Muhammad Danish Zubair, Assel Tukinova* and Zhanna Mussabekova

A study of medical students' perceptions and knowledge of climate change and its impact on health

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Abstract

Objectives: Climate change presents a significant threat to the well-being of medical students, further impacting their physical and mental health in the context of already demanding academic and clinical responsibilities. This study aims to examine how future healthcare professionals perceive the health-related consequences of climate change and to what extent they feel equipped to address the challenges posed by this global issue.

Methods: A cross-sectional survey was conducted using an online questionnaire to gather data. The invitation to participate was extended to students from different academic programs within a medical university. A total of 697 students completed the survey.

Results: Most respondents were male students aged between 21 and 23 years, with the majority hailing from Pakistan, India, and Kazakhstan. The survey showed a high level of awareness among students about the health impacts of climate change: 80 % expect serious health impacts in their communities in the next 20 years. The majority believe that climate change will increase the burden of health care, lead to an increase in infectious and mental diseases, and affect vulnerable populations. 72.9 % support the inclusion of climate in health education. The relationship between awareness and support for mandatory climate education is statistically confirmed ($p<0.001$).

Conclusions: This study highlights medical students' strong awareness of climate change's impact on health and the importance of integrating this topic into medical education. Enhancing future physicians' knowledge and resilience to environmental threats is crucial for effective healthcare in a changing climate.

Keywords: climate change; impact on health; knowledge; medical students; perception

Introduction

The current climate change represents one of the most significant global health threats of the twenty-first century [1]. Failing to address climate change adequately could reverse the progress made in global health over the past 50 years. Climate is defined by the long-term patterns of temperature, moisture, wind, and rainfall in a specific region, typically measured over 30 years. The global health crisis driven by climate change demands urgent recognition of its wide-ranging and severe effects on populations worldwide. Global warming, a primary consequence of climate change, is largely driven by human dependence on fossil fuels at a massive scale [2]. Two authoritative health organizations, WHO [3] and The Lancet [4], have highlighted the health risks posed by climate change. Medical students, who experience unique pressures due to their academic and clinical training, are particularly vulnerable to these risks. Their demanding schedules, long hours, and constant exposure to clinical environments increase their susceptibility to the negative impacts of climate change [5]. Environmental factors such as extreme heat, poor air quality, and the emergence of new infectious diseases exacerbate existing health problems among medical students, affecting their mental functions, concentration, and overall well-being [6]. Studies indicate that medical students are well aware of the health risks associated with climate change, including environmental damage, increased health dangers, and natural disasters [7]. Despite their awareness, their heightened vulnerability to physical and mental health issues due to the pressures of their training persists. The psychological impacts of climate change, such as eco-anxiety, are profound and contribute to medical students' stress, particularly concerning their future careers and the potential for climate-driven disasters. Recent research

***Corresponding author: Assel Tukinova**, Department of Epidemiology and Biostatistics, Semey Medical University, Semey, Kazakhstan, E-mail: tukinova_asel@mail.ru. https://orcid.org/0000-0003-0191-4392
Muhammad Danish Zubair, Fifth-Year Student of General Medicine, Semey Medical University, Semey, Kazakhstan. https://orcid.org/0009-0009-4146-8594
Zhanna Mussabekova, School of Postgraduate Education, Alumni Employability and Career, Semey Medical University, Semey, Kazakhstan. https://orcid.org/0000-0003-3442-4963

highlights the prevalence of climate-related stress among medical students, though this stress does not always manifest as anxiety or depression, it still represents significant distress [8]. Healthcare trainees are increasingly experiencing "eco-anxiety" due to growing concerns over environmental degradation. Psychiatry research suggests that professional anxiety can lead to feelings of helplessness, burnout, and reduced job performance among medical staff. It is essential to address these mental health concerns as untreated psychological distress can negatively impact medical education, clinical training, and the quality of healthcare provided by medical students. Exposure to extreme heat in unregulated clinical environments can lead to heat exhaustion, heat stroke, and other heat-related illnesses. Rising pollution levels and allergens exacerbate respiratory problems and asthma among medical personnel [9]. Climate change also alters the distribution of disease vectors, resulting in the spread of new infectious diseases, which presents further challenges for medical students' health and training [10].

