



CLIMATE CHANGE AS A PUBLIC HEALTH ISSUE: AWARENESS, ENVIRONMENTAL HEALTH BEHAVIORS, AND PERCEPTIONS OF ITS EFFECTS ON RESPIRATORY, CARDIOVASCULAR, AND INFECTIOUS DISEASES AMONG HEALTHCARE PROFESSIONALS

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Abstract

Background: Climate change is an emerging public health challenge with important consequences for respiratory, cardiovascular, and infectious diseases. Healthcare professionals play a critical role in recognizing climate-related health risks, promoting preventive measures, and supporting environmentally sustainable healthcare practices. However, gaps may exist between awareness, perceptions, and actual environmental health behaviors.

Objectives: To assess healthcare professionals' awareness of climate change as a public health issue, determine their perceptions regarding its effects on respiratory, cardiovascular, and infectious diseases, evaluate environmental health behaviors, identify perceived barriers to climate-related healthcare practices, and examine associations between demographic/professional characteristics, awareness, perceptions, and environmental behaviors.

Methodology: A hospital-based cross-sectional analytical study was conducted at Dow University Hospital among 300 healthcare professionals recruited through non-probability consecutive sampling. Data were collected using a structured self-administered questionnaire assessing demographic and professional characteristics, climate-change awareness, perceptions of climate-related health effects, and environmental health behaviors. Awareness was categorized as good, moderate, or poor. Data were analyzed using IBM SPSS Statistics version 22. Chi-square test, independent-samples t-test, one-way ANOVA, Pearson correlation, and multivariable logistic regression were applied, with statistical significance set at $p < 0.05$.

Results: Among 300 healthcare professionals, 44.0% demonstrated good awareness, 41.3% moderate awareness, and 14.7% poor awareness, with a mean awareness score of $68.4 \pm 13.7\%$. Most participants recognized climate-related respiratory risks (91.3%), effects on cardiovascular health (81.0%), and altered vector-borne disease distribution (85.7%). Frequently reported environmental

behaviors included appropriate healthcare waste segregation (79.0%), switching off unused electrical equipment (74.7%), and electronic documentation (73.7%), whereas counseling patients about climate-related health risks (34.3%) and participation in institutional environmental initiatives (30.3%) were less common. Awareness was positively correlated with perceptions ($r=0.52$, $p<0.001$) and environmental health behaviors ($r=0.39$, $p<0.001$). Previous climate-health education was the strongest independent predictor of good awareness (adjusted OR=2.84, 95% CI: 1.79–4.51, $p<0.001$). Lack of formal training was the most frequently reported barrier (62.0%).

Conclusion: Healthcare professionals demonstrated generally favorable recognition of climate change and its health consequences, but detailed awareness and translation of knowledge into environmental health practices remained suboptimal. Previous exposure to climate-health education was strongly associated with better awareness, while awareness and perceptions were positively related to sustainable behaviors. Integrating climate-change education into healthcare curricula and continuing professional development, together with institutional policies and practical sustainability initiatives, may strengthen climate-resilient healthcare practice.

Keywords: Climate change; Public health; Healthcare professionals; Climate-health awareness; Environmental health behavior; Respiratory diseases; Cardiovascular diseases; Infectious diseases; Sustainable healthcare; Climate-resilient healthcare.

INTRODUCTION

Climate change has emerged as one of the most important global public health challenges of the twenty-first century. Rising global temperatures, changing precipitation patterns, recurrent heatwaves, air pollution, extreme weather events, water insecurity, and ecological disruption are increasingly affecting human health[1,2]. Although climate change is frequently discussed in terms of environmental and economic consequences, its effects on population health are equally substantial. Healthcare professionals are increasingly required to recognize, prevent, communicate, and manage health conditions that are directly or indirectly influenced by environmental and climatic changes[3].

The health consequences of climate change are multidimensional and extend across almost every major organ system. Increased ambient temperatures and prolonged heatwaves may contribute to dehydration, heat exhaustion, heat stroke, electrolyte disturbances, and exacerbation of underlying chronic diseases[4-6]. Climate-related changes in air quality, particularly increased concentrations of particulate matter, ozone, smoke, and other pollutants, can worsen respiratory conditions such as asthma, chronic obstructive pulmonary disease, respiratory infections, and allergic disorders[7]. Individuals with pre-existing cardiovascular disease are particularly vulnerable to extreme temperatures and air pollution because of their effects on vascular function, cardiac workload, blood pressure, coagulation, and systemic inflammation.

