Knowledge and Perceptions of the Health Impacts of Climate Change Among Canadians

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Abstract

Background At a time of intersecting public health crises of COVID-19 and climate change, understanding public perceptions of the health risks of climate change is critical to inform risk communication and support the adoption of adaptive behaviours. In Canada, very few studies have explored public understandings and perceptions of climate impacts on health.

Methods This study addresses this gap through a nationally-representative survey of Canadians (n=3,014) to explore public perceptions and awareness regarding the link between climate change and health in Canada. The 116-question survey measured awareness of the link between climate change and health, affective assessment of climate health impacts, unprompted knowledge of climate health impacts, and concern about a range of impacts. Kruskal-Wallis tests were used to test for differences in median values among sociodemographic groups. The survey also measured baseline climate opinion, which was used to segment the public into different audiences through a latent class analysis.

Results Three climate opinion classes were identified in the sample (disengaged, concerned, and alarmed) and perceptions of climate health impacts were compared across these classes and other sociodemographic variables. Approximately half (53%) of respondents have considerable awareness of the link between climate change and health, and even more (61%) perceive climate change as bad for health. The majority of respondents (58%) can name one or more health impact without prompting. Concern about health impacts of climate change is highest among the alarmed and lowest among the disengaged, as compared to concerns about other categories of climate impacts such as economic. Across the survey, knowledge and concern are highest for water- and food-related health impacts.

Conclusions The differential knowledge, awareness, and concern of climate health impacts across segments of the Canadian population can inform targeted communication and engagement to build broader support for adaptation and mitigation measures.

Introduction

From increased frequency and intensity of heat waves and wildfires to the proliferation of infectious diseases, food and water insecurity, and mental health challenges, climate change presents an immense threat to public health globally [1]. Public perceptions of the health impacts of climate change are not well understood, yet are critical for risk communication and ultimately the adoption of behaviours that support climate adaptation and mitigation.

Studies that have explored public perceptions of health and climate change have often found a relatively superficial understanding. A global systematic review of public and health professionals' perceptions of the health implications of climate change found ten studies from English-speaking Nations, and eight studies from non-English speaking Nations on public perceptions of the health impacts of climate change [2]. The review found that the majority of North Americans perceive climate change as having negative health impacts, yet few can list specific issues or name who is specifically at risk without being

prompted [2]. In a national US survey, Maibach et al [3] found that “most Americans have little understanding of the health relevance of climate change.” Comparing surveys from the US, Canada, and Malta, Akerlof et al. [4] found that despite the majority of people across all three countries viewing climate change as a health risk, “climate change appears to lack salience as a health issue” based on the limited depth of answers to open-ended questions. Studies in other parts of the world such as Nepal [5], Bangladesh [6], and Hong Kong [7] have found varying degrees of awareness around the public health impacts of climate change.

In Canada, recent reports have summarized the latest research on the health impacts of climate change (e.g. [8, 9]), but very few studies have explored public understanding and perceptions of these impacts. A 2008 survey by Health Canada found that respondents did not often associate climate change with health impacts, but when prompted they were likely to accept their relationship [10, 11]. A subsequent national survey found a slight increase in Canadians’ knowledge of the health risks posed by climate change, though a minority of people actually took steps to protect themselves [12]. An interview-based study in southern Ontario found that 77% of participants identified health impacts of global environmental change when prompted, but were not able to describe this link in detail or in relation to their own lives [13]. A focus group case study exploring perceptions of climate change and Lyme disease in Manitoba also found low levels of understanding regarding the link between health and climate as well as the challenges and opportunities this presents for effective climate and risk communication [14].

Understanding public risk perception is not only important as an indication of public willingness to support climate adaptation and mitigation measures [15, 16], but also to inform public risk communication approaches and frames. In particular, an emerging body of research in the climate communications field suggests that by communicating the health risks of climate change and focusing on the relevance of these issues to personal and community health and well-being, there is greater potential to engage a wider audience [17–19]. However, other studies have found that framing climate communications from a health perspective may not be a straightforward or universal approach, and there is a need to better understand how this framing may be operationalized [20–24].

Given the urgency of communicating and acting on climate change combined with the evolving discourse regarding public health in the context of the COVID-19 pandemic, there is a need for an updated understanding of Canadians’ perceptions of the health risks of climate change. To address this, we conducted a nationally-representative survey to explore public perceptions and awareness regarding the link between climate change and health in Canada. This study had the following objectives:

(1) To determine the extent to which Canadians understand the link between climate change and health;

(2) To evaluate Canadians’ level of concern about the health impacts of climate change; and

(3) To explore how climate and health risk perceptions can inform public engagement and communications

Methods

Study area

This study and associated survey sought to understand the perceptions and attitudes of Canadians regarding climate change and health. Framed by three oceans, Canada is the second largest country in the world by total area, and has numerous large cities as well as diverse rural and remote regions. The survey was conducted across all of the country's ten provinces and three territories, among a total population of 35.15 million people (as of the 2016 Census).

Development of survey instrument

The survey instrument was designed considering a review of surveys on climate change, health, and risk perceptions. Some questions were modified from previous studies [3, 10, 25, 26], while others were developed for the specific context of this study. The survey instrument was reviewed and pre-tested among the researchers and their networks and the final instrument contained 116 questions (the full survey instrument is in supplementary materials, S1). Respondents were asked questions related to their perceptions, experiences, and awareness regarding climate change and health impacts as well as responses to specific communication materials (the latter of which will be reported in forthcoming publications). Most questions were asked on an 11-point scale, from zero to ten.

