INTERNATIONAL SCIENTIFIC JOURNAL | GEOGRAPHICA PANNONICA

Perceptions of Heat Risk Among Street Vendors, Its Associations With Knowledge and Impacts on Adaptive Measures in a Tropical Indian City

Rajashree Kotharkar[A1], Sagar Rajopadhye[A]
[A] Department of Architecture and Planning, Visvesvaraya National Institute of Technology (VNIT) Nagpur, Maharashtra, India; ORCID RK: 0000-0002-5063-2757

Received: February 20, 2025| Revised: September 20, 2025| Accepted: Sepember 21, 2025

doi: 10.5937/gp29-56909

Abstract
There has been a concerning rise in heatwave-related deaths in India over the past few decades, particularly affecting the informal work sector exposed to high outdoor temperatures. This study aimed to understand how outdoor workers and street vendors in the landlocked tropical city of Nagpur perceive heat risks and how this perception relates to their knowledge and adaptive measures. A cross-sectional study using face-to-face surveys was conducted, introducing a novel Heat Risk Perception (HRP) Index to quantify participants' risk perception. The findings revealed that 70% of street vendors had high HRP, with a mean index score of 0.72. Local knowledge and past heat experiences significantly influenced risk perception, despite gaps in scientific knowledge resulting from limited access to training programs. A strong positive relationship was observed between HRP and adjustments in work routines during hot weather, especially when vendors perceived health risks. This suggest that risk perception is crucial for adopting protective behaviours. Demographic factors did not significantly affect heat risk perception. Notably, 69% of vendors perceived themselves as vulnerable to heat's negative effects, and perceived vulnerability emerged as a significant predictor of high HRP. The findings highlight the importance of risk perception in mitigating heat-related risks among vulnerable populations. The study's results can inform the development of targeted interventions to protect street vendors and outdoor workers from heat-related risks.

Key Words: heat risk perception; extreme heat; heatwaves; adaptation; informal workers

Introduction
The Intergovernmental Panel on Climate Change's Sixth Assessment Report (IPCC AR6) highlights that we can expect more frequent and intense heat extremes, including heatwaves, with near certainty. These events are likely to have a greater impact on people than most other climate change phenomena (IPCC, 2023). Unlike extreme weather events like floods or earthquakes, which have immediate and visible effects, the risks associated with extreme heat can be less apparent. However, research suggests that extreme temperatures are a significant

[1] Corresponding author: Rajashree Kotharkar; rskotharkar@arc.vnit.ac.in

contributor to weather-related mortality around the world (Murray et al., 2020). In India, for instance, deaths from extreme heat surged by 55% between 2000-2004 and 2017-2021 (Romanello et al., 2021). The March 2022 heatwave, the warmest month recorded since 1901 in India, exposed up to 75% of the labour force dependent on heat-exposed labour to potentially life-threatening temperatures (Rajeevan et al., 2023). Given that this sector contributes roughly half of India's GDP, the country is particularly vulnerable to job losses due to heat stress. This vulnerability could lead to around 34 million of the projected 80 million global job losses by 2030 (Woetzel et al., 2020).

Heat risks can be mitigated through adaptation strategies, which require governmental implementation of comprehensive infrastructure plans, early warning systems, and behavioural guidelines (National Disaster Management Authority, 2019). Most Heat-Health Warning Systems (HHWs) are designed to reduce illnesses and deaths related to extreme heat. There's been a lot of research on the quality and content of these warning systems and how they integrate with Heat Action Plans (HAPs) (Li et al., 2022). However, their effectiveness is less studied. The success of HHWs depends heavily on the community's willingness to respond to these warnings (Toloo et al., 2013). It turns out that perception plays a crucial role in shaping this response. Heat risk perception (HRP) reflects how concerned someone is about the negative effects of extreme heat. This perception can influence how well people understand the risks and whether they take steps to protect themselves, making it a key factor in predicting protective behaviours (Li et al., 2024).

Several studies have explored the public's perception and attitudes towards extreme heat. Some researchers have conducted large-scale surveys to understand how people across entire nations view the risks associated with heat (Beckmann & Hiete, 2020; Howe et al., 2019; Li et al., 2024; Parichehr Shamsrizi et al., 2023; Schoessow et al., 2022). Others have focused on smaller regions or specific cities to gain insights into local attitudes and behaviours (Liu et al., 2013; Rauf et al., 2017; Williams et al., 2018; Akompab et al., 2013; Ban et al., 2017; Dong et al., 2024; Hass & Ellis, 2019; Heidenreich & Thieken, 2021; Huang et al., 2017; Lane et al., 2014; Madrigano et al., 2018; Suldovsky et al., 2024; Maheshwari, 2022). National studies provide a broad overview of how a country's population perceives heat risks. However, focusing on smaller areas or specific cities offers more detailed and localized insights. This is important because climate, demographics, work practices, and individual adaptations can vary significantly from one region to another. Local studies help identify the unique challenges and risk factors related to extreme heat in specific populations (Han et al., 2021). Different methods have been used to assess heat risk perception (HRP). For instance, a study in the U.S. used a heat risk perception index, scored from 0 to 100, to gauge how people view the risks and health impacts of heat waves (Howe et al., 2019). Another study in China looked at risk perception, adaptation behaviours, and heatstroke among participants using structured questionnaires and statistical analysis (Liu et al., 2013). These approaches, including surveys, questionnaires, and statistical analyses, have been instrumental in measuring HRP. They help identify what influences people's perceptions, understand why people change their behaviours in response to heat, and evaluate awareness of heat-related risks across different populations and locations.

Extreme heat affects different groups in various ways, making it essential to understand its impact on vulnerable populations. Street vendors are especially at risk because their work is physically demanding, they often lack access to shade, and they have limited cooling options. These conditions increase their chances of suffering from heat-related illnesses and can negatively impact their productivity and earnings (Kjellström et al., 2019; Singh et al., 2019;

Luber & McGeehin, 2008). HRP among vulnerable groups has been extensively studied. This includes outdoor workers in sectors like construction, waste disposal, and agriculture, as well as migrant workers and the homeless (Bonafede et al., 2022; Elshamy et al., 2024; Putra et al., 2024; Yovi et al., 2023; Han et al., 2021; How et al., 2021; Xiang et al., 2016; Lohrey et al., 2021; Messeri et al., 2019; Permatasari et al., 2023; Iswarya et al., 2024; Robertson et al., 2024). A study in Hanoi found that street vendors, as a distinct income group, may have varying levels of knowledge about heat impacts and preventive measures, which can influence their risk perceptions (Lohrey et al., 2021). Despite the frequent occurrence of heat waves in India, no studies, to our knowledge, have specifically examined heat risk perception. This gap in the literature highlights the need for more research to understand the challenges these vulnerable groups face in managing heat-related risks and to develop targeted interventions.

The present study has the following objectives:

(a) To measure and analyze heat risk perception among outdoor workers and street vendors in Nagpur using a HRP index.
(b) To investigate how current knowledge, awareness, sociocultural factors, and demographic characteristics shape heat risk perceptions and influence adaptive behaviours.

By pursuing these objectives, the study aims to fill a crucial knowledge gap by examining how people understand, perceive, and adapt to heat waves, and by identifying the key factors that influence these aspects. The findings of this research can inform similar studies in areas experiencing extreme heat waves and contribute to making Heat-Health Warning Systems (HHWs) more effective. Ultimately, this may help reduce illnesses and deaths related to extreme heat and strengthen Heat Action Plans (HAPs). This study is one of the first in India to focus specifically on heat risk perception among informal workers and street vendors. Data collection for this study involved a survey administered in a specific area, utilizing a questionnaire as the primary research method. Due to the lack of previous research on subjective responses to heat-related inquiries among informal workers, there is no pre-existing documentation or secondary data available for comparison or validation.

Study Area

The study was conducted in Nagpur, an important urban area in central India. The city experiences a tropical savanna climate (Aw), with temperatures varying from 48 degrees Celsius in summer to 6 degrees Celsius in winter. Extreme temperatures are experienced during the month of May, and those days are locally referred to as ‘Nava Tappa’. The city has also recorded 246 heat wave days annually in 50 years from 1969 to 2019 (IMD), making it an appropriate location to conduct the study.

The workforce participation ratio in Nagpur city is at 37%, with male workers contributing around 78% and female workers 22%, to the total workforce. Street vending is an indispensable economic activity in the city as is the case in most urban India, with about 90,000 street vendors or hawkers in the city in 2015, accounting for about 10% of the workforce. The informal markets in Nagpur can be classified into three main types: weekly markets, daily markets serving the city or a part of the city, and neighbourhood cluster markets. These markets

can be further categorized as city level, sub-city level, or neighbourhood level markets based on the number of units, scale, and year of establishment. The study seeks to include all types of markets with an active presence of street vendors to gather a holistic data pool, as shown in Figure 1.

