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Association of youth climate change worry with present and past mental health symptoms: a longitudinal population-based study

Francis Vergunst¹ · Caitlin M. Prentice² · Massimiliano Orri^{3,4} · Helen L. Berry⁵ · Vincent Paquin⁴ · Frank Vitaro⁶ · Richard Tremblay^{7,8} · Sylvana M. Côté^{7,9} · Marie-Claude Geoffroy⁴

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Abstract

Young people are worried about climate change but the association with current and past mental health symptoms is rarely examined in longitudinal population-based samples. Drawing on a population-based birth cohort from the Canadian province of Quebec ($n=1325$), this study used a cross-over design to (1) test the association between climate change worry at age 23-years and concurrent mental health symptoms assessed on standardised instruments, and (2) test the association between adolescent (15 and 17 years) symptoms of anxiety, depression, inattention-hyperactivity, and aggression-opposition and climate worry at age 23-years. Participant sex, cognitive ability, socioeconomic status, and parental mental health were adjusted for. Descriptive statistics showed that most participants were worried about climate change: 190 (14.3%) were extremely worried, 383 (28.9%) were very worried, 553 (41.7%) were somewhat worried, and 199 (15.0%) were not at all worried. In analysis 1, worry about climate change was associated with significantly higher concurrent anxiety, depression, and self-harm symptoms, even after adjustment for adolescent symptoms. In analysis 2, anxious adolescents were significantly more likely to be extremely worried about climate change six years later ($RRR=1.51$, $95\%CI=1.10-2.07$), while aggressive-oppositional adolescents were significantly less likely to be somewhat worried ($RRR=0.79$, $95\%CI=0.63-0.99$), very worried ($RRR=0.61$, $95\%CI=0.48-0.78$), or extremely worried ($RRR=0.51$, $95\%CI=0.37-0.72$). Taken together, participants who were worried about climate change had more concurrent mental health symptoms but were also more likely to have prior symptoms. Adolescents with higher anxiety were more likely to worry about climate change in early adulthood, while those with higher aggression-opposition were less likely to worry. Future studies should track climate worry longitudinally alongside symptoms using prospective follow-up studies.

Keywords Climate change · Climate anxiety · Mental health · Prospective · Longitudinal · Youth · Anxiety · Self-harm · Depression · Opposition-defiance · Aggression

Extended author information available on the last page of the article

1 Introduction

Climate change is one of the most pressing challenges facing humanity (IPCC 2022; WHO 2021). Many effects are irreversible and changes to ocean temperatures, sea levels, and ice-sheets will persist for hundreds of years, with profound consequences for ecosystems and human societies (IPCC 2021). Extreme weather events – such as heatwaves, storms, floods, and wildfires – are becoming more frequent, unpredictable and severe and are already undermining human health, wellbeing, education, and livelihoods (Prentice et al. 2024; UNICEF 2021; Vergunst and Berry 2022; WHO 2022). International surveys show that young people are worried about climate change. One large-scale study found that roughly one-half of respondents felt that climate worry affected their daily functioning (Hickman et al. 2021) while reports of clinical presentations of climate worry are also increasing (Budziszewska and Jonsson 2022; Dodds 2021). Given these high levels of reported distress, questions have been raised about the relationship between climate change worry and mental health. Yet few longitudinal studies have examined the link between climate worry and current and past mental health symptoms, which the present study sought to address.

Literature reviews show that the observed and anticipated impacts of climate change elicit complex emotional responses including feelings of fear, worry, anxiety, anger, frustration, guilt, and hopelessness, often tied to observed or anticipated losses associated with climate change (Heeren et al. 2022; Martin et al. 2023; Ojala et al. 2021). These diverse emotional responses differ across individuals and populations and may co-occur within individuals. One view of the problem, which has gained significant media attention, is that climate change worry is contributing to an increase in mental health problems among young people, including rates of anxiety, depression and self-harm (Whitmarsh et al. 2022). Indeed, several multi-national surveys of young people indicate that negative emotions about climate change are associated with self-reported distress, insomnia, and reduced wellbeing (Hickman et al. 2021; Lawrance et al. 2022; Ogunbode et al. 2021, 2022; Sciberras and Fernando 2022). However, most studies have employed cross-sectional designs, or lacked controls for important confounding variables such as pre-existing mental health (Sciberras and Fernando 2022), and therefore cannot address the question of direction of association (Heeren and Asmundson 2022).

