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RECEIVED 30 January 2025

ACCEPTED 11 March 2025

PUBLISHED 31 March 2025

CITATION

König L, Schröder R, Breves P, Linnemann GA, Hamer T and Suhr R (2025) Climate change distress and impairment among adolescents in Germany.
Front. Clim. 7:1568676.
doi: 10.3389/fclim.2025.1568676

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Climate change distress and impairment among adolescents in Germany

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Introduction: Climate change is one of the most consequential challenges in the 21st century with widespread consequences, including its effect on mental health. A recently developed questionnaire distinguishes between the affective responses to climate change, including negative emotions (distress), and functional impairments. Adolescents are considered particularly vulnerable but have not yet been studied concerning these dimensions. This study investigates the prevalence and distribution of climate change distress and impairment and their association with sociodemographic factors and health literacy in a representative sample of adolescents living in Germany.

Materials and methods: In a cross-sectional quota-based survey, $N = 1,021$ adolescents (inclusion criteria: age 12–17 years, enrollment in school, living in Germany, sufficient German knowledge) completed an online or face-to-face interview assessing the climate change distress and impairment scales (CC-DIS), sociodemographic information and a health literacy questionnaire (HLS-EU-Q16). ANOVAs and t -tests were used to analyze differences between sociodemographic groups and different levels of health literacy.

Results: The results show that many adolescents are both distressed and impaired by climate change. Higher distress was found in girls vs. boys, those with high vs. low levels of education and high social status vs. lower social status. Higher impairment was found in girls vs. boys, 14–15-year-olds vs. 12–13-year-olds and 16–17-year-olds, those with low vs. high levels of education, and those with inadequate and problematic vs. adequate health literacy.

Discussion: Further research is needed to explore the underlying mechanisms and develop effective strategies to support adolescent mental health in the face of climate change.

KEYWORDS

climate change, distress, impairment, mental health, survey, adolescents

1 Introduction

Climate change presents one of the most pressing challenges of the 21st century with far-reaching consequences for the environment, public health and global politics (Romanello et al., 2021; World Meteorological Organization, 2024). For example, climate change can have negative effects on both physical and mental well-being. Climate change affects these outcomes both directly and indirectly (Clemens et al., 2022; Jarrett et al., 2024). Examples for direct effects on mental health include posttraumatic stress disorders and affective disorders

following the experience of climate change-induced natural disasters (Clemens et al., 2022; Jarrett et al., 2024). Indirect effects may occur through loss of land, food insecurities or migration experiences as a consequence of climate change. Additionally, increased awareness of climate change can indirectly lead to negative affective responses, e.g., feelings of frustration and hopelessness (Clemens et al., 2022; Jarrett et al., 2024).

In recent years, new phenomena of climate-change related affective responses have been observed and conceptualized, including *eco-anxiety* and *climate anxiety* (Coffey et al., 2021; Kurth and Pihkala, 2022; Pihkala, 2022; Boehme et al., 2024). While a uniform definition of these phenomena is still subject of ongoing debate, many publications refer to *eco-anxiety* as a broad range of negative emotions related to climate change and environmental threats whereas *climate anxiety* is more specifically related to anthropogenic climate change (Coffey et al., 2021). These constructs are correlated with a variety of different outcomes including negative states such as low mental health and increased stress as well as concrete environmental attitudes and behaviors (Boluda-Verdú et al., 2022; Léger-Goodes et al., 2022).

However, an important distinction lies between the affective responses to climate change, including negative emotions such as anger, anxiety and sadness, and functional impairments related to – and possibly resulting from – climate change (Heeren et al., 2023; Chan et al., 2024). Negative affective responses to climate change do not necessarily imply long-lasting negative health consequences for the individual experiencing these emotions. Rather, they might even promote adaptive behavior including pro-environmental actions (Boluda-Verdú et al., 2022; Heeren et al., 2023). Climate change impairment, however, might require immediate action to prevent potential negative health consequences (Hepp et al., 2023). While functional impairment is already incorporated in at least one widely used questionnaire to assess climate anxiety, it is not separated from the affective dimension of climate anxiety in this questionnaire so that the two dimensions cannot be investigated independently (Clayton, 2020). To fill this gap, recently, a new questionnaire has been developed and validated focusing on the differentiation of climate change distress as an umbrella term for negative emotional responses to climate change and climate change impairment that covers general, social and work or school related impairment (Hepp et al., 2023). The initial validation of the questionnaire pointed to satisfactory convergent and discriminant validity (Hepp et al., 2023). Since then, the questionnaire has been employed in a large sample representative of the population in Germany showing associations with sociodemographic and health-related measures including health literacy (König et al., 2024a), which refers to knowledge, motivation and competencies with regard to accessing, understanding, appraising and applying health-related information (Sørensen et al., 2012). Specifically, it has been shown that women, individuals under the age of 30, people from West Germany, and those with a high level of formal education experience higher levels of climate change distress. Higher levels of climate change impairment are experienced by women, people over 65 years, people from West Germany, people with a low level of formal education, people with a low or middle social status, and people with inadequate or problematic health literacy (König et al., 2024a). This pattern of results underlines that climate change distress and impairment are distinct concepts unevenly distributed in the general population and that they relate to health-related outcomes such as health literacy.