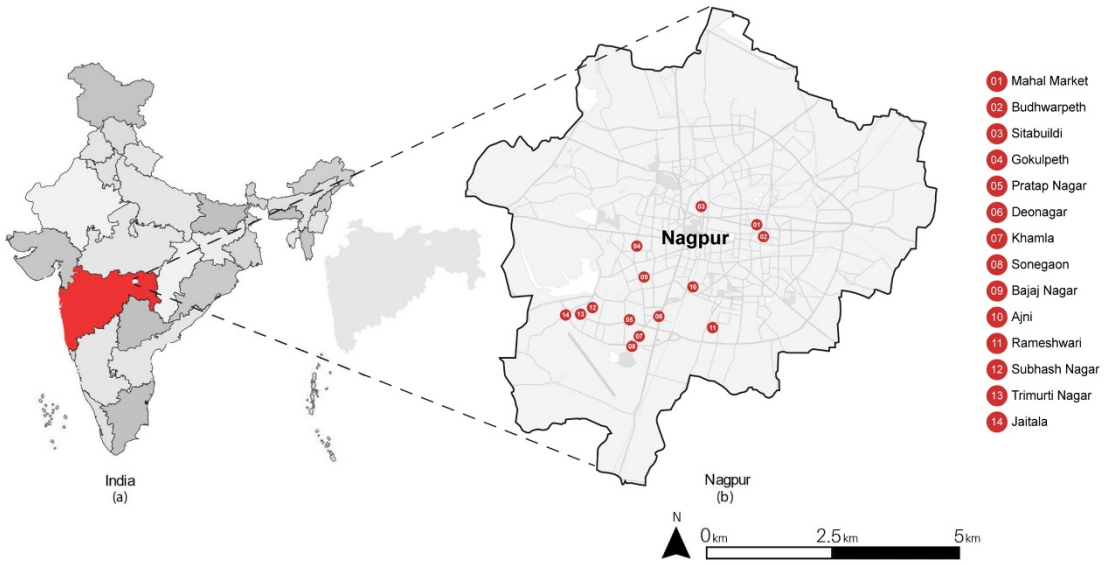


Figure 1. Study Area

Data and Methods

In this study, Heat Risk Perception (HRP) refers to how individuals perceive, assess, and respond to extreme heat risks according to their beliefs, awareness, and attitudes. The study introduces a Heat Risk Perception Index, ranging from 0 to 1, which is derived from questionnaires that capture various aspects such as the likelihood, severity, worry, concern, and fear reported by individuals regarding their own health and economic prospects. Through statistical analysis, the study also reveals how sociodemographic factors, knowledge, and past experiences with heatwaves and associated illnesses influence these perceptions.

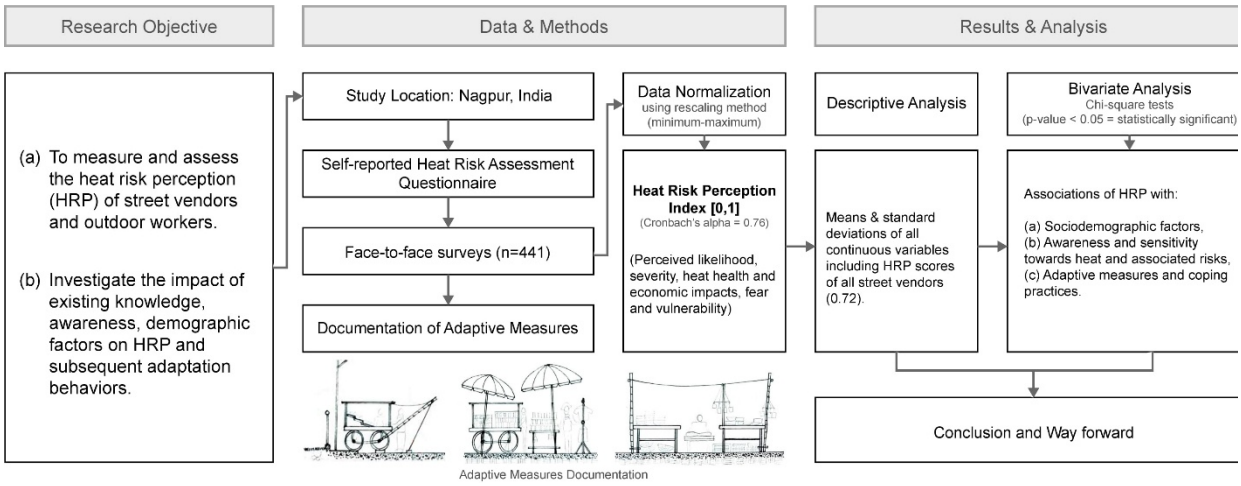


Figure 2. Study Methodology

Questionnaire Design

A questionnaire was specially created drawing on established research on heat risk perception and its known predictors. This questionnaire was designed to self-report perceived heat risk, specifically focusing on the experiences of street vendors during heatwaves (Ban et al., 2017; Huang et al., 2017). The questionnaire was divided into four sections, building on previous research but adapted to better address the unique challenges faced by street vendors.

The sociodemographic section of the questionnaire gathered information on age, gender, education, family structure, migrant status, and any pre-existing health conditions. To assess knowledge and awareness about heat, we asked participants about their past experiences with heatwaves, their perceptions of rising temperatures, how often they check weather forecasts, whether they have participated in heat-related training, and if they have received heat warnings. Additionally, respondents were asked to share their past experiences with extreme heat, any heat-related illnesses they encountered at work, and the measures they took to combat these illnesses.

Given that risk perception is multifaceted, the questionnaire used various risk characteristics to measure it. Participants rated the likelihood and severity of heat waves and their impacts on Nagpur using a five-point Likert scale, considering both the likelihood and intensity of these events. They were also asked about their worries related to the health impacts of heat, particularly focusing on risks to themselves, their families, and their communities. Individuals rated their personal risk on a five-point Likert scale, where '1' represented 'Low' and '5' represented 'Severe,' with higher scores indicating a higher perceived risk. For family and community risks, respondents simply answered "Yes" or "No" to express their concerns. Similarly, concerns about the impact of heat on expenses, productivity, and employment were answered with “Yes,” “Maybe,” or “No.” Respondents also indicated their fear of adverse health effects of heat by selecting “Yes,” “Maybe,” or “No”.

Finally, participants were queried whether they believed heat posed a risk to their lives, with the goal of determining whether they considered themselves vulnerable to extreme heat (ref. Appendix A). The Heat Risk Perception Index (Cronbach’s alpha = 0.76) was derived by combining responses from a survey tool consisting of 10 questions. These questions explored perceptions of the adverse effects of extreme heat, including its likelihood, severity, health-related concerns and fears, economic implications, and overall vulnerability. Additionally,

questions about adaptive strategies and protective actions centred on physical measures and lifestyle changes implemented during extreme heat events, along with their perceived effectiveness.

Data Collection and Processing

The research employed in-person surveys conducted in May 2022, coinciding with a heatwave across much of India. Respondents were informed about the study's objective, and verbal consent was obtained before starting the survey. The questionnaires were administered in the respondent's preferred language, and each survey took approximately twenty minutes to complete. In total, 441 completed questionnaires used in the final data analysis.

The survey comprised questions with various response formats, including a five-point Likert scale (ordinal) and nominal choices like "Yes," "Maybe," and "No" or simply "Yes" and "No." To ensure consistency, indicator values measured in different units were standardized to a common scale using a min-max normalization approach. This adjusted the values to a standardized range of [0,1]. To calculate the Heat Risk Perception (HRP) index score, the mean of all ten indicator questions was computed for each respondent.

Statistical Analysis

Data collected was exported to Excel, which acted as the main database for conducting descriptive and bivariate analyses using R and RStudio (RStudio Team, 2020; R Core Team, 2020). The 'vcd' package (Meyer et al., 2022) was utilized to create mosaic plots that visualized Pearson residuals. Descriptive analysis summarized all sections of the questionnaire and calculated means and standard deviations for continuous variables. Bivariate analysis involved applying Chi-square tests, adjusted for expected cell frequencies of five or fewer, to investigate relationships among categorical variables such as socio-demographics, knowledge, adaptation, and risk perception. This process aimed to determine key influencing factors, with associations considered statistically significant if the p-value was less than 0.05.

