaptive, approach coping has often been associated with greater psychological adjustment and better health outcomes, particularly when a threat is prolonged [7,24,26]. Avoidance coping can be adaptive in the short-term and temporarily reduce distress, however, in the long term, such strategies are often associated with more negative health outcomes and decreased engagement in health behaviors [7,24,27–29].

When a threat is prolonged, as is the case of disease threat during a pandemic, avoidant strategies may be maladaptive and inhibit engagement in preventive action. Supporting this is evidence from research conducted during prior infectious disease outbreaks. For example, research conducted during the 2003 SARS outbreak found that avoidance coping was associated with higher levels of maladaptive behavioral responses, but not adaptive health behaviors [30,31]. Similarly, during the H1N1 pandemic of 2009, avoidance coping was associated with reduced engagement in recommended preventive behaviors [32]. The association between avoidance coping and reduced engagement in preventive health measures has also been documented in the context of the COVID-19 pandemic. For instance, one study found that coping through use of denial was associated with reduced adherence to social distancing guidelines [33]. Another study found that avoidance coping and approach coping were negatively and positively associated with engagement in COVID-19 preventive behaviors respectively [34]. In the case of vaccine hesitancy, one study conducted during the H1N1 pandemic found that participants who responded to disease threat with greater use of avoidance coping were less likely to report intending to be vaccinated whereas those who used more approach strategies reported greater intention [35]. However, at time of writing, the roles of approach and avoidance coping in COVID-19 vaccine hesitancy have yet to be reported.

In line with the transactional model of stress and coping which emphasises the synergistic effects of threat appraisals and coping processes, we sought to examine both the direct effects of perceived threat of COVID-19 and coping responses on vaccine hesitancy as well as their interactions [20–22]. In the present study, we assessed participants' general levels of perceived threat of COVID-19 and tendencies to engage in approach and avoidance coping throughout the pandemic. We then tested whether these assessments were related to vaccine hesitancy at the time when the first COVID-19 vaccines were being approved for use in North America [36]. We hypothesized that lower perceived threat of COVID-19 and greater use of avoidance coping would both be associated with increased likelihood of being vaccine hesitant. However, we hypothesized that when perceived threat of COVID-19 was low, approach coping would buffer the association between low perceived threat of COVID-19 and vaccine hesitancy.

2. Method

2.1. Data collection and participants

Data for the present study were collected as part of an ongoing longitudinal study assessing the psychosocial impacts of the COVID-19 pandemic. The study began in March 2020 and was comprised of a baseline survey followed by weekly follow-up questionnaires through May 2020 and monthly follow-up thereafter. Recruitment for the study was done through English language social media and news media outlets. Further Information on participant recruitment is documented in prior publications off earlier waves of data [37,38]. Participants completed a monthly follow up survey distributed on December 1st, 2020, just prior to the first COVID-19 vaccines being approved for use in North America [36]. While the study was open to an international sample, given the disparities in vaccine availability, rollout, and public opinion in various nations, included here are data from North American participants. In addition to completing a baseline survey and the monthly survey distributed in December 2020, to be included in the present sample, participants must have completed at least one additional monthly survey between June and November 2020. Participation in the study was voluntary and no compensation was offered. Informed consent was obtained from all participants and the study protocol was approved by the UBC Behavioural Research Ethics Board.

A total of 1726 participants met inclusion criteria; of these, 70 participants were excluded from analyses presented here due to not reporting their vaccine hesitancy. An additional 86 cases were excluded due to missing data on predictor variables, leaving an analytic sample of 1570 participants. Participants in the analytic sample were mostly women (85 %), college educated (73 % had at least a four-year college degree), and had a mean age of 49.39 years (SD = 15.45). The majority of participants resided in Canada (75 %), and identified their political orientation as liberal (68 %). Individuals excluded due to missing data did not differ from the analytic sample on any of the variables examined apart from age (those excluded were on average 6.19 years younger than those in the analytic sample, $t(187.06) = 4.85$, $p < .001$.

2.2. Measures

2.2.1. Vaccine hesitancy

The outcome of interest, COVID-19 vaccine hesitancy, was assessed in the December 2020 monthly survey. Participants were asked "When a COVID-19 vaccine becomes available, how likely is it that you will choose to get it?" with response options "very likely," "somewhat likely," "somewhat unlikely," "very unlikely," and "don't know." The majority of participants indicated that they were "very likely" to be vaccinated (77 % of participants selected this option). In light of this, and in order to capture any degree of uncertainty toward vaccine uptake, we dichotomized the variable such that 1 corresponds to vaccine hesitancy and indicates any response aside from "very likely." Vaccine willingness is coded as 0 and corresponds to a high degree of willingness to receive a COVID-19 vaccine.