Critically, due to the novelty of the measure to our knowledge no further large-scale investigations on the climate change distress and impairment questionnaire have been conducted to date, despite its promising and innovative focus on impairment (Hepp et al., 2023). The lack of research in different samples, e.g., different age groups and nationalities, is an important gap in the literature that needs to be addressed in order to gain insight into how climate change distress and impairment are distributed in different communities, to strengthen the questionnaires' validity and to inform future studies. Adolescents present a particularly interesting group for studies on climate change consequences as younger generations will be disproportionately more affected by these (Clemens et al., 2022; Léger-Goodes et al., 2022; Proulx et al., 2024). Adolescents experience a variety of mostly – but not exclusively – negative emotional responses to the awareness of climate change, including anger, sadness and guilt (Léger-Goodes et al., 2022). However, little is known regarding their impairment in relation to climate change. In addition, the relationship between levels of health literacy and climate change distress and impairment has not yet been investigated in this target group. Therefore, the present study seeks to investigate for the first time the prevalence and distribution of climate change distress and impairment in adolescents with the help of a large representative sample of adolescents living in Germany. In addition, we seek to explore how sociodemographic factors and health literacy relate to climate change distress and impairment in order to analyze and discuss differences and similarities to the general population (König et al., 2024a).

2 Materials and methods

2.1 Ethical considerations

The study was conducted in accordance with the ethical principles set out in the Declaration of Helsinki, as well as with local and institutional legislation. The study protocol was submitted to the ethics committee of the Berlin Medical Association, which did not raise any ethical or professional objections (reference number Eth-64/23). Informed consent to participate in the study was obtained from all participants as well as from parents or legal guardians for participants aged 15 and younger. Participants were permitted to withdraw from the study at any given time without any negative consequences. The independent non-profit foundation Stiftung Gesundheitswissen did not offer any form of compensation to participants. Only anonymized data was provided to the foundation.

The data presented in this paper was collected as part of a larger research project focusing on a variety of different topics (health literacy, eating disorders, depression, social media usage, climate change distress and impairment, health and health behaviors, sociodemographic factors). In order to optimize resource use, sample recruitment and data collection for these different research objectives were combined in a single online survey. However, the results are presented in separate publications (König et al., 2024a; König et al., 2024b, 2024c) to allow in-depth analyses and discussion for each topic. It is likely that additional publications will arise from the multi-thematic research project in the future.

2.2 Data acquisition and sampling

A cross-sectional quota-based survey with standardized questionnaires was used for data collection. Data collection was carried out by the market research institute GIM (Gesellschaft für innovative Marktforschung mBH) with a mixed-mode approach. About two thirds of all interviews were conducted as online questionnaires with the help of an online-access panel, the remaining interviews were conducted as computer-assisted face-to-face interviews. Inclusion criteria for the study were: age 12–17 years, enrollment in school at the time of data collection, living in Germany, and sufficient knowledge of the German language to complete the interviews. A minimum sample size of at least 1,000 adolescents was aimed for. Sampling was based on quotas of the study population regarding age (12–13 years, 14–15 years and 16–17 years), gender and type of school. Quotas were informed by data from the German Federal Statistics Office, the ma Radio survey and the most recent Mikrozensus. Survey weights were provided and calculated by the research institute in an iterative procedure with the following weight variables and combinations: age × gender, level of education and federal state. Sample characteristics before and after the weighting procedure can be found in [Table 1](#).