Results and Analysis

In total, 441 street vendors and informal workers participated in the survey, with 83.4% being men and 16.6% women—a gender distribution broadly reflective of the city's overall workforce composition. The respondents had an average age of 39.56 ± 12.41 years, with 42% falling within the 36–50 age group. Many had finished only high school (29.7%), while 13% lacked formal education. Among those surveyed, 28% had migrated to Nagpur for work, predominantly men (87.1%). The survey found that 72.3% of respondents had family members under 15 or over 65 years old, suggesting they were primary caregivers for individuals more vulnerable to extreme heat (Romanello et al., 2021; Stanberry et al., 2018). Furthermore, 11.6% had a pre-existing chronic illness, most of whom were aged 36-50 (45%). Most of vendors worked outdoors for over 5 hours daily, and 62.8% found their work physically strenuous. Nearly half of the individuals surveyed (47.8%) had encountered heat illnesses while working, including exhaustion, rashes, and even stroke. Common symptoms reported included tiredness, headache, dizziness, heavy sweating, and thirst (Table 1). Coping strategies employed by individuals included increasing fluid intake, taking breaks in shaded areas, and cooling off by splashing water. It was noted that vendors tended to seek medical attention only after experiencing severe symptoms.

Table 1. Common heat-health symptoms and coping strategies

% of respondents who reported heat-illnesses	Top heat-related symptoms reported	% of all reported illnesses	Top Heat Coping Strategies
47.80%	Tiredness or Weakness	16.70%	• Resting in shaded areas • Increasing fluid intake • Taking regular breaks and rest. • Taking days off. • Cooling down by moving to shaded areas or splashing water on the body. • Consulting doctor.
	Feeling Hot	13.60%	
	Heavy Sweating	12.30%	
	Feeling Thirsty	11.60%	
	Dizziness	11.10%	
	Headache	10.70%	
	Heat Rash	6.70%	
	Nausea or Vomiting	5.40%	

Knowledge and Awareness

Most vendors (76.4%) were familiar with heatwaves, but only a few could specify the temperature threshold for declaring a heatwave in the city. A large majority of vendors were aware of the local term for extreme heat period 'Nava tappa', showing a shared understanding among the community. The study also found that majority of the street vendors (68%) had previously encountered heatwaves, and 85.3% believed that summers had become hotter over time. They attributed the rise in temperatures to the building of concrete roads, decreased tree coverage, and pollution in the city.

El-Shafei et al. (2018) suggest that training and education are crucial in preventing heat-related illnesses and injuries. However, 96% of vendors did not have access to such programs. Only 48% received heatwave warnings through sources like newspapers, internet, TV/radio etc. Despite this, 13% of respondents were not concerned about these warnings because they had experienced extreme heat for many years. Most vendors (70%) did not check the weather forecast daily due to the belief that it was unnecessary, as work had to proceed regardless. Additionally, not all vendors possessed smartphones, and newspapers were delivered after they had already left for work. As a result, many vendors were left unaware of impending extreme heat conditions, putting them at risk of heat-related illnesses and accidents.

Heat Risk Perception

The research evaluated heat risk perception scores of participants on an index [0,1], where higher scores denoted greater perceived risk. Those with elevated HRP scores were more likely to: (a) Anticipate a higher probability of heatwave occurrences, (b) Acknowledge the severe nature of heatwaves in the city, (c) Worry about the adverse effects of heat on their personal, family, and community health, (d) Worry about impact of heat on expenditure, employment, and work productivity, (e) Be fearful of heat-related health issues, and (f) Perceive themselves as vulnerable to extreme heat.

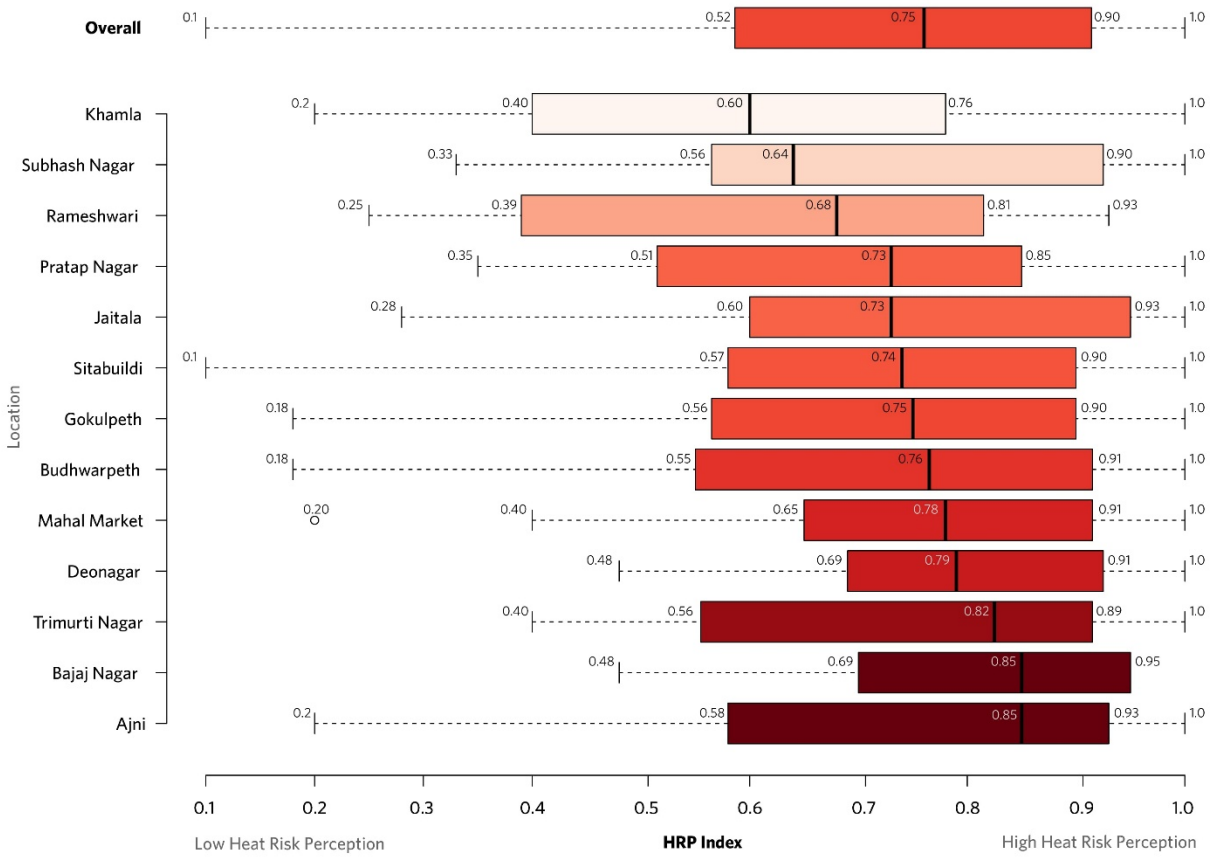


Figure 3. Boxplot of market-wise heat risk perception.

The average HRP Index across all city markets was 0.72, although minor differences in the mean HRP were noted depending on the location (see Figure 3). Males had a slightly higher HRP (0.721 ± 0.22) compared to females (0.708 ± 0.03). Cart pullers had the highest HRP score (0.800 ± 0.21), while tea vendors demonstrated the lowest score (0.671 ± 0.12). This indicates a connection between HRP, sun exposure, and physical demands of the job (see Table 2). Additionally, those who had migrated to the city tended to have a higher HRP, as did individuals with family members under 15 or over 65.

Table 2. Mean of HRP Index across sociodemographic characteristics

Sociodemographic Characteristics	Category	HRP Score (Mean)	Sociodemographic Characteristics	Category	HRP Score (Mean)
Gender	M	0.720	Occupation	Beverage Cart	0.671
	F	0.718		Flower Seller	0.684
Age	≤ 20	0.788		Puncture Repair Shop	0.689
	21-35	0.719		Vegetable Seller	0.702
	36-50	0.723		Clothing Accessories Vendor	0.734
	51-65	0.708		Autorickshaw Driver	0.753
	66-80	0.679		Fruit Vendor	0.759
Highest Education	No Formal Education	0.699		Clothing Seller	0.760
	Class 4	0.678		Metal Items Seller	0.797
	Class 7	0.737		Handcart Puller	0.800
	Class 10	0.723	Migration Status	Migrant	0.733
	Class 12	0.721		Non-migrant	0.714
	Undergraduate	0.752	Chronic Illness	Yes	0.722
	Postgraduate	0.566		No	0.719

Many sellers were worried about heatwaves, with 63% believing that Nagpur faces them nearly every year and 70.3% deeming them highly severe. About 47% thought heatwaves were dangerous to their well-being, 74% expressed concern for their families' health, and 57% were worried about the well-being of their community. Several vendors refrained from disclosing their own heat-related health illnesses, though 37% confirmed experiencing at least one. Financial constraints prevented vendors from taking time off during heatwaves, with nearly three-quarters of them (74%) experiencing a decrease in employment and productivity, impacting their earnings. Furthermore, vendors encountered increased costs at both work (64.9%) and home (77.6%) in the summer due to expenses related to water, shading, and cooling techniques. To manage, more than a third switched jobs based on the season and some, even during the day.

Overall, based on the self-assessment, almost 70% of vendors considered themselves vulnerable and at risk to the negative impacts of extreme heat.