While worry about climate change could negatively affect mental health, it may also have an adaptive function, representing a healthy psychological response to a major stressor that lacks tractable solutions (Bhullar et al. 2022; Clayton 2020; Cunsolo et al. 2020). A growing literature shows that many negative climate change emotions, such as worry about climate change and a more pessimistic view of the future, are linked with more pro-environmental attitudes and motivation to participate in collective action (Hogg et al. 2021; Ojala et al. 2021; Pickering and Dale 2023; Verplanken et al. 2020; Whitmarsh et al. 2022). For example, a study of Australian adolescents found that higher climate change worry has been linked with greater societal engagement (Sciberras and Fernando 2022), while a UK study found that climate worry was associated with self-reported efforts to save energy and reduce waste (Whitmarsh et al. 2022). Furthermore, participation in pro-environmental behaviours has been associated with greater feelings of purpose and life satisfaction (Cotton Bronk et al. 2009), but lower levels of wellbeing (Ogunbode et al. 2022), while collective action may moderate the potential effects of climate anxiety on depression symptoms (Schwartz et al. 2022). According to this “adaptive” view, some worry about climate may be an indicator

of better adjustment, even if it entails discomfort for the individual, because it precipitates problem solving and proactive engagement with the problem (Ojala et al. 2021).

Another important unresolved question, alluded to above, is whether individuals with prior mental health problems are more or less prone to worry about climate change. More generally, childhood internalising symptoms, characterised by anxiousness, low-mood, and social withdrawal, are associated with increased risk of anxiety and depressive disorders in adulthood (Hovenkamp-Hermelink et al. 2021; Kagan and Snidman 1999; Willner et al. 2016). Because anxious adults are more likely to worry about any number of things, including climate change (Berry and Peel, 2015), we might expect that people who worry more about climate change also had higher levels of internalising symptoms when they were younger. Our study aimed to test this possibility. Another set of early mental health difficulties that may be relevant to climate worry are externalising problems (Achenbach and Edelbrock 1978; Carragher et al. 2015). Externalising problems are characterised by inattentive, hyperactive, impulsive, oppositional, and aggressive behavioural symptoms that underpin some of the most prevalent and costly childhood psychiatric disorders including ADHD, oppositional defiant disorder, and conduct disorder. Prevalence rates for externalising disorders are high among school aged children with estimates of 6.6% for ADHD (Salari et al. 2023; Sayal et al. 2018), 3.6% for oppositional defiant disorder (Polanczyk et al. 2015), and 3.0% for conduct problems (Ayano et al. 2024). Moreover, many more children exhibit externalising symptoms without meeting criteria for specific diagnoses (Tremblay 2010). Externalising problems are associated with delinquent and antisocial behavior in adolescence and adulthood, including social deviancy and norm violation (Brook et al. 2011; Commisso et al. 2024; Mordre et al. 2011), such that individuals who exhibit these traits might be more likely to reject mainstream views and values, including worry about climate change. Taken together, prior mental health symptoms could increase or decrease the likelihood of future climate worry, depending on whether they are characterised by internalising or externalising problems (Carragher et al. 2015; Willner et al. 2016). Clarifying the association between climate worry and different types of problems would have implications for the provision of tailored support strategies for individuals worried about climate change. The present study sought to address these questions.

1.1 Aims

In this study, we examined the prevalence of climate change worry in a Canadian population-based sample, then, using a cross-over design, tested the association between present and past symptoms. The study had two key aims. First, we examined the link between worry about climate change and concurrent anxiety, depression, and self-harm at age 23 years, assessed on standardised instruments. The purpose of this analysis was to describe and quantify associations between climate worry and contemporaneous mental health symptoms, before and after adjustment for prior symptoms. Second, we examined whether prior internalising and externalising symptoms at age 15 and 17 years were associated with future worry about climate change at age 23 years, before and after adjustment for anxiety symptoms at age 23 years. We adjusted for participant sex, family socioeconomic status, child cognitive ability, and parental mental health, which are known to covary with mental health risk. Furthermore, since sex and socioeconomic status are robustly linked with mental health across the life course, they could moderate the association between adolescent

mental health symptoms and climate change worry at age 23 years. These variables were therefore examined as moderators in our analyses.

2 Methods

2.1 Participants and procedure

Participants came from the Québec Longitudinal Study of Child Development (QLSCD), a population-based birth cohort study of youth living in Quebec ($n=2120$), conducted by the Institut de la Statistique du Québec (ISQ). Participants were born in 1997–1998 in Quebec, Canada, recruited and assessed at age 5 months via their parents and followed up annually (<https://www.iamillbe.stat.gouv.qc.ca/default.htm>) (Orri et al. 2021). At inception, the sample was representative of around 98% of children born to French- and English-speaking mothers, covering a range of socioeconomic backgrounds, but excluding children from indigenous communities and very remote regions of Quebec. The ethnic composition of the sample was 80.1% Caucasian European, 2.8% Native American, 2.9% African/Haitian origin, and 13.9% ‘Other’. Behavioral symptoms and mental health were self-reported at ages 15 and 17 years, and again at age 23 years using standardised questionnaires, described below. Informed written consent, assent, or both were obtained from the children’s parents prior to the present and all prior waves of data collection. The study was approved by the ethical committees of ISQ and Centre Hospitalier Universitaire Sainte-Justine. The 2021 Special Round data collection, conducted during the COVID-19 pandemic when participants were aged 23 years, was approved by the Douglas Research Ethics Committee and by CHU Ste-Justine research ethics committee.