Measurement of outcome variables

To assess knowledge of climate health impacts, prior to answering specific questions respondents were asked to self-assess their previous thinking and concern regarding these issues. In order to identify knowledge of the health impacts of climate change when unprompted, respondents were asked the open-ended question: "In what ways, if any, do you think climate change will affect the health of Canadians?". The answers to this open-ended question were coded, and code frequencies were analysed. To assess health impacts of highest concern to Canadians, we asked respondents their levels of concern for 15 different health impacts of climate change. We measured baseline sociodemographic variables and levels of concern related to climate change, health (including COVID-19), and other global issues through a range of questions in order to compare the climate and health information by these variables.

Data collection

After approval by the University of Winnipeg Human Ethics Research Board, the survey was conducted from December 14-23, 2020, with support of Nanos Research. The survey was self-administered online by respondents in either English or French according to their preference. The sample was drawn from a probability panel, recruited through random digit dialling land and cell phone lines. Research has found that online surveys from probability samples yield more accurate results than telephone interviews or nonprobability online surveys [27]. To ensure representation in less populated areas, recruitment was supplemented by phone calls which directed respondents to the online survey. Each section of the survey was on a separate webpage that did not allow for participants to review previous pages, and thus allowed

more information to be revealed as the survey proceeded. Participants received a small compensation for their time of five dollars for completion of the survey. The average completion time was 17 minutes and 22 seconds and the response rate of the survey was 13%. This low response rate may be attributed in part to the survey being distributed in December, close to the holidays and during the height of the second wave of COVID-19 across Canada, as well as the length of the survey requiring considerable time. Studies on response rates within Canadian public health research demonstrate that online surveys have limitations (e.g. passive engagement, difficulty issuing reminders, etc.) that lead to the lowest response rates of all survey methods available [28].

Analysis

We used a Latent Class Analysis (LCA) model to identify groups of respondents with similar climate change opinions. Following the approach used by Chryst et al. [29], we used four questions from our survey: climate change concern, certainty, personal risk perception, and perceived impacts on future generations. We used the *poLCA* package in R [30] to estimate models with 2 - 10 classes, using 5000 iterations to increase the probability of obtaining a global, rather than local maximum of the log-likelihood function. The model with three classes consistently had the lowest AIC values, and was therefore chosen as the best model. All test values for the different LCA models are reported in the Supplementary Information (S2 Table 1).

Statistical analyses were conducted using the software R [31]. Non-parametric Kruskal-Wallis tests and Friedman tests were conducted to test for differences in median values among groups. Full results of the statistical analyses are reported in Supplementary Information.

Qualitative coding of the open-ended question was overseen by three members of the research team. The researchers developed a preliminary coding scheme, based on previous studies and literature on the health impacts of climate change relevant in Canada [12, 32]. Examples of initial code categories include air quality, temperature-related morbidity and mortality, and infectious diseases. A sample of the responses were reviewed independently by two researchers, and the initial coding scheme was added to and adapted. All responses were then coded through two rounds, conducted by one researcher in conversation with a second when discrepancies arose. A broad, holistic definition of the health impacts of climate change was adopted, which includes physical, mental and social aspects of health and well-being.

For the purposes of simpler visualization, data from the 11-point scale are discussed and visualized here in five categories: very low (0-1), low (2-3), medium (4-6), high (7-8), and very high (9-10), with “don’t know / refused to answer” responses included as not applicable (NA). The Yukon, Northwest Territories, and Nunavut are grouped together as the northern ‘territories’ in this analysis of results.

Results

Sample description

The sample includes 3,014 respondents, with sufficient sample sizes from each province and territory in Canada to allow for regional analyses (Table 1). For the parts of the analysis in which we seek to describe the results as nationally representative, data have been weighted by province, gender, and age so that the results reflect the demographic distribution of the Canadian population (2016 Census). For results of the open-ended question, data remain unweighted to reflect direct numbers of responses. Unweighted data is indicated with an asterisk (*) throughout.

Table 1
Sociodemographic characteristics of the sample (n=3014) before and after weighting

	N (unweighted)	N (weighted)	% (weighted)	Census (%)
	3014	**3000**		
Gender				
Female	1447	1544	51.5%	50.9%
Male	1567	1456	48.5%	49.1%
Age				
18 to 34	477	820	27.3%	19.5% †
35-54	1198	1023	34.1%	27.2%
55+	1339	1157	38.6%	30.9%
Province/Territory				
East				
Newfoundland and Labrador	200	46	1.53%	1.48%
New Brunswick	200	65	2.17%	2.13%
Nova Scotia	200	81	2.70%	2.68%
Prince Edward Island	150	12	0.400%	0.410%
Central				
Quebec	451	702	23.4%	23.2%
Ontario	666	1148	38.3%	38.2%
Prairies				
Manitoba	200	105	3.50%	3.64%
Saskatchewan	200	90	3.00%	3.13%
Alberta	200	336	11.2%	11.6%
West				
British Columbia	397	406	13.5%	13.2%
North				
Territories	150	9	0.300%	0.220%

† This is percentage of age 20-34, as the Census data is recorded in ages 15-19 and 20-24.

The latent class analysis identified three climate opinion classes: the alarmed (49%); the concerned (31%); and the disengaged (19%). The alarmed are characterized by high certainty that climate change is real, high concern about the issue, and high perceived risk for self and future generations. The alarmed are more often politically moderate (58%) and left leaning (23%), and have higher levels of formal education (95% have education beyond high school). The concerned are relatively certain and somewhat concerned about the issue, and perceive some risk for self and future generations. They are most often politically moderate (56%) and right (25%). The disengaged are characterized by a range of certainty about climate change, ranging from dismissive to accepting of the scientific reality of the issue, but generally low concern and perceived risk. This group most often identifies as politically right wing (49%), practising of a faith (49%), and with the largest proportion of high-income people (23% making over $150,000 per year) and people living in the Prairies (36%). These three climate opinion classes are used throughout the results to understand knowledge and perceptions of the climate-health link across the climate opinion spectrum.