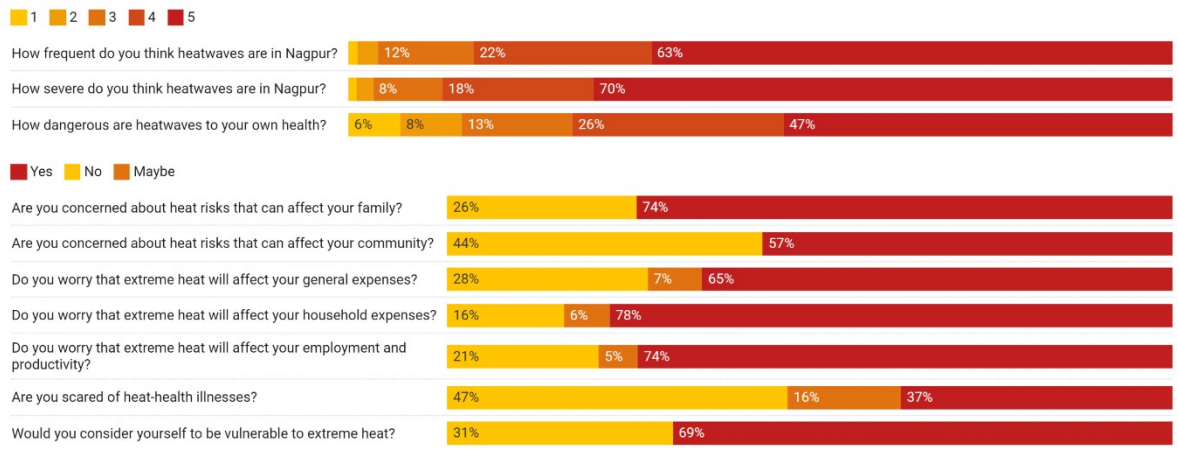


Figure 4. Heat risk perception responses

Adaptive Measures

The study identified two types of adaptive measures: physical adaptations in the workplace and lifestyle changes in behaviour. Around 43% of street vendors believed it was necessary to adjust their work habits to prevent heat illnesses, and 55% consistently implemented measures to adapt when stepping out of their homes (Figure 5). Common lifestyle adaptive measures included staying well-hydrated, wearing light-coloured, full-sleeved cotton clothing, seeking shade or cooler areas, and modifying dietary habits. Furthermore, some individuals managed to avoid the midday heat by carefully planning outdoor activities, altering their work hours (extending night shifts and shortening daytime shifts), and taking extended lunch breaks. A significant number of vendors (76.2%) made changes to their work environment, with the most popular adjustment being the installation of a green sunshade HDPE net (52%). Others opted for garden or rain umbrellas (14%), while some utilized gunny bags (11.3%) or a table fan if there was access to electricity.

Some individuals failed to take necessary precautions to avoid heat-related illnesses for various reasons. The majority of them (63.9%) were used to hot weather conditions and did not feel the need to adapt. Another significant portion (30%) lacked the capability to change their behaviour to prevent heat-related issues. Only a small percentage believed that heat waves did not pose a threat to them (5.3%) or that the weather was not sufficiently hot (2.4%). Vendors who sold goods that were prone to damage or decay from heat focused mainly on safeguarding their products by ensuring they were kept in the shade, rather than prioritizing their own protection.

Figure 5. Adaptive measures responses

Associations Between Heat Risk Perception and Sociodemographic Characteristics, Knowledge, and Adaptive Measures

This section investigates how street vendors' heat risk perception is related to their sociodemographic characteristics, heat wave knowledge, and adaptive measures.

Sociodemographic Characteristics

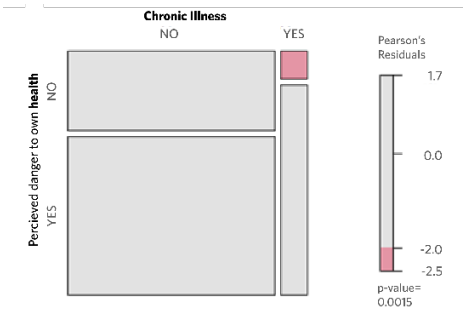
The study found that women were more inclined than men, to view themselves as vulnerable to extreme heat ($\chi^2(1, N = 441) = 12.321$, $p < 0.001$). Women also expressed greater concern about general and household expenses. However, factors such as age, occupation, education, and migrant status did not show significant associations with HRP (ref. Table 3).

Table 3. Pearson Chi-Squared test results for HRP and Sociodemographic factors

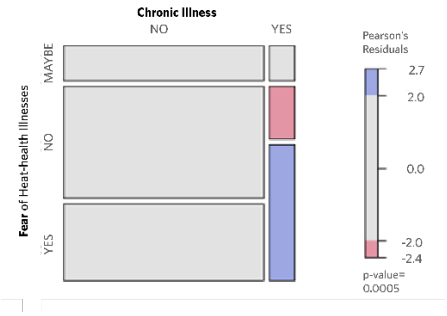
Pearson Chi-Square Tests											
Socio-demographic Characteristics	HRP Factors	Frequency	Severity	Concern (Personal Health)	Concern (Family Health)	Concern (Community Health)	Fear (Heat Illnesses)	Worry (General Expenses)	Worry (Household Expenses)	Worry (Employment& Productivity)	Perceived Vulnerability
Gender	Chi-square	5.096	7.277	9.010	3.103	3.072	5.299	6.763	8.310	1.499	12.321
	Sig.	0.278	0.122	0.061	0.078	0.080	0.071	**.034***	**.016***	0.473	**.000***
Age	Chi-square	17.466	49.402	30.516	18.161	7.234	11.380	14.979	7.661	8.178	8.231
	Sig.	0.356	-	-	-	0.124	0.181	-	-	-	-
Education	Chi-square	24.110	21.643	28.838	8.356	6.063	21.802	9.096	8.958	17.346	8.344
	Sig.	0.455	0.601	0.226	0.213	0.416	-	0.695	0.707	0.137	0.214
Chronic Illness	Chi-square	3.167	3.175	8.456	6.128	7.641	15.150	3.531	3.826	1.336	10.032
	Sig.	0.53	0.529	0.076	**.013***	**.006***	**.001***	0.171	0.148	0.513	**.002***
Migration Status	Chi-square	9.062	6.616	8.403	0.413	0.414	1.022	1.480	0.884	0.344	0.322
	Sig.	0.06	0.158	0.078	0.520	0.520	0.600	0.477	0.643	0.842	0.571

*. The Chi-square statistic is significant at the $p < 0.05$ level.

The study found that respondents with family members under 15 or over 65 years old expressed greater concern about heat-health risks in their community ($\chi^2(1, N = 441) = 5.461$), and were more likely to be fearful of heat-health issues ($\chi^2(2, N = 441) = 7.108$, $p = 0.029$). Additionally, pre-existing chronic illness emerged as a significant factor influencing heat risk perception. Individuals with chronic conditions exhibited higher levels of concern about the impacts of heat on their families ($p = 0.013$) and communities ($p = 0.006$), besides a heightened fear of heat-related illnesses ($p = 0.001$) and a greater sense of vulnerability to heat risks ($p = 0.002$) (see Figures 6 and 7).

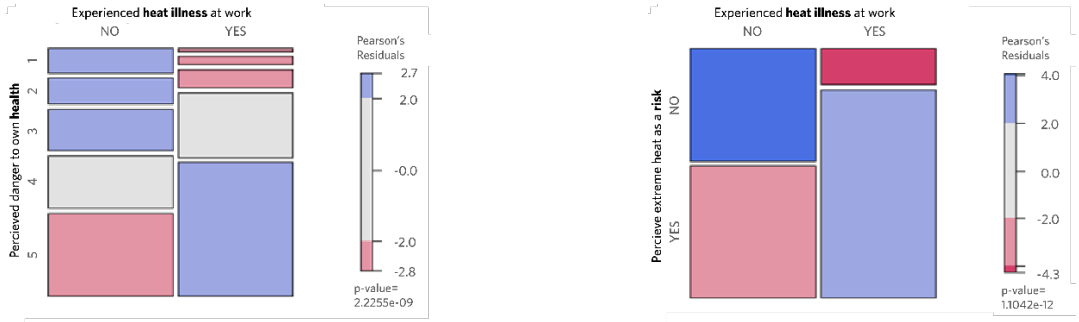


(6A)



(6B)

Figure 6. Mosaic plot illustrating the association between pre-existing chronic condition and perceived personal health risk (6A) and fear of heat-related illnesses (6B)



(7A) (7B)

Figure 7. Mosaic plot illustrating the connection between experience of heat illness at work and perceived personal health risk (7A) and considering extreme heat as a risk (7B).