2.2.2. Perceived threat of COVID-19

Perceived threat of COVID-19 was assessed at each timepoint using an adapted version of a scale developed to measure perceived threat of infection in the context of prior infectious disease outbreaks [30–32]. The scale had participants respond to the statements "I don't really think I could get COVID-19," "I feel nervous about getting COVID-19," "COVID-19 is threatening my health," "I don't feel worried about getting COVID-19," and "my daily rou-

tine has been disrupted due to thoughts about COVID-19" on a 5-point Likert scale ranging from 1 (*not at all true*) to 5 (*extremely true*). In order to capture perceived threat of COVID-19 leading up to the point at which participants reported their vaccine hesitancy, we computed the mean of their perceived threat scores across their monthly timepoints from June through November of 2020 (M = 5.01 timepoints, SD = 1.46). Internal consistency of the perceived threat scale was high (α = 0.83).

2.2.3. Approach and avoidance coping

Approach and avoidance coping were assessed at each timepoint using items from the Ways of Coping Questionnaire adapted for use in the context of the pandemic [21]. Participants were asked to report the extent to which they had managed their concerns or fears about COVID-19 in the past month with respect to a range of possible coping responses. Coping items were each rated on a 4-point scale ranging from 0 (*not at all*) to 3 (*a great deal*). The approach coping scale included the items "doubled my efforts to avoid getting COVID-19," "planned strategies for what I hoped would be the best possible outcome," "talked to someone about how I was feeling about COVID-19," and "talked to someone to find out more about COVID-19." Internal consistency for the approach coping scale was α = 0.73. Avoidance coping was assessed with the items "hoped a miracle would happen," "refused to believe it was happening," "wished the outbreak would go away or somehow be over with," "avoided reading, talking or hearing about COVID-19," and "tried to forget about the situation." Internal consistency of the avoidance coping scale was α = 0.70. As with perceived threat, approach and avoidance coping scores were computed by taking the mean of participant's own scores across their monthly timepoints prior to the assessment of vaccine hesitancy. This provided an assessment of their general tendency to engage in each strategy [39]. The mean number of timepoints included in mean score calculations was 4.99 (SD = 1.48) for both approach and avoidance coping.

2.2.4. Demographic covariates

Demographic variables including age, gender, health, political orientation, country of residence, and education were assessed in the baseline survey and included in our analyses. We included these variables as controls in our analysis given their previously demonstrated associations with vaccine hesitancy [13,40]. In the analyses, age was included as a continuous variable. Gender was dummy coded with three levels (men, women, other) with women as the reference category. Health was included as a continuous variable and was assessed with the single item "in general, would you say your health is…" with the response options ranging from 1 (*very poor*) to 6 (*excellent*). The remaining covariates were treated as dichotomous variables. In the analyses, politics = 1 corresponds to identifying as liberal and 0 indicates identifying as conservative or moderate. Country = 1 indicates the participant resides in Canada and 0 in the United States. Education is coded with a variable indicating whether or not the participant reported a college degree (1 indicates the participant reported, at minimum, a four-year bachelor's degree and 0 indicates they did not).

2.2.5. Analytic strategy

We first examined univariate and bivariate statistics of study variables and compared participants who were vaccine hesitant to those who were not. We then used logistic regression to examine how participants' average levels of perceived threat of COVID-19 and their coping responses across prior timepoints related to their subsequent likelihood of being vaccine hesitant in December 2020. After centering all continuous predictors, we ran a model including just covariates to compare model fit with subsequent models. We then ran three models including our variables of interest. In the first model, we tested main effects of perceived threat of COVID-19, avoidance coping, and approach coping on vaccine hesitancy, controlling for the effects of covariates (age, gender, health, political orientation, place of residence, and education). In the second model, we added an interaction between perceived threat and avoidance coping to the main effects model and in the third, we added an interaction between perceived threat and approach coping. To compare models, we used Pearson's chi-square tests and calculated pseudo R^2 values using the Aldrich-Nelson index with Veall-Zimmermann correction. We chose this method to compute pseudo R^2 given the close approximation to OLS R^2 values [41]. We conducted all analyses in R version 4.1.0 [42] and RStudio version 1.4.1106 [43].