Medical students, as future healthcare providers, are particularly susceptible to climate change-related health risks due to the nature of their education and hospital workloads. Long clinical hours and exposure to extreme heat and poor air quality at work place students at risk for heat stress, cognitive impairments, and respiratory issues, which can interfere with their ability to deliver effective clinical care. Environmental changes facilitate the spread of new pathogens, heightening the risk that medical trainees will contract climate-sensitive diseases. Medical students face elevated levels of stress, anxiety and burnout, exacerbated by changing health needs driven by climate change and increasing incidence of climate-induced public health crises. In the face of increasing workload, there is an urgent need to implement psychological support for trainees in medicine, as their future ability to cope with new threats is directly dependent on their psycho-emotional well-being [7].

The relevance of integrating climate aspects into medical education programs is becoming more and more evident. Knowledge about the impact of climate change on health allows students to advocate for the implementation of environmentally sustainable practices in medical institutions. Medical schools should implement measures to reduce student vulnerability by creating a climate-resilient educational environment, developing climate education, and providing psychological resilience programs. Effective preparation of future doctors for climate challenges directly depends on the initiatives taken by educational and medical institutions [11].

However, there is a lack of research on the direct impact of climate change on the health of medical students, despite the well-studied public health implications of climate change. Developing effective wellbeing programs requires a clear understanding of how climate stressors affect the physical and mental well-being of students. It is important to pay immediate attention to the threats posed by heat, respiratory illness and climate anxiety. A study on students' views on climate-related health threats and their readiness to respond will help identify gaps in current learning. Such data will form the basis for transforming medical education to fully prepare professionals for new challenges [12].

The research objective of this research article is to analyze the perceptions and knowledge of medical students regarding climate change and its impact on health.

Methods

This cross-sectional study was conducted among students of Semey Medical University in Kazakhstan to assess their perceptions and knowledge regarding climate change and its health-related impacts. Data were collected through a structured questionnaire, which was adapted from a previously validated international survey tool [2]. The final version of the questionnaire consisted of 18 items and was organized into four key sections: 1) demographic information – including participants' age, gender, nationality, and year of study; 2) perceptions of climate change – examining students' views on climate change and its perceived effects on themselves, public health, the healthcare system, and disease patterns; 3) awareness of health impacts – evaluating knowledge of how climate change influences the prevalence of infectious diseases, mental health conditions, and the incidence of foodborne and vector-borne illnesses; 4) attitudes toward climate education – assessing opinions on the importance of integrating climate-related topics into medical education and professional development programs for healthcare providers.

The questionnaire consisted of a combination of multiple-choice items and statements evaluated using a Likert scale, aimed at measuring participants' levels of agreement with various topics.

Participant recruitment

The survey was directed at both domestic and international students enrolled in different academic programs and years of study, allowing for a wide spectrum of insights and educational backgrounds. Participation was entirely voluntary. Before beginning the questionnaire, students were

provided with detailed information about the study's purpose, and assurances were given regarding the confidentiality and anonymity of their responses. A convenience sampling approach was utilized, enabling any qualifying student who wished to take part to do so.

Data collection procedure

Data were gathered through an online survey created using Google Forms. This digital method was selected for its practicality, offering easy access to students across various faculties and academic levels. Additionally, it provided flexibility in response timing and proved efficient in terms of both time and resources.

Despite these advantages, certain limitations associated with online surveys were acknowledged: limited access for students with poor internet connectivity or low digital literacy; self-selection bias, as students already interested in climate-related topics may have been more likely to participate; lack of environmental control, meaning responses could potentially be influenced by external input or distractions.

Statistical analysis

Descriptive statistics were used to summarize the data and identify general trends and frequencies. To examine associations between categorical variables the Chi-square test (χ^2) was applied. This non-parametric test was selected due to its suitability for categorical data and its ability to detect statistically significant relationships without assuming normality. A p-value <0.05 was considered statistically significant. The use of the Chi-square test supported the reliability of the results by confirming whether observed differences in responses were likely due to actual associations rather than random variation.

The study was conducted in full accordance with the ethical standards outlined in the Declaration of Helsinki. Informed consent was obtained from all participants before data collection commenced.

Results

697 students took part in the study. The results of the study presented in Table 1 show that majority of the respondents (36.3 %) belonged to the age group of 21–23 years, while the smallest proportion were participants above 27 years of age (7.7 %). Guys (60.8 %) predominated while girls accounted for 39.2 %. In terms of ethnicity, Pakistanis (41.5 %) were the largest number of respondents, followed by Indians (27.7 %) and Kazakhs (22.5 %). Most participants were in their second year of study (25.1 %), while the first, third and fifth years had approximately the same number of respondents.