Knowledge

According to studies like Iorfa et al. (2020) and Ning et al. (2020), knowledge acquired through formal education or practical experience has the potential to prompt individuals to develop a more pragmatic understanding of risk, facilitate the appropriate assessment of potential losses, and devise strategies to prevent or alleviate adverse consequences that could emerge. Our findings showed that vendors familiar with heatwaves reported a significantly higher perceived likelihood ($p < 0.001$) and severe nature ($p < 0.001$) of heatwaves in the city. Similarly, prior exposure to heatwaves impacted the perception of heat risk by influencing factors such as perceived probability and intensity. Vendors who acknowledged the increased temperature were more prone to perceiving a higher heat risk. On the other hand, participants who did not perceive a rise in temperature were significantly less likely to view themselves at risk from the adverse impacts of extreme heat, highlighting another factor influencing perceived risk. Additionally, a history of heat illness at work emerged as a key predictor of heat risk perception, affecting nearly all risk factors. These factors included personal health concerns, worries about family and community, heightened health fear, and worries about economic and employment impacts (ref. Figure 7).

Precautionary actions, like tracking weather advisories, were linked to heightened concerns for family ($p = .047$) and community ($p = .013$) health, along with a greater fear of heat-related health issues ($p = .001$). This suggests that individuals with these concerns were more inclined to take preventive measures. Heat warnings led to elevated levels of concern ($p = .031$) and fear ($p < .001$) regarding the health impacts of heat waves. Moreover, the study revealed that individuals who had experienced previous heat-related illnesses themselves were significantly more inclined to heed heat warnings and implement precautionary measures to safeguard their own well-being ($p = .015$). Due to limited availability of training and awareness programs, their impact could not be properly assessed. However, individuals who had undergone heat-related training showed higher concerns and fears about heat-related health issues compared to those who had not received such training.

Adaptive Measures

Heat risk perception was associated with modifications in work routines during hot weather, particularly when vendors felt their personal (p = .007), family (p < .001), or community health (p = .001) was at risk, along with feeling vulnerable (p = .014). Vendors who thought they should modify their work habits were more inclined to proactively adopt adaptive behaviours. These behaviours included changing their routine on receiving a heat alert (p < .001) and implementing protective measures while outdoors (p < .001). Those who viewed heat as a threat to their employment or productive work were more inclined to respond to heatwave warnings (p = .016), resulting in a decreased likelihood of going outdoors without adaptive measures. Additionally, vendors concerned about heat-related illnesses for themselves (p = .019) or their family (p < .001) commonly took protective actions like wearing light-coloured clothing, using headgear, staying hydrated, and were more likely to modify their work environment (see Figures 8 and 9). Overall, the research found that HRP and adaptive measures were significantly associated.

Figure 8. Vendors engaging in adaptive behaviours

Figure 9. Vendors not engaging in adaptive behaviours

Discussion

In the study, about 70% of the street vendors saw extreme heat as a risk to their health, employment and productivity with a mean HRP score of 0.72. Since this is one of the first HRP studies to specifically examine street vendors, direct comparisons are not appropriate; however, the risk perception percentage is higher than that reported in earlier studies conducted on citizens in urban and peri-urban Pakistan (57% and 66%, respectively), and lower than that of Delhi NCT (75.6%), Nanjing (87.6%) and Guangdong (85.2%) (Huang et al., 2017; Liu et al., 2013; Rauf et

al., 2017; Maheshwari, 2022). The relatively lower percentage of street vendors who perceive heat risk, compared to other citizens, could be due to a few key factors. Regular exposure to extreme heat at work may have made them less sensitive to it. Additionally, the lack of job alternatives and financial pressures might force them to continue working in hot conditions, despite the risks.

Research has shown that HRP varies among different demographic groups, with factors like age, gender, race, and income level playing significant roles (Beckmann & Hiete, 2020; Madrigano et al., 2018). Additionally, education and prior knowledge have been shown to affect HRP levels (Ban et al., 2017; Liu et al., 2013; Rauf et al., 2017; Williams et al., 2018). Occupational exposure to extreme heat can also affect individuals' risk perceptions and behaviours (Liu et al., 2013). In our study, male vendors had a slightly higher HRP score (0.721 ± 0.216) compared to female vendors (0.708 ± 0.027). This finding contrasts with previous studies in Australia (Akompab et al., 2013), China (Liu et al., 2013), Pakistan (Rauf et al., 2017), and the USA (Howe et al., 2019), whose findings generally showed that women had a higher perception of heat risk. However, our study did find that women were more inclined than men to view themselves as vulnerable to extreme heat. The unequal representation of males and females among the participants in our study could potentially introduce bias into the results. Additionally, the study did not find any significant associations between HRP and age, education, occupation or migrant status. In other words, street vendors responded similarly regardless of their sociodemographic backgrounds. These findings align with those of Ban et al. (2017), where the majority of demographic variables did not impact HRP. The family background, however, impacted HRP, particularly for those with an at-risk family member. This aligns with findings by Akompab et al. (2013), which suggested that concern for the well-being of someone you live with can heighten the perceived heat risk. Additionally, various studies, including one by Han et al. (2021) on construction workers, have shown that individuals with chronic diseases tend to view heat as a greater risk (Beckmann & Hiete, 2020; Maheshwari, 2022). Our study supports this observation, as respondents with pre-existing chronic illnesses were more likely to be fearful of heat-related health issues.

Even though occupational heat exposure and chronic health issues can elevate HRP, lack of autonomy and feelings of helplessness can result in workers giving heat safety a lower priority while on the job (Hass & Ellis, 2019; Liu et al., 2013; Singh et al., 2019; Zander et al., 2017). For example, many workers felt that weather alerts had minimal impact on their daily routines since they had to work regardless of the forecast. As a result, they often didn't check heatwave information and assumed their current knowledge was sufficient. However, those who had access to weather reports, heat warnings, and training programs tended to have a higher HRP. Our study found that past experiences with heatwaves influenced how people perceived heat risk, making them more concerned about the likelihood and severity of future events. The study also confirmed that previous experiences can motivate adaptive measures, as reported in the findings of other research (Akompab et al., 2013; Ban et al., 2017; Esplin et al., 2019; Hass & Ellis, 2019; Rauf et al., 2017; Zander et al., 2017). This aligns with the observation that individuals who have experienced physical risks tend to have higher psychological risk perceptions and are more likely to engage in adaptive behaviours (Ban et al. 2019; Musacchio et al., 2021). Though, outdoor workers being exposed to higher daily risks may cause them to underestimate the dangers of heat exposure and view them as less severe than other hazards (Hass & Ellis, 2019; Lane et al., 2014; Permatasari et al., 2023; Williams et al., 2019). Our research revealed that many vendors have

grown accustomed to the heat and don't perceive it as a novel risk anymore. This is worrisome because it reduces their awareness of the significantly increased heat risk because of factors such as the urban heat island effect and climate change (Coleman, 2022; Reid et al., 2009).

The study found that 66% of respondents changed their lifestyle and engaged in protective behaviours to lower the risk of heat impacts, while 76% of respondents took physical adaptive measures at their workplace. Lifestyle measures may be more popular because they are easier to implement (such as changing work hours, wearing summer scarves, and staying adequately hydrated) and do not require much additional monetary investment. However, our study found that migrant workers were less likely to engage in either lifestyle adjustments or workplace modifications. The study by Messeri et al. (2019) provides insights into this, suggesting that migrants perceive lower levels of heat and exhibit reduced productivity decline in comparison to local workers, potentially due to a higher threshold for heat tolerance or a poorer heat risk perception.

The cross-sectional survey approach used for the study enabled direct engagement via face-to-face questionnaires during an active heatwave, which captured immediate perceptions and reduced recall bias. It also allowed to simultaneously document existing adaptive measures and coping strategies. However, the gender imbalance in the data limits generalizability and highlights the structural barriers in accessing female vendors. The comprehensive HRP Index effectively combined cognitive and affective dimensions with acceptable internal consistency (Cronbach's alpha = 0.76). The study used an unweighted mean of normalized indicators, assuming that each indicator contributes equally to the overall HRP construct. This approach was optimal given the research objectives and target population constraints, though future research could improve by assigning weights based on relative importance to the latent construct.

Conclusion

The research evaluated how 441 outdoor workers and street vendors in Nagpur perceive heat risks, using HRP scores on an index scale ranging from 0 to 1. The HRP index showed a generally high heat risk perception, with an average score of 0.72. Perceived vulnerability was identified as the key predictor of risk perception, significantly influenced by individual's previous experiences with heat. The study highlighted several important predictors of heat risk perception, such as acknowledging increasing temperatures, past negative experiences with heatwaves, and fear of heat-related illnesses. Vendors considered health risks as the primary factor in assessing overall heat risk. Fear of heat illnesses was found to be a strong motivator for positive behaviour change. Consistent with previous studies such as Ban et al. (2019), Hass & Ellis (2019), and Liu et al. (2013), our findings showed that HRP and the uptake of adaptive behaviours were significantly associated. This study confirms that heat risk perceptions are important predictors of adaptive measures for street vendors, just like they are for other demographic groups. The study determined that specific sociodemographic factors, such as chronic illnesses and vulnerable family members, influence heat risk perception (HRP). Most sociodemographic factors, however, were not significantly associated with heat risk perception. It also found that knowledge-related aspects, including training and awareness programs, positively impact on HRP. It also follows that those with less access to relevant information are less likely to engage in adaptive behaviours. However, conventional education alone proves inadequate and less effective, highlighting the need to explore alternative approaches tailored to

the specific needs of vendors. These approaches should also incorporate local wisdom and pre-existing knowledge within the community.