2.3 Measures

2.3.1 Sociodemographic information

Participants were asked to indicate their gender (male, female, diverse) and age and were grouped into three age groups for further analyses (12–13 years, 14–15 years and 16–17 years).

In addition, participants were asked to provide the type of school they currently attend. This information was used to categorize participants into two levels of education (low and high). High levels of education were assigned to those individuals who currently attend the most advanced type of secondary school, where a general university entrance qualification can be obtained (i.e., *Gymnasium*). Pupils from all other types of school were assigned to the low level of education category.

Social status was assessed using the German version of the revised Family Affluence Scale (FAS-III; [Torsheim et al., 2016](#); [University Medicine Greifswald, 2024](#)). The FAS-III consists of six items with two to four response options. Each item refers to the living situation of the respondent's family, e.g., the number of computers, laptops or tablets they own. Answers were added up across all items and a final sum score was calculated (range 0–14). Three social status groups were determined based on this sum score, i.e., low (scores 0–5), middle (scores 6–9) and high social status (scores 10–14; [Corell et al., 2021](#); [Moor et al., 2024](#)).

In addition, participants were grouped according to the region they live in, i.e., East Germany (former territory of the German Democratic Republic, i.e., the states of Brandenburg, Mecklenburg Western Pomerania, Saxony, Saxony-Anhalt, Thuringia), and West Germany (all other states, including Berlin).

Participants were asked to indicate if they had a migration background or not. A migration background was defined as being born outside Germany or having at least one parent who was born outside Germany.

TABLE 1 Sample characteristics of the weighted and unweighted sample of adolescents.

Variable	Unweighted sample, N (%)	Weighted sample, N (%)
Gender		
Male	514 (50.3%)	527 (51.6%)
Female	504 (49.4%)	492 (48.2%)
Diverse	3 (0.3%)	3 (0.3%)
Age		
12–13 years	340 (33.3%)	339 (33.2%)
14–15 years	346 (33.9%)	343 (33.6%)
16–17 years	335 (32.8%)	339 (33.2%)
Level of education		
Low	603 (59.1%)	603 (59.1%)
High	418 (40.9%)	418 (40.9%)
Social status		
Low	115 (11.3%)	114 (11.2%)
Middle	668 (65.4%)	666 (65.2%)
High	238 (23.3%)	241 (23.6%)
Migration background		
Yes	194 (19.0%)	194 (19.0%)
No	827 (81.0%)	827 (81.0%)
Region		
East	151 (14.8%)	145 (14.2%)
West (incl. Berlin)	868 (85.0%)	874 (85.6%)
Health literacy		
Inadequate/problematic	548 (53.7%)	544 (53.3%)
Adequate	473 (46.3%)	477 (46.7%)

Due to sample weighting and rounding, percentages may exceed or fall below 100%.

2.3.2 Climate change distress and impairment

To assess climate change distress and impairment the German version of the recently developed climate change distress and impairment scale (CC-DIS) was employed ([Hepp et al., 2023](#)). The scale consists of 15 items on climate change distress including anger, sadness and anxiety related to climate change as well as eight items on climate change impairment covering general, social and work-related impairment. Responses to each item are collected on a 5-point Likert scale ('strongly disagree', 'disagree', 'neutral' [neither agree nor disagree], 'agree', 'strongly agree', corresponding to the values from one to five). A total of nine items are reverse-coded and were recoded for further analyses. A mean score is calculated separately for each subscale by adding up responses across the items of that subscale and dividing this sum score by the number of items (15 and eight, respectively). In this mean score, higher values denote higher climate change distress and impairment, respectively.

2.3.3 Health literacy

Health literacy was assessed with the short version of the German translation of the Health Literacy Survey Instrument (HLS-EU-Q16; [Sørensen et al., 2013](#); [Pelikan et al., 2014](#); [Jordan and Hoebel, 2015](#)).

In this 16-items questionnaire, participants are asked to indicate their subjective difficulty in accessing, understanding, appraising and applying information on the subjects of healthcare, disease prevention and health promotion. Each item is answered on a 4-point Likert scale ('very easy', 'fairly easy', 'fairly difficult', 'very difficult'). For further analysis, item responses are dichotomized (1 = 'very easy' and 'fairly easy', and 0 = 'very difficult' and 'fairly difficult'). A final sum score is computed by adding up responses across the dichotomized items, resulting in a score ranging from 0 to 16 with higher values indicating higher health literacy. Participants were divided into two groups according to their overall score (König et al., 2024a; König et al., 2024b, 2024c), i.e., those with adequate health literacy (score 13–16) and those with inadequate or problematic health literacy (score 0–12).