Climate change also has important implications for infectious diseases. Changes in temperature, humidity, rainfall, and ecological conditions can alter the geographical distribution and seasonal transmission of vector-borne diseases[8]. Expansion of mosquito habitats and changes in vector activity may influence diseases such as dengue, malaria, chikungunya, and other arboviral infections. Flooding and disruption of sanitation systems may increase the risk of waterborne and foodborne diseases[9,10]. In addition, population displacement following floods, droughts, storms, and other climate-related disasters may increase exposure to communicable diseases and place additional pressure on already constrained healthcare systems.

Healthcare professionals occupy a particularly important position in addressing climate-related health risks. Physicians, nurses, pharmacists, allied health professionals, and other healthcare workers can contribute to climate change mitigation and adaptation through clinical practice, patient education, preventive health interventions, community engagement, research, and advocacy[11]. Their understanding of climate-related health risks can influence the extent to which these issues are incorporated into clinical assessment and health promotion.

Despite the increasing recognition of climate change as a health issue, climate-related health education remains inadequately integrated into many healthcare curricula and professional development programs. Healthcare professionals may have general awareness of climate change but limited knowledge of its specific effects on respiratory, cardiovascular, infectious, and other diseases[12-14]. Similarly, awareness does not necessarily translate into environmentally responsible behaviors, such as reducing unnecessary energy consumption, minimizing healthcare waste, conserving water, promoting sustainable transportation, and encouraging environmentally responsible practices among patients and colleagues[15].

Understanding the knowledge, perceptions, and environmental health behaviors of healthcare professionals is therefore essential[16-19]. Healthcare workers represent a highly influential group whose professional attitudes and practices can contribute to both individual and population-level responses to climate change. Assessing their awareness of climate-related health consequences can identify educational gaps and inform the development of targeted training programs.

The present study was designed to assess awareness of climate change as a public health issue, evaluate environmental health-related behaviors, and determine healthcare professionals' perceptions regarding the effects of climate change on respiratory, cardiovascular, and infectious diseases. The study also explored the association between demographic/professional characteristics and levels of climate-change awareness and environmentally responsible behavior.

OBJECTIVES

The objective of this study is to assess the level of awareness among healthcare professionals regarding climate change as a public health issue. include determining healthcare professionals' perceptions of the effects of climate change on respiratory, cardiovascular, and infectious diseases, and assessing their environmental health behaviors related to energy conservation, waste management, water conservation, transportation, and sustainable healthcare practices. The study will also examine the association between demographic and professional characteristics and climate-change awareness, and evaluate the relationship between climate-change awareness, perceptions of health effects, and environmental health behaviors. Finally, it seeks to identify the perceived barriers to incorporating climate-change-related health practices into routine healthcare delivery..

METHODOLOGY

A hospital-based cross-sectional analytical study was conducted at Dow university Hospital to assess awareness, perceptions, and environmental health behaviors related to climate change among healthcare professionals .The study population included medical doctors, nurses, pharmacists, physiotherapists, medical laboratory professionals and other allied healthcare professionals involved in direct patient care and healthcare-related academic or clinical activities.

A total of 300 healthcare professionals were recruited using non-probability consecutive sampling. Participants were included if they were ≥ 18 years of age, currently working in a healthcare institution, had at least six months of professional experience, and provided informed consent. Healthcare professionals on extended leave during the study period, those who declined participation, and those with incomplete questionnaires were excluded.

Data were collected using a structured, self-administered questionnaire developed after reviewing relevant literature. The questionnaire comprised four sections. *Section A* captured demographic and professional characteristics including age, gender, professional category, years of experience, educational qualification, workplace, and prior exposure to climate-change education. *Section B* assessed climate change awareness across concepts such as global warming, greenhouse gases, extreme temperatures, air pollution, climate-related disasters, climate-sensitive diseases, healthcare system vulnerability, and mitigation/adaptation strategies. Each correct response was scored as one point, and total awareness was categorized as good $\geq 75\%$, moderate 50–74%, and poor $< 50\%$.

Section C evaluated perceptions of climate-related health effects on respiratory, cardiovascular, and infectious diseases using a five-point Likert scale ranging from strongly disagree to strongly agree. *Section D* assessed environmental health behaviors related to energy conservation, waste management, water conservation, transportation, and sustainable healthcare practices, with responses categorized as always, often, sometimes, rarely, or never, and a composite behavior score calculated.