3. Results

3.1. Univariate and bivariate statistics

Univariate statistics among vaccine hesitant and vaccine willing participants are outlined in Table 1. Among the sample, 23 % of participants were vaccine hesitant. Those who were vaccine hesitant reported lower perceived threat, greater use of avoidance coping, and less use of approach coping than those who were vaccine willing. They were also younger, less likely to have a college degree, and more likely to report moderate or conservative political views. Bivariate correlations are depicted in Table 2 and indicate that approach and avoidance coping were correlated with each other and with perceived threat. The association between approach coping and perceived threat was greater than that between avoidance coping and perceived threat, z = 9.93, p <.001 [44]. In addition, avoidance coping and perceived threat were positively and negatively associated with vaccine hesitancy respectively. There was also a small, but significant, negative relationship between approach coping and vaccine hesitancy, $r(1568)$ = -0.06, p = 0.023.

3.2. Multivariate analyses

We began by testing a model predicting vaccine hesitancy from covariates (age, gender, political orientation, and health). This model was statistically significant ($\chi^2(7)$ = 67.20, p <.001) and accounted for 8 % of variance in vaccine hesitancy. Table 3 depicts

Table 1
Participant characteristics broken down by vaccine hesitancy status.

Characteristic	Vaccine Hesitant (n = 362) *M (SD)* or *n (%)*	Vaccine Willing (n = 1208) *M (SD)* or *n (%)*	p[a]
Perceived Threat	3.34 (0.72)	3.55 (0.63)	<0.001
Avoidance Coping	0.99 (0.51)	0.84 (0.46)	<0.001
Approach Coping	0.94 (0.50)	1.00 (0.50)	0.024
Age	48.02 (14.98)	49.80 (15.57)	0.049
Health	4.51 (0.99)	4.60 (1.00)	0.13
College Degree[b]	242 (67 %)	899 (74 %)	0.006
Politics (Liberal)	195 (54 %)	880 (73 %)	<0.001
Gender			0.11
Female	318 (88 %)	1009 (84 %)	
Male	37 (10 %)	175 (14 %)	
Other	7 (1.9 %)	24 (2.0 %)	
Country (Canada)	281 (78 %)	893 (74 %)	0.2

[a] Welch Two Sample t-test was used for continuous variables and Pearson's Chi-squared test was used for categorical variables.
[b] Coded 1 = bachelor's degree in college (4-year) or higher, 0 = less than bachelor's degree.

Table 2
Means, standard deviations, and correlations of study variables.

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Vaccine Hesitancy[a]	0.23	0.42								
2. Perceived Threat	3.50	0.66	−0.14***							
3. Avoidance Coping	0.88	0.47	0.13***	0.17***						
4. Approach Coping	0.99	0.50	−0.06*	0.46***	0.22***					
5. Age	49.39	15.45	−0.05	−0.04	−0.20***	−0.04				
6. Health	4.58	1.00	−0.04	−0.28***	−0.07**	−0.09***	−0.03			
7. College Degree[b]	0.73	0.45	−0.07**	0.02	−0.13***	0.01	−0.09***	0.09***		
8. Politics (Liberal)	0.68	0.46	−0.17***	0.14***	−0.10***	0.06*	−0.17***	−0.01	0.21***	
9. Country (Canada)	0.75	0.43	0.04	−0.16***	−0.03	−0.16***	0.07**	0.01	−0.18***	−0.11***

[a] Coded 1 = vaccine hesitant, 0 = vaccine willing.
[b] Coded 1 = bachelor's degree in college (4-year) or higher, 0 = less than bachelor's degree.
*p ≤ 0.05. **p ≤ 0.01. ***p ≤ 0.001.

Table 3
Results from logistic regression models predicting vaccine hesitancy.

