

Title: Healthcare professionals at the frontline of Climate Change: knowledge, attitudes, and practices

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24 **Abstract**

25 Healthcare professionals (HCPs), as trusted cadre of community, play a crucial role
 26 advocating climate action to reduce its impact on health. This study aimed to assess the
 27 knowledge, attitudes, practices and perceived responsibilities (KAPP), associated factors, of
 28 healthcare providers in Karachi, Pakistan, regarding climate change and its associated health
 29 effects.

30 We conducted a cross-sectional study among 486 HCPs from two tertiary care hospitals, one
 31 public and one private using a structured questionnaire adopted from previous studies.
 32 Composite KAPP scores were calculated for each domain; scores >50% were classified as
 33 adequate knowledge, positive attitudes, or good practices, while scores ≤50% were classified
 34 as inadequate/poor. Linear regression was used to examine associations between domain
 35 scores and co-variables. Variables significant at $p \leq 0.10$ in bivariate analysis were included in
 36 multivariable models. Results are presented as beta coefficients with 95% confidence
 37 intervals.

38 Overall, 51% of participants demonstrated adequate knowledge, 68% had positive attitudes,
 39 50% reported good climate-related practices and 90% felt responsibility for the issue. Most
 40 respondents agreed that climate change harms general health (96.7%) and affects patient
 41 health (89%). Key barriers to discussing climate change with patients included time
 42 constraints (82.9%) and insufficient knowledge (78.2%). In adjusted analyses, HCPs in
 43 private hospitals had significantly lower practice scores compared to those in public hospitals
 44 ($\beta = -0.84$, $p < 0.01$). Postgraduate education and House Officer designation were associated
 45 with higher knowledge scores, while higher income was linked to better knowledge and
 46 attitudes. A significant gap was noted between high intent and low personal practice, with
 47 40% never using public transport/carpool and 46.3% never walking/biking.

48 We found generally positive attitudes, but substantial gaps exist in knowledge and practice.
49 We recommend integration of climate change into medical curricula, and institutional
50 support to strengthen HCPs capacity to address climate-related health challenges.

51 **Keywords:** Climate change, Healthcare professionals, Knowledge, Attitudes, Practices,
52 Public health, Karachi, Pakistan.

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54 **Introduction:**

55 By the year 2050, climate change is projected to cause an additional 14.5 million deaths
 56 worldwide, as well as \$12.5 trillion in economic losses(1-3). Increased frequency of extreme
 57 weather-related events, rising global temperature, environmental pollution and shifting disease
 58 patterns lead to a burden on health services. The health consequences of climate change are
 59 multifaceted, affecting air quality, food security, water security, and the prevalence of both
 60 communicable and non-communicable diseases(4-7). Children, pregnant women, the elderly,
 61 and those in low-resource settings constitute vulnerable population and face disproportionate
 62 risks, underscoring the urgent need for effective, equitable, and sustainable responses to protect
 63 population health(8-10).

64 Healthcare professionals (HCPs) serve as the first line of defence against the health impacts
 65 of climate change (11-14). They are trusted sources of information for the populace, are
 66 uniquely positioned to educate patients and communities about climate-related health risks
 67 and to promote preventive strategies that reduce vulnerability(15). By leveraging their
 68 expertise and influence, HCPs can drive meaningful change at individual, community, and
 69 societal levels, ultimately safeguarding health (7, 16). Pakistan as a low- and middle-income
 70 country had very little role in causing climate change and yet it is one of the countries most
 71 severely affected by it (17, 18). Karachi is the economic hub, and the largest and most
 72 densely populated city of Pakistan. It is acutely exposed to the health consequences of
 73 climate change, specifically severe heatwaves, droughts, urban flooding, and chronically high
 74 levels of air pollution (19, 20).

75 Recent studies assessing the knowledge, attitudes, and practices of HCPs have revealed
 76 important insights. For example, in a survey of over 4,400 HCPs in Minnesota, United States,
 77 found that the majority (78%) recognized climate change as a significant threat to patient

health, only a small proportion (21%) felt adequately prepared to counsel patients on climate change (21). Similarly, a multinational survey highlighted that although most health professionals acknowledged the health impacts of climate change, many did not feel adequately equipped to take meaningful steps (22), and limited knowledge has been identified as a key barrier to effective engagement, leading to hesitancy in addressing climate change in clinical practice (21, 23). Differences in knowledge and attitudes have also been observed across regions and specialties, with some studies noting that targeted education and resources can improve confidence and engagement among HCPs(24).

The relationship between knowledge, attitudes, and practices is a critical consideration in understanding HCPs engagement with climate change. Evidence suggests that greater knowledge about climate change and its health implications is positively associated with more proactive attitudes and a stronger sense of professional responsibility toward climate action(22, 25). Studies have found that HCPs who are better informed about climate-related health risks are more likely to discuss these issues with patients, advocate for sustainable practices within their institutions, and support policy changes aimed at reducing greenhouse gas emissions (22, 23).

We found only one study from Pakistan that assesses knowledge, attitude and practices on climate change but that has only included nurses for the purpose (26). In this context, we set forth to determine HCPs level of knowledge, attitudes and practices (KAP) and their determinants regarding climate change and health in Karachi, Pakistan. This will help us in identifying gaps and will lead to better interventions to reduce the impact of climate change on health.

Methodology:

Study Design and Setting

This was a cross-sectional study. One public sector tertiary care teaching hospital and one private sector tertiary care teaching hospital of Karachi was chosen.