Nagpur, like many tropical cities, has long experienced high temperatures, which has led some vendors to become acclimated, consequently lowering their perception of heat risk. Although initiatives like the Heat Action Plan (HAP) are in place, risk communication campaigns often provide basic advice, such as increasing water intake, staying in the shade etc. Vendors may not find this advice practical or helpful. While multiple awareness workshops could be beneficial, their effectiveness hinges on the public's risk perception. Our study provided evidence that vendors recognizing heat as a risk are more likely to adopt mitigation measures, thereby reducing the negative health and economic impacts of heat exposure. However, vendors infrequently adopting physical (24%) or lifestyle (14.5%) measures face increased vulnerability. This finding underscores a significant gap in addressing heat-related issues among vendors and highlights the need for enhanced training and education efforts targeting this vulnerable group. Simply improving knowledge about heat through formal training may not substantially increase preventive behaviours. Health campaigns may achieve greater success if they consider both cognitive and affective risk perceptions (Shamsrizi et al., 2023), since these perceptions are moulded by personal experiences, cultural beliefs, social influences, and psychological factors (Lerner & Keltner, 2001; Slovic & Peters, 2006). Neglecting this issue may lead to higher mortality and morbidity rates. Our study suggests that enhancing vendors' heat risk perception can improve their response. However, it is crucial to interpret this result with caution, as heightened risk perception does not always translate into precautionary behaviour. Higher risk perception is more likely to lead to such actions when individuals believe that practical safety measures are available and within their capability to implement.

This research provides actionable insights for climate adaptation policy by quantifying heat risk perception among a previously understudied vulnerable population. The HRP Index offers a standardized measurement tool that could inform targeted interventions, though its effectiveness requires validation across different contexts and seasons. The study documents that 47.8% of street vendors experience heat-related illness, providing quantified evidence for local health authorities to prioritize heat-health interventions relevant to sustainable development goal (SDG) 3 targets on environmental health risks. The study's identification of local knowledge systems and existing adaptation practices provides entry points for policy makers to build upon existing community knowledge rather than imposing external solutions. Evidence that 76.2% of vendors already modify their work environments suggests policy support for low-cost cooling solutions (shade nets, fans) could be effective. It also points to implementation pathways towards SDG 11, such as urban planning policies that mandate shade structures in informal market areas and development of climate-responsive public space design standards. The research also provides insights for building adaptive capacity among climate-vulnerable populations, an important target of SDG 13. The methodology and findings contribute to knowledge systems for climate action in developing country contexts. However, success in contributing to SDG targets requires robust monitoring systems that may not currently exist for informal worker populations. The informal nature of street vending also creates challenges for systematic intervention delivery.

Further research on heat risk perception among diverse vulnerable populations is essential for developing dedicated Heat-Health Warning Systems (HHWS). Since a single policy may not be suitable for everyone, these insights can help tailor provisions for distinct groups. For

instance, older adults might benefit from staying indoors during heatwaves, but this may not be practical for outdoor workers. It's important to note that this study focused on urban street vendors, so its findings may not directly apply to vendors in other regions. Our study highlighted that HRP is extremely subjective and shaped by various factors, including local conditions. To better understand how specific vulnerable groups perceive heat risk in their regions, localized studies are essential. Results from comparable studies in rural or peri-urban locations might yield different insights, contributing to a more comprehensive understanding of heat risk perception. This study's findings should be considered in light of two limitations. Firstly, a significant portion of the respondents were male workers, which may introduce bias and limit the generalizability of the results to all workers. Secondly, the study did not explore the impact of vendors' income on their heat risk perception (HRP) due to the challenges in obtaining accurate income responses from respondents. Given that income affects the ability to protect oneself from heat and overcome adaptation barriers, it is essential for future studies to explore the income-heat risk perception relationship in depth. Despite these limitations, the study provides valuable insights into heat risk perception among informal vendors and their individual protective responses. It emphasizes the need for impactful behavioural measures and adaptation plans to address the challenges faced by this vulnerable group.

Acknowledgements

The authors would like to thank the American Red Cross and the Global Disaster Preparedness Center (GDPC) for sponsoring the study. They also acknowledge the technical support provided by the GDPC, the Red Cross Red Crescent Climate Center, and the Global Heat Health Information Network (GHHIN) throughout the research process.

References

Akompab, D., Bi, P., Williams, S., Grant, J., Walker, I., & Augoustinos, M. (2013). Heat Waves and Climate Change: Applying the Health Belief Model to Identify Predictors of Risk Perception and Adaptive Behaviours in Adelaide, Australia. *International Journal of Environmental Research and Public Health*, *10*(6), 2164–2184. https://doi.org/10.3390/ijerph10062164

Ban, J., Huang, L., Chen, C., Guo, Y., He, M. Z., & Li, T. (2017). Integrating new indicators of predictors that shape the public's perception of local extreme temperature in China. *Science of the Total Environment*, *579*, 529–536. https://doi.org/10.1016/j.scitotenv.2016.11.064

Ban, J., Xu, X., Li, H., Zhou, Y., & Sun, Y. (2019). Health-risk perception and its mediating effect on protective behavioral adaptation to heat waves. *Environmental Research, 172,* 27–33. https://doi.org/10.1016/j.envres.2019.02.014

Beckmann, S. K., & Hiete, M. (2020). Predictors Associated with Health-Related Heat Risk Perception of Urban Citizens in Germany. *International Journal of Environmental Research and Public Health*, *17*(3), 874. https://doi.org/10.3390/ijerph17030874

Bonafede, M., Levi, M., Pietrafesa, E., Binazzi, A., Marinaccio, A., Morabito, M., Pinto, I., de' Donato, F., Grasso, V., Costantini, T., & Messeri, A. (2022). Workers' Perception Heat Stress: Results from a Pilot Study Conducted in Italy during the COVID-19 Pandemic in

2020. *International Journal of Environmental Research and Public Health*, *19*(13), 8196. https://doi.org/10.3390/ijerph19138196

Coleman, J. (2022). Climate change made South Asian heatwave 30 times more likely. *Nature*. Advance online publication. https://doi.org/10.1038/d41586-022-01444-1

Dong, W., Jiang, R., Dong, Y., & Pei, M. (2024). Relationship between heat risk perception and physical activity of residents in the context of climate change. *Fengjing Yuanlin, 31*(4), 21–28. https://doi.org/10.3724/j.fjyl.202310050447

El-Shafei, D. A., Bolbol, S. A., Awad Allah, M. B., & Abdelsalam, A. E. (2018). Exertional heat illness: knowledge and behavior among construction workers. *Environmental Science and Pollution Research*, *25*(32), 32269–32276. https://doi.org/10.1007/s11356-018-3211-8

Elshamy, R. A., Eladl, A. M., & Zaitoun, M. F. (2024). Climatic changes: knowledge and adaptation behavior to heat-related illness among solid waste disposal workers. *Journal of the Egyptian Public Health Association*, *99*(1). https://doi.org/10.1186/s42506-024-00155-x

Esplin, E. D., Marlon, J. R., Leiserowitz, A., & Howe, P. D. (2019). "Can You Take the Heat?" Heat-Induced Health Symptoms Are Associated with Protective Behaviors. *Weather, Climate, and Society*, *11*(2), 401–417. https://doi.org/10.1175/wcas-d-18-0035.1

Han, S.-R., Wei, M., Wu, Z., Duan, S., Chen, X., Yang, J., Borg, M. A., Lin, J., Wu, C., & Xiang, J. (2021a). Perceptions of workplace heat exposure and adaption behaviors among Chinese construction workers in the context of climate change. *BioMed Central Public Health*, *21*(1). https://doi.org/10.1186/s12889-021-12231-4

Hass, A. L., & Ellis, K. N. (2019). Motivation for Heat Adaption: How Perception and Exposure Affect Individual Behaviors During Hot Weather in Knoxville, Tennessee. *Atmosphere*, *10*(10), 591. https://doi.org/10.3390/atmos10100591

Heidenreich, A., & Thieken, A. (2021, April 19–30). Is heat a hot topic? – Exploring risk perception, risk communication, and adaptation to heat stress with a household survey. *EGU General Assembly 2021* (EGU21-15315). Copernicus Meetings. https://doi.org/10.5194/egusphere-egu21-15315