Varying concern about the health impacts of climate change compared to other impacts

When asked their level of concern about a range of 16 climate impacts - within the broad categories of national security, health, economics, and biophysical impacts - there was moderate concern across categories, with slightly more answering high or very high concern for health (54%) and biophysical impacts (54%), than for economic impacts (50%) and national security impacts (44%) (S4 Table 2a).

When these broad categories are compared across the three classes outlined above there are larger differences. The alarmed are relatively more concerned about climate health impacts (76% high or very high) and biophysical impacts (76%) compared to economic and national security, while the opposite is true for the disengaged (only 7% high or very high concern for health and biophysical) (Fig. 1; S4 Table 2c). The disengaged are more concerned about climate impacts on national security (29% high or very high) and the economy (27% high or very high). These results mirror trends in baseline concerns about these issues irrespective of climate change. For instance, 58% of the alarmed, 57% of the concerned, and 38% of the disengaged are highly or very highly concerned about their personal health, while 83% of the disengaged are highly or very highly concerned about the economy, compared to 76% of the concerned and 69% of the alarmed (S4, Table 1a).

Awareness of the link between climate change and health varies across demographics

When asked how much they had thought about the health impacts of climate change before taking this survey (i.e. awareness of the climate-health link), results show substantial awareness of this connection, with 53% answering high or very high and 20% answering low or very low across the entire sample.

The alarmed say they have thought about the link between climate change and health often (73% high or very high), significantly more than the disengaged (21% high or very high) (Fig. 2; S4 Table 4a). The concerned show more of a range of responses on how much they have thought about the connection between climate change and health.

Geographically, there is the highest awareness of the climate-health link in Quebec (58% high or very high) and British Columbia (56%) and lowest in Saskatchewan (40%), Alberta (40%), and Newfoundland and Labrador (40%). There are differences across political lines, with 76% of people on the political 'left' reporting having thought about the health impacts of climate change often (high or very high) before taking the survey compared to 55% of those who identify as 'moderate' or 37%* of those on the political 'right' (S4, Table 4b). Those with more formal education report more awareness of the climate-health link (61% high or very high among people with postgraduate degrees, 53% who attended college or university) compared with those with only high school education (37%) (S4, Table 4c).

People with high or very high concern about their personal health have a higher awareness of the link between climate change and health (62% high or very high) compared to those with low or very low personal health concern (33%)(S4, Table 4d). Similarly, people highly or very highly concerned about COVID-19 reported higher awareness of the link between climate change and health (55%) than those with low or very low concern about COVID-19 (33%) (S4, Table 4e).

The majority of Canadians perceive climate change as bad for people's health

On the affective assessment of climate change, with 0 being "very good for people's health" and 10 being "very bad for people's health", 61% of people responded 7 or above, and 6.5% responded 3 or below. The alarmed are much more likely to perceive climate change as having a negative impact on peoples' health (89% 7+), whereas the disengaged more often answered that the health impacts of climate change were neutral (62%) or positive (30%) (S4 Table 5a). Among the concerned, 54% perceive a negative impact on health and 41% say the impacts are neutral.

More women perceive climate change as bad or very bad for health (69%) than men (53%) (S4 Table 5b). Politically, left-leaning people more often perceive negative impacts of climate change on people's health (87%) than people on the right (39%), with politically moderate people in the middle (64%) (S4, Table 5c). Additionally, people who have a higher awareness of the link between climate change and health perceive greater negative health impacts; of those with high or very high awareness of the climate-health link, 83% think climate change will be bad or very bad for health, while among those who have low or very low awareness of the climate-health link only 24% think it will be bad or very bad for health (S4, Table 5d).

More than half of Canadians can name one or more health impact of climate change

In response to an open-ended question about the health impacts of climate change, 2162 respondents (72%*) wrote answers; 1740 answers were coded as including one or more health impacts, while 422 were not coded as they did not answer the question. 25%* of respondents listed one health impact, 15.7%* listed two health impacts, and 17.1%* named three or more health impacts.

The alarmed more often answered the question with at least one health impact (71%* of the alarmed), as compared to the concerned (55%*) and the disengaged (29%*). 61%* of people aged 55+ named at least one health impact, compared to 50.3%* of people 18-35 years old. 66%* of those with low income (<40K) answered with one or more health impact compared to 55%* of those with high income (>100K). Politically, 71%* of those on the left answered, while only 48%* of those on the right did.

Open-ended answers were coded and 21 health impacts were identified (full list of codes and definitions in S3 Table 1). These included conventional health impacts commonly found in the literature such as air quality and infectious diseases, as well as other more broadly interpreted impacts on health and well-being, such as impacts on economics or ecosystems. The most common climate health impacts identified were: food security and agriculture (n=494), air quality (367), temperature related morbidity and mortality (357), infectious diseases (339), extreme events and weather-related natural hazards (331), and respiratory problems (292) (Fig. 3). Additionally, some indirect answers were common, including which groups are most vulnerable to health impacts (235) as well as the economic impacts of climate change (182). There were some regional differences in the frequencies of health impacts listed. Accidents and injuries were highest in the North; respiratory problems and temperature-related morbidity and mortality were highest in Central and lowest in the North; infectious diseases were higher in North and Central; and mental health was highest in the North and West. Looking at the top six health impacts across climate opinion classes, we see that food security and agriculture was particularly common among the alarmed, but there is generally a similar pattern of relative frequencies between classes.