Study Population and Eligibility Criteria

Male and female HCPs (consultants, nurses, residents, interns/house officers, dentist and others) who were 18 years or above, have at least 6 months' work experience and those who provide us with consent were included in this study. HCPs who were public health professionals and those associated with specific responsibility or expertise on climate change (have formal professional degree or training on climate change) were excluded.

Sample Size

Sample size was calculated using WHO sample size software using data from a study titled "Nurses' Perception, Knowledge and Information Sources on Climate Change and Health at Dow University Hospital Karachi"(26). The sample size was calculated using a 95% confidence level and a 5% margin of error, resulting in a minimum required sample size of 384 participants. Considering an anticipated non-response/refusal rate of approximately 15%, the adjusted sample size was increased to 452 participants. We were required to recruit 221 participants from each institute. To ensure adequate representation from all participating institutes, a total of 486 participants were eventually recruited.

Sampling Procedure

A multistage sampling approach was employed for participant recruitment. In the first stage, two hospitals were purposively selected, and administrative permission was obtained from each institution prior to data collection. In the second stage, a list of all HCPs working in each hospital was obtained from the respective hospital administrations. The distribution of HCPs across professional categories was determined from these lists, and the required sample from each category was allocated using a population proportionate to size (PPS) approach.

For example, if nurses constituted 30% of the healthcare workforce in a hospital, 30% of the required sample from that hospital was allocated to nurses. Participants within each professional category were subsequently recruited using convenience sampling until the allocated sample size for each category was achieved.

Data Collection Procedures

We collected data through face-to-face interviews and through online forms on REDCap. Most of the data collection (90%) was through face-to-face interviews as online forms had a very low response rate. Each questionnaire took about 30-45 minutes to fill. The interview forms were then uploaded on to the REDCap software by the data collectors, and the entries were reviewed by the PI.

The data collection for this study was undertaken between January 2023 till August 2023. Informed written consent was taken from the study participants before data collection. Confidentiality of data was strictly maintained. For this purpose, unique IDs were assigned to the questionnaire and the forms with personal identification were kept in separate compartments under lock and key. We also ensured that the clinical activities of the HCPs were not affected for this purpose we informed the HCPs a few days before the actual data collection so that they would inform us on their availability and free time. The internal audit of this process was also completed by the Aga Khan University.

Study Instrument (Questionnaire)

A structured questionnaire was developed for this study by contextually modifying and adopting items from several previously validated instruments. This was done as most of the questionnaires were used in high income settings and needed to be modified for use in our context. These source tools included: Climate change in the American mind (27), Global warming's six Americas screening tools (28), A survey of African American physicians on

the health effects of climate change (29), public health nurses' knowledge and attitudes regarding climate change (30), and the UNDP-JCCCCP In-Country specific campaign for Grenada: Results of climate change awareness survey (31). This questionnaire consists of a total of 5 sections. First section is on socio-demographics and consists of a total 7 questions. Second section is on knowledge related questions on climate change and health, and it consists of 15 questions. Third section is on attitude regarding climate change and health, and it consists of 15 questions. The fourth section consists of questions on practices, and it consists of 10 questions. The fifth section consists of question on the responsibilities regarding climate change and consists of 4 questions.

Ethical Considerations

Ethical approval was received from the Ethical Review Committee (ERC reference #2022-6974). Prior permission from the hospital authorities were taken after explanation the study objectives. In addition, informed written consent was taken from the study participants before data collection.

Data Management and Statistical Analysis

Data was analysed using Stata version 16.0. Descriptive statistics i.e. frequencies and percentages were calculated for categorical variables like gender, education level, income, current occupation and type of hospital. Data completeness was verified prior to analysis. Missing data across the questionnaire items were minimal, typically less than 3% for any single item. Given the low level of missingness, no imputation methods were used for the primary analysis. For questions with missing responses, list-wise deletion was applied. Mean and standard deviation were calculated for continuous variables such as age. The primary outcome knowledge, attitude, practices, and responsibilities (KAPP) were calculated as the sum of all the responses in the relevant sections. Composite KAPP scores were calculated for each

domain; scores $>50\%$ were classified as adequate knowledge, positive attitudes, or good practices, while scores $\leq 50\%$ were classified as inadequate/poor. A linear regression model was used to predict the relationship between a continuous outcome score (Knowledge, Attitude, Practice, or Responsibility) and one or more independent variables. Selected variables with a p-value ≤ 0.10 in bivariate analysis were included in multivariate regression analysis. The results are reported as beta coefficients with 95% CI. Data completeness was verified prior to analysis.

Results:

Of the 486 HCPs 59.9% were females, 52.2% belonged to public sector, 62.3% were 18-30 years. About 53.9% had graduate degrees while 41.9% were postgraduates. About 44.6% earned monthly salary in the range of 50000-100000 Rs. Gender distribution was similar across public and private sector and females comprised the majority in both sectors. (Table 1).