As shown in Table 2, the majority of students realize the negative impact of climate change on health and society. The majority of respondents believe that climate change is harmful to both students (66.3 %) and human health (64.7 %). 70.2 % agree that climate change is mainly caused by human activities. Almost 80 % believe that in the next 20 years, the effects of climate change will seriously affect health in their community. Also, 80.2 % believe that climate change will increase the burden on health care systems, requiring adaptation to new diseases. More than half of students recognize that climate change contributes to mental health disorders (55.8 %) and increased morbidity related to ecosystem change (67.9 %). 65.7 % believe there will be an increase in vector-borne diseases in the future. 72.9 % believe that incorporating education about climate impacts on health into medical education will improve people's health. The majority of respondents also agree that climate change will affect vulnerable populations such as the elderly and people with chronic diseases (77.3 %), as well as lead to an increase in extreme weather events that affect public health practices (77.2 %). Respondents also believe that health programs should include education on health issues related to climate change in order to improve health in communities.

Analysis of the data from Table 3 shows a strong statistical relationship between medical students' awareness of

Table 1: Socio-demographic data of respondents.

Variable		n	%
Age	Up to 18 years old	86	12.3
	18–20 years	185	26.5
	21–23 years	253	36.3
	24–26 years	119	17.1
	27 & above	54	7.7
Gender	Female	273	39.2
	Male	424	60.8
Nationality	Kazakh	157	22.5
	Russian	34	4.9
	Pakistani	289	41.5
	Indian	193	27.7
	Others	24	3.4
Year of study	First year	105	15.1
	Second year	175	25.1
	Third year	101	14.5
	Fourth year	142	20.4
	Fifth year	108	15.5
	Other	66	9.5

Table 2: Students' awareness of the impact of climate changes.

Variable		n	%
Do you think climate change is bad or good for students?	Very good	80	11.5
	Little good	63	9.0
	Somewhat Good	127	18.2
	Somewhat bad	148	21.2
	Little bad	105	15.1
	Very bad	174	25.0
Do you think climate change is bad or good for human health?	Very good	85	12.2
	Little good	60	8.6
	Somewhat Good	111	15.9
	Somewhat bad	132	18.9
	Little bad	91	13.1
	Very bad	218	31.3
Do you agree with the statement: That climate change is mainly caused by human activities?	Yes	489	70.2
	No	141	20.2
	I don't know	67	9.6
In the next 20 years, if the health-related impacts of climate change be serious in the community?	Strongly Disagree	77	11.0
	Mildly disagree	71	10.2
	Somewhat Disagree	72	10.3
	Somewhat Agree	129	18.5
	Mildly agree	109	15.6
	Strongly agree	239	34.3
Do you perceive that climate change will increase the burden on healthcare systems, requiring them to adapt to new types of diseases and conditions?	Yes	559	80.2
	No	53	7.6
	I don't know	85	12.2
Do you agree mental health conditions are a health of climate change?	Yes	389	55.8
	No	194	27.8
	I don't know	114	16.4
Do you believe that climate change will lead to an increase in vector-borne diseases in the coming decades?	Yes	458	65.7
	No	97	13.9
	I don't know	142	20.4
Are you aware that climate change may lead to the spread of antibiotic-resistant diseases due to changing ecosystems?	Yes	473	67.9
	No	79	11.3
	I don't know	145	20.8
Should medical curricula worldwide include mandatory training on the health impacts of climate change and its related diseases?	Yes	512	73.5
	No	80	11.5
	I don't know	105	15.1
Do you agree that cold-related illness is a health impact of climate change?	Yes	490	70.3
	No	116	16.6
	I don't know	91	13.1
Do you believe that climate change will lead to an increase in the incidence of foodborne diseases in their region?	Yes	444	63.7
	No	123	17.6
	I don't know	129	18.5
Do you think that addressing climate change in medical education could improve the health outcomes of communities most affected by it?	Yes	508	72.9
	No	75	10.8
	I don't know	114	16.4
Do you believe that climate change will disproportionately affect vulnerable populations such as the elderly and those with pre-existing health conditions?	Yes	539	77.3
	No	68	9.8
	I don't know	90	12.9
Do you believe that climate change is a primary factor in the increase of extreme weather events, which will directly affect their healthcare practice?	Yes	538	77.2
	No	83	11.9
	I don't know	76	10.9

the health impacts of climate change and their support for mandatory climate education in health programs (all variables are significant at $p<0.001$). The majority of students who recognize the health impacts of climate change, especially on vulnerable populations and the frequency of extreme weather events, support mandatory education (65.1 and 64.8 %, respectively). Support is also high among those who are aware of the mental health implications, the spread of infections and the rise in antibiotic resistance (54–65 % on average). In contrast, support for education is significantly lower among students who do not believe in the climate and health connection (less than 10 %). Those who chose the answer "Don't know" are also less likely to support compulsory education, underscoring the importance of awareness raising.