Water- and food-related impacts are of high concern, among other climate health impacts

Respondents were empirically surveyed about their level of concern for 15 specific climate change health impacts. Worry about future generations, threats to agricultural food production, water quality, food security, and respiratory impacts from air pollution or wildfires are among the top concerns (Fig. 4). We see a divide within the mental health impacts of climate change, with “worry about wellbeing of future generations” being highest overall (70% high or very high) while “personal climate anxiety” (33%) and “stress from evacuation during extreme weather events” (41%) were the lowest. “Heat stroke” (46%) and “diseases spread in water, such as gastrointestinal illnesses” (45%) were also relatively low.

These 15 impacts were grouped into five categories: water- and food-related impacts, mental health, infectious diseases, temperature-related impacts, and air quality. Between these five broad categories, water- and food-related health impacts have the highest levels of concern (60% high or very high) though the others also have high levels of concern. Mental health (48% high or very high) and heat (51% high or

very high) are the lowest by a small margin (S4 Table 3b, 3c). The alarmed are generally more concerned about these categories of health impacts of climate change (Fig. 5; S4 Table 3d). There is also variation across incomes; people with low income (<$40,000/year) consistently have higher concern across the health impacts, and those with high income (>$150,000/year) consistently have the lowest levels of concern (S4 Table 3e).

Discussion

The goal of this study was to investigate how people across Canada understand and perceive the link between climate change and health. The study provides a baseline understanding of public perceptions on these intersecting issues, at a time of complex and compounding public health challenges with the COVID-19 pandemic and worsening climate health impacts. The survey was conducted in the winter of 2020, prior to the record setting heatwaves and wildfires that transpired across Canada in the summer of 2021, and set an important national baseline for climate and health opinion moving forward. These results offer insight that can be useful for public engagement and communications, which will allow for targeted interventions that are mindful of pre-existing climate concerns and how this affects attendant perceptions and behaviours associated with health impacts.

Concern about health impacts of climate change

Overall, the results find that levels of concern about health impacts are similar to levels of concern about biophysical, economic, and national security impacts of climate change among people in Canada. Within climate opinion classes, health impacts are of higher concern among the alarmed and lower concern among the disengaged compared to other categories of climate impact. Water- and food-related impacts are of highest concern across classes and most common in response to the open-ended question. This differs from a previous Canadian survey in which air quality impacts were the most commonly named in response to an open-ended question [12]. Somewhat surprisingly, given recent discussion on these matters (e.g. [33]), mental health concerns ranked the lowest; although there was high “worry about future generations”, there was low concern about “personal climate anxiety” and “stress from evacuation during extreme weather events.” The low concern about mental health impacts is interesting considering that climate change poses a serious threat to mental health in Canada [34], with some projecting mental health impacts to be among the costliest of all health impacts [35]. At the same time, mental health has been underrepresented in research on climate change and health historically [36, 37] and a recent survey found that only 44% of Canadian public health organizations report working on climate-related mental health risks [38]. This suggests that perhaps less information has been mobilized to the public regarding this pressing health issue and its linkage with climate change. Low concern about climate anxiety may also be due in part to the lack of widespread understanding and a common operational definition of the term [39, 40].

On the whole, these results illustrate the well-documented phenomenon of psychological distancing, which describes how people are more likely to believe the worst impacts of climate change are far away

temporally, socially, and geographically [41, 42], and thus more likely to be concerned for the future generations than their own personal well-being. This distancing is consistent with previous research on public perceptions of climate impacts in Manitoba [14] and Ontario [13]. Recent research in the US shows that the spatial and temporal distribution of climate-related health impacts are far more immediate, localized, and costly than currently understood [43], which speaks to the need to carefully consider risk communications that take into account psychological distancing that may actually run counter to the best available climate and health sciences.

In some cases, concern about the health impacts of climate change parallels indicators of vulnerability across sociodemographic characteristics. Interestingly, people with low income, older people (55+), and women consistently have higher concern regarding health impacts. Given that income, age, and gender are indicators of vulnerability to climate impacts generally [44], it is increasingly clear that those who are most affected by climate change are also more likely to be concerned about the impacts, and speaks to the larger health equity issues climate change poses for Canadians. People with higher incomes, for example, likely have more resources available to them to adapt and insulate themselves from the effects of climate change on their personal health, and thus may be less concerned because they are less likely to be affected. These results are consistent with previous research in other parts of the world which has found a similar relationship between indicators of vulnerability and risk perception on climate change (e.g. [45–47]).

Awareness and affective assessment of health impacts

Respondents reported considerable awareness of climate change health impacts, with just over half of Canadians responding high or very high on the question of how much they had thought about the connection between climate change and health, and only one fifth of respondents answered low or very low. By comparison, research in the US in 2014 found that only a third of Americans had thought about the health impacts of climate change “a great deal” or a “moderate amount” [3], while in 2020 significantly more Americans thought that climate change health effects would become more common [48]. While a substantial amount of Canadians report having thought about the link between climate change and health, the results show that this awareness is not evenly distributed across the population. The alarmed have thought about climate change health impacts about two to three times as much as the concerned and disengaged, respectively. Though perhaps unsurprising, this correlation between climate opinion and climate-health link indicates that there is a significant gap in awareness for half of the population, namely the concerned and disengaged, perhaps in part due to a lack of exposure to information on health impacts. At a global level, despite increasing public and scientific work on climate change and health [49], “in absolute terms, climate change continues to be framed in ways that pay little attention to its health dimensions” [50]. Public health agencies and units are poised as effective messengers on climate change health risks [3, 51, 52], and in some jurisdictions are mandated to communicate this information, such as the Canadian province of Ontario [53]. However, a recent survey of Canadian public health organizations found that only 48% of organizations had engaged in climate change and health education and outreach with the public, and only 36% had undertaken education or

training on climate change and health risks and adaptation among staff or professionals [38]. Further health-focused climate communications campaigns (e.g. [54]) are needed to target those less engaged on climate change if we hope to reach widespread understanding of and participation in adaptive health behaviours, and the results of this Canada-wide study are helpful in this regard.