Table: 1. Socio-demographic characteristics of public and private sector health care providers Karachi, Pakistan			
Variable	N= 486(%)	Public hospital N=254(%)	Private hospital N=232(%)
Gender			
Male	195 (40.1)	106 (41.7)	89(38.3)
Female	291(59.9)	148 (58.2)	143 (61.6)
Age			
≤ 30	303 (62.3)	182 (71.6)	121 (52.1)
31-40	93 (19.1)	40 (15.7)	53 (22.8)
≥41	65 (13.3)	23 (9.0)	42 (18.1)
No response	25 (5.1)	9 (3.5)	16 (6.8)
Educational level			
Secondary	20 (4.1)	15 (5.9)	5 (2.1)
Graduate	262 (53.9)	144(56.6)	118 (50.86)
Postgraduate	204 (41.9)	95 (37.4)	109 (46.9)
Current Occupation			
House officer/ Intern	73 (15.0)	61 (24.0)	12 (5.1)
Resident	111 (22.8)	57 (22.4)	54 (23.2)
Consultant	51 (10.4)	23 (9.0)	28 (12.0)
Nurse/ Nursing Assistant	157 (32.3)	66 (25.9)	91 (39.2)
Dentist	14 (2.8)	5 (1.9)	9 (3.8)
Other	80 (16.4)	42 (16.5)	38 (16.3)
Monthly Income			
Up to 50,000	137 (28.1)	73 (28.7)	64 (27.5)
Between 50,001-100,000	217 (44.6)	136 (53.5)	81 (34.9)
Between 100,001-150,000	92 (18.9)	32 (12.5)	60 (25.8)
More than 150,000	40 (8.2)	13 (5.1)	27 (11.6)

The percentage point of knowledge was 51%, attitude of 68.2%, practice of 50%, and responsibility 90% (Fig 1).

Figure 1: The percentage point of Knowledge, attitude, practices and responsibility scores of HCPs

Most of the participants agreed regarding detrimental effect of climate change. About 96.7% agreed that climate change harms health, 89% agreed that it impacts patients' health, and 87% agreed that climate change leads to financial losses. Regarding the barriers to discussing climate change with patients, 82.9% agreed that time constraints hinder such discussions however knowledge deficit was a perceived barrier reported by 78.2% of the respondents. The participants were asked if the discussions about climate change are unlikely to affect patient health to which almost 63.8% agreed. A large majority (93.83%) agreed that patients are disinterested in climate issues. Majority (82.3%) of HCPs expressed deep support for clean energy transition in Pakistan (Fig2).

Figure 2: A summary of some of the key questions asked in the attitude domain from the participants

Most HCPs reported (57%) that they did not discuss climate change frequently with their family and peers. 40% HCPs never used public transport or car pool. For active lifestyle, 46.3% reported never walking or biking. Among the HCPs, 35% communicated willingness to support measures against companies that act against climate action, while the majority (65%) did not support these measures. HCPs were also asked questions on their personal behaviour intentions, 41% planned to walk or bike instead of driving, and 45% intended to use public transport or carpool. It was also however, noted that most HCPs (67%), planned to convert to LED bulbs in their homes (Fig 3 A &B).

Figure 3A: A summary of some of the key questions in the practice domain

Figure 3B: A summary of some of the key questions in the practice domain

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Table 2. Univariate regression showing association of Knowledge, attitude, practices and responsibility regarding Climate change with independent variables of healthcare providers in Karachi, Pakistan

Characteristics	Knowledge β (95% CI)	Attitude β (95% CI)	Practices β (95% CI)	Responsibility β (95% CI)
Gender				
Male	Ref.	Ref.	Ref.	Ref.
Female	0.95*(0.37, 1.53)	0.67** (0.15, 1.20)	-0.22(-0.63, 1.80)	-0.02(-0.18, 0.13)
Age (year)				
	-0.009*(-0.03, 0.015)	0.007(-0.01, 0.02)	-0.001(-0.01, 0.01)	0.003(-0.003, 0.01)
Hospital				
Public	Ref.	Ref.	Ref.	Ref.
Private	0.45(-0.11, 1.03)	0.013(-0.50, 0.53)	-0.85**(-1.25, -0.45)	-0.12(-0.28, 0.03)
Education				
Secondary	Ref.	Ref.	Ref.	Ref.
Graduate	2.55*(1.12, 3.98)	3.50** (2.22, 4.77)	-0.21(-1.24, 0.80)	0.24(-0.16, 0.65)
Postgraduate	3.58** (2.13, 5.02)	4.00** (2.71, 5.29)	-0.48(-1.51, 0.55)	0.40*(-0.01, 0.81)
Current Occupation				
House officer	Ref.	Ref.	Ref.	Ref.
Resident	-1.24**(-2.10, -0.37)	-0.55(-1.39, 0.27)	-0.59*(-1.25, 0.06)	0.25*(-0.01, 0.52)
Consultant	-0.90*(-1.94, 0.14)	-0.29(-1.29, 0.71)	-0.19(-0.99, 0.60)	0.35** (0.03, 0.67)
Nurse/ NA	-3.50**(-4.31, -2.69)	-1.26**(-2.05, -0.48)	-0.27(-0.89, 0.34)	0.04(-0.20, 0.29)
Dentist	-2.72**(-4.39, -1.05)	-0.20 (-1.81, 1.41)	-1.29**(-2.57, -0.01)	-0.03(-0.55, 0.47)
Others	-3.58 (-4.51, -2.66)	-2.26** (-3.16, -1.37)	0.26 (-0.44, 0.97)	0.15 (-0.12, 0.44)
Monthly Income				
Up to 50,000	Ref.	Ref.	Ref.	Ref.
>50k- 1 lac	1.89** (1.23, 2.55)	1.14** (0.53, 1.75)	-0.27(-0.75, 0.20)	0.10(-0.08, 0.30)
>1 lac-1.5lac	2.24** (1.42, 3.06)	1.30** (0.54, 2.05)	-0.19(-0.78, 0.40)	0.14(-0.09, 0.38)
>1.5lac	2.71** (1.62, 3.79)	1.64** (0.63, 2.65)	-0.53(-1.32, 0.26)	0.18(-0.12, 0.50)

*Denotes a P-value of <0.1

**Denotes a P-value of <0.05

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235 Gender

236 Female HCPs demonstrated significantly higher knowledge and attitude scores compared to
237 males in the univariate model ($\beta = 0.95$; 95% CI: 0.37–1.53 and $\beta = 0.67$; 95% CI: 0.15–1.20,
238 respectively) (Table 2).