Data were entered and analyzed using IBM SPSS Statistics version 22. Categorical variables were presented as frequencies and percentages, and continuous variables as mean $\pm$ standard deviation. Associations between categorical variables were assessed using the Chi-square test. The independent-samples t-test was used to compare means between two groups, and one-way ANOVA was applied for comparisons involving more than two groups. Pearson correlation was performed to examine the relationships between awareness, perception, and environmental health behavior scores. To identify independent predictors of good climate-change awareness and positive environmental health behavior, multivariable logistic regression analysis was conducted. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the ethical committee of Dow university of Health sciences. Written informed consent was obtained from all participants. Participation was voluntary, and participants were informed that they could withdraw from the study at any time. maintained

RESULTS

Table 1. Demographic and Professional Characteristics of Participants (n=300)

Age		
20–29 years	96	32.0
30–39 years	112	37.3
40–49 years	58	19.3
≥ 50 years	34	11.3
Professional experience		
<5 years	118	39.3
5–10 years	91	30.3
11–20 years	57	19.0
>20 years	34	11.3
Previous climate-health education		
Yes	126	42.0
No	174	58.0

The study included 300 healthcare professionals, with a mean age of approximately 34.7 ± 9.2 years. Females constituted 57.3% of participants, while males accounted for 42.7%. Physicians represented the largest professional group (42.0%), followed by nurses (32.0%).

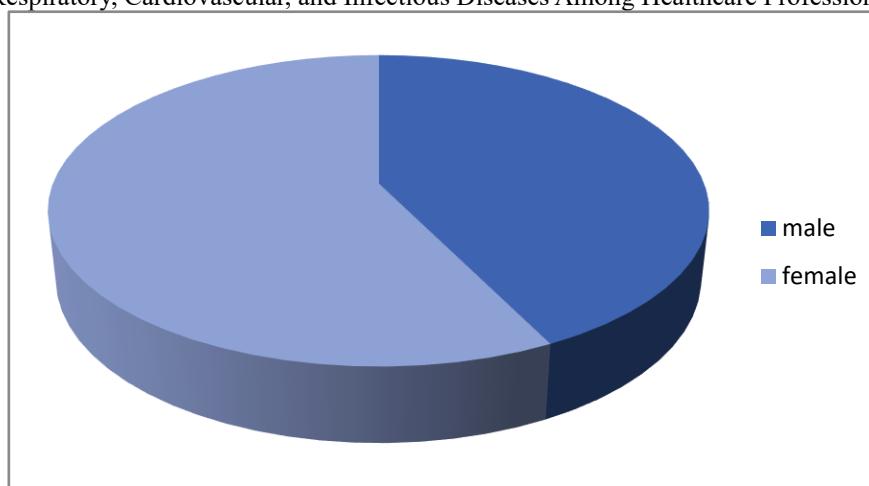


Figure 1 showed the Gender wise distribution of the participants

Most participants had fewer than 10 years of professional experience. Notably, only 42.0% reported previous exposure to formal education or training concerning climate change and health, whereas 58.0% had received no such training.

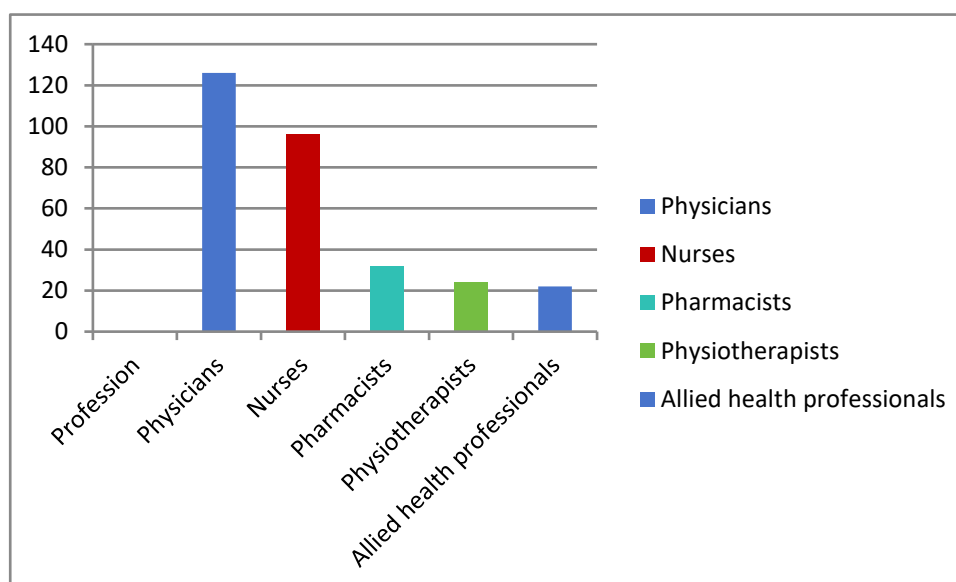


Figure 2 showed the Profession wise distribution of the participants

Table 2. Awareness of Climate Change as a Public Health Issue (n=300)