2.2 Climate change worry and mental health symptoms at age 23 years

Participants were asked the question “How worried are you about climate change?” coded on a 4-point Likert scale: 0=not at all worried, 1=somewhat worried, 2=very worried, 3=extremely worried. (This was the first inclusion of climate-related measure in the cohort and additional questions were not possible due to space limitations.) Anxiety was assessed using the well-validated Generalized Anxiety Disorder scale (GAD-7) (Spitzer et al. 2006). The 7-item instrument asks about feelings of anxiety in the past week (e.g., “Feeling nervous, anxious or on edge”) and is scored from 0=not at all to 3=nearly every day for each item. Depression was assessed using the Centre for Epidemiological Studies-Depression Scale, short form (CES-D). This 12-item questionnaire asks about feelings of depression in the past two-weeks (e.g., “I felt depressed”), with items scored from 0=rarely/never to 3=most/all of the time (Ferro et al. 2015; Poulin et al. 2005; Radloff 1977). For the sensitivity analysis, clinically meaningful cut-offs were used, where scores of 21–36 and of 15–21 indicate severe levels of depression and anxiety, respectively, and scores of 12–20 and 10–14 to indicate moderate levels, respectively (Radloff 1977; Spitzer et al. 2006). Non-suicidal self-injury was assessed by asking participants “In the past 12 months, did you ever deliberately harm yourself but not mean to take your life?” Answers were coded as 0=never, 1=rarely, 2=quite often, 3=very often).

2.3 Adolescent mental health

Adolescent mental health symptoms in the past 12-months were self-reported at age 15 and 17 years using the Mental Health and Social Inadaptation Assessment for Adolescents (Côté et al. 2017). Symptoms were assessed in the following domains: anxiety (9 items), depression (8 items), inattention-hyperactivity (16 items), and opposition-aggression (26 items). (Inattention and hyperactivity symptoms were combined due to the sub-scales being highly correlated; aggression and opposition were combined for the same reason). For each item, behaviors were rated on a frequency scale (0=never/not true, 1=sometimes/somewhat true, 2=often/very true). For each symptom category, participant scores were averaged across all items at each time point. Alpha scores for the anxiety, depression, inattention-hyperactivity and aggression-opposition symptoms, at ages 15 and 17 years, ranged from 0.82 to 0.92 (eTable 1). The mean of the combined scores at ages 15 and 17 were used in the analyses.

2.4 Potential confounding factors

We adjusted for several factors previously linked with mental health vulnerability and environmental concern/awareness. Socioeconomic status (SES), which has a well-documented association with mental health, was assessed using a standardized index based on annual gross income, parental education level and occupational prestige (Willms and Shields 1996). The scale has a mean of 0 with a range from -3 to 3 with higher scores indicating higher SES. Family composition was categorized as intact (living with both biological parents) or non-intact (single, separated, divorced, or widowed). Family SES was assessed at age 15 and 17 years with scores averaged across the two time points. Participant cognitive ability, which could affect climate literacy, was assessed at age 41-months using the *Wechsler Intelligence Scale for Children Block Design* (Wechsler 1991), with scores adjusted for participants' relative age in months. Since a family history of mood disorders and antisocial behavior are associated with increased risk of anxiety, depression and self-harm in offspring, we adjusted for parental history of depression and adolescent antisocial behaviours. These measures were obtained at baseline when the study participants were aged 5 months. Parental depression was assessed using the abbreviated version of the *Center for Epidemiologic Studies Depression Scale* (12-item) (Radloff 1977). Parents reported the frequency of depressive symptoms in the past 2 weeks coded on a 4-point scale. The parents' antisocial behavior during adolescence was assessed via a self-report questionnaire. Parents rated the frequency of 5 behaviors during their high school period based on DSM-IV criteria for conduct disorder and antisocial personality disorder. Total scores for all continuous covariates were z-standardised prior to analysis.

2.5 Attrition and missing data

Participants who completed the climate change worry question at age 23 were retained for analysis ($n=1325$, 62.5%). Compared to included participants, excluded participants were more likely to come from lower SES households (small effect size), to have lower childhood cognitive ability (small effect size), to be male (medium effect size), and to have mothers with history of depression (small effect size) (eTable 2). To account for attrition, inverse probability weightings were generated and included in the multivariable models. Missing

covariate data, which ranged from 0% (sex) to 14.0% (paternal depression), were handled using multiple imputations by chained equations (Azur et al. 2011). Models were estimated across 40 datasets and the results were pooled.

2.6 Descriptive statistics and analyses

Descriptive statistics were carried out using correlation analyses and two sample t-tests. Effect sizes were calculated using Cohen's *d* for continuous variables and Cohen's *h* for categorical variables. For the multivariable analyses we used linear regression models for continuous outcomes and multinomial regression for count outcomes with results reported as beta estimates and relative risk ratios (RRR) respectively. To facilitate interpretation of results from the multivariable models, continuous variables were z-standardised prior to analysis (mean=0, SD=1).

