

HEAT PERCEPTION STUDY FOR MEDAN, INDONESIA

October 2025



FOREWORD

Greetings from PMI,

It is my privilege to congratulate the publication of the **Heat Perception Study Report, a collaborative effort by the Indonesian Red Cross, American Red Cross, Climate Center, and IFRC** to deepen our understanding of how communities in Indonesia, specifically in urban areas, are experiencing and responding to rising heat conditions. This study is relevant as we stand at the forefront of an increasingly warming world, while the extreme heat has quietly become one of the highest climate risks we face. Unlike storms or floods, the heat often strikes invisibly, particularly to the most vulnerable populations.

This study has been set out with an objective — to explore the **knowledge, attitude, practice, and perception** of different population-at-risk groups regarding extreme heat in the heat-prone areas in two cities, Surabaya City (East Java Province) and Medan City (North Sumatra Province), as the two biggest cities in Indonesia. The study results have provided an overview and understanding of how the community thinks and practices their daily activity during the heat period and how the heat influences the community's life. Through extensive data collection in both cities, the study has gathered insights into how heat is perceived across different neighborhoods, age groups, and socio-economic contexts.

I would like to extend my appreciation with our dedicated team of researchers, volunteers, and all the residents who participated and shared their experiences. Your voices are the foundation of this report, and your stories are what will drive meaningful change. As we present the findings today, I encourage everyone to view this not as the end of a study, but as the beginning of a stronger, more inclusive response to climate-driven heat impacts. Let this report guide our policies, inform our planning, and most importantly inspire collaboration across sectors.

Thank you for being part of this important journey.

Jakarta, February 2026



A. M. Fachir

CEO/Secretary General

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This study was led by the American Red Cross – in particular, its Asia Pacific Division and Indonesia Delegation – in collaboration with Red Cross Red Crescent Climate Centre (Climate Centre) and International Federation of Red Cross and Red Crescent Societies (IFRC). Special recognition goes to Ramiz Khan, Urban Advisor at the Climate Centre; Colin Fernandes, Preparedness Technical Advisor at the American Red Cross, Asia Pacific Division; and Ishma Soepriadi as Lead in Design, Monitoring, Evaluation, Research and Learning (also known as DMERL) for the American Red Cross, Indonesia Delegation. We are extremely grateful for their expert guidance, technical review, critical feedback and tireless support throughout this study.

Special thanks are also due to Heidy Angelica Suharno as a contributing writer, and for her help in developing a robust analytical framework, data interpretation methodology and core narrative – efforts that provided a strong foundation for this Heat Perception Study for Medan.

Thanks to the Margaret A. Cargill Philanthropies Responsive Support grant, we have been able to continue our work in Indonesia through an urban heat project focused on enhancing resilience to extreme heat through community-based adaptation and capacity-building for the Indonesian Red Cross/PMI. We would also like to thank the Quadrature Climate Foundation (QCF), and USAID for their support of this work.

We hope that this publication will contribute to academic knowledge and practical applications in the fields of climate change adaptation, disaster risk reduction and urban resilience. Our wish is that it serves as a valuable reference for researchers, practitioners and policymakers at the local, national and international levels.

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EXECUTIVE SUMMARY

Extreme heat is a growing concern in Indonesia. According to the latest reports, the average number of hot days in Indonesia has increased from 45 days (2005–2014) to 63 days (2015–2024) – an average rise of approximately 18 days over this period.¹

Given this alarming growth in extreme heat days, a household survey was conducted in Medan to assess city dwellers' vulnerability to extreme heat along with their perception of heat risks as well as the impacts on their health and livelihoods in addition to their adaptive capacity and access to early warning systems (EWS). The survey covered 1,238 respondents (61 per cent women and 39 per cent men) across 21 sub-districts and population groups identified as highly vulnerable to extreme heat. This included residents of informal settlements, outdoor workers, older people, pregnant women, people with disabilities, and students. The findings provide evidence to inform inclusive urban heat risk management policies and interventions for the city, with a special focus on vulnerable groups.

The sample selection ensured that respondents covered all age groups and socioeconomic profiles to inform the development of more inclusive future policies on heat. Most respondents were women (61.47 per cent) with adults comprising over half of the sample (52.5 per cent), followed by youth (30.77 per cent) and older people (16.72 per cent). Educational attainment is relatively moderate, with most respondents having completed secondary education (57 per cent), while 2 per cent reported no formal education. Income levels are predominantly low, with more than three-quarters of respondents earning below 2,000,000 Indonesian rupiahs (IDR) (118 US dollars (USD)) per month. This reflects limited financial capacity to prepare and respond to climate-related shocks.