239 Age

An increase in age was significantly associated with a slight decrease in knowledge scores ($\beta = -0.009$; 95% CI: -0.03 – 0.015 ; $p < 0.1$).

Hospital Type

HCPs working in private hospitals had significantly lower practice ($\beta = -0.94$; 95% CI: -1.36 to -0.51 ; $p < 0.05$) and responsibility ($\beta = -0.85$; 95% CI: -1.25 to -0.45 ; $p < 0.05$) scores compared to those in public hospitals.

In the second model, private hospital staff similarly showed significantly lower practice scores ($\beta = -0.84$; 95% CI: -1.25 to -0.43 ; $p < 0.01$)(Table 3)

Education

Participants with graduate and postgraduate qualifications had significantly higher knowledge scores than those with secondary education ($\beta = 2.55$; 95% CI: 1.12 – 3.98 ; $p < 0.1$ and $\beta = 3.58$; 95% CI: 2.13 – 5.02 ; $p < 0.05$, respectively).

Postgraduates also exhibited significantly higher attitude ($\beta = 4.00$; 95% CI: 2.71 – 5.29 ; $p < 0.05$) and responsibility scores ($\beta = 0.40$; 95% CI: -0.01 – 0.81 ; $p < 0.1$).

Occupation

Compared with house officers, all other designations had significantly lower knowledge, attitude, and practice scores. Specifically, residents ($\beta = -2.06$; 95% CI: -3.34 to -0.77 ; $p < 0.01$), consultants ($\beta = -1.76$; 95% CI: -3.22 to -0.31 ; $p < 0.05$), nurses ($\beta = -3.34$; 95% CI: -4.19 to -2.50 ; $p < 0.01$), dentists ($\beta = -3.64$; 95% CI: -5.57 to -1.72 ; $p < 0.01$), and others ($\beta = -3.01$; 95% CI: -4.09 to -1.94 ; $p < 0.01$) scored significantly lower on knowledge.

Nurses ($\beta = -1.23$; 95% CI: -2.05 to -0.41 ; $p < 0.05$) and others ($\beta = -1.53$; 95% CI: -2.56 to -0.50 ; $p < 0.01$) also showed significantly lower attitude scores compared to house officers. In contrast, residents ($\beta = 0.27$; 95% CI: 0.02 – 0.66 ; $p < 0.05$) and consultants ($\beta = 0.37$; 95% CI: 0.02 – 0.77 ; $p < 0.05$) demonstrated significantly higher responsibility scores.

Monthly Income

Higher monthly income was positively associated with knowledge and attitude scores. Compared to participants earning up to PKR 50,000, those earning PKR 50,001–100,000 had higher knowledge ($\beta = 1.89$; 95% CI: 1.23–2.55; $p < 0.05$) and attitude ($\beta = 1.14$; 95% CI: 0.53–1.75; $p < 0.05$) scores. PKR 100,001–150,000 showed statistically significant higher knowledge ($\beta = 2.24$; 95% CI: 1.42–2.06; $p < 0.05$) and attitude ($\beta = 1.30$; 95% CI: 0.54–2.05; $p < 0.05$) scores. Above PKR 150,000 demonstrated higher knowledge ($\beta = 2.71$; 95% CI: 1.62–3.79; $p < 0.05$) and attitude ($\beta = 1.64$; 95% CI: 0.63–2.65; $p < 0.05$) scores. Income between PKR 100,001–150,000 and above PKR 150,000 was also significantly associated with higher knowledge in the second model ($\beta = 1.06$; 95% CI: 0.06–2.00; $p < 0.05$ and $\beta = 1.27$; 95% CI: 0.008–2.54; $p < 0.05$).

Table 3. Multivariate linear regression models showing association of knowledge, attitude, practices and responsibilities regarding Climate change with independent variables of Healthcare providers in Karachi, Pakistan

Characteristics	Knowledge β (95% CI)	Attitude β (95% CI)	Practices β (95% CI)	Responsibility β (95% CI)
Gender				
Male	(Ref.)	(Ref.)	-----	-----
Female	0.29(-0.25, 0.84)	0.19(-0.33, 0.72)		
Age	-0.005(-0.03, 0.02)	-----	-----	-----
Hospital				
Public	-----	-----	(Ref.)	-----
Private			-0.84**(-1.25, -0.43)	
Education				
Secondary	(Ref.)	(Ref.)		-----
Graduate	1.34(-0.16, 2.84)	2.64(1.14, 4.10)	-----	
Postgraduate	1.88* (0.21, 3.55)	3.16(1.55, 4.77)		
Current Occupation				
House officer	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Resident	-2.06**(-3.34, -0.77)	-1.15(-2.38, -0.08)	-0.32(-0.98, 0.33)	0.27* (0.02, 0.66)
Consultant	-1.76*(-3.22, -0.31)	-0.93(-2.34, 0.46)	0.12(-0.67, 0.92)	0.37* (0.02, 0.77)
Nurse/ NA	-3.34**(-4.19, -2.50)	-1.23**(-2.05, -0.41)	0.07 (-0.56, 0.70)	0.04 (-0.20, 0.30)
Dentist	-3.64**(-5.57, -1.72)	-0.74 (-2.59, -1.10)	-0.88 (-2.16, 0.38)	-0.01 (-0.57, 0.53)
Other	-3.01**(-4.09, -1.94)	-1.53** (-2.56, -0.50)	0.53 (-0.17, 1.24)	0.27 (-0.04, 0.58)
Monthly Income				
Up to 50,000	(Ref.)	(Ref.)		
>50k- 1 lac	0.66(-0.04, 1.37)	0.28(-0.40, 0.96)		
<1 lac-1.5lac	1.06*(0.06, 2.00)	0.36(-0.59, 1.32)	-----	-----
<1.5lac	1.27*(0.008, 2.54)	0.67(-0.55, 1.89)		