Present mental health The first set of multivariable analyses were conducted in several steps. First, we examined the association between worry about climate change at age 23 years (predictor) and contemporaneous mental health symptoms (outcomes), with adjustment for confounders. Separate models were used for each symptom category with robust standard errors applied to account for heteroscedasticity in the continuous outcomes (anxiety and depression). In a second step, we produced a fully adjusted model by also accounting for mental health symptoms at age 15 and 17 years that were significantly associated with climate worry at age 23 years in bivariate associations (decided a priori). Furthermore, as a sensitivity analysis, we examined whether worry about climate change at age 23 was associated with including mild, moderate, or severe anxiety or depression (or infrequent, quite frequent, or very frequent self-harm) based on clinically validated cut-points.

Past mental health The second set of analyses were conducted as follows. First, we use multinomial regression to examine the association between mental health at age 15 and 17 years (predictor) and worry about climate change at age 23 (outcome), with adjustment for confounding factors. Adolescent symptoms that were significantly associated with climate worry at age 23 years in bivariate associations, decided a priori, were included in the analysis i.e., anxiety and aggression-opposition. In the second step, we produced a fully adjusted model by also controlling for anxiety symptoms at age 23 years. Since participant sex and their socioeconomic status (SES) could moderate the association between adolescent symptoms and subsequent climate change, these variables were included as moderators in the analysis (i.e., entered as an interaction). Analyses were conducted using Stata 17.0. Significance thresholds were set at 0.05 and all tests were two-tailed.

3 Results

Of the 1325 participants who completed the question about climate change worry at age 23 years, 199 (15.0%) were not at all worried, 553 (41.7%) were somewhat worried, 383 (28.9%) were very worried, and 190 (14.3%) were extremely worried (Fig. 1). An indepen-

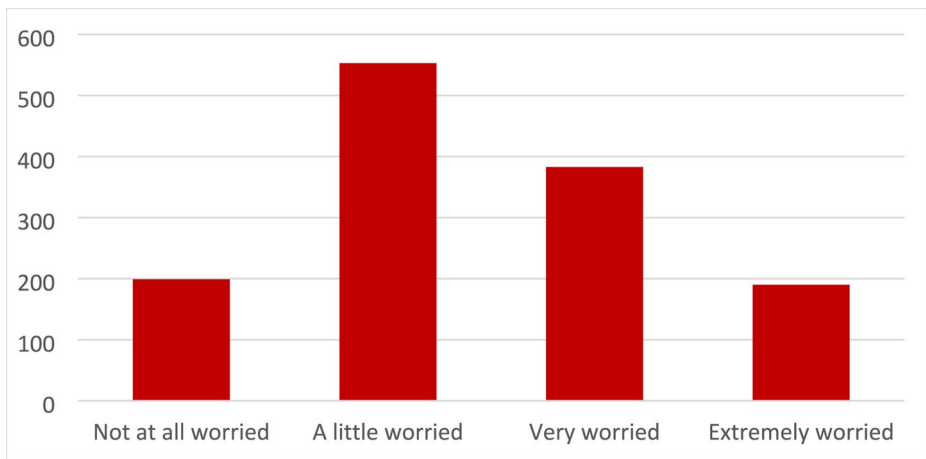


Fig. 1 Self-reported worry about climate change in a population-based sample from Quebec, Canada ($n=1325$). Note – Data were compiled from the final master file of the Québec Longitudinal Study of Child Development (1998–2021), ©Gouvernement du Québec, Institut de la statistique du Québec

Table 1 Mental health symptoms and background characteristics for participants in the Québec Longitudinal Study of Child Development ($n=1350$)

Variable	Mean or N (SD of %)	[Range]
Mental health		
Early adulthood (23 years)		
Anxiety	6.36 (5.33)	[0–21]
Depression	10.32 (6.94)	[0–36]
Self-harm	1.12 (0.41)	[1–4]
Adolescence (15–17 years)		
Anxiety	4.32 (1.99)	[0–10]
Depression	3.70 (2.07)	[0–10]
Aggression-opposition	1.47 (0.91)	[0–6.9]
Inattention-hyperactivity	2.88 (1.52)	[0–9]
Potential confounding factors		
Parental socioeconomic status	0.0 (1)	[-3.07–2.64]
Childhood cognitive ability	6.54 (3.96)	[0–24]
–Female	764 (57.7%)	-
–Male	561 (42.3%)	-
Parental mental health		
Maternal depression	1.35 (1.31)	[0–9.2]
Paternal depression	0.98 (0.95)	[0–7.7]
Maternal antisocial behavior	0.83 (0.95)	[0–5]
Paternal antisocial behavior	0.64 (0.91)	[0–4]

Means show unstandardised scores. Data were compiled from the final master file of the Québec Longitudinal Study of Child Development (1998–2021), ©Gouvernement du Québec, Institut de la statistique du Québec

dent samples t-test indicated that female participants were significantly more likely to be worried about climate change than male participants ($t=-2.61, p=0.009$). Characteristics of the sample, including current and past mental health symptoms, and social and family background characteristics, are shown in Table 1.