Table 4 shows that the majority of students consider climate change to have a negative impact on human health, with 4.2–6 % across different years selecting the option "very bad." Between 8.5 and 15.4 % of students, depending on their year of study, agreed that climate change is mainly caused by human activities. More than 12 % of first-year students, 20.2 % of second-years, and 17.2 % of fourth-years believe that climate change will increase the burden on the healthcare system. Support for including mandatory training on the health impacts of climate change in medical curricula ranged from 11.9 to 17.5 %. Expectations of an increase in vector-borne diseases were expressed by 9.5–14.6 % of respondents. In all cases, the differences by year of study were statistically significant (χ^2 ranging from 33.07 to 89.22; $p<0.001$).

As shown in Table 5, statistically significant differences were found in the responses of students from different nationalities (χ^2=32.85 and 21.38; $p<0.001$ and $p=0.006$). A total of 32.7 % of Pakistani, 16.4 % of Indian, 15.9 % of Kazakh, 3 % of Russian students, and 2.2 % of students from other nationalities agreed that climate change is caused by human activity. Support for including mandatory climate-related education in medical curricula was expressed by 32.3 % of Pakistani, 19.1 % of Indian, 16.8 % of Kazakh, 2.9 % of Russian students, and 2.4 % of students from other nationalities.

As shown in Table 6, the analysis revealed statistically significant differences between male and female students in

Table 3: Support for mandatory climate education: associations with medical students' awareness and attitudes toward climate-related health impacts.

Variable	Should medical curricula worldwide include mandatory training on the health impacts of climate change and its related diseases?			X^2	*df*	p-Value
	Yes	No	I don't know			
Do you believe that climate change is a primary factor in the increase of extreme weather events, which will directly affect their healthcare practice?						
Yes	452 (64.8 %)	42 (6.0 %)	44 (6.3 %)	194.1	4	p<0.001
No	37 (5.3 %)	29 (4.2 %)	17 (2.4 %)			
I don't know	23 (3.3 %)	9 (1.3 %)	44 (6.3 %)			
Do you believe that climate change will disproportionately affect vulnerable populations such as the elderly and those with pre-existing health conditions?						
Yes	454 (65.1 %)	48 (6.9 %)	37 (5.3 %)	224.9	4	p<0.001
No	22 (3.2 %)	28 (4.0 %)	18 (2.6 %)			
I don't know	36 (5.2 %)	4 (0.6 %)	50 (7.2 %)			
Do you think that addressing climate change in medical education could improve the health outcomes of communities most affected by it?						
Yes	447 (64.1 %)	33 (4.7 %)	28 (4.0 %)	288.9	4	p<0.001
No	32 (4.6 %)	31 (4.4 %)	12 (1.7 %)			
I don't know	33 (4.7 %)	16 (2.3 %)	65 (9.3 %)			
Do you believe that climate change will lead to an increase in the incidence of foodborne diseases in their region?						
Yes	382 (54.8 %)	36 (5.2 %)	26 (3.7 %)	133.1	6	p<0.001
No	57 (8.2 %)	33 (4.7 %)	33 (4.7 %)			
I don't know	73 (10.5 %)	11 (1.6 %)	46 (6.6 %)			
Do you agree that cold-related illness is a health impact of climate change?						
Yes	405 (58.1 %)	36 (5.2 %)	49 (7.0 %)	82.3	4	p<0.001
No	59 (8.5 %)	31 (4.4 %)	26 (3.7 %)			
I don't know	48 (6.9 %)	13 (1.9 %)	30 (4.3 %)			
Are you aware that climate change may lead to the spread of antibiotic-resistant diseases due to changing ecosystems?						
Yes	395 (56.7 %)	37 (5.3 %)	41 (5.9 %)	106.3	4	p<0.001
No	35 (5.0 %)	27 (3.9 %)	17 (2.4 %)			
I don't know	82 (11.8 %)	16 (2.3 %)	47 (6.7 %)			
Do you believe that climate change will lead to an increase in vector-borne diseases in the coming decades?						
Yes	380 (54.5 %)	34 (4.9 %)	44 (6.3 %)	127.5	4	p<0.001
No	46 (6.6 %)	37 (5.3 %)	14 (2.0 %)			
I don't know	86 (12.3 %)	9 (1.3 %)	47 (6.7 %)			
Do you agree mental health conditions are a health of climate change?						
Yes	324 (46.5 %)	33 (4.7 %)	32 (4.6 %)	67.2	4	p<0.001
No	125 (17.9 %)	36 (5.2 %)	33 (4.7 %)			
I don't know	63 (9.0 %)	11 (1.6 %)	40 (5.7 %)			
Do you perceive that climate change will increase the burden on healthcare systems, requiring them to adapt to new types of diseases and conditions?						
Yes	453 (65.0 %)	44 (6.3 %)	62 (8.9 %)	97.2	4	p<0.001
No	25 (3.6 %)	18 (2.6 %)	10 (1.4 %)			
I don't know	34 (4.9 %)	18 (2.6 %)	33 (4.7 %)			