2.4 Statistical analyses

The statistical software SPSS (version 29.0.2.0, IBM) was used for all statistical analyses. All inferential analyses were calculated with an α -level of 0.05. To determine reliability, internal consistencies for the climate change distress and impairment scales and the HLS-EU-Q16 questionnaire were computed using Cronbach's α . *T*-tests were computed to test for differences between the factor levels of the dichotomous factors (gender, education, migration background, region, health literacy). In the inferential analyses, gender was analyzed as a dichotomous factor (male, female) due to the low frequencies of individuals identifying as 'diverse'. Degrees of freedom were adjusted in the *t*-tests when Levene's test for equality of variances indicated that variances were not homogeneous. For the factors with more than two factor levels (age, social status) separate univariate analyses of variance (ANOVAs) were computed to test for group differences, and main effects

were determined. η^2 was used as an effect size measure for the ANOVAs, and Cohen's *d* was used as an effect size measure for all *t*-tests. Significant ANOVA main effects were followed up with Bonferroni-corrected *t*-tests for pairwise comparison of each pair of factor levels. For these analyses, the corrected α -threshold and uncorrected *p*-values are reported.

3 Results

3.1 Sample characteristics

A total of $N = 1,021$ adolescents completed the survey. Details on the absolute number and proportion of individuals across sociodemographic groups and health literacy categories are shown in Table 1 for the weighted and unweighted sample.

3.2 Reliability

Internal consistency of the climate change distress scale was $\alpha = 0.92$, internal consistency of the climate change impairment scale was $\alpha = 0.80$, and internal consistency of the HLS-EU-Q16 questionnaire was $\alpha = 0.88$.

3.3 Climate change distress and impairment

Descriptive statistics for climate change distress and impairment for the entire sample and the subgroups are in Table 2. Detailed responses to the climate change distress and impairment items are in Tables 3, 4,

TABLE 2 Descriptive statistics [mean (M) and standard deviation (SD)] of the climate change distress and impairment scales for adolescents in Germany by gender, age, level of education, social status, migration background, region and health literacy categories.

Factor	Levels	Climate change distress		Climate change impairment	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Entire sample	Overall	3.33	0.78	2.16	0.72
Gender	Male	3.25	0.81	2.10	0.74
	Female	3.43	0.73	2.23	0.70
Age	12–13 years	3.27	0.77	2.14	0.69
	14–15 years	3.32	0.74	2.26	0.77
	16–17 years	3.41	0.83	2.09	0.68
Education	Low	3.25	0.75	2.21	0.73
	High	3.45	0.80	2.09	0.70
Social status	Low	3.15	0.81	2.22	0.77
	Middle	3.33	0.76	2.14	0.71
	High	3.43	0.80	2.20	0.71
Migration background	No	3.27	0.84	2.17	0.75
	Yes	3.35	0.76	2.16	0.71
Region	East Germany	3.32	0.78	2.21	0.66
	West Germany (incl. Berlin)	3.34	0.78	2.15	0.73
Health literacy	Inadequate/ Problematic	3.36	0.75	2.24	0.72
	Adequate	3.30	0.81	2.08	0.71

TABLE 3 Detailed responses to the climate change distress subscale.