*Denotes a P-value of <0.05

**Denotes a P-value of <0.01

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291 Discussion:

292 This study is one of the first comprehensive assessments of the knowledge, attitude, practices
293 and responsibility of HCPs on climate change and health in Karachi. According to our study,
294 HCPs in Karachi exhibited a strong sense of responsibility (90.0%) and positive attitudes
295 (68.2%), yet their actual practices (50.0%) and knowledge (51.0%) remained moderate. This
296 finding revealed important insights consistent with and distinct from prior regional and
297 international research. Karachi, as Pakistan's largest and most densely populated city, is
298 acutely exposed to the health consequences of climate change, specifically severe heatwaves,

droughts, urban flooding, and chronically high levels of air pollution. Our findings must be interpreted against this backdrop of direct and immediate climate-health threats. The demographic distribution in this study, where a majority were females (59.9%) and young adults aged 18-30 years (62.3%), aligns with similar HCPs profiles reported in Pakistan and comparable settings(24, 26, 32). This significant gap between high concern and moderate action is a primary finding, consistent with similar studies in other developing and developed countries These results align with both regional and international literature, underscoring a recurring global pattern where HCPs acknowledge the health threats of climate change yet struggle to translate this awareness into meaningful clinical practice and sustainable behaviours (23, 25, 33-41).

Regarding knowledge, the mean score of 51% indicates moderate awareness of climate change health impacts among Karachi HCPs. In our study, Female HCPs displayed significantly higher knowledge and attitude scores than males, though practice scores were lower but not significantly. These findings echo global studies which consistently report moderate awareness with substantial knowledge gaps. For instance, Müller et al. (2024) and Armand et al. (2024) found that primary care clinicians in the US recognized climate change as a health issue but lacked detailed understanding of health pathways. gender difference echoes findings from Müller et al. (2024) and Speck et al. (2023), who also noted variability in knowledge and attitudes across different HCPs and genders, emphasizing the need for targeted educational interventions to bridge gaps and enhance overall climate-health literacy (42).(43) c

The high consensus among participants that climate change detrimentally affects health corroborates findings from Pakistani medical students exhibiting strong environmental health consciousness (32) and Afghan medical students showing positive attitudes towards climate change mitigation activities (44)). However, sizable portion of HCPs perceived patient

disinterest (93.8%) and barriers such as time constraints and knowledge deficits in discussing climate change with patients. These challenges mirror those reported in Karachi nurses' perceptions and studies from other contexts where clinical discussions on climate issues remain limited despite growing awareness(22, 26). Overall, attitudes toward climate change were overwhelmingly positive among Karachi HCPs, a finding consistent with international literature(22, 42, 43, 45, 46).

Despite strong attitudes, reported practices were limited in Karachi, with only half of participants demonstrating positive climate-friendly behaviours, and most reporting infrequent discussions of climate change with patients. This mirrors the global attitude to practice gap. For example, Kalogirou et al. (2020) found that Canadian nurses acknowledged climate threats but rarely integrated climate considerations into patient care(47). Likewise, Lister et al. (2022, 2025) in South Africa and Namibia reported that HCPs were motivated but unable to engage in sustainable practices due to systemic barriers(35, 48). Even in high-income contexts such as Germany and the US, health professionals demonstrated strong concern but inconsistent personal or clinical behaviours (22, 34). Thus, the Karachi findings are part of a broader global trend in which knowledge and attitudes fail to consistently translate into professional or personal action (49). The readiness of Karachi HCPs to adopt clean energy solutions and active transport is promising, yet only about a third supported stronger measures against climate-negative corporate actors, indicating ambivalence or possible socio-economic constraints analogous to findings in mixed-methods studies from low-resource settings(41).

An important finding of this study was that house officers demonstrated significantly higher knowledge, attitude, and practice scores compared to residents, consultants, and nurses. This likely reflects the more recent and updated exposure of house officers to climate change and health topics during their undergraduate medical education. In contrast, more senior

clinicians and nurses may not have received such focused training and may rely more on clinical experience rather than formal education on climate issues. Busy clinical responsibilities among residents and consultants may also limit their opportunities to engage with emerging topics like climate-health.

This study also found that HCPs with a monthly income between PKR 100,000 to 150,000 and above 150,000 had significantly higher knowledge scores about climate change and health. This association likely reflects the positive influence of higher socioeconomic status on access to information, educational resources, and professional development opportunities and mirrors similar findings from regional studies, underscoring financial capacity as a key determinant. Addressing financial and educational disparities among HCPs is therefore essential for equitable climate-health knowledge dissemination and capacity building(50). Significant associations of higher education and income with better knowledge and attitudes but lower practice domain scores among private sector providers highlight disparities that may relate to institutional priorities. This reinforces results from studies in Pakistan revealing urban and education gradients in climate-health awareness (Shariff et al., 2024) and similar KAP differentials observed by Lam et al. (2024) and Lister et al. (2022) in healthcare sustainability fields(32, 48, 51).