their perception of the impact of climate change on health (χ^2=17.25; p=0.004) and in their support for including climate-related topics in medical education (χ^2=6.55; p=0.038). Men were more likely to rate the impact of climate change as "very bad" (21.4 vs. 9.9 %) and "very good" (8.8 vs. 3.4 %), while women more often selected moderate responses. Mandatory climate-related education was supported by 43.8 % of male and 29.7 % of female students, with men also more frequently responding "no" (8.5 vs. 3 %). Differences regarding the link between climate change and mental health were not statistically significant (χ^2=0.27; p=0.873).

Discussion

The results of our survey show that most participants recognize the negative impacts of climate change on health and society. Respondents believe that climate change is primarily related to human activities and predict serious health impacts in the future, including an increased burden on health systems and an increase in diseases associated with ecosystem change. The majority of respondents expressed strong support for integrating topics related to the health consequences of climate change into medical and health education curricula. They also acknowledged the importance of addressing the needs of high-risk groups, including the elderly and individuals living with chronic illnesses. Overall, the findings highlight the critical need to

Table 4: Relationship between year of study and students' perceptions of climate change impacts.

Variable	Year of study						X^2	*df*	p-Value
	First year	Second year	Third year	Fourth year	Fifth year	Other			
Do you think climate change is bad or good for human health?									
Little bad	12 (1.7 %)	20 (2.9 %)	9 (1.3 %)	22 (3.2 %)	17 (2.4 %)	11 (1.6 %)	89.22	25	p<0.001
Somewhat bad	13 (1.9 %)	43 (6.2 %)	14 (2 %)	43 (6.2 %)	13 (1.9 %)	6 (0.9 %)			
Very bad	35 (5 %)	38 (5.5 %)	42 (6 %)	29 (4.2 %)	40 (5.7 %)	34 (4.9 %)			
Little good	15 (2.2 %)	20 (2.9 %)	9 (1.3 %)	8 (1.1 %)	3 (0.4 %)	5 (0.7 %)			
Somewhat good	15 (2.2 %)	39 (5.6 %)	15 (2.2 %)	13 (1.9 %)	26 (3.7 %)	3 (0.4 %)			
Very good	15 (2.2 %)	15 (2.2 %)	12 (1.7 %)	27 (3.9 %)	9 (1.3 %)	7 (1 %)			
Do you agree with the statement: That climate change is mainly caused by human activities?									
Yes	79 (11.3 %)	99 (14.2 %)	79 (11.3 %)	107 (15.4 %)	66 (9.5 %)	59 (8.5 %)	42.62	10	p<0.001
No	13 (1.9 %)	51 (7.3 %)	17 (2.4 %)	24 (3.4 %)	29 (4.2 %)	7 (1 %)			
I don't know	13 (1.9 %)	25 (3.6 %)	5 (0.7 %)	11 (1.6 %)	13 (1.9 %)	0 (0 %)			
Do you perceive that climate change will increase the burden on healthcare systems, requiring them to adapt to new types of diseases and conditions?									
Yes	85 (12.2 %)	141 (20.2 %)	82 (11.8 %)	120 (17.2 %)	76 (10.9 %)	55 (7.9 %)	56.84	10	p<0.001
No	6 (0.9 %)	3 (0.4 %)	11 (1.6 %)	2 (0.3 %)	22 (3.2 %)	9 (1.3 %)			
I don't know	14 (2 %)	31 (4.4 %)	8 (1.1 %)	20 (2.9 %)	10 (1.4 %)	2 (0.3 %)			
Should medical curricula worldwide include mandatory training on the health impacts of climate change and its related diseases?									
Yes	83 (11.9 %)	122 (17.5 %)	82 (11.8 %)	101 (14.5 %)	72 (10.3 %)	52 (7.5 %)	33.07	10	p<0.001
No	8 (1.1 %)	12 (1.7 %)	7 (1 %)	24 (3.4 %)	23 (3.3 %)	6 (0.9 %)			
I don't know	14 (2 %)	41 (5.9 %)	12 (1.7 %)	17 (2.4 %)	13 (1.9 %)	8 (1.1 %)			
Do you believe that climate change will lead to an increase in vector-borne diseases in the coming decades?									
Yes	66 (9.5 %)	102 (14.6 %)	62 (8.9 %)	99 (14.2 %)	82 (11.8 %)	47 (6.7 %)	45.85	10	p<0.001
No	11 (1.6 %)	18 (2.6 %)	14 (2 %)	20 (2.9 %)	17 (2.4 %)	17 (2.4 %)			
I don't know	28 (4 %)	55 (7.9 %)	25 (3.6 %)	23 (3.3 %)	9 (1.3 %)	2 (0.3 %)			