Good awareness	132	44.0
Moderate awareness	124	41.3
Poor awareness	44	14.7
Total	300	100.0

Mean awareness score: $68.4 \pm 13.7\%$

Individual Awareness Items

Climate change can affect human health	284 (94.7)
Extreme heat can cause illness and death	271 (90.3)
Air pollution can worsen respiratory disease	278 (92.7)
Climate change can influence cardiovascular disease	229 (76.3)
Climate change can influence infectious diseases	248 (82.7)
Climate change can alter mosquito/vector distribution	236 (78.7)
Flooding can increase waterborne disease risk	251 (83.7)
Healthcare systems can be affected by climate-related disasters	241 (80.3)
Healthcare professionals have a role in climate adaptation	219 (73.0)
Climate change should be included in healthcare education	267 (89.0)

Overall, 44.0% of participants demonstrated good awareness, while 41.3% had moderate awareness and 14.7% demonstrated poor awareness.

Table 3. Perceptions Regarding Climate Change and Respiratory, Cardiovascular, and Infectious Diseases

Climate change increases respiratory health risks	274 (91.3)
Air pollution associated with climate change can worsen asthma/COPD	269 (89.7)
Heatwaves may increase cardiovascular morbidity	243 (81.0)
Climate change can increase cardiovascular mortality among vulnerable populations	228 (76.0)
Climate change may contribute to hypertension and cardiovascular stress	201 (67.0)
Climate change can alter the distribution of vector-borne diseases	257 (85.7)
Climate change can increase dengue transmission risk	252 (84.0)
Flooding may increase waterborne infections	263 (87.7)
Climate change can influence seasonal patterns of infectious diseases	246 (82.0)
Climate-related disasters can increase healthcare demand	279 (93.0)
Healthcare professionals should counsel patients about climate-	238 (79.3)

related health risks	
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The majority of healthcare professionals perceived climate change as an important determinant of respiratory, cardiovascular, and infectious diseases. The strongest perception was observed regarding the effect of climate-related disasters on healthcare demand (93.0%), followed by respiratory health risks (91.3%) and the relationship between air pollution and asthma/COPD (89.7%).

Table 4. Environmental Health Behaviors Among Healthcare Professionals

Switch off unused lights/equipment	224 (74.7)
Avoid unnecessary printing	193 (64.3)
Practice appropriate healthcare waste segregation	237 (79.0)
Conserve water at workplace	205 (68.3)
Reuse materials when safe and appropriate	164 (54.7)
Reduce use of unnecessary disposable items	178 (59.3)
Use electronic documentation where available	221 (73.7)
Use environmentally sustainable transportation	117 (39.0)
Encourage colleagues to adopt sustainable practices	152 (50.7)
Discuss climate-related health risks with patients	103 (34.3)
Participate in institutional environmental initiatives	91 (30.3)

The most frequently reported environmentally responsible behaviors were appropriate healthcare waste segregation (79.0%), switching off unused electrical equipment (74.7%), and electronic documentation (73.7%). In contrast, relatively low participation was observed in institutional environmental initiatives (30.3%) and counseling patients regarding climate-related health risks (34.3%).

A significant association was observed between professional category and climate-change awareness ($p=0.018$). Physicians demonstrated a higher proportion of good awareness compared with other professional groups. Awareness also increased significantly with professional experience ($p=0.031$). The strongest association was observed between previous exposure to climate-health education and awareness level ($p<0.001$).

Table 5. Correlation Between Awareness, Perception, and Environmental Health Behavior Scores

Awareness vs. perception score	0.52	<0.001
Awareness vs. environmental behavior	0.39	<0.001
Perception vs. environmental behavior	0.43	<0.001

A statistically significant positive correlation was observed between awareness and perceptions of climate-related health effects ($r=0.52$, $p<0.001$). Awareness was also positively correlated with environmentally responsible behavior ($r=0.39$, $p<0.001$). Similarly, stronger perceptions of climate-related health risks were associated with better environmental health behaviors ($r=0.43$, $p<0.001$).