The results also found that about sixty percent of people, particularly women, perceive climate change as bad or very bad for human health. This suggests that the majority of the public perceive climate change as harmful to health, or are inclined to answer as such when prompted, despite half of people not having thought a significant amount about health impacts in particular. Similarly, a 2015 survey of Americans found that while only 10% of people had previously thought about climate change and health “a great deal,” 31% responded that climate change is “very bad” for health [3]. As Maibach et al. [3] suggest, this discrepancy could be in part due to people making inferences or momentary judgements about the negative impacts of climate change on health due to their general understanding of the issue, the context of the survey, and/or their suppositions about what the “right” answer is.

Unprompted knowledge of health impacts

More than half of Canadians can name one or more health impacts of climate change when unprompted, with the most common impacts related to food security and agriculture, air quality, temperature related morbidity and mortality, and extreme events. Answers to open-ended questions such as this are likely more realistic representations of peoples true understandings of climate change and health as compared with close-ended questions that may prompt certain responses [3, 55]. Results here show a slight decline compared to previous surveys which found 69% of climate change believers in 2017 and 63% of Canadians in 2008 were able to identify one or more health impacts of climate change in response to an open-ended question [10, 12]. On the other hand, the results are significantly higher than a survey of US adults in 2015 which found that only 27% of respondents could name at least one health impact of climate change unprompted. The different coding schemes used to classify open-ended responses in these different surveys may be responsible for some of the variation in results. In general, however, the results here suggest that there has not been a notable increase in public knowledge on the health impacts of climate change over the past decade. The fact that only about half of the concerned and less than a third of the disengaged can correctly name one health impact of climate change indicates that levels of knowledge on health and climate remain low among these groups. This speaks to the importance of strategic and ongoing health-focused climate communications

Opportunities and challenges for health framing within climate communications

The results of this study can help researchers and policymakers as they seek to engage the public with more focused, effective, and audience-specific communications on health-related climate issues. While some recent literature points to a health framing as a potentially effective way to engage people across political and ideological divides [17, 18, 56], the results of this study find relatively low concern regarding climate health impacts among the disengaged, and suggests this may not hold true for this audience in

Canada. In other studies testing climate health framing, one found that public health framing in climate communications was effective at a local scale, but “backfired” for discussing impacts at a distance, and increased polarization across the climate concern spectrum [23]. Another study in Manitoba looking at climate change and Lyme disease similarly found a lack of resonance of climate health impacts with more skeptical audiences, and suggested that health messages might be ‘strategically decoupled’ to best engage these audiences depending on the goal of the communicator [14, 21]. Results here suggest that for those less concerned about climate change, discussing the health impacts of climate change may not be more effective for engaging them than other climate change frames such as the economy. On the other hand, for communicating with the alarmed, health frames may be particularly beneficial, as this group is more concerned about impacts on health than impacts on national security and the economy. A summary of key findings and implications for health and climate communications are found in Table 2. Specific written and visual materials with health and non-health related frames were tested in the latter part of this survey study and the results will be published in a subsequent paper.

Table 2
Key findings and implications for health and climate communications

Key findings of public perceptions	*Implications for health and climate communications*
When prompted, most Canadians perceive climate change as harmful to human health.	- There is some resonance of the health harms of climate change, which suggests that a public health framing in climate communications may resonate to some extent with Canadians but not a panacea. - The majority of people are likely open to information about the health risks of climate change, given that they accept that it is harmful.
The alarmed have thought more about, and are relatively more concerned about, climate health impacts than the rest of the Canadian population.	- Variable levels of concern suggest that a health frame is not equally resonant across audiences in Canada and may not be effective to bridge the political divide on climate change. Health framing in climate communications is likely to be more successful in reaching those already worried about climate change (i.e. the alarmed and concerned).
Canadians have different levels of concern about specific health impacts, with highest concern for future generations, food and water security, and respiratory impacts from air quality, and lowest for mental health and heat stroke impacts.	- Communicators seeking to operationalize targeted public health framings in climate change communications may choose to focus on specific health impacts of high or low concern, depending on their objectives. - Climate communicators hoping to reach the largest audiences with messages that resonate might use the areas of highest concern in their messaging. - On the other hand, if a communicator is aiming to increase awareness and concern on climate health impacts of lower concern, they must be aware of the specific audiences that may (or may not) resonate with this message.
Unprompted knowledge of climate change health impacts is high among the alarmed, but remains low among the concerned and disengaged.	- More targeted education on the health impacts of climate change is needed to reach those less concerned and engaged on the issue.

Limitations and areas for future research

A significant limitation of the study was the sample size from Indigenous and racialized communities which was not sufficient for analysis according to ethnicity. This is an important limitation, given that racialized communities are disproportionately impacted by climate change now and into the future, including the health impacts of climate change, due to systemic marginalization and racism [49, 57]. In this way, the survey overlooked a large and potentially significantly at-risk portion of the population. Sufficient sample representation for comparison by race is also important considering previous research in the United States which has found that People of Colour are more often concerned about climate change impacts than white people [58]. Future surveys should ensure sufficient representation from Indigenous and racialized communities through more targeted recruitment and sampling, in order for the results to be applicable and useful to these communities.