Main Effects Model			Avoidance Interaction Model			Approach Interaction Model		
Variable	OR	95 % CI	Variable	OR	95 % CI	Variable	OR	95 % CI
Intercept	0.51***	[0.35–0.75]	Intercept	0.51***	[0.35–0.74]	Intercept	0.47***	[0.32–0.68]
College Degree	0.89	[0.67–1.17]	College Degree	0.89	[0.67–1.18]	College Degree	0.90	[0.68–1.18]
Age	0.99*	[0.98–1.00]	Age	0.99*	[0.98–1.00]	Age	0.99*	[0.98–1.00]
Gender (Men)	0.61*	[0.41–0.91]	Gender (Men)	0.60*	[0.40–0.90]	Gender (Men)	0.59**	[0.39–0.88]
Gender (Other)	1.29	[0.53–3.12]	Gender (Other)	1.30	[0.54–3.16]	Gender (Other)	1.22	[0.50–2.95]
Country (Canada)	1.03	[0.76–1.39]	Country (Canada)	1.01	[0.75–1.37]	Country (Canada)	1.04	[0.77–1.41]
Politics (Liberal)	0.47***	[0.36–0.61]	Politics (Liberal)	0.46***	[0.36–0.60]	Politics (Liberal)	0.47***	[0.36–0.61]
Health	0.83**	[0.73–0.94]	Health	0.83**	[0.73–0.94]	Health	0.83**	[0.73–0.94]
Perceived Threat	0.56***	[0.45–0.69]	Perceived Threat	0.54***	[0.43–0.67]	Perceived Threat	0.58***	[0.46–0.73]
Avoidance Coping	1.84***	[1.40–2.41]	Avoidance Coping	1.92***	[1.46–2.53]	Avoidance Coping	1.84***	[1.40–2.41]
Approach Coping	0.89	[0.67–1.19]	Approach Coping	0.89	[0.67–1.18]	Approach Coping	0.86	[0.65–1.15]
			Perceived Threat × Avoidance Coping	1.33	[0.94–1.89]	Perceived Threat × Approach Coping	1.68**	[1.20–2.37]
			Model Fit Statistics					
$\chi^2(10) = 117.47$, $p < .001$			$\chi^2(11) = 120.05$, $p < .001$			$\chi^2(11) = 126.15$, $p < .001$		
Pseudo-R^{2a} = 0.13			Pseudo-R^{2a} = 0.14			Pseudo-R^{2a} = 0.14		

Note. N = 1570. All continuous predictor variables centered prior to analysis.
[a]Aldrich-Nelson pseudo-R^2 with Veall-Zimmermann correction.
*p ≤ 0.05. **p ≤ 0.01. ***p ≤ 0.001.

results from three logistic regression models including the variables of interest (perceived threat of COVID-19, avoidance coping, and approach coping). The main effects model improved model fit compared to that including only demographic covariates ($\chi^2(3) = 50.27$, $p < .001$), and accounted for 13 % of variance in vaccine hesitancy. The model revealed that holding other predictors constant, higher perceived threat of COVID-19 was associated with lower likelihood of vaccine hesitancy. In contrast, avoidance coping was associated with increased likelihood of vaccine hesitancy. Men, those who were older, healthier, or liberal, were less likely to report vaccine hesitancy. In our second model, we added an interaction between perceived threat of COVID-19 and avoidance coping, however, the interaction was non-significant ($p = .11$). In our final model, the addition of the interaction term between perceived threat of COVID-19 and approach coping was significant ($p = .003$). This model improved model fit ($\chi^2(1) = 8.68$, $p = .003$) and explained 14 % of variance in vaccine hesitancy.

The significant interaction between perceived threat of COVID-19 and approach coping is depicted in Fig. 1. The interaction suggests a protective effect of approach coping on vaccine hesitancy when perceived threat is low. Simple slopes analysis revealed that slopes at the mean, and one standard deviation below the mean on approach coping differed significantly from 0 ($p < .001$ for both), whereas slopes one standard deviation above the mean on approach coping did not ($p = .06$). This indicates that for individuals who engaged in high levels of approach coping, their likelihood of being vaccine hesitant was low, regardless of their perceived threat of COVID-19. In contrast, for those who engaged in low to moderate levels of approach coping, low perceived threat of COVID-19 was associated with increased likelihood of being vaccine hesitant.

4. Discussion

Results from the present study add to the body of work examining psychosocial predictors of vaccine hesitancy. The transactional model [20–22] informed our predictions. We categorized coping responses into the higher-order categories of approach and avoidance and examined these as risk and protective factors for COVID-19 vaccine hesitancy. In line with our hypotheses, we found that while low perceived threat of COVID-19 was associated with increased likelihood of vaccine hesitancy, approach coping buffered this association. This finding points to approach coping as a potentially adaptive strategy in the context of the pandemic, particularly when an individual does not feel personally threatened by COVID-19. In contrast, avoidance coping was associated with increased likelihood of vaccine hesitancy, thus pointing to greater engagement in avoidance coping as a potential risk factor for vaccine hesitancy. Given that both perceived threat and coping are alterable and thus potential targets for intervention [7,45], close examination of these effects and the mechanisms underlying their associations is warranted.