How, V., Singh, S., Dang, Q. T., & Guo, H. R. (2021). Factors Associated with Health-Risk Perception of Heat Waves among Agroecological and Conventional Farmers in the Tropics. *The International Journal of Climate Change: Impacts and Responses*, *14*(1), 45–60. https://doi.org/10.18848/1835-7156/cgp/v14i01/45-60

Howe, P. D., Marlon, J. R., Wang, X., & Leiserowitz, A. (2019). Public perceptions of the health risks of extreme heat across US states, counties, and neighborhoods. *Proceedings of the National Academy of Sciences*, *116*(14), 6743–6748. https://doi.org/10.1073/pnas.1813145116

Huang, L., Yang, Q., Li, J., Chen, J., He, R., Zhang, C., Chen, K., Dong, S. G., & Liu, Y. (2017). Risk perception of heat waves and its spatial variation in Nanjing, China. *International Journal of Biometeorology*, *62*(5), 783–794. https://doi.org/10.1007/s00484-017-1480-4

Iorfa, S. K., Ottu, I. F. A., Oguntayo, R., Ayandele, O., Kolawole, S. O., Gandi, J. C., Dangiwa, A. L., & Olapegba, P. O. (2020). COVID-19 Knowledge, Risk Perception, and Precautionary Behavior Among Nigerians: A Moderated Mediation Approach. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.566773

IPCC. (2023). *Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (H. Lee & J. Romero, Eds.). IPCC. https://doi.org/10.59327/ipcc/ar6-9789291691647

Iswarya, R., Rajini, S., Premnath, D., & Pravinraj, S. (2024). Risk perceptions of heat-related illnesses, assessing vulnerability and adaptive capacity of brick-kiln workers in rural Puducherry: A cross-sectional study. *Indian Journal of Community Medicine, 49*(Suppl 1), S91. https://doi.org/10.4103/ijcm.ijcm_abstract314

Kjellstrom, T., Lemke, B., & Lee, J. (2019). Workplace Heat: An increasing threat to occupational health and productivity. *American Journal of Industrial Medicine*, *62*(12), 1076–1078. https://doi.org/10.1002/ajim.23051

Lane, K., Wheeler, K., Charles-Guzman, K., Ahmed, M., Blum, M., Gregory, K., Graber, N., Clark, N., & Matte, T. (2013). Extreme Heat Awareness and Protective Behaviors in New York City. *Journal of Urban Health*, *91*(3), 403–414. https://doi.org/10.1007/s11524-013-9850-7

Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. *Journal of Personality and Social Psychology*, *81*(1), 146–159. https://doi.org/10.1037/0022-3514.81.1.146

Li, J., Sun, R., Li, J., Ma, Y., Zhang, M., & Chen, L. (2024). Human extreme heat protective behaviours: the effects of physical risks, psychological perception, and public measures. *Humanities and Social Sciences Communications*, *11*, 327. https://doi.org/10.1057/s41599-024-02790-3

Li, T., Chen, C., & Cai, W. (2022). The global need for smart heat–health warning systems. *The Lancet*, *400*(10362), 1511–1512. https://doi.org/10.1016/s0140-6736(22)01974-2

Liu, T., Xu, Y. J., Zhang, Y. H., Yan, Q. H., Song, X. L., Xie, H. Y., Luo, Y., Rutherford, S., Chu, C., Lin, H. L., & Ma, W. J. (2013). Associations between risk perception, spontaneous adaptation behavior to heat waves and heatstroke in Guangdong province, China. *BioMed Central Public Health*, *13*(1). https://doi.org/10.1186/1471-2458-13-913

Lohrey, S., Chua, M., Gros, C., Faucet, J., & Lee, J. K. W. (2021). Perceptions of heat-health impacts and the effects of knowledge and preventive actions by outdoor workers in Hanoi, Vietnam. *Science of the Total Environment*, *794*, 148260. https://doi.org/10.1016/j.scitotenv.2021.148260

Luber, G., & McGeehin, M. (2008). Climate Change and Extreme Heat Events. *American Journal of Preventive Medicine*, *35*(5), 429–435. https://doi.org/10.1016/j.amepre.2008.08.021

Madrigano, J., Lane, K., Petrovic, N., Ahmed, M., Blum, M., & Matte, T. (2018). Awareness, Risk Perception, and Protective Behaviors for Extreme Heat and Climate Change in New

York City. *International Journal of Environmental Research and Public Health*, *15*(7), 1433. https://doi.org/10.3390/ijerph15071433

Maheshwari, V. (2022). Analysis of Public Awareness, Health Risks, and Coping Strategies Against Heat Waves in NCT of Delhi, India. In: Sajjad, H., Siddiqui, L., Rahman, A., Tahir, M., Siddiqui, M.A. (eds) *Challenges of Disasters in Asia. Springer Natural Hazards*. Springer, Singapore. https://doi.org/10.1007/978-981-19-3567-1_19

Messeri, A., Morabito, M., Bonafede, M., Bugani, M., Levi, M., Baldasseroni, A., Binazzi, A., Gozzini, B., Orlandini, S., Nybo, L., & Marinaccio, A. (2019). Heat Stress Perception among Native and Migrant Workers in Italian Industries—Case Studies from the Construction and Agricultural Sectors. *International Journal of Environmental Research and Public Health*, *16*(7), 1090. https://doi.org/10.3390/ijerph16071090

Meyer, D., Zeileis, A., & Hornik, K. (2022). *vcd: Visualizing categorical data* (Version 1.4-10) [R package]. Comprehensive R Archive Network (CRAN). https://CRAN.R-project.org/package=vcd

Murray, C. J. L., Aravkin, A. Y., Zheng, P., Abbafati, C., Abbas, K. M., Abbasi-Kangevari, M., Abd-Allah, F., Abdelalim, A., Abdollahi, M., Abdollahpour, I., Abegaz, K. H., Abolhassani, H., Aboyans, V., Abreu, L. G., Abrigo, M. R. M., Abualhasan, A., Abu-Raddad, L. J., Abushouk, A. I., Adabi, M., & Adekanmbi, V. (2020). Global Burden of 87 Risk Factors in 204 Countries and territories, 1990–2019: a Systematic Analysis for the Global Burden of Disease Study 2019. *The Lancet*, *396*(10258), 1223–1249. https://doi.org/10.1016/s0140-6736(20)30752-2

Musacchio, A., Andrade, L., O'Neill, E., Re, V., O'Dwyer, J., & Hynds, P. D. (2021). Planning for the health impacts of climate change: Flooding, private groundwater contamination and waterborne infection – A cross-sectional study of risk perception, experience and behaviours in the Republic of Ireland. *Environmental Research*, *194*, 110707. https://doi.org/10.1016/j.envres.2021.110707

National Disaster Management Authority. (2019). *National disaster management plan. Ministry of Home Affairs, Government of India. https://ndma.gov.in/sites/default/files/PDF/ndmp-2019.pdf*

Ning, L., Niu, J., Bi, X., Yang, C., Liu, Z., Wu, Q., Ning, N., Liang, L., Liu, A., Hao, Y., Gao, L., & Liu, C. (2020). The impacts of knowledge, risk perception, emotion and information on citizens' protective behaviors during the outbreak of COVID-19: a cross-sectional study in China. *BioMed Central Public Health*, *20*(1). https://doi.org/10.1186/s12889-020-09892-y

Permatasari, N., Yovi, E. Y., & Kuncahyo, B. (2023). Mitigating heat exposure: Exploring the role of knowledge, risk perception, and precautionary behavior. *Jurnal Sylva Lestari: Journal of Sustainable Forest, 12*(1), 11–26. https://doi.org/10.23960/jsl.v12i1.773

Putra, F. D., Yovi, E. Y., & Kuncahyo, B. (2024). Heat-Resilient Workforce: Unveiling the Relationships Between Heat-related Knowledge, Risk Perception, and Precautionary Behavior in Indonesian Pine Forest Workers. *European Journal of Forest Engineering, 10*(1), 67–77. https://doi.org/10.33904/ejfe.1374811

Rajeevan, M., Rohini, P., Nair, S. A., Tirkey, S., Goswami, T., & Kumar, N. (2023). Heat and cold waves in india processes and predictability. *IMD Met. Monograph: MoES/IMD/Synoptic Met/01 (2023)/28*, *28*, 26–128.