Nr.	Item	Strongly disagree	Disagree	Neutral (neither agree nor disagree)	Agree	Strongly agree
1	I feel angry when I see how little is done to combat climate change.	13.1%	14.8%	32.2%	29.0%	10.9%
2	When I think about climate change, I worry about the future.	10.2%	13.9%	24.7%	35.8%	15.4%
3	I am not sad about climate change. (r)	22.4%	26.7%	29.2%	15.8%	5.9%
4	I am enraged that we have missed many chances to stop climate change.	10.5%	14.1%	32.2%	28.5%	14.7%
5	I do not fear for my future on this planet. (r)	14.6%	27.6%	27.7%	20.4%	9.7%
6	News about climate change makes me feel depressed.	13.5%	18.2%	29.1%	28.5%	10.7%
7	I am not mad when others damage the climate. (r)	23.8%	27.9%	30.8%	12.7%	4.8%
8	The uncertainty about how climate change will progress scares me.	11.8%	14.3%	34.0%	31.1%	8.8%
9	I feel sad that climate change is causing people and animals to suffer.	4.5%	8.2%	22.1%	41.5%	23.6%
10	I do not get upset when others ignore climate change. (r)	16.7%	24.5%	33.9%	17.5%	7.4%
11	I am scared that people will lose their homes because of climate change.	9.0%	13.6%	31.6%	33.5%	12.3%
12	I feel sad that some parts of the environment will not recover from the effects of climate change.	7.2%	8.8%	25.8%	40.4%	17.8%
13	I am not angry that some countries have missed their climate protection goals. (r)	18.7%	27.1%	32.1%	15.9%	6.2%
14	The impact that climate change has had on the planet saddens me.	7.9%	12.7%	27.0%	37.8%	14.6%
15	I feel carefree when I think about climate change. (r)	23.5%	30.9%	30.4%	9.0%	6.2%

The items are extracted from an article (Hepp et al., 2023) that is licensed under a Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>). In our sample, the German version of the items was employed. Due to sample weighting and rounding, percentages may exceed or fall below 100%.

respectively. The climate change distress subscale correlated positively with climate change impairment subscale, $r = 0.17$, $p < 0.001$.

3.4 Sociodemographic factors and health literacy

3.4.1 Gender

$N = 3$ individuals reported 'diverse' as their gender. These individuals were excluded from the analyses concerning gender due to too low cell frequencies. Therefore, in the following analyses, only girls and boys were compared. Girls had significantly higher climate change distress, $t(1016) = -3.86$, $p < 0.001$, $d = -0.24$, and impairment than boys, $t(1016) = -2.84$, $p = 0.005$, $d = -0.18$.

3.4.2 Age

There was no significant effect of age on climate change distress, $F(2,1017) = 2.55$, $p = 0.079$, $\eta^2 = 0.005$. Descriptively, climate change distress increased from the younger to the older age groups. There was a significant effect of age on climate change impairment, $F(2,1017) = 4.99$, $p = 0.007$, $\eta^2 = 0.010$. Post-hoc Bonferroni-corrected t -tests (corrected $\alpha = 0.017$) revealed significant differences only between the 14–15-year-olds and the 16–17-year-olds, $t(672.28) = 3.04$, $p = 0.002$, $d = 0.23$, but not between the 12–13-year-olds and the 14–15-year-olds, $t(680) = -2.09$, $p = 0.037$, $d = -0.16$, and the 12–13-year-olds and the 16–17-year-olds, $t(676) = 0.99$, $p = 0.324$, $d = 0.08$. Descriptively, impairment was highest in the 14–15-year-olds and lower in the younger and older age groups.

3.4.3 Education

Climate change distress was significantly higher in individuals with higher levels of education than in those with lower levels of education, $t(860.22) = -3.96$, $p < 0.001$, $d = -0.26$. Conversely, climate change impairment was significantly higher in individuals with lower levels of education than in those with higher levels of education, $t(1019) = 2.63$, $p = 0.009$, $d = 0.17$.

3.4.4 Social status

There was a significant effect of social status on climate change distress, $F(2,1017) = 5.03$, $p = 0.007$, $\eta^2 = 0.010$. Post-hoc Bonferroni-corrected t -tests (corrected $\alpha = 0.017$) revealed significant differences between the low and middle social status groups, $t(778) = -2.42$, $p = 0.016$, $d = -0.25$, and the low and high social status groups, $t(353) = -3.06$, $p = 0.002$, $d = -0.35$. However, there were no significant differences between the middle and high social status groups, $t(905) = -1.57$, $p = 0.116$, $d = -0.12$. Descriptively, climate change distress increased with increasing social status.

There was no significant effect of social status on climate change impairment, $F(2,1017) = 1.02$, $p = 0.359$, $\eta^2 = 0.002$. On the descriptive level, impairment was highest in individuals with low social status, followed by those with high social status and those with middle social status.

3.4.5 Migration background

Migration background had no significant effect on climate change distress, $t(1019) = -1.27$, $p = 0.206$, $d = -0.10$, nor on climate change impairment, $t(1019) = 0.26$, $p = 0.789$, $d = 0.02$.

TABLE 4 Detailed responses to the climate change impairment subscale.