The correlation matrix in Table 2 shows that participants who were worried about climate change at 23 years were more likely to have concurrent and past mental health symptoms, to come from higher SES households, to have higher childhood cognitive ability, to be female, and to have a mother without a history of adolescent delinquency. Mental health symptoms at age 23 years were highly correlated: anxiety was correlated with depression ($r=0.74$) and self-harm ($r=0.29$), while depression and self-harm were also correlated ($r=0.35$). Adolescent anxiety and aggression-opposition were associated with later climate worry at age 23 years and were retained for analysis in the multivariable models.

3.1 Present mental health

Multivariable analyses examining the associations between worry about climate change at age 23 and contemporaneous mental health symptoms are shown in Table 3. After adjustment for potential confounding factors, worry about climate change was associated with contemporaneously assessed symptoms of anxiety ($b=0.10$, $95\%CI=0.04-0.17$, $p<0.001$) and depression ($b=0.11$, $0.04-0.19$, $p<0.001$). Relative to participants who reported “never” self-harming in the past 12-months, participants who were worried about climate change were more likely to report self-harming “rarely” ($RRR=1.28$, $p=0.047$), “quite often” ($RRR=1.69$, $p=0.027$), and “very often” ($RRR=3.24$, $p=0.011$) in the past 12-months. Further adjustment for prior (anxiety and aggression-opposition symptoms at age 15 and 17 years) marginally attenuated the estimates. The sensitivity analysis showed that worry about climate change was associated with clinically “severe” depression ($RRR=1.47$, $p=0.002$) and self-harm that was occasional ($RRR=1.28$, $p=0.047$), frequent ($RRR=1.69$, $p=0.027$) and very frequent ($RRR=3.24$, $p=0.012$), while the association with severe anxiety did not reach statistical significance ($RRR=1.13$, $p=0.066$) (eTable 3). As in the main analysis, these estimates were attenuated somewhat by adjustment for symptoms at age 15 and 17 years. Overall, worry about climate change was associated with higher contemporaneous mental health symptoms in both unadjusted and adjusted statistical models.

3.2 Past mental health

Table 4 shows the associations between anxiety and aggression-opposition in adolescence (age 15 and 17 years) and climate worry six years later at age 23 years. In the partially adjusted model, a 1 SD increase in adolescent anxiety was associated with increased relative risk of 33% for being very worried ($RRR=1.33$, $95\%CI=1.02-1.73$) and 68% for being extremely worried ($RRR=1.68$, $95\%CI=1.25-2.26$). In contrast, a 1 SD increase in adolescent aggression-opposition was associated with 33% decreased risk of being somewhat worried ($RRR=0.77$, $95\%CI=0.63-0.95$), a 40% decreased risk of being very worried ($RRR=0.60$, $95\%CI=0.47-0.76$), and a 48% risk of being extremely worried ($RRR=0.52$, $95\%CI=0.38-0.71$). Neither inattention-hyperactivity nor depression symptoms in adolescence were significantly associated with climate worry at age 23-years. Further adjustment of the model to account for anxiety symptoms at age 23 years led to a small attenuation of the estimates (Table 4). Neither participant sex nor SES moderated the association between behavioral problems in adolescence and worry about climate change at age 23 years in partially or fully adjusted models (eTable 4). Taken together, this set of analyses revealed that the extent to which participants worried about climate change was partially explained by

Table 2 Bivariate associations between worry about climate change at age 23 and present and past mental health and background factors

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Climate change worry (23 yrs)	1													
2. Anxiety (23 yrs)	0.10**	1												
3. Depression (23 yrs)	0.12**	0.74**	1											
4. Self-harm (23 yrs)	0.14**	0.29**	0.35**	1										
5. Anxiety (ado.)	0.10**	0.34**	0.35**	0.14**	1									
6. Depression (ado.)	0.04	0.33**	0.38**	0.15**	0.78**	1								
7. Aggression-opposition (ado.)	-0.14**	0.17**	0.15**	0.11**	0.35**	0.42**	1							
8. Inattention-hyperactivity (ado.)	-0.01	0.24**	0.23**	0.08**	0.52**	0.61**	0.67**	1						
9. Socioeconomic status (ado.)	0.01	-0.01	-0.03	-0.03	-0.03	-0.03	-0.9**	-0.05	1					
10. Child cognitive ability	0.12**	-0.09*	-0.06	-0.00	-0.02	-0.02	-0.07*	-0.09**	0.11**	1				
11. Sex (f)	0.07**	0.22**	0.18**	0.05	0.37**	0.37**	-0.00	0.08**	-0.03	0.05	1			
12. Maternal depression	0.02	0.02	0.02	0.07	0.05	0.02	0.05	0.05	-0.03	-0.02	0.03	1		
13. Paternal depression	-0.02	-0.01	0.01	0.04	0.02	0.01	0.00	-0.00	-0.03	0.01	-0.03	0.24	1	
14. Maternal delinquency	-0.08**	-0.06	-0.02	-0.01	-0.06*	-0.03	0.03	0.03	-0.07	-0.02	-0.08**	0.10	0.07*	1
15. Paternal delinquency	-0.05	0.03	0.04	0.03*	0.01	-0.01	0.02	0.04	-0.09	-0.09**	-0.05	0.06	0.09**	0.17**