Finally, the survey is limited in its scope given a finite number of variables that could be explored and the limitations inherent with measuring evaluative judgments. As Maibach et al [3] explains, “evaluative judgments are not necessarily comprehensive representations of an individual’s “true” attitudes, but rather are based on momentarily accessible, salient information”. The context of the questions within the survey focused on climate change could have influenced participants’ responses. Additionally, the measures here (i.e. concern, awareness, affective assessment, and unprompted knowledge) do not necessarily fully capture issue value or importance. It is possible that people are not overly concerned about the climate health impacts presented, yet they do significantly value health, which may mean that we are underestimating the effectiveness of a health frame. The conclusions drawn with respect to applications in communications framings are limited given that these results just deal with perceptions and do not directly test health frames in communications materials. Test of health framing materials was done in a subsequent part of the survey and will be published in a future article.

Future research should seek further resolution of climate health perceptions and knowledge in Canada and the efficacy of health framing between demographics, geographic regions, and locally germane climate impacts. Studies testing the effects of specific climate and health communication campaigns on uptake of adaptive behaviours and support for policy change are also needed, as an alternative measure of the efficacy of these frames, and would contribute to the evolving literature on climate/health indicators [49]. Additionally, further exploration into the relationship between people’s personal health attitudes, experiences of climate impacts, and perceptions of climate health risks may shed more light on what informs and underlies the different perceptions found here.

Conclusion

This research has investigated public perceptions of the health impacts of climate change across Canada though a nationally-representative online survey that was carried out in the winter of 2020 at the height of the COVID-19 pandemic. We find that awareness, knowledge, and concern about climate health impacts is high among portions of the population, namely those who are “alarmed” about climate change, while remaining lower among other segments of the population who are less engaged on climate change. This study helps to clarify the different climate concern classes across Canada, especially as they relate to health impacts, and provides a more nuanced understanding of national risk perceptions and opportunities to communicate with these various audiences. Health impacts related to food and water, air quality, and worry about future generations were of highest concern, while heat and mental health impacts were of lower concern. Given the extreme heat, wildfires and evacuations that ravaged Canada in the summer of 2021, this study sets a crucial baseline for considering how climate impacts affect perceptions of health risks moving forward. Results from this survey can inform areas of education and communications on health and climate change – of use to public health practitioners and communicators, as well as climate change communicators and researchers. Given the COVID-19 pandemic, there is greater awareness regarding health issues and thus greater potential for strengthening national understanding regarding the relationship between climate change and public health. This study suggests that there is significant work ahead – and thus opportunity – within the Canadian context to

translate climate and health linkages into citizen-level understanding that will meaningfully support the societal-wide climate action that is necessary for a healthy future.

Declarations

Ethics approval and consent to participate: Ethics approval for this research was granted by the University of Winnipeg Human Research Ethics Board. All survey participants were provided a summary of the research and provided written informed consent at the outset of the survey. All procedures were performed in accordance with relevant guidelines

Consent for publication: Not applicable.

Availability of data and materials: The data that support the findings of this study are available from The University of Winnipeg but restrictions apply to the availability of these data, as they will be used in further publications. Requests for the data can be made to the corresponding author.

Competing Interests: The authors declare no conflict of interest.

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Author Contributions: Conceptualization, NC, IM, LC, RR; methodology, NC, IM, LC, RR; formal analysis, NC, LC, KFH, IM; resources and data curation, NC, LC, KFH; writing—first draft preparation, LC; writing—review, editing and final draft NC, IM, KF, LC; supervision, IM, NC; project administration, LC, IM; funding acquisition, IM. All authors have read and agreed to the published version of the manuscript.