Table 5: The relationship between students' nationality and their views on climate change and medical education.

Variable	Nationality					X^2	*df*	p-Value
	Kazakh	Russian	Pakistani	Indian	Others			
Do you agree with the statement: That climate change is mainly caused by human activities?								
Yes	111 (15.9 %)	21 (3 %)	228 (32.7 %)	114 (16.4 %)	15 (2.2 %)	32.85	8	p<0.001
No	27 (3.9 %)	7 (1 %)	49 (7 %)	54 (7.7 %)	4 (0.6 %)			
I don't know	19 (2.7 %)	6 (0.9 %)	12 (1.7 %)	25 (3.6 %)	5 (0.7 %)			
Should medical curricula worldwide include mandatory training on the health impacts of climate change and its related diseases?								
Yes	117 (16.8 %)	20 (2.9 %)	225 (32.3 %)	133 (19.1 %)	17 (2.4 %)	21.38	8	0.006
No	8 (1.1 %)	6 (0.9 %)	34 (4.9 %)	30 (4.3 %)	2 (0.3 %)			
I don't know	32 (4.6 %)	8 (1.1 %)	30 (4.3 %)	30 (4.3 %)	5 (0.7 %)			

Table 6: Gender differences in perceptions of climate changes and climate education.

Variable	Gender		X^2	*df*	p-Value
	Female	Male			
Do you think climate change is bad or good for human health?					
Little bad	41 (5.9 %)	50 (7.2 %)	17.25	5	0.004
Somewhat bad	57 (8.2 %)	75 (10.8 %)			
Very bad	69 (9.9 %)	149 (21.4 %)			
Little good	28 (4 %)	32 (4.6 %)			
Somewhat good	54 (7.7 %)	57 (8.2 %)			
Very good	24 (3.4 %)	61 (8.8 %)			
Do you agree mental health conditions are a health of climate change?					
Yes	155 (22.2 %)	234 (33.6 %)	0.27	2	0.873
No	73 (10.5 %)	121 (17.4 %)			
I don't know	45 (6.5 %)	69 (9.9 %)			
Should medical curricula worldwide include mandatory training on the health impacts of climate change and its related diseases?					
Yes	207 (29.7 %)	305 (43.8 %)	6.55	2	0.038
No	21 (3 %)	59 (8.5 %)			
I don't know	45 (6.5 %)	60 (8.6 %)			

enhance awareness and strengthen preparedness for the growing health challenges associated with a changing climate.

Climate change has grown silently until it became unavoidable for all living beings on Earth [13]. According to our study, More than half of students recognize that climate change contributes to mental health disorders (55.8 %). Our studies are justified by other studies, as the impact of global warming upon vulnerable nations produces vital consequences, which lead to depression and anxiety disorders among their people. The research from Gislason et al. (2021) demonstrates that youth and children experience rising mental health problems from climate change through depression, remorse and sleep modifications, poor concentration and sadness, along with land separation and solastalgia symptoms [14].

Our results show that 70.2 % agree that climate change is mainly caused by human activities. Kotcher J et al. show in their study that the survey participants exhibited complete awareness that human activities drive climate change while assessing it as an expanding health threat to their nation and placing themselves responsible for public education [15]. Research conducted by the American Thoracic Society (ATS) with its healthcare professional members demonstrated wide agreement that present-day patients experience effects from climate change, while most experts predict this situation will deteriorate throughout the upcoming 20 years [16]. Results from an earlier study (2014) with National Medical Association African-American physicians showed identical findings regarding human-induced climate change alongside patient care [17].