Table 6. Perceived Barriers to Addressing Climate Change in Healthcare

Lack of formal training	186 (62.0)
Lack of institutional policies	171 (57.0)
Heavy clinical workload	163 (54.3)
Limited resources	157 (52.3)
Lack of awareness among colleagues	149 (49.7)
Lack of patient awareness	137 (45.7)
Lack of incentives for sustainable practices	129 (43.0)
Lack of clear professional guidelines	124 (41.3)

The most frequently reported barrier was lack of formal training (62.0%), followed by inadequate institutional policies (57.0%) and heavy clinical workload (54.3%).

Table 7. Multivariable Predictors of Good Climate-Change Awareness

Previous climate-health education	2.84	1.79–4.51	<0.001
Physician profession	1.91	1.17–3.13	0.010
Professional experience >10 years	1.76	1.08–2.86	0.024
Female gender	1.24	0.80–1.93	0.338
Age ≥40 years	1.38	0.86–2.21	0.181

Previous climate-health education was the strongest independent predictor of good awareness. Healthcare professionals who had previously received climate-related education had approximately 2.8-fold higher odds of demonstrating good awareness compared with those without previous education.

The study demonstrated that although healthcare professionals generally recognized climate change as an important public health issue, substantial gaps remained in detailed knowledge and translation of awareness into environmental health behaviors.

Among the 300 participants, 44.0% demonstrated good overall awareness, while 41.3% had moderate awareness. Most participants recognized the relationship between climate change and respiratory diseases, with 91.3% agreeing that climate change increases respiratory health risks. Similarly, 81.0% recognized that heatwaves may increase cardiovascular morbidity, while 85.7% recognized that climate change can alter the distribution of vector-borne diseases.

Environmental health behaviors were comparatively less developed. Although waste segregation and energy conservation were relatively common, fewer participants reported counseling patients

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about climate-related health risks or participating in institutional environmental sustainability initiatives.

Previous exposure to climate-health education was strongly associated with better awareness. Participants who had received climate-health education were significantly more likely to demonstrate good awareness than those without previous training. Awareness and perceptions were also positively correlated with environmentally responsible behaviors, suggesting that improving knowledge may contribute to more sustainable healthcare practices.

The findings further indicated that lack of formal training, inadequate institutional policies, workload, and limited resources were major barriers to integrating climate-related health practices into routine healthcare.

DISCUSSION

Climate change is increasingly recognized as a major public health challenge, with consequences extending beyond environmental degradation to respiratory, cardiovascular, infectious, nutritional, and other health outcomes. Healthcare professionals occupy a particularly important position in responding to these challenges because they are directly involved in disease prevention, diagnosis, treatment, health education, community engagement, and advocacy. The present study assessed awareness, perceptions, environmental health behaviors, and perceived barriers related to climate change among 300 healthcare professionals. The principal findings demonstrated that although most participants recognized climate change as an important determinant of health, the level of detailed awareness and translation of this awareness into environmentally responsible professional behaviors remained suboptimal[20,21]. Only 44.0% of participants demonstrated good awareness, while 41.3% had moderate awareness and 14.7% had poor awareness. At the same time, perceptions of climate-related health effects were generally strong, whereas participation in patient counseling and institutional sustainability activities was considerably lower.

The study indicate that basic awareness of climate change is relatively well established among healthcare professionals, but more detailed or professionally oriented knowledge may be less developed. This distinction is important because recognition that climate change is harmful does not necessarily indicate sufficient knowledge to identify climate-sensitive diseases, vulnerable populations, adaptation strategies, or appropriate clinical and public health responses[22].

Our findings are consistent with previous research demonstrating that healthcare professionals commonly recognize climate change as a health threat but may have insufficient depth of knowledge to translate this recognition into professional practice.

Evidence from Pakistan similarly demonstrates generally favorable awareness but important gaps in knowledge and preparedness. A nationwide survey conducted following the devastating 2022 floods found that 92.9% of participants had heard of climate change, while healthcare workers and medical students demonstrated significantly greater knowledge than other participants. However, the study also demonstrated that knowledge was influenced by exposure to climate-related events and information sources.

A recent qualitative study among medical and public health professionals in Karachi provides particularly relevant contextual evidence. Participants recognized climate change as an important health challenge and identified infectious diseases, food insecurity, disasters, and urban resource constraints as major consequences[23]. However, inadequate training, limited resources, and weak policy implementation were identified as important barriers. These findings closely support the present observation that awareness exists but requires stronger educational and institutional support.

Respiratory health was one of the strongest perceived areas of climate-related health impact in the present study. Approximately 91.3% of participants agreed or strongly agreed that climate change increases respiratory health risks, while 89.7% recognized that climate-related air pollution can worsen asthma and chronic obstructive pulmonary disease.