Nr.	Item	Strongly disagree	Disagree	Neutral (neither agree nor disagree)	Agree	Strongly agree
16	Climate change drains all my energy.	39.0%	26.2%	28.3%	4.4%	2.2%
17	My thoughts and feelings about climate change do not affect how well I sleep. (r)	9.1%	11.7%	22.5%	25.6%	31.1%
18	When I think about climate change, I get a headache or stomachache.	42.6%	28.1%	21.7%	5.7%	1.9%
19	Because of climate change, I am overwhelmed by everyday activities.	48.7%	27.3%	16.6%	5.3%	2.1%
20	My thoughts and feelings about climate change do not negatively impact my everyday life. (r)	11.0%	11.0%	22.9%	28.4%	26.7%
21	I have no trouble mentally tuning out climate change. (r)	6.8%	13.0%	29.3%	29.9%	21.0%
22	Constant discussions about climate change are affecting my relationships.	36.2%	28.6%	26.8%	5.7%	2.7%
23	When I think about climate change, I cannot bring myself to work/study.	48.0%	24.3%	22.1%	4.2%	1.5%

The items are extracted from an article (Hepp et al., 2023) that is licensed under a Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>). In our sample, the German version of the items was employed. Due to sample weighting and rounding, percentages may exceed or fall below 100%.

3.4.6 Region

There was no significant difference on climate change distress between participants from East and West Germany, $t(1017) = 0.21$, $p = 0.831$, $d = 0.02$. Likewise, there was no significant difference on climate change impairment between participants from East and West Germany, $t(1017) = -0.87$, $p = 0.386$, $d = -0.08$.

3.4.7 Health literacy

Climate change distress did not significantly differ between individuals with inadequate and problematic health literacy when compared to individuals with adequate health literacy, $t(1019) = 1.31$, $p = 0.191$, $d = 0.08$. For climate change impairment, however, there was a significant group difference with lower impairment in individuals with adequate health literacy when compared to those with inadequate and problematic health literacy, $t(1019) = 3.47$, $p < 0.001$, $d = 0.22$.

4 Discussion

4.1 Principal findings

This study assessed climate change distress and climate change impairment in a large representative sample of adolescents living in Germany. Overall, means and standard deviations of the adolescent sample were similar to those found in the validation studies for the recently published climate change distress and impairment questionnaire and in a representative population sample in Germany (Hepp et al., 2023; König et al., 2024a). Participants reported moderate values of climate change distress and low to moderate values of climate change impairment. These findings largely correspond to previous findings on climate change-induced affective responses in adolescents (Hickman et al., 2021; Léger-Goodes et al., 2022). They add to the literature by showing that adolescents not only respond negatively to climate change on an affective level but that their general, social and work or school-related functioning is also impaired. In line with previous findings, our findings suggest that many individuals

experience some degree of climate change distress, but fewer are significantly impaired by climate change (Hepp et al., 2023; König et al., 2024a). The two subscales showed a positive low to moderate intercorrelation in the range of those found in the validation studies (Hepp et al., 2023). This pattern of results highlights the independence of the two subscales and the value of analyzing them as separate constructs. Importantly, recent evidence suggests that climate change distress might be the precedent of climate change impairment (Heeren et al., 2023; Chan et al., 2024). Future research should investigate under which circumstances distress may result in impairment and how this transition may be prevented.

Both subscales showed high internal consistency in line with previous research speaking for the reliability of the measure also in adolescents (Hepp et al., 2023; König et al., 2024a).

When comparing different subgroups stratified by sociodemographic factors and health literacy, significant differences were observed for some, but not all factors. Girls were significantly more distressed than boys, consistent with previous research in the general population (Hepp et al., 2023; König et al., 2024a). In the present study, girls also experienced more pronounced impairment than boys. In the general population, this gender difference has not consistently been observed (Hepp et al., 2023; König et al., 2024a). Interestingly, there is evidence that girls not only experience more climate change-related worry but also more hope (Léger-Goodes et al., 2022) in line with research showing that girls generally experience more positive emotions and more internalizing emotions (e.g., sadness, anxiety) than boys (Chaplin and Aldao, 2013). Our results suggest that girls might particularly benefit from interventions to reduce impairment. As higher distress can also lead to pro-environmental behaviors (Boluda-Verdú et al., 2022; Heeren et al., 2023; Hepp et al., 2023) distressed individuals might also be addressed to promote action against climate change.