A major strength of this study lies in the statistically calculated sample size using WHO software based on prior local data, ensuring sufficient power and representativeness. The use of a multistage sampling technique with population-proportionate selection further enhances sample representativeness and minimizes selection bias. Ethical rigor was maintained through approvals from relevant review committees and strict confidentiality protocols. Collecting data primarily via structured face-to-face interviews allowed for in-depth responses. There were also certain limitations with this study. This design captures exposure and outcome data simultaneously, limiting causality. The non-probability convenience sampling at the hospital

selection stage and within individual categories may introduce selection bias and affect external validity. The reliance on self-reported data may be subject to reporting bias. Overall, the study provides an insightful snapshot of climate-health KAP among HCPs in Karachi, offering a robust foundation for tailored interventions and future longitudinal research.

Conclusion:

The study revealed that HCPs in Karachi have moderate knowledge and positive attitudes about climate change and its health impacts, but their practices remain suboptimal. These findings are consistent with global literature across both high-income and LMIC settings. Key barriers include time constraints and lack of knowledge to effectively discuss climate change with patients. Education and institutional support are essential to empower HCPs to act as informed advocates for climate-health issues. Empowering HCPs to act as knowledgeable practitioners is both timely and essential in the context of Pakistan.

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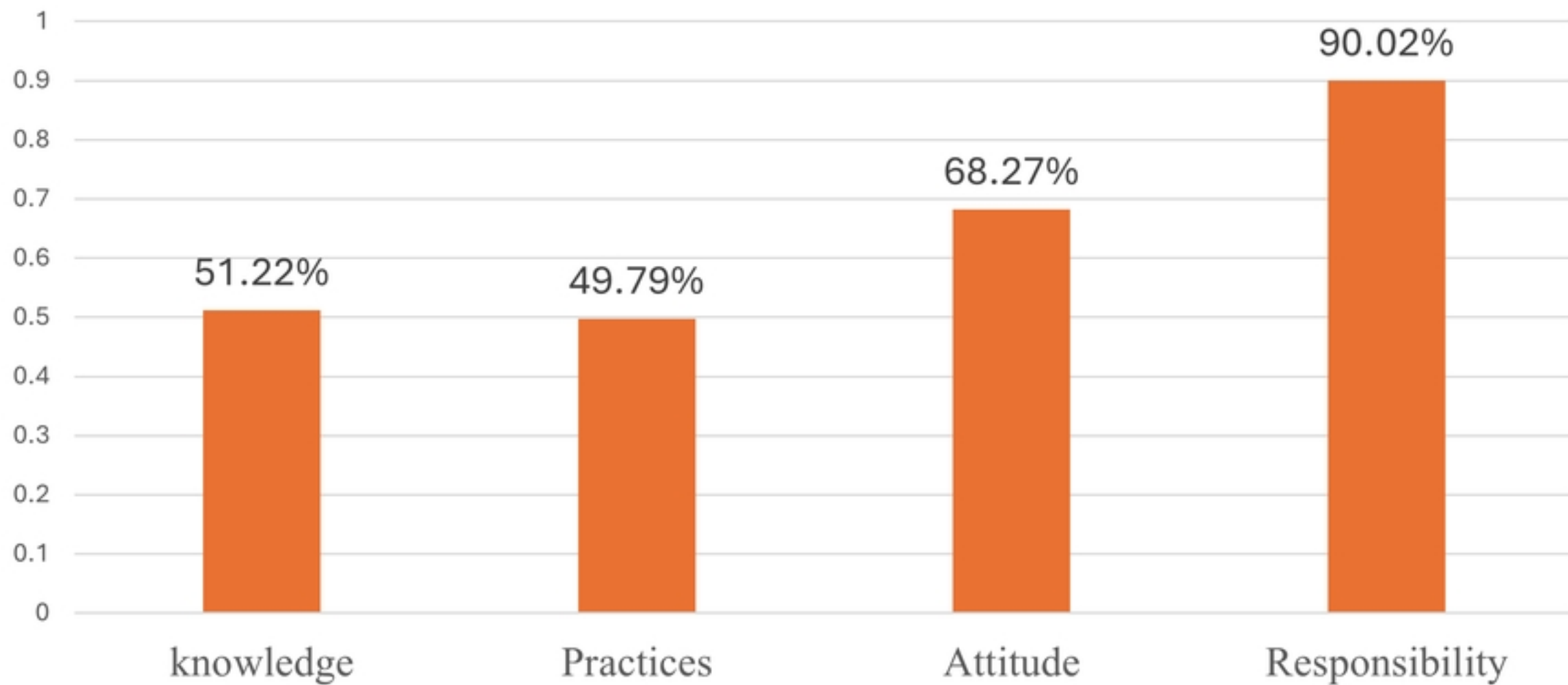