This strong perception is clinically relevant because changes in temperature, air pollution, particulate matter, ozone, wildfire smoke, allergens, and extreme weather events can influence respiratory morbidity. Healthcare professionals are therefore likely to encounter climate-sensitive respiratory conditions in routine clinical practice[24,25]. Recognition of this relationship may also provide an important opportunity for patient education, particularly among individuals with asthma, COPD, allergic respiratory disorders, and other chronic pulmonary diseases.

The high level of recognition in the present study is encouraging, but it should be distinguished from the ability to incorporate climate-related information into clinical decision-making. Awareness that climate change worsens respiratory disease does not necessarily mean that clinicians routinely assess environmental exposure, provide climate-related preventive counseling, or modify management according to periods of extreme heat or poor air quality[26]. This distinction is important because only 34.3% of participants in the present study reported frequently discussing climate-related health risks with patients.

The cardiovascular consequences of climate change were also recognized by most participants, although awareness of this domain was somewhat lower than awareness of respiratory effects. In the present study, 81.0% agreed that heatwaves may increase cardiovascular morbidity, while 76.0% recognized the potential for increased cardiovascular mortality among vulnerable populations. However, only 67.0% agreed that climate change may contribute to hypertension and cardiovascular stress.

These findings suggest that healthcare professionals are more likely to recognize the immediate association between extreme heat and cardiovascular morbidity than the broader physiological mechanisms linking environmental changes with cardiovascular health. Extreme temperatures and air pollution may place additional physiological stress on individuals with pre-existing cardiovascular disease, particularly older adults and those with multiple comorbidities.

The relatively lower recognition of hypertension and cardiovascular stress compared with respiratory effects indicates an area where climate-health education could be strengthened[27]. Educational programs should therefore move beyond general statements regarding climate change and provide clinically relevant information concerning heat exposure, cardiovascular stress, vulnerable populations, medication-related considerations, air pollution, and prevention of climate-sensitive cardiovascular events.

The present study demonstrated substantial recognition of the relationship between climate change and infectious diseases. Approximately 85.7% of participants agreed that climate change can alter the distribution of vector-borne diseases, while 84.0% recognized a potential increase in dengue transmission. Similarly, 87.7% recognized that flooding may increase waterborne infections and 82.0% recognized that climate change can influence seasonal patterns of infectious diseases.

These findings are particularly relevant in the Pakistani context, where changing rainfall patterns, flooding, temperature variation, water insecurity, and urban environmental conditions can influence infectious disease transmission. The findings from Karachi-based qualitative research similarly identified infectious diseases as a major concern among healthcare professionals and highlighted the importance of strengthening healthcare-sector preparedness.

The relatively high perception scores in this domain may partly reflect direct professional experience with climate-sensitive infectious diseases. Dengue, for example, is a familiar public health concern in Pakistan, and healthcare professionals may therefore more readily recognize the relationship between environmental conditions and vector-borne disease transmission[28].

However, recognition alone is insufficient. Healthcare professionals also require practical competencies in surveillance, early recognition, patient counseling, outbreak preparedness, vector-control advocacy, and communication of preventive measures. Integrating climate-sensitive

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infectious disease content into continuing professional development could therefore help convert awareness into preparedness.

The strongest perception in the present study concerned the effect of climate-related disasters on healthcare demand, with 93.0% of participants agreeing or strongly agreeing that climate-related disasters can increase healthcare demand. This finding highlights an important dimension of climate change: its impact is not restricted to individual disease outcomes but extends to the capacity and resilience of healthcare systems.

Extreme weather events can increase patient volumes, disrupt healthcare infrastructure, affect supply chains, displace populations, and increase demands for emergency and public health services. Healthcare professionals therefore need to understand climate change not only as a cause of individual disease but also as a systems-level challenge.

The finding that 79.3% of participants believed healthcare professionals should counsel patients regarding climate-related health risks is encouraging. Nevertheless, this favorable perception was not fully reflected in reported behavior, because only 34.3% reported discussing climate-related health risks with patients frequently. This discrepancy represents one of the most important findings of the study and demonstrates a gap between perceived professional responsibility and actual implementation.

Environmental health behaviors were variable. Appropriate healthcare waste segregation was the most frequently reported behavior, with 79.0% of participants reporting that they always or often practiced it. Switching off unused lights and equipment was reported by 74.7%, while electronic documentation was reported by 73.7%. Water conservation was practiced by 68.3%, and avoidance of unnecessary printing by 64.3%.