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Figures

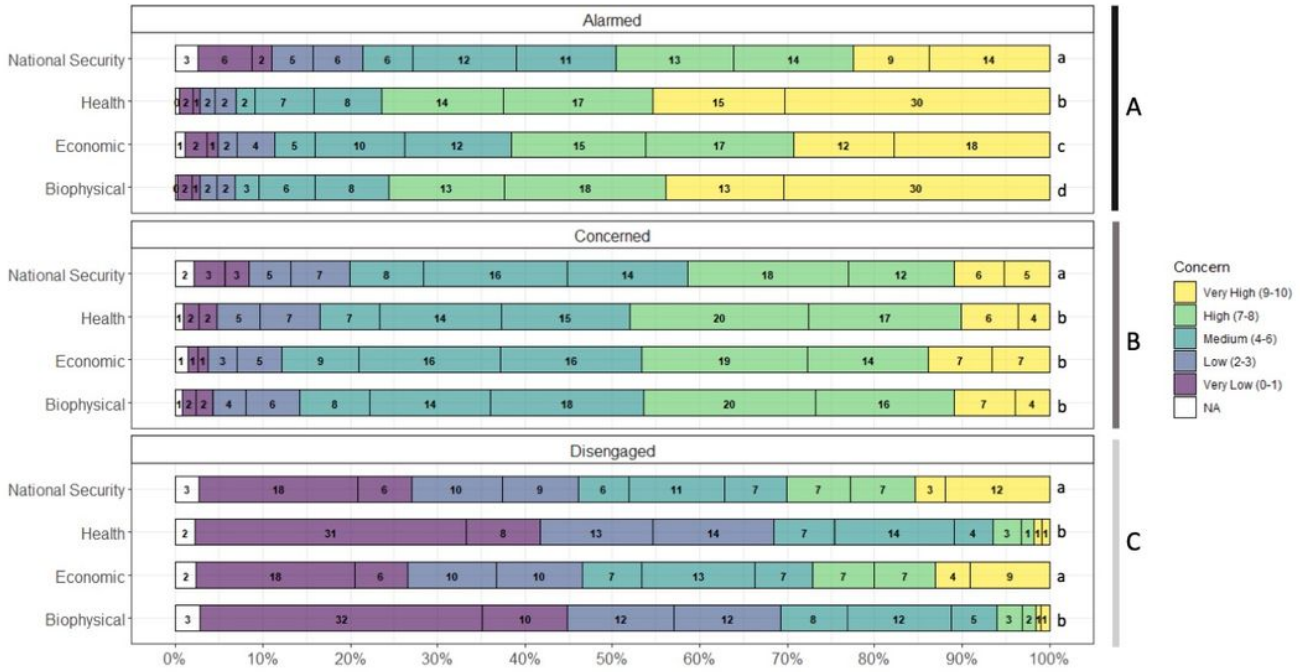

Figure 1

Concern about a range of climate impacts - grouped into the categories of national security, health, economic, and biophysical impacts - compared across alarmed, concerned, and disengaged climate opinion classes (weighted). Lowercase and uppercase letters indicate statistical differences (see S4 Tables 2b and 2c).

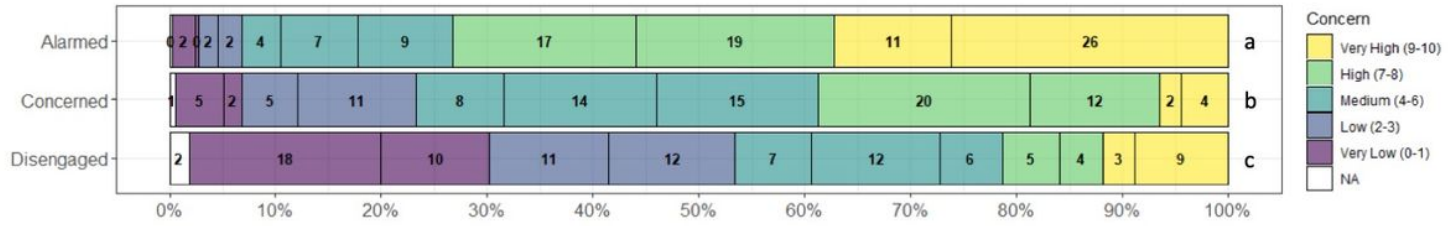

Figure 2

Awareness of the link between climate change and health across the alarmed, concerned, and disengaged climate opinion classes (weighted). Lowercase letters indicate statistical differences (see S4 Table 4a).

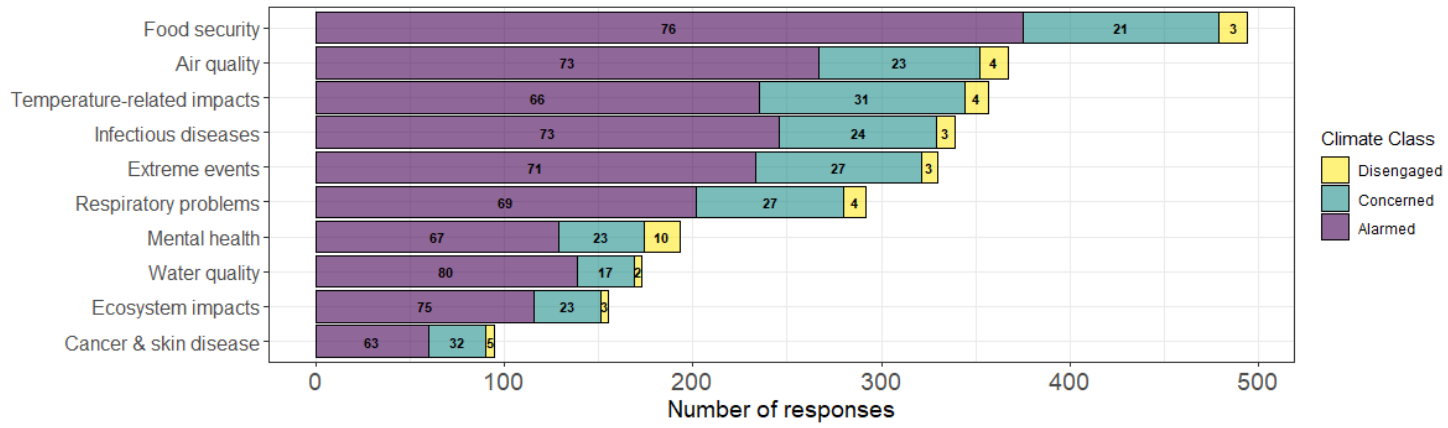

Figure 3

Frequencies of the ten most common health impacts identified by respondents in response to an open-ended question by climate opinion class (unweighted) (indirect answers such as 'vulnerable groups' and 'economic losses' are not included)