Within our limited age group (12–17 years), we did not observe an effect of age on climate change distress suggesting equal levels of distress across the sample. In samples with a wider age range, either small to moderate negative correlations of climate change distress with age were observed (i.e., decreasing distress with increasing age; Hepp

et al., 2023) or a more nuanced u-shaped pattern emerged, suggesting that younger and older generations were most distressed, and middle-aged individuals show lower levels of distress (König et al., 2024a). More large-scale studies are recommended to better understand how age relates to climate change distress. Jointly, the current evidence suggests that adolescents, young and possibly also elderly adults are particularly distressed by climate change.

For the impairment scale, we found highest values in the 14–15-year-olds with lower impairment in the younger and older groups. In the general population, König et al. (2024a) observed highest impairment in the youngest (< 30 years) and oldest participants (> 65 years) and lowest impairment in the middle-aged group, similar to the findings for the distress scale. In the initial validation studies, no consistent pattern has been observed concerning age. As the statistical design in Hepp et al. (2023) did not allow to test for non-linear associations and fewer older adults were recruited, it remains unclear whether a similar pattern would have been observable in this sample. In general, climate anxiety seems to be higher in younger vs. older subgroups of society (Searle and Gow, 2010; Hajek and König, 2022; Whitmarsh et al., 2022). The current study adds to the literature by showing that impairment is unevenly distributed across adolescent age groups with highest impairment in mid-adolescence.

Consistent with the findings in the general population (König et al., 2024a), climate change distress was higher in participants with higher levels of education when compared to those with lower levels of education. Conversely, impairment due to climate change was more pronounced in individuals with lower levels of education in both samples. This pattern aligns with research on the relationship of educational attainment and mental health demonstrating higher prevalences of mental health issues in individuals with lower levels of education (Kocalevent et al., 2013; Erickson et al., 2016; Chlapecka et al., 2020; Hapke et al., 2022). Our findings suggest that education might serve as a protective factor for climate change impairment. While individuals with higher levels of education reported higher levels of distress – possibly due to a higher belief in science (Hajek and König, 2024) –, they experienced lower levels of impairment compared to those with lower educational levels. This discrepancy could be attributed to various factors such as more effective coping mechanisms including pro-environmental action (Meyer, 2015) and access to resources in those with higher education. Further research is needed to explore the underlying mechanisms and to lower the negative impact of climate change on mental health for all levels of educational attainment.

Interestingly, the effects of social status were less clear than the effects of education which means that the results cannot be fully accounted for by shared variance between the two factors. For distress, we found higher values with increasing social status, similar to the findings concerning levels of education. In the general population, the middle social status group was most distressed with comparable values in the low social status groups and lower values in individuals with high social status (König et al., 2024a). In the present adolescent sample, there was no significant association between social status and climate change impairment in contrast to the findings of König et al. (2024a) in the general population, where higher impairment was found in the low and middle social status groups when compared to the high social status group. This pattern of results suggests that

effects of social status on climate change impairment might only develop later in life. Consequently, late adolescence might be a particularly valuable time for focused interventions to prevent climate-change related impairments later in life across social status groups.

In accordance with König et al. (2024a) no effects of migration background were found in the present investigation suggesting that individuals with and without a migration background are equally distressed and impaired by climate change. These findings are encouraging in light of the fact that individuals with a migration background are often considered particularly vulnerable for adverse mental health outcomes (Close et al., 2016; Vonneilich et al., 2023). Although climate change is a major driver of global migration movements (Kaczan and Orgill-Meyer, 2020), it appears to have a limited influence on climate change-related mental health among migrants in Germany.

While König et al. (2024a) found more pronounced climate change distress and impairment in the general population from West Germany, we did not delineate regional differences in adolescents in the current study. More than three decades after the German reunification substantial cultural and political differences persist between the two former German states (Pickel and Pickel, 2023). For example, in West Germany a greater proportion of the population believe in and are concerned by climate change, and more importance is paid to collective measures to mitigate climate change than in East Germany (Mewes et al., 2024). We can only speculate why the pattern observed in the general population was not replicated in adolescents. One reason might be that, in contrast to their parents and older generations, younger individuals did not grow up in the former German Democratic Republic which may have resulted in the development of different attitudes.