These relatively common behaviors are encouraging because they represent practical activities that can be incorporated into routine healthcare workflows[29]. However, more complex behaviors requiring institutional support or professional engagement were considerably less common. Only 39.0% reported environmentally sustainable transportation, 50.7% reported encouraging colleagues to adopt sustainable practices, and only 30.3% participated in institutional environmental initiatives.

The pattern suggests that individual, relatively simple behaviors may be easier to adopt than activities requiring organizational infrastructure, leadership support, dedicated programs, or changes in professional roles. This interpretation is consistent with international research. A South African mixed-methods study found positive attitudes and strong interest in sustainability but only tentative implementation of environmentally responsible practices, with lack of knowledge, resources, and policies identified as barriers.

One of the most important findings of the present study was the relatively low proportion of healthcare professionals who reported discussing climate-related health risks with patients. Although 79.3% believed healthcare professionals should counsel patients, only 34.3% reported actually engaging in such discussions.

This finding demonstrates that awareness and professional attitudes do not automatically translate into clinical communication. Several factors may explain this gap. Climate-health counseling may not be included routinely in clinical history-taking or health education, healthcare professionals may perceive insufficient time during consultations, and many may lack confidence regarding what practical advice to provide. In addition, climate change may still be viewed primarily as an environmental or policy issue rather than a routine clinical topic.

Recent research supports the importance of addressing this educational gap. A study of 2,417 clinicians found that climate change and healthcare sustainability were considered relevant to

clinical practice, and participation in a structured quality-improvement educational measure was associated with increased perceived knowledge.

Similarly, a recent study of Italian healthcare workers found that healthcare professionals who had received information through training courses were more likely to engage in educating patients about sustainability and health protection[30]. The authors concluded that tailored training and integration of sustainability into healthcare education could strengthen the role of healthcare workers in climate adaptation and mitigation.

The association between awareness and behavior, although statistically significant, was weaker than the association between awareness and perception. This finding is particularly important because it suggests that increasing knowledge alone may not be sufficient to produce substantial behavioral change. Environmental behavior is influenced by multiple factors, including institutional policies, availability of resources, workload, professional culture, infrastructure, incentives, and leadership.

This interpretation is consistent with the emerging international literature demonstrating a persistent knowledge-practice gap among healthcare professionals. A recent integrative review found that healthcare professionals generally recognized the relationship between climate change and health but reported a discrepancy between awareness and implementation of sustainable practices. Institutional support was repeatedly identified as an important determinant of behavior.

The present findings therefore support integration of climate-health content into undergraduate and postgraduate healthcare curricula. Training should not be restricted to theoretical information. It should include practical clinical competencies such as recognizing climate-sensitive diseases, identifying vulnerable populations, communicating climate-related health risks, responding to heatwaves and disasters, promoting sustainable healthcare practices, and understanding healthcare-sector environmental impacts.

Professional category was significantly associated with climate-change awareness ($p=0.018$), with physicians demonstrating a higher proportion of good awareness than other professional groups. Awareness also increased significantly with professional experience ($p=0.031$). In multivariable analysis, being a physician remained independently associated with higher odds of good awareness (adjusted OR=1.91, 95% CI: 1.17–3.13; $p=0.010$), while more than 10 years of professional experience was also independently associated with awareness (adjusted OR=1.76, 95% CI: 1.08–2.86; $p=0.024$).

These findings may reflect differences in exposure to clinical decision-making, postgraduate education, professional literature, research, and public health information. More experienced professionals may also have greater exposure to climate-sensitive disease patterns and disaster-related healthcare demands.

However, these differences should not be interpreted as indicating that climate-health education is unnecessary for experienced professionals or non-physician healthcare workers. On the contrary, the multidisciplinary nature of climate-related health problems requires physicians, nurses, pharmacists, physiotherapists, laboratory professionals, and other healthcare workers to develop shared competencies.

A recent systematic review among nurses demonstrated considerable variation in climate-change knowledge and sustainability practices, reinforcing the importance of profession-specific and multidisciplinary educational strategies.

The most frequently reported barrier in the present study was lack of formal training (62.0%), followed by lack of institutional policies (57.0%), heavy clinical workload (54.3%), and limited resources (52.3%). These findings are important because they demonstrate that the observed knowledge-practice gap cannot simply be attributed to individual motivation or lack of concern.

The identification of institutional policies as the second most important barrier indicates that healthcare professionals may require organizational structures that facilitate sustainable behavior. Even motivated professionals may have limited ability to reduce waste, improve energy efficiency, implement sustainable transportation, or participate in environmental initiatives when institutional systems do not support such actions.