*Sig at the .05 level, **Sig at the .01 level. Ado. =adolescence (15 and 17 years). Data were compiled from the final master file of the Québec Longitudinal Study of Child Development (1998–2021), ©Gouvernement du Québec, Institut de la statistique du Québec

Table 3 Association between worry about climate change at age 23 years and contemporaneous mental health symptoms

	Anxiety ^c			Depression ^d			Self-harm ^e								
	b	p-value	95% CI	b	p-value	95% CI	IRR ^f	p-value	95% CI						
Partially adjusted model ^a															
Climate change worry	0.10	0.007	0.03 0.17	0.11	0.003	0.04 0.19	1.28	0.047	1.0 1.63	1.69	0.027	1.06 2.71	3.24	0.011	1.30 8.11
Fully adjusted model ^b															
Climate change worry	0.09	0.005	0.03 0.16	0.10	0.002	0.04 0.18	1.31	0.032	1.02 1.68	1.77	0.021	1.09 2.88	3.13	0.017	1.23 7.95

*b*standardised beta. *RRR*relative risk ratio. ^aAdjusted for participant sex, family socioeconomic status, childhood cognitive ability, maternal and paternal history of depression and antisocial behavior. ^bAlso adjusted for anxiety and aggression-opposition symptoms at age 15 and 17 years assessed with the Mental Health and Social Inadaptation Assessment for Adolescents (Côté et al. 2017). ^cGeneralized Anxiety Disorder scale (GAD-7) (Spitzer et al. 2006). ^dCentre for Epidemiological Studies-Depression Scale, short form (CES-D) (Ferro et al. 2015; Radloff 1977). ^eParticipants were asked “In the past 12 months, did you ever deliberately harm yourself but not mean to take your life?” Responses were coded as 0=never, 1=rarely, 2=quite often, 3=very often, with participants who responded “never” treated as the reference group (not shown). ^fSelf-harm “rarely”. ^gSelf-harm “quite often”. ^hSelf-harm “very often”. Data were compiled from the final master file of the Québec Longitudinal Study of Child Development (1998–2021). ©Gouvernement du Québec, Institut de la statistique du Québec

Table 4 Association between adolescent mental health problems and worry about climate change at age 23 years

	Not worried		Somewhat worried		Very worried		Extremely worried						
	RRR	p-value	RRR	p-value	RRR	p-value	RRR	p-value					
Partially adjusted model ^a													
Anxiety	Ref	1.22	0.111	0.96	1.55	1.33	0.034	1.02	1.73	1.68	0.001	1.25	2.26
Aggression-opposition	Ref	0.77	0.016	0.63	0.95	0.60	0.001	0.47	0.76	0.52	0.001	0.38	0.71
Fully adjusted model (anxiety at age 23) ^b													
Anxiety	Ref	1.16	0.225	0.91	1.50	1.24	0.113	0.95	1.64	1.51	0.011	1.10	2.07
Aggression-opposition	Ref	0.79	0.037	0.63	0.99	0.61	0.001	0.48	0.78	0.51	0.001	0.37	0.72

RRR relative risk ratio. ^a Adjusted for participant sex, family socioeconomic status, childhood cognitive ability, and maternal and paternal history of depression and antisocial behavior. ^b Also adjusted for anxiety symptoms at age 23 assessed using the Generalized Anxiety Disorder scale (GAD-7) (Spitzer et al. 2006). Anxiety and aggression-opposition symptoms measured at age 15 and 17 years using the Mental Health and Social Inadaptation Assessment for Adolescents (Côté et al. 2017). Data were compiled from the final master file of the Québec Longitudinal Study of Child Development (1998–2021), ©Gouvernement du Québec, Institut de la Statistique du Québec

their previously reported mental health symptoms, such that participants who were anxious in adolescence were more likely to worry about climate change at age 23 years, while those who were aggressive-oppositional in adolescence were less likely to worry about climate change at age 23.

4 Discussion

This Canadian population-based study examined the association between worry about climate change at age 23 years and present and past mental health symptoms. Most participants were worried about climate change with more than four-in-five reporting being at least “somewhat worried”. In the first analysis, participants who were worried about climate change had significantly higher concurrent symptoms of anxiety, depression, and self-harm behaviours (including clinically significant levels of depression and self-harm). These associations were partially explained by mental health symptoms reported six years earlier. Further analyses showed that adolescents with higher anxiety symptoms at age 15 and 17 years were significantly more likely to worry about climate change at age 23 years, while adolescents with higher aggression-opposition symptoms were significantly less likely to worry about it, even after adjustment for contemporaneous anxiety symptoms. Adolescent inattention-hyperactivity and depression symptoms were not significantly associated with subsequent worry about climate change. Our results underscore the need for caution when interpreting cross-sectional associations between climate worry and contemporaneous psychological distress without adjusting for prior mental health symptoms.