Concerning health literacy, our results show no effect for climate change distress. However, importantly, climate change impairment was more pronounced in those with inadequate and problematic health literacy when compared to those with adequate health literacy, replicating the findings in the general population (König et al., 2024a). The fact that health literacy presents a modifiable characteristic (Walters et al., 2020; König et al., 2022; König and Suhr, 2023) makes it a promising target for interventions aimed at reducing climate change impairment. It is important to note that our cross-sectional study design does not allow for causal interpretations of these associations, as applies to all findings in this paper (Wang and Cheng, 2020). Therefore, it needs to be determined in the future with more complex experimental and longitudinal study designs whether low health literacy is indeed a precursor of higher levels of climate change impairment and whether targeted health literacy interventions might also help to reduce the burden of climate change.

Overall, all effects detected in this study had small effect sizes. This means that although some variation has been observed in terms of groups vulnerable to climate change distress and impairment, these differences are relatively subtle. Therefore, it might be inferred that interventions aimed at reducing climate change distress and impairment do not necessarily need to address only those individuals identified as more vulnerable. Instead, the general adolescent population can be targeted to lower the current burden and prevent future mental health impairments related to climate change. It should be noted that the development of interventions designed to reduce

negative affective responses to climate change is still very much in its early stages. First reviews of the literature (Baudon and Jachens, 2021) show that existing interventions focus on fostering the clients' inner resilience, helping clients to find social connection and emotional support, encouraging clients to take action, focusing on practitioner's inner work and education, and connecting clients with nature (Baudon and Jachens, 2021). Crucially, more research is needed into the effectiveness of these interventions in different communities and settings.

4.2 Limitations and future directions

The results presented in this paper should be interpreted in the light of several limitations. Firstly, as noted above, this study was exploratory and used a cross-sectional study design that does not allow causal interpretation of the investigated associations (Wang and Cheng, 2020). Future research is needed in order to determine potential causal relationships. Secondly, due to the exploratory nature of the study, only univariate analyses were conducted here. This limitation can be overcome in the future by more sophisticated multivariate analyses plans to look at shared and unique variance and potential interactions of the study variables. Thirdly, in the initial validation study of the climate change distress and impairment questionnaire individuals who do not believe in anthropogenic climate change were excluded (Hepp et al., 2023). We did not follow this procedure for this study in order to get a broad perspective on climate change distress and impairment across diverse sociodemographic groups. Differences between our and the initial studies might have been confounded by not excluding these individuals. Fourthly, a quota-based sample was used here with the sociodemographic factors age, gender and type of school. Hence, we cannot guarantee representativeness of the sample in other potentially relevant aspects.

5 Conclusion

Overall, the present study was the first to employ the recently developed climate change distress and impairment questionnaire in a large sample of adolescents. The key findings show that adolescents are moderately distressed by climate change and a considerable proportion also experience some level of impairment. It was found that climate change distress and impairment are unevenly distributed across subgroups stratified by sociodemographic measures and health literacy. Vulnerable groups for climate change distress are girls, those with high levels of education and high social status. Vulnerable groups for climate change impairment are girls, 14–15-year-olds, those with low levels of education, and those with inadequate and problematic health literacy. Further research is needed to explore the underlying mechanisms and develop effective strategies to support adolescent mental health in the face of climate change.

Data availability statement

The datasets presented in this article are not readily available because the datasets generated and analyzed during this study are the property of the independent, nonprofit foundation Stiftung

Gesundheitswissen. Requests to access the datasets should be directed to lars.koenig@stiftung-gesundheitswissen.de.

Ethics statement

A study protocol was submitted to the ethics committee of the Berlin Medical Association. The ethics committee had no ethical or professional objections to the study protocol (reference Eth-64/23). Written informed consent for participation in this study was provided by the participants and their legal guardians/next of kin if they were younger than 16 years.

Author contributions

LK: Methodology, Writing – review & editing, Conceptualization, Supervision. ReS: Methodology, Writing – review & editing, Formal analysis, Writing – original draft. PB: Conceptualization, Writing – review & editing. GL: Conceptualization, Writing – review & editing. TH: Validation, Writing – review & editing. RaS: Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research was funded by the independent, nonprofit foundation Stiftung Gesundheitswissen.

Acknowledgments

The authors want to thank the editor and the reviewers for taking the time and effort necessary to review the manuscript. Their insightful comments helped to improve the quality of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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