The findings of this study are particularly relevant to Pakistan because the country is highly exposed to climate-related hazards, including extreme heat, flooding, changing rainfall patterns, air pollution, and climate-sensitive infectious diseases. Recent Pakistani research has demonstrated substantial public awareness of climate change, while also identifying gaps in detailed knowledge and preparedness. Following the 2022 floods, a nationwide survey found that most respondents had heard of climate change and recognized flooding and rainfall changes as important manifestations, while healthcare workers and medical students demonstrated greater knowledge than other groups.

More recent evidence from Karachi has highlighted the perspectives of healthcare and public health professionals specifically. Participants recognized the health consequences of climate change and identified infectious diseases, environmental disasters, and healthcare-system pressures as important concerns. However, training limitations, inadequate resources, and policy weaknesses restricted their ability to respond effectively.

In addition, recent research among pharmacy students in Karachi reported very high awareness of climate-change consequences and strong recognition of the need for action, but actual mitigation practices were substantially lower. This pattern closely parallels the present findings, in which recognition and perceptions were stronger than implementation of patient counseling and institutional sustainability activities.

Together, these findings suggest that Pakistan may have a substantial foundation of climate-health awareness among current and future healthcare professionals, but systematic integration of climate-health competencies into healthcare education and institutional practice remains necessary.

Healthcare institutions should complement education with organizational interventions. Climate-health committees, institutional sustainability policies, staff training programs, waste-reduction systems, energy-monitoring programs, and climate-resilient emergency preparedness plans may facilitate behavioral change. Healthcare professionals should also be supported to discuss climate-related health risks with patients, particularly those with chronic respiratory or cardiovascular disease and those vulnerable to heat and infectious diseases.

Strengths of the study

Several strengths should be acknowledged. First, the study included a relatively large multidisciplinary sample of 300 healthcare professionals. Second, it assessed multiple dimensions of climate-health preparedness, including awareness, perceptions, environmental behaviors, barriers, and predictors. Third, the study examined relationships between awareness, perceptions, and environmental behavior rather than considering these domains independently. Fourth, multivariable logistic regression allowed identification of independent predictors of good awareness. Finally, the study provides contextually relevant evidence from a Pakistani healthcare setting, where climate-related health challenges are increasingly important.

Limitations

The study also has several limitations. First, its cross-sectional design prevents determination of causal relationships. Although previous climate-health education was strongly associated with good awareness, the findings cannot establish that education alone caused the higher awareness levels. Second, participants were recruited through non-probability consecutive sampling from a hospital setting, which may limit generalizability to healthcare professionals working in other institutions or regions of Pakistan.

Third, environmental health behaviors were self-reported and may therefore be affected by recall and social-desirability bias. Fourth, the questionnaire was developed after reviewing relevant literature, but the available methodology does not report extensive external validation of the instrument; therefore, measurement variability should be considered when interpreting the results. Fifth, although the study assessed multiple professional categories, the distribution of some professional groups may have influenced comparisons between occupations.

Finally, the study measured reported behaviors rather than directly observed institutional environmental outcomes. Future research should therefore combine questionnaire-based assessment with objective measures such as healthcare waste generation, energy consumption, water use, sustainable procurement indicators, and participation in institutional sustainability programs.

CONCLUSION

The present study demonstrates that healthcare professionals recognize climate change as an important public health concern and generally perceive significant effects on respiratory, cardiovascular, and infectious diseases. However, the level of detailed awareness and translation of this knowledge into environmental health behaviors remains suboptimal.

Although most participants acknowledged the effects of climate change on respiratory illness, cardiovascular health, vector-borne diseases, and waterborne infections, fewer healthcare professionals reported engaging in patient counseling or institutional sustainability initiatives. This indicates an important gap between awareness, professional perception, and actual environmental health practice.

Previous exposure to climate-change-related education was significantly associated with higher awareness, while awareness and positive perceptions were positively correlated with environmentally responsible behaviors. These findings emphasize the importance of incorporating climate change and health education into undergraduate medical, nursing, pharmacy, and allied health curricula, as well as continuing professional development programs.

Healthcare institutions should also establish practical environmental sustainability policies, including appropriate waste segregation, energy and water conservation, reduction of unnecessary disposable materials, sustainable procurement, and climate-resilient healthcare planning. Healthcare professionals should be empowered to educate patients and communities regarding climate-sensitive diseases and preventive measures.

Overall, addressing climate change should become an integral component of modern healthcare education and practice. Strengthening healthcare professionals' knowledge, perceptions, and environmental behaviors may improve both the sustainability of healthcare systems and their ability to respond effectively to the growing health consequences of climate change.

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