On a descriptive level, our results show that young Canadians share the same high levels of worry about climate change as their international peers. For example, a widely cited survey of 10,000 young people aged 16–25 years across ten countries found that 84% of respondents were at least moderately worried about climate change, and 59% were very or extremely worried, with only 5% reporting being “not at all worried” (Hickman et al. 2021). These figures match those reported in a more recent population survey of 1000 young Canadians aged 16–25 years in which only 5% reported being “not at all worried” about climate change (Galway and Field 2023). A recent international study of more than 59,000 adults from 63 countries found that 86% of respondents were at least somewhat concerned about climate change, as measured by questions about whether climate change was a serious threat to humanity and whether action was necessary to avoid a global catastrophe (Vlasceanu et al. 2024). Our results support growing evidence that young people are highly, and increasingly, concerned about climate change.

Consistent with most previous studies, we found that female participants were significantly more concerned about climate change than male participants (Martin et al. 2023). This may be because of their increased vulnerability to climate change impacts and lack of perceived influence over important climate-related decision making (Hunter et al. 2004; IPCC 2022; MacGregor 2010; McCright and Xiao 2014). Girls and women are also known to show higher concern for environmental causes more generally possibly due to socialisation around gender-based nurturing and care-giving roles (Hunter et al. 2004; McCright and Xiao 2014). We did not find that participant sex or socioeconomic background moderated the relationship between adolescent symptoms and climate worry at age 23 years, possibly due to small effects and a lack of statistical power to detect them.

Results from our longitudinal analyses indicate that current climate worry is related to prior mental health symptoms and caution is needed when interpreting cross-sectional associations in which causality cannot be determined. Although causal links between climate worry and psychological distress have been implied in a number of reports, especially in the popular media, most studies are cross-sectional, or lack key control variables, and reverse causation is possible and indeed likely (Taylor 2020). Our findings suggest that prior mental health partially, though not fully, explains individual differences in climate worry and its association with contemporaneous symptoms, most likely because past anxiety predicts future anxiety (Copeland et al. 2009; Hovenkamp-Hermelink et al. 2021).

To our knowledge, this is the first study to show a significant negative association between aggressive-oppositional behaviours and subsequent worry about climate change. This is significant because these traits are core features of some of the most prevalent childhood psychiatric disorders (Barican et al. 2022), including conduct disorder and oppositional defiant disorder, and they are also prevalent in population-based samples (Broidy et al. 2003). One explanation for this finding is that aggressive-oppositional youth are more likely to exhibit antisocial social behaviours, characterised by low straightforwardness, low compliance, and low deliberation (Jones et al. 2011), with the result that “mainstream” beliefs about issues such as climate change are more likely to be rejected. Accordingly, self-reported worry about climate change could be a consequence of underlying political identity and value signaling in addition to interactions with pre-existing psychological states on the other (Berry and Peel 2015; Heeren and Asmundson 2022). The fact that aggressive-oppositional behaviours are more prevalent in males could also partially explain the well-documented observation that levels of climate worry are lower in this group than among females (Martin et al. 2023).

A broader question that emerges from our findings concerns the adaptiveness of negative psychological responses to the observed threat of climate change. Here, research has produced conflicting findings. For example, concern and worry about climate change are usually correlated with greater engagement with news and politics, more pro-environmental behaviours, and more proactive engagement in collective action (Hogg et al. 2021; Ojala et al. 2021; Pickering and Dale 2023; Verplanken et al. 2020; Whitmarsh et al. 2022). The states of “eco-depression” and “eco-anger” have similarly been linked with a greater likelihood of engaging in collective action, while “eco-anxiety” has been linked with a lower likelihood of engagement in some studies (Stanley et al. 2021) and higher engagement in others (Anneser et al. 2024; Ogunbode et al. 2022). Heeren and colleagues have suggested that the adaptiveness of climate worry and engagement could be explained by the strength of the link between relevant cognitive and emotional responses to the problem (Heeren et al. 2022). Using network analysis, they found that people whose cognitive understandings of climate change was less strongly linked to their emotions were more likely to engage in action while maintaining mental resilience (adaptive response), while those with a stronger link between climate-related cognitions and emotions experienced greater functional impairment (maladaptive response). Further studies are needed to replicate these findings and establish the temporal relationship between climate worry and the cognitive, emotional and behavioural domains using longitudinal designs or by experimentally manipulating the constituent dimensions.