Rauf, S., Bakhsh, K., Abbas, A., Hassan, S., Ali, A., & Kächele, H. (2017). How hard they hit? Perception, adaptation and public health implications of heat waves in urban and peri-urban Pakistan. *Environmental Science and Pollution Research*, *24*(11), 10630–10639. https://doi.org/10.1007/s11356-017-8756-4

Reid, C. E., O'Neill, M. S., Gronlund, C. J., Brines, S. J., Brown, D. G., Diez-Roux, A. V., & Schwartz, J. (2009). Mapping Community Determinants of Heat Vulnerability. *Environmental Health Perspectives*, *117*(11), 1730–1736. https://doi.org/10.1289/ehp.0900683

Robertson, B. W., Dow, K., Salinas, J., & Cutter, S. L. (2024). Heat Risk Perceptions and Coping Strategies of the Unhoused. *International Journal of Environmental Research and Public Health*, *21*(6), 737. https://doi.org/10.3390/ijerph21060737

Romanello, M., McGushin, A., Napoli, C. D., Drummond, P., Hughes, N., Jamart, L., Kennard, H., Lampard, P., Rodriguez, B. S., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Cai, W., Campbell-Lendrum, D., Capstick, S., Chambers, J., Chu, L., Ciampi, L., Dalin, C., & Dasandi, N. (2021). The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. *The Lancet*, *398*(10311), 1619-1662. https://doi.org/10.1016/S0140-6736(21)01787-6

RStudio Team. (2020). *RStudio: Integrated development for R*. RStudio, PBC. http://www.rstudio.com/

Schoessow, F. S., Li, Y., Marlon, J. R., Leiserowitz, A., & Howe, P. D. (2022). Sociodemographic Factors Associated with Heatwave Risk Perception in the United States. *Weather, Climate, and Society*, *14*(4), 1119–1131. https://doi.org/10.1175/wcas-d-21-0104.1

Shamsrizi, P., Jenny, M. A., Sprengholz, P., Geiger, M., Jäger, C. B., & Betsch, C. (2023). Heatwaves and their health risks: Knowledge, risk perceptions and behaviours of the German population in summer 2022. *European Journal of Public Health, 33*(5), 841–843. https://doi.org/10.1093/eurpub/ckad109

Singh, R., Arrighi, J., Jjemba, E., Strachan, K., Spires, M., Kadihasanoglu, A. (2019). Heatwave Guide for Cities. Red Cross Red Crescent Climate Centre.

Slovic, P., & Peters, E. (2006). Risk Perception and Affect. *Current Directions in Psychological Science*, *15*(6), 322–325. https://doi.org/10.1111/j.1467-8721.2006.00461.x

Stanberry, L. R., Thomson, M. C., & James, W. (2018). Prioritizing the needs of children in a changing climate. *Public Library of Science (PLOS) Medicine*, *15*(7), e1002627. https://doi.org/10.1371/journal.pmed.1002627

Suldovsky, B., Molly Baer Kramer, & Fink, J. (2024). Extreme heat & public perception in Portland, Oregon: Evidence of a compounding vulnerability effect for climate hazards.

Public Library of Science (PLOS) Climate, *3*(5), e0000386–e0000386. https://doi.org/10.1371/journal.pclm.0000386

Toloo, G., FitzGerald, G., Aitken, P., Verrall, K., & Tong, S. (2013). Are heat warning systems effective? *Environmental Health*, *12*(1). https://doi.org/10.1186/1476-069x-12-27

Williams, S., Hanson-Easey, S., Nitschke, M., Howell, S., Nairn, J., Beattie, C., Wynwood, G., & Bi, P. (2018). Heat-health warnings in regional Australia: examining public perceptions and responses. *Environmental Hazards*, *18*(4), 287–310. https://doi.org/10.1080/17477891.2018.1538867

Woetzel, L., Pinner, D., Samandari, H., Engel, H., Krishnan, M., Boland, B., & Powis, C. (2020, January 16). *Climate risk and response: Physical hazards and socioeconomic impacts*. McKinsey Global Institute. https://www.mckinsey.com/capabilities/sustainability/our-insights/climate-risk-and-response-physical-hazards-and-socioeconomic-impacts

Xiang, J., Hansen, A., Pisaniello, D., & Peng Bi. (2016). Workers' perceptions of climate change related extreme heat exposure in South Australia: a cross-sectional survey. *BioMed Central Public Health*, *16*, 549. https://doi.org/10.1186/s12889-016-3241-4

Yovi, E. Y., Nastiti, A., & Kuncahyo, B. (2023). Heat-Related Knowledge, Risk Perception, and Precautionary Behavior among Indonesian Forestry Workers and Farmers: Implications for Occupational Health Promotion in the Face of Climate Change Impacts. *Forests*, *14*(7), 1455. https://doi.org/10.3390/f14071455

Zander, K. K., Moss, S. A., & Garnett, S. T. (2017). Drivers of self-reported heat stress in the Australian labour force. *Environmental Research*, *152*, 272–279. https://doi.org/10.1016/j.envres.2016.10.029

Appendix A: Questionnaire

Section A. Sociodemographic Information

Q1. Gender

a. Male
b. Females

Q2. Occupation

a. Fruit Vendor
b. Vegetable Vendor
c. Flower Vendor
d. Food and Drinks Vendor (Lemonade. Fruit Juice, Cookies, Snacks, Grains, Spices)
e. Metal Article Vendor
f. Chai/Coffee/Pan Stall
g. Clothes Vendor
h. Clothing Accessories
i. Books, Stationery and Paper
j. Puncture & Repairing
k. Autorickshaw
l. Cart Puller/Handyman/Porters
m. Miscellaneous (Disposables, Barber, Butcher, Cobbler, Band Musician, Pooja Items, Potter, Laundryman, Key Maker, Handmade Items, Mobile Accessories, Home Accessories, Scarp Vendor, Security Guard, Shoe Polish, Tailor)

Q3. Age

a. ≤20
b. 21-35
c. 36-50
d. 51-65
e. 66-80

Q4. Highest Education

f. No formal education
g. Primary School (Till 4th)
h. Middle School (Till 7th)
i. High School (Till10th)
j. Junior College (Till 12th)
k. Undergraduate
l. Postgraduate

Q5. Does your family have children under 15 or elders above 65?

a. Yes
b. No

Q6. Have you migrated to Nagpur?

a. Yes
b. No

Q7. If yes, where are you from?

a. Madhya Pradesh
b. Delhi
c. Rajasthan
d. Bihar
e. Chhattisgarh
f. Karnataka
g. Uttar Pradesh
h. Gujarat

Q8. Do you have any chronic illnesses?

a. Yes
b. No

Section B. Awareness, Sensitivity and Previous Experience (Knowledge of heat and related risks)

Q9. How do you define heat/hot weather?

□ When the temperature rises above a certain threshold
□ When changes are needed in normal behaviours or activities
□ When discomfort is felt
□ When health effects are experienced

Q10. Do you check the weather forecast daily before leaving your house?

a. Yes
b. No
c. Sometimes

Q11. Have you heard about "heatwaves" in the past?

a. Yes
b. No
c. Maybe

Q12. Have you ever experienced a heatwave?

a. Yes
b. No
c. Maybe

Q13. Do you receive heat warnings?

a. Yes
b. No

Q14. If yes, how did you get this information?

a. Past Experience
b. Word of mouth
c. Newspaper
d. Internet
e. TV/ Radio
f. Mobile broadcast

Q15. Did you ever have access to a training/awareness program for heat-related risks?

a. Yes
b. No

Q16. In the past several years, did you feel the weather was hotter than before?

a. Yes
b. No
c. I don't know

Q17. Have you ever experienced a heat illness at work?

a. Yes
b. No

Q18. If yes, which have you experienced?

□ Do not remember
□ Heavy Sweating
□ Cold, pale, clammy skin
□ Heat Rash
□ Nausea or vomiting
□ Muscle cramps
□ Tiredness or weakness
□ Dizziness
□ Headache
□ Fainting
□ Feeling hot
□ Thirsty
□ Cough
□ Other:

Q19. If yes, what measures did you take to combat your heat-related illness?

Section C. Heat Risk Perception Variables

Perceived Aspect	Question	Response
LIKELIHOOD	How frequent do you think the heatwaves are in Nagpur?	• 1 (Never) • 2 (Rarely) • 3 (Sometimes) • 4 (Often) • 5 (Always)
SEVERITY	How severe do you think the heatwaves are in Nagpur?	• 1 (None) • 2 (Very Mild) • 3 (Mild) • 4 (Moderate) • 5 (Severe)
CONCERN (HEALTH)	How dangerous are heat waves to your own health?	• 1 (Low) • 2 (Moderate) • 3 (Considerable) • 4 (High) • 5 (Severe)
	Are you concerned about heat-related risks that can affect your family?	• Yes • No
	Are you concerned about heat-related risks that can affect the community?	• Yes • No
CONCERN (ECONOMIC)	Do you worry that extreme heat will affect your general expenses?	• Yes • Maybe • No
	Do you worry that extreme heat will affect your household expenses?	• Yes • Maybe • No
	Do you worry that extreme heat will affect your employment and productivity?	• Yes • Maybe • No
FEAR (HEALTH)	Are you scared of heat-health illnesses?	• Yes

		• Maybe • No
VULNERABILITY	Would you consider yourself to be vulnerable to extreme heat?	• Yes • No