Our results show that an increased morbidity is related to ecosystem change (67.9 %). Similarly, studies show that Human actions have caused massive and growing transformations to Earth's natural systems which affect all parts of the planet quickly. Our changing human activities produce various health effects we have only managed to describe incompletely. Study of Myers SS et al. indicate that human health suffers detriment across its various aspects and researchers predict this negative impact to grow increasingly heavier as ecosystem degradation builds up [18].

65.7 % of respondents believe there will be an increase in vector-borne diseases in the future due to climate change. Additional evaluations confirmed that vector-borne diseases and respiratory problems, and mental health challenges emerged as essential health risks because of climate change [19]. The majority of respondents also agree that climate change will affect vulnerable populations such as the elderly and people with chronic diseases (77.3 %). From climate change, mostly elderly population is mostly affected, with having different acute exacerbated and chronic diseases like respiratory, cardiovascular, dermatological, allergic and infectious diseases. The recent outbreak of multiple emerging infectious diseases caused significant disease-related deaths and hospitalizations, and experts predict a further increase in outbreaks because of climate-change-related pathogen variations and environmental and population effects. Environmentally-triggered climate changes produce four main effects: enlargement of EID reservoirs while boosting host-pathogen contact rates and spillover possibilities, as well as damaging susceptible population health to create new emerging infectious disease outbreaks [20]. Pollutant exposure is also linked with higher prevalence of childhood asthma and exacerbation of existing asthma and allergic disease. The relationship between rising exposure to existing allergens and air pollutants due to climate change has unclear effects on sensitization and new allergic disease development [21]. The research conducted in Dezful regarding climate change health effects revealed occasional evidence of people's heat adaptation in their results. Aghababaeian et al. (2023) reported no substantial change in cardiovascular mortality when temperatures rose high [22].

When considering students' awareness of the health impacts of climate, it is important to consider alternative perspectives. Some studies indicate a high level of awareness

among young people, especially in the academic environment where the environmental agenda is actively discussed. On the other hand, there is a perception that students' knowledge is often superficial and not accompanied by a real understanding of mental and physical health implications. Given these differences, the present study aims at an objective assessment, avoiding one-sided conclusions and providing a more balanced analysis of the problem.

The data obtained in this study regarding the level of awareness among medical students align with theoretical models such as the "One Health" concept and the Social Determinants of Health framework, both of which emphasize the connection between environmental factors and population health. In the context of public health systems, this highlights the need to integrate climate-related aspects into educational and preventive strategies, in line with current global agendas on sustainable development and climate adaptation. Thus, the study not only identifies educational gaps but also contributes to the broader scientific discourse on the importance of training healthcare professionals capable of effectively responding to the challenges posed by a changing environment.

The combination of escalating service needs with limited operational planning and strengthening of program infrastructure, and the additional stress factors accounts for these challenges [23]. Primary care clinicians show willingness to address climate change with patients in their practice yet they need more education and self-assurance to do so. Respondents also believe that health programs should include education on health issues related to climate change to improve health in communities. The implementation of climate change curricula in student education grows stronger but there remain no educational programs for mid- and late-career clinicians [24]. Research helps comprehend information retrieval patterns among students who belong to different educational disciplines while demonstrating their understanding about Climate Changes sources and their grasp of global warming origins and healthcare worker responsibilities in climate protection efforts [25].

Healthcare workers face numerous issues because of climate change according to medical students in their research. The medical professionals experience rising workloads and staffing shortages as well as physical exhaustion and mental strain and patient care pitfalls and treatment quality decline. Clinical students observed that healthcare facilities faced a combination of equipment scarcity alongside a shortage of beds, delayed laboratory test results, increased medication requirements, distribution challenges, difficulty providing patient transfers and care and reduced health service access and elevated pandemic risks. Future climate change effects worry people most about their overall magnitude and intensity [7].

Climate change leads vectors to transmit diseases such as malaria, dengue and cholera because environmental changes affect temperature and humidity and water access [26, 27]. Personal hygiene maintenance forms an important strategy for preventing illnesses caused by contaminated food and water when dealing with climate change [26]. The increased presence of healthcare professionals in social conversations about the climate connection leads people toward better efforts in climate change reduction [28]. Clinical professionals are now receiving more widespread endorsement to be more actively involved in climate change response activities [29].

Students residing in regions that experience direct climate change effects, such as Pakistan, India and Kazakhstan, showed higher awareness about fast-approaching public health threats attributed to climate change. Research demonstrates that this age group, from 21-23-year-old population, is well aware of climate change and its threats to human health. Among these ages majority of women are well aware of eco-anxiety and how climate change affects them emotionally. Research demonstrates that the younger population have good knowledge about climate change and its effects on health due to more exposure to environmental change, and information provided by educational institutions. [30].