Another consideration is that climate worry and climate anxiety, though related, may be conceptually and empirically distinct. For example, Whitmarsh and colleagues reported that

worry about climate change was widespread in a UK adult population sample, but climate anxiety measured by Clayton and Karaszia's climate anxiety scale was much less prevalent (Whitmarsh et al. 2022). There is no consensus on how to define negative psychological responses to climate change and a recent systematic review concluded that we still lack high quality instruments (Martin et al. 2023). At a minimum, a clearer distinction between worry and anxiety seems necessary, since they are overlapping but distinct concepts. Worry is understood to have a stronger cognitive component (Tallis et al. 1991), characterised by intolerance of uncertainty and a distinct problem-solving style (Newman et al. 2013; Zebb and Beck 1998), while anxiety relates to emotional and physiological responses including measures of negative affect (Newman et al. 2013; Zebb and Beck 1998). Furthermore, worry is an important feature of anxiety disorders, especially generalised anxiety disorder (Olatunji et al. 2010), and is therefore subsumed by anxiety. Future studies on climate change worry and "climate anxiety" should better address these distinctions.

Climate change is affecting every region on earth and the impacts on human societies are widely visible (IPCC 2021, 2022; Romanello et al. 2022; Vergunst et al. 2022). Arguably, it is irresponsible, even irrational, to *not* worry. As such, raising public awareness and concern about climate change should be given greater policy priority and customised messaging is more likely to succeed. Our findings suggest that strategies to engage young people might be tailored according to mental health characteristics – for example, anxious adolescents may benefit from strategies that offer support and engage them in action while approaches focused on education and awareness may be more appropriate for aggressive-oppositional youth. Previous work shows that the correct framing of climate change – specifically as a collective problem with collective solutions – can bolster pro-environmental behaviours and political action (Noth and Tonzer 2022; Obradovich and Guenther 2016; Schwartz et al. 2022). Importantly, evidence from meta-analyses shows that environmental education for children and adolescents can improve environmental knowledge, attitudes, intentions, and behaviour (van de Wetering et al. 2022). Such interventions have the co-benefit of building social cohesion around the shared challenge of adapting to climate change which is itself a powerful protective factor for mental health (Berry 2009).

4.1 Strengths and limitations

The strengths of the study include the large population-based birth cohort design, its repeated mental health assessments, standardised symptom measures, and robust confounding control. Several limitations should also be highlighted. First, our study revealed a significant association between worry about climate change and concurrent anxiety, depression, and self-harm – even after adjustment for adolescent anxiety and depression symptoms. One interpretation is that worry about climate change is linked to increasing internalising symptoms in a way that is causal. Although our study cannot address this question, no previous studies, to our knowledge, have convincingly demonstrated such causal links. Indeed, the reverse is likely preponderant, namely that anxious and depressed individuals are more likely to worry about any number of things, including climate change. Future studies using longitudinal cross-lag models are needed to investigate the bidirectional associations between climate worry and mental health problems. Second, our study lacked earlier assessments of climate worry, so it is possible that climate worry was already contributing to an increase in symptoms in adolescence. While this is plausible for anxiety, depression, and self-harm symptoms, it seems

unlikely that climate worry – or lack-of-thereof – led to an increase in self-reported aggressive-oppositional behaviours. Third, we used a single-item measure of climate worry which cannot capture the diversity of psychological and emotional responses associated with concern about climate change. Further work is needed to clearly define negative psychological responses to climate change, including climate worry, for which there remains a lack of quality instruments (Martin et al. 2023). Fourth, the study used self-reported measures of climate anxiety and mental health problems. This may have artificially increased the strength of associations due to shared method variance. Fifth, the study cohort had some attrition across follow-up, resulting in a final sample with lower-than-average psychopathology compared to the original population. This could reduce the generalisability of our findings, which likely represent a more conservative estimate of the true association. Sixth, and relatedly, our study is based on a Canadian settler population and is therefore not necessarily representative of the experiences of the global majority (Deivanayagam et al. 2023; Martin et al. 2023). More specifically, our study did not include participants living in indigenous communities, who have been identified as being especially vulnerable to climate change impacts, and who may have different climate change worries and mental health needs, when compared to the settler majority in Quebec (Lebel et al. 2022).

4.2 Summary and conclusions

This Canadian population-based study found high levels of worry about climate change among young people, with more than four-in-five expressing at least some level of concern. We found significant associations between climate worry and concurrent symptoms, including clinically significant symptoms, although these associations were partially explained by prior mental health. Specifically, adolescents who were already anxious at age 15 and 17 years were more likely than their peers to subsequently worry about climate change at age 23 years, while aggressive-oppositional adolescents were less likely to do so. Further work is needed to understand the link between mental health characteristics and climate worry so that individuals can be effectively supported. More broadly, this study shows that climate change worry in adolescents and young adults cannot be understood using a one-size-fits-all approach. Both mental health professionals and educators, especially those located in formal education contexts, are well-placed to help develop and implement differentiated programs that foster healthy and adaptive responses to climate change.

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Data availability To protect participant confidentiality, the data used in this study are not publicly available. They can be accessed by arrangement with Institut de la Statistique du Québec via participating Canadian universities.

Declarations

Ethical The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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