Figure1

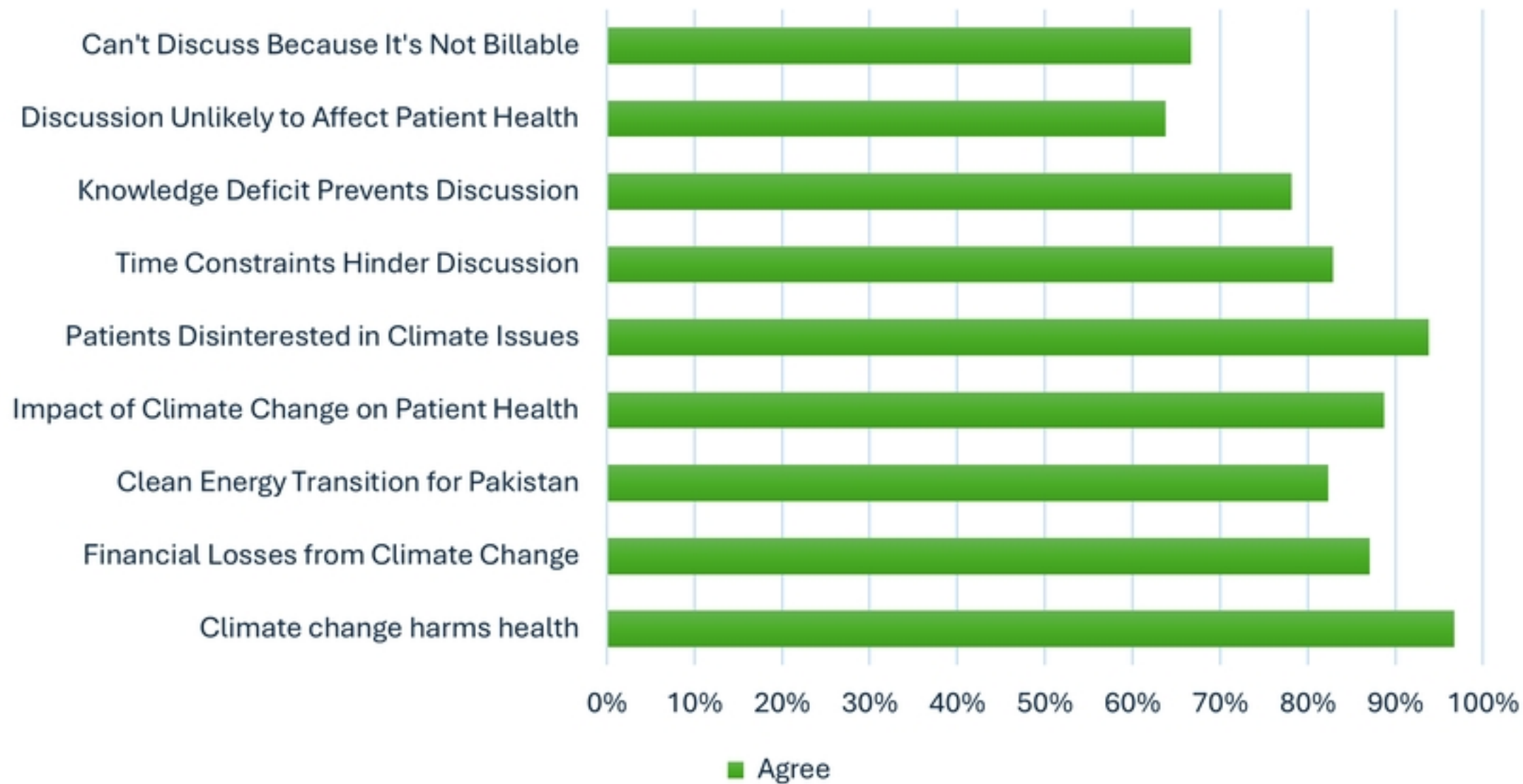


Figure2

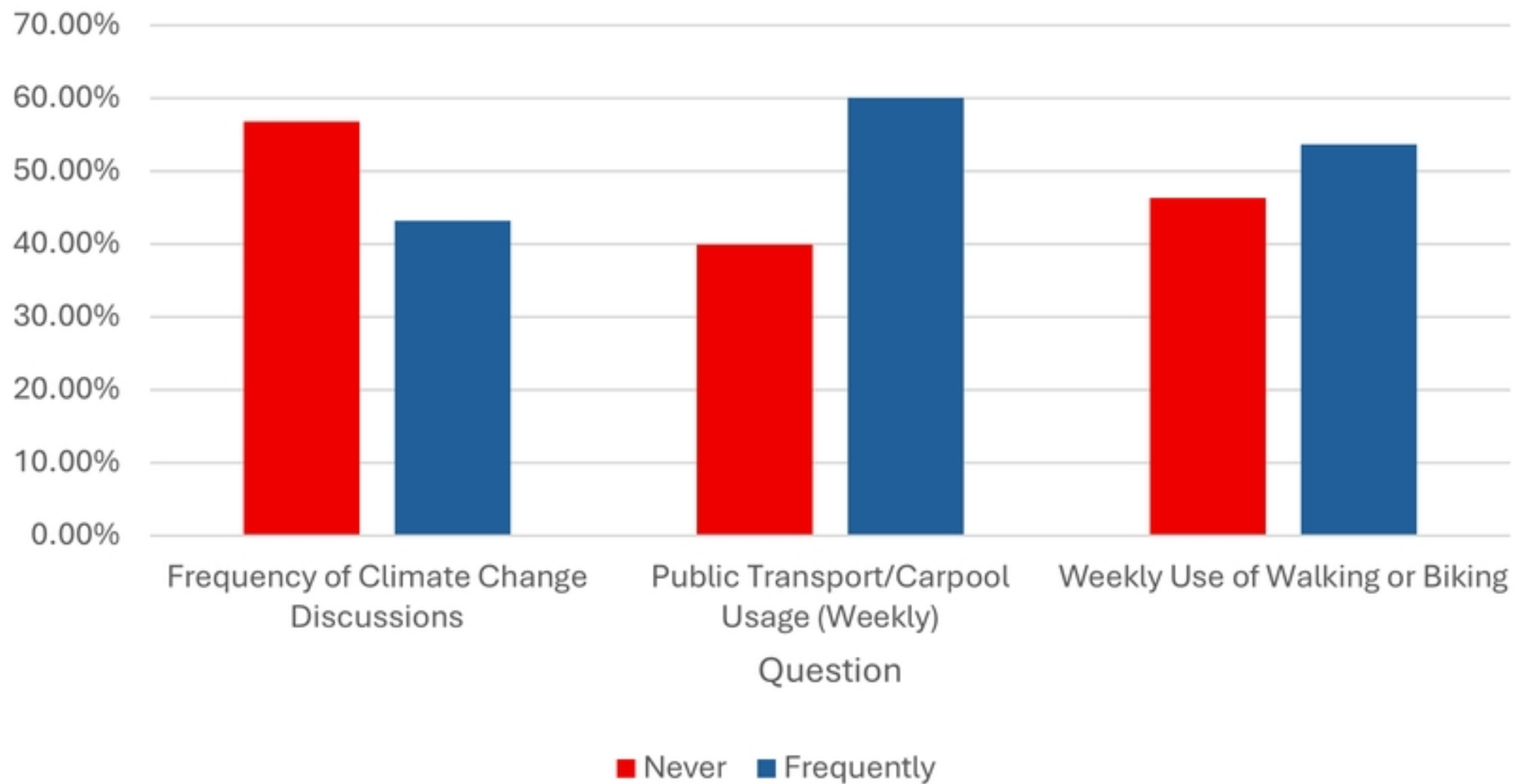