According to the results, mostly of students are well known of climate change and its effects on human health. This is very important for healthcare professionals to implement all knowledge in their practice for the welfare of human health. Most healthcare students understood that following environment-friendly practices should be standard both at their medical institutions and in domestic spaces. Such behavior promotion remains essential since healthcare facilities generate considerable greenhouse gas emissions. The large potential of healthcare professionals exists to move swiftly from environmental destruction as consumers to ecological revolution leadership because their professional ethics prevent harm to the environment [31].

The research findings can be used to justify the inclusion of mandatory interdisciplinary courses in educational programs, covering environmental risks, climate resilience, and their connection to public health. Furthermore, they provide a basis for initiating a review of educational standards with an emphasis on prevention and adaptation to climate change. In practical terms, this may involve the development of clinical protocols that take climate factors into account, training medical personnel to act in environmental crisis situations, and shaping resilient models of healthcare delivery in vulnerable regions. Thus, the results lay the

groundwork for creating a roadmap aimed at integrating a climate-oriented approach into medical education and healthcare organization.

Healthcare institutions and service providers are encouraged to take the following practical steps to integrate climate change issues into educational and support initiatives:

- Develop and implement specialized modules or courses focused on the health impacts of climate change, covering topics such as sustainable healthcare systems, climate-related diseases, and adaptation strategies in clinical practice.
- Engage experts from related fields – such as ecology, epidemiology, and public health – to foster a comprehensive understanding of climate risks and their implications for health.
- Introduce simulation-based training and clinical case studies related to climate emergencies (e.g., natural disasters) to build students' practical response skills.
- Establish accessible and confidential mental health programs for students, including psychological counseling and group sessions aimed at reducing anxiety related to climate threats and overall professional stress.
- Implement systems for regular assessment of students' knowledge and anxiety levels regarding climate and health issues, followed by adjustments to educational and support programs as needed.

These measures will help create a resilient and adaptive educational environment that prepares competent and emotionally resilient professionals to meet the growing challenges posed by climate change.

Information about climate change should be added to the curriculum for a better grip and knowledge to be practically applied in the field to overcome effects. Educational students have taken leadership roles to tackle this problem in their institutions [32] creating an opportunity to develop programs that enhance educational quality and prepare health practitioners for Climate Change health threats [33]. The students acknowledged Climate Change represents a significant problem for both present healthcare practitioners and forthcoming patients, yet medical students conveyed lower levels of worry than their nursing and other professional peers.

One limitation of our study is the limited sample, as only students from one university participated. This may limit the generalizability of the findings to broader populations. In addition, the use of a cross-sectional research design imposes certain limitations on the ability to identify causal relationships between variables, as this method only allows us to analyze relationships at a certain point in time without considering possible changes in dynamics.

Existing research focuses on the physiological consequences of climate change – the increase in heat-related diseases, the spread of infections, and the deterioration of air quality. However, psychological aspects, including such phenomena as eco-anxiety, feelings of uncertainty about the future, and decreased mental well-being, have so far been covered in a fragmented manner. Most works focus on objective climate risks and health impacts, leaving aside young people's perception of these threats and their readiness to adapt. The lack of a comprehensive analysis of students' knowledge, attitudes and behavioral strategies in this area is a key gap that this study aims to fill.

For further research in this area, it is recommended to expand the sample to include participants from different regions and educational institutions, which will increase the validity and universality of the findings. It is advisable to adopt a broader range of research methods, including qualitative approaches such as interviews and focus group discussions. These techniques can provide deeper insight into participants' perspectives and lived experiences, while also uncovering more complex interconnections among the variables being studied. Future investigations would benefit from focusing more specifically on how individual climate-related factors affect health, with an emphasis on variations in population responses. Understanding these patterns is essential for identifying potential links to the emergence of new illnesses or the worsening of pre-existing chronic conditions. Moreover, assessing the level of knowledge among healthcare professionals – such as physicians and allied health workers – regarding the health consequences of climate change is crucial. Such evaluations can help uncover knowledge gaps and inform recommendations for enhancing medical education programs to better equip healthcare providers to respond effectively to climate-related health threats.

Conclusions

The findings of this study reveal a strong awareness among medical students about the health implications of climate change and highlight the need to incorporate this subject into academic curricula. A substantial number of participants recognized that climate change contributes to increased health risks and places additional strain on healthcare systems. Strengthening the awareness and adaptive capacity of future physicians to deal with environmental challenges is a key step toward ensuring the delivery of effective healthcare in an era of global climate transformation.

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