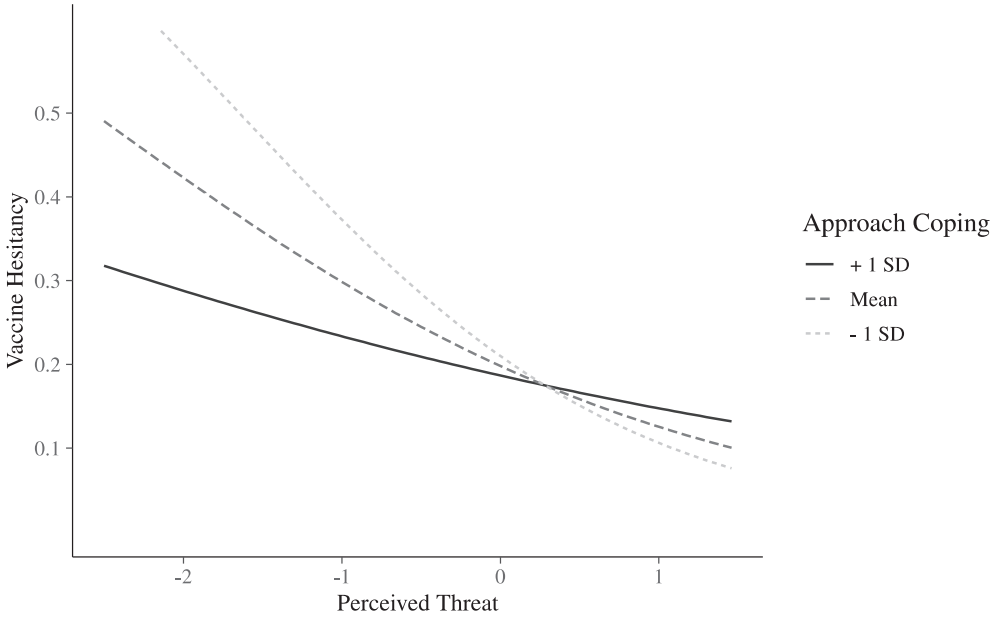

Fig. 1. Vaccine hesitancy as a function of perceived threat of COVID-19 and approach coping.
Note. All variables centered. Y-axis values reflect probability of reporting vaccine hesitancy in December 2020.

The association between low perceived threat of COVID-19 and vaccine hesitancy is consistent with models of health behavior which point to perceived threat as a key contributor to preventive behavior intent and engagement [19]. In line with this, research conducted during the COVID-19 pandemic [10–15] and during prior infectious disease outbreaks [16–18] has found heightened disease threat to be associated with greater intent to be vaccinated. The buffering effect of approach coping that we observed at low levels of perceived threat is also consistent with literature indicating that approach coping is often associated with increased engagement in preventive health behaviors [7,24,26,35]. The lack of effect at high levels of perceived threat is consistent with work examining earlier waves of data from the present study which found that relationship-focused coping strategies contributed to preventive behavior engagement when perceived threat of COVID-19 was low [37]. From an intuitive standpoint, this phenomenon makes sense given that when perceived threat of disease is sufficiently heightened, this may be a potent enough predictor of behavioral intent, leaving coping to exert comparatively little impact. In the case of vaccine hesitancy, this translates to approach coping only serving as a protective factor against vaccine hesitancy when an individual does not feel personally threatened and would otherwise be more likely to be vaccine hesitant. This line of reasoning is consistent with the transactional model which indicates that the effects of a given coping response will invariably differ as a function of both perceived threat and other intra-individual and social-contextual factors [20–22].

The bivariate relationships among study variables provide greater insight into the nuance required in interpreting the effects of perceived threat and coping in multivariate models. For example, the correlation between approach and avoidance coping indicates that those who engaged in greater approach coping, tended to also engage in more avoidance coping. While counterintuitive at first glance, this finding is consistent with previous work on coping [20] and likely reflects both an individual difference in the degree to which participants engage in coping efforts and differential levels of stress experienced. This is evidenced by the positive association between both forms of coping and perceived threat indicating that those who felt more threatened by COVID-19 were more likely to engage in coping efforts. It also is consistent with work indicating that individuals typically engage in multiple ways of coping with any given threat [20]. We also found that the correlation between perceived threat and avoidance coping was of reduced magnitude compared to that between perceived threat and approach coping. While this finding could indicate that individuals low in perceived threat tend to use more avoidance coping, or that avoidance coping could be effective in reducing one's perceived threat, we hesitate to make substantive claims on this topic due to issues inherent in the measurement of avoidance coping. It has long been recognized that self-report measures of coping that rely on a pre-defined list of strategies provide an impoverished view of the underlying construct [46]. This argument is particularly relevant in the context of avoidance coping given that those who are successful in use of such responses (e.g., denial), would likely be unaware they are engaging in it. Furthermore, this may have introduced bias into our sample given its self-selected nature. It is plausible that individuals successfully coping through the use of avoidance may have either been unaware of, or neglected to participate in a study examining a threat they deemed inconsequential or nonexistent.