Figure3A

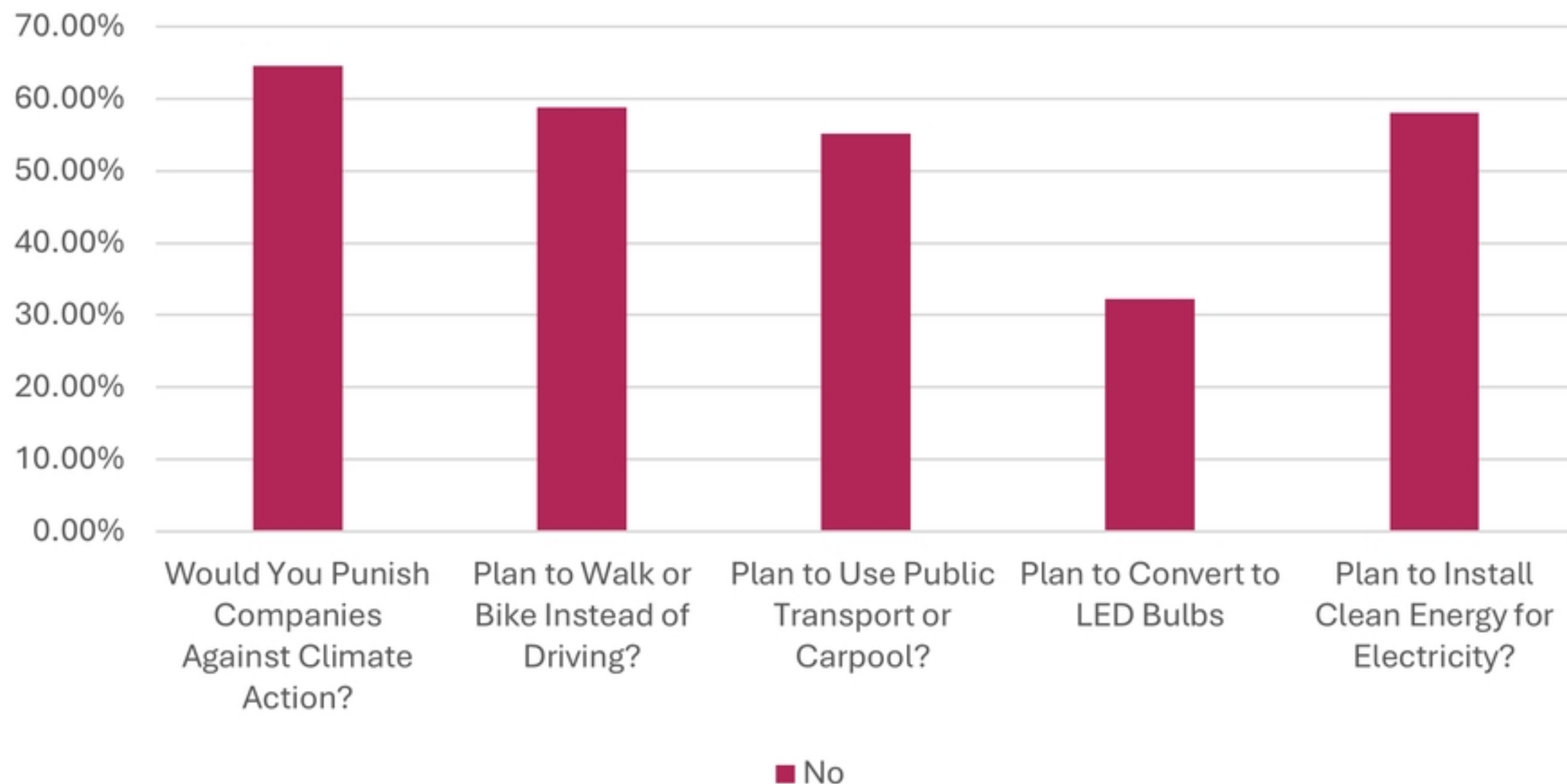


Figure3B