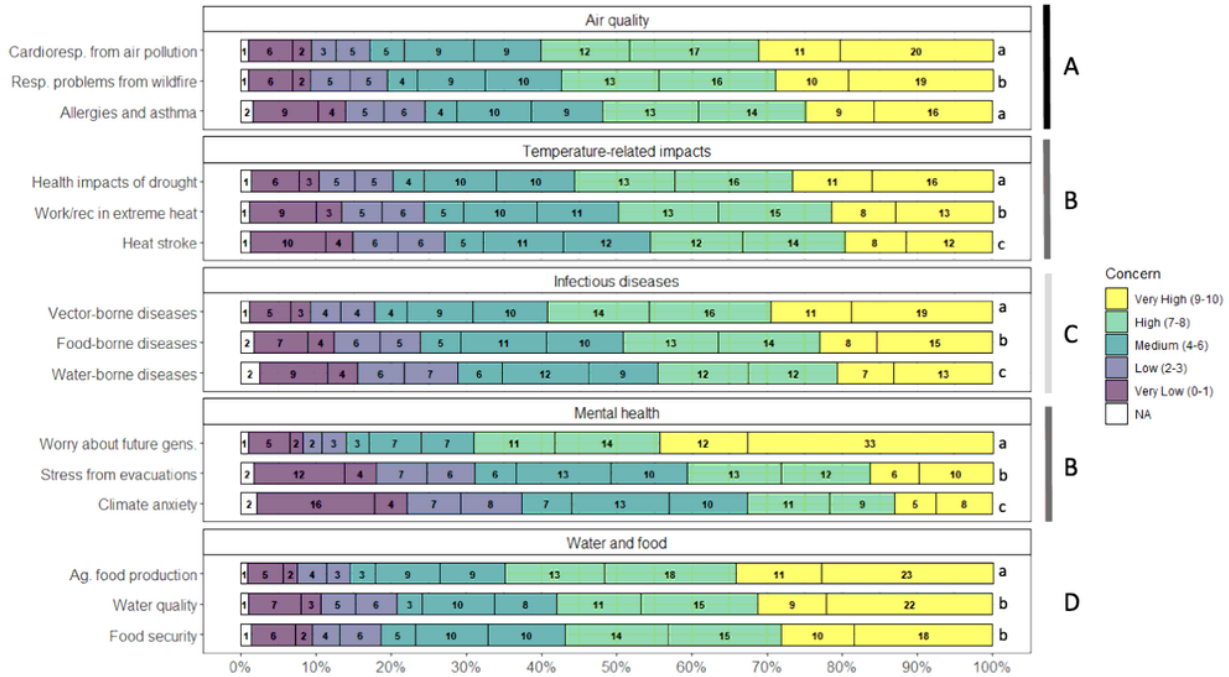

Figure 4

Concern about specific climate health impacts within five categories across the entire sample (weighted). Lowercase and uppercase letters indicate statistical differences (see S4 Tables 3b and 3c). (Note: some of the climate health impacts are abbreviated here; for full text as it was tested in the survey, see questions 38-52 in the survey instrument (S1)).

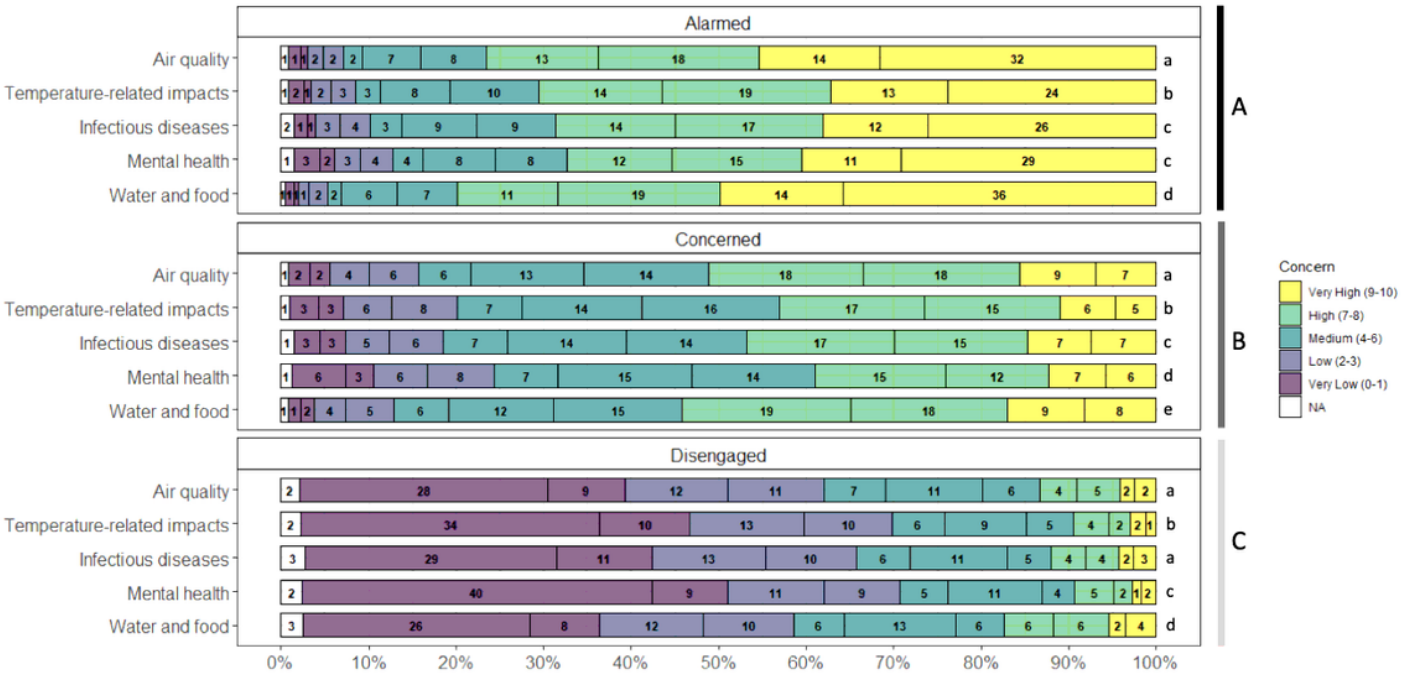

Figure 5

Concern about health impacts of climate change related to water and food, mental health, infectious diseases, heat, and air quality across the three climate concern classes (weighted). Lowercase and uppercase letters indicate statistical differences (see S4 Table 3a and 3d).

Supplementary Files

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