In addition to the aforementioned difficulties that arise when relying on self-report data to assess avoidance coping, another limitation concerning our measurement of coping is the non-exhaustive list of items included in our assessments. Approach and avoidance coping can include a wide range of coping responses that vary based on individual and social-contextual factors [7]. As such, our measures are limited to the extent that they can capture the full variability in these phenomena. Another limitation of the present study pertains to the self-selected nature of the sample, namely, the lack of demographic diversity. Our sample was predominantly comprised of women, those who were college educated, those residing and Canada, and those identifying as liberal. While we controlled for these variables in our analyses, future work should recruit more diverse samples in order to investigate how results may vary as a function of demographic factors. Given the complex ways that individual and social contextual factors

interact to influence health beliefs and behaviors, examining the synergistic effects of these variables will be crucial to attain a more comprehensive view of the roles of perceived threat and coping in vaccine hesitancy [9]. This is particularly relevant given that our sample demographics largely resemble those of populations most willing to be vaccinated for COVID-19 [40]. Incorporating greater representation of those who are vaccine hesitant will be crucial in order to enrich understanding of predictors of the phenomenon.

That said, our use of a convenience sample and online survey methodology resulted in a number of important strengths, most notably, our ability to recruit and retain a relatively large sample. We were also able to enter the field quickly at the initial onset of the pandemic and in doing so, were able to obtain assessments of perceived threat of COVID-19 and coping responses prior to availability of a COVID-19 vaccine. This allowed us to average participants' scores across multiple timepoints, thus obtaining a more accurate assessment of their general level of threat and coping throughout the pandemic, prior to the introduction of vaccines [39]. Given the temporal ordering of our assessments, we can also be confident that assessments of perceived threat and coping were not influenced by dilemmas that emerged following vaccine rollout (for example, limited access and ethical concerns relating to leaving the vaccines for those most vulnerable). Similarly, our measurement of vaccine hesitancy was likely not influenced by practical or situational constraints such as vaccine availability or ease of access. While further research is needed to extend the generalizability of our findings beyond the present sample, characteristics of our sample did resemble trends within the broader population, thus mitigating some concern regarding generalizability. For example, we observed a vaccine hesitancy rate of 23 % which, according to a recent met-analysis of studies with nationally-representative samples, is similar to both the global rate and that within Canada (where the majority of our sample was located) [47]. In addition, we observed similar patterns of demographic associations with COVID-19 vaccine hesitancy as reported in prior research, most notably, that those with left-leaning political ideologies and higher educational attainment are less likely to be vaccine hesitant [13,40].

Our findings provide compelling evidence that coping responses can be meaningful contributors to vaccine hesitancy in the context of the COVID-19 pandemic. These results add value to the existing vaccine hesitancy literature given that coping responses can serve as actionable targets for intervention [7,45]. This is in contrast to other risk factors for COVID-19 vaccine hesitancy that reflect more stable between-person differences such as political ideology [40,48], or conversely, attitudinal determinants such as trust in the government and medical professionals [49,50]. Intervening in either one of these domains would require either altering worldviews and belief systems, or large-scale societal change. In contrast, the present study points to coping responses as a malleable risk factor. Although further research is needed to explicate the observed effects and delineate if causal mechanisms are at play, such work could indicate if interventions targeting coping responses to reduce COVID-19 vaccine hesitancy are warranted. For example, our findings suggest the potential efficacy of interventions designed to promote more approach-oriented coping strategies in the context of infectious disease outbreaks. Research expanding this work beyond COVID-19 to examine if approach and avoidance coping play a role in vaccine hesitancy more broadly is also needed. Such work could contribute to our understanding of vaccine hesitancy as a phenomenon and in doing so, help mitigate its impact on public health. In particular, our findings point to the need for treatment matching to consider how perceived threat and coping behave synergistically when developing public health interventions. In this way, our findings can help to inform not only the development of interventions, but also identify populations at risk for vaccine hesitancy.

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Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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