It was also noted that respondents' livelihood profiles further heighten their exposure to extreme heat. One-third of the outdoor workers, residents of informal settlements, older people and pregnant women reported long working hours (more than ten hours per day) under hot conditions. These working conditions increase the likelihood of heat stress and related illnesses, particularly among groups with pre-existing health vulnerabilities (8.3 per cent).

Access to cooling devices such as air conditioning remains limited, especially among the residents of informal settlements. These realities places them more at risk to increasing heat and strain their ability to adopt self-protective measures during extreme heat events, including reducing working hours, accessing healthcare or purchasing cooling equipment.

Almost all respondents (91 per cent) reported experiencing unusually hot or uncomfortable weather with nearly three-quarters perceiving that they are vulnerable to extreme heat and its increasing incidence; though understanding of the risk of mortality due to the heat was low (64 per cent).

Moreover, there is a confidence and action gap, where fewer than one-third of respondents believe that the impacts of extreme heat can be prevented. This combination of high exposure, uneven risk awareness and low confidence in prevention creates a substantial gap in heat literacy. This can be seen where only 22 per cent of respondents consistently change their behaviour during periods of extreme heat by taking self-protective action, compared to respondents in informal settlements for example who were seen to be extremely unlikely to change their behaviour.

Institutional support during extreme heat events is minimal. Almost no respondents reported seeking assistance from government agencies, non-governmental organizations or humanitarian actors. This translates into limited awareness of available support mechanisms, weak institutional outreach and potential knowledge gaps between vulnerable communities and formal institutions.

The survey found an alarming relationship between respondents receiving hazard/disaster-related warnings and their response to those warnings. Almost 80 per cent of respondents did not take any action based on the warnings they received. This calls for deeper investigation into the causal factors as well as tailored strategies to address them.

¹ Arrighi, D., Keeping, G., Singh, O., Vahlberg, T., et al. (2025). *Ten years of the Paris Agreement: The present and future of extreme heat*, Climate Central, World Weather Attribution. <https://climatecentral.org/report/10th-anniversary-paris-agreement>

Respondents reported that information received is predominantly technical (20 per cent), focusing on temperatures and weather conditions, rather than providing actionable guidance on how to reduce heat risk. This has been the situation when communicating *any* hazard event by relevant government agencies, where people are at a loss on how to prepare and respond accordingly.

The following actions should be considered by decision- and policymakers to reduce the impact of extreme heat on people's health, wellbeing and productivity:

- 1. Integrate extreme heat into urban development and social protection policies:** Investments should be prioritized in informal settlements to improve housing ventilation, increase shaded public spaces and establish cooling centres that can be accessible by all. Heat adaptation should be integrated with development and welfare programmes, targeting low-income households, older people, pregnant women and people with disabilities.
- 2. Strengthen protection for outdoor and informal workers:** In collaboration with employers, municipal authorities should promote heat-sensitive labour protection for outdoor workers (e.g., construction workers or delivery service motorbike drivers), including access to shaded rest areas and drinking water as well as scheduled rest breaks during peak heat hours.
- 3. Improve access to water and basic cooling resources:** Reliable access to safe drinking water during extreme heat periods should be prioritized, particularly for the residents of informal settlements, outdoor workers and people with disabilities. The provision of community water points along with water distribution during extreme heat events can significantly reduce health risks.
- 4. Develop practical, inclusive and action-oriented risk communication:** Heat risk communication should provide simple, clear and practical advice (e.g., on the importance of staying hydrated, resting regularly, seeking cooler spaces, caring for vulnerable family members). Communication materials must be tailored to specific groups for increased effectiveness and action.
- 5. Embed heat risk management within public health systems:** Primary healthcare facilities and personnel should be trained to identify and manage heat-related illnesses, with targeted outreach to high-risk groups. Heat-health action plans should be developed at the city level, linking health surveillance, early warnings and corresponding community action.
- 6. Strengthen community-based capacity and trust in institutions:** Local governments should work with community-based organizations, including PMI, to build awareness during extreme heat events. Community programmes and local heat preparedness initiatives can strengthen adaptive capacity and encourage self-protective behaviours among vulnerable groups.

CHAPTER 1: INTRODUCTION

Indonesia is the world's largest archipelago and crosses the equator. With a growing economy and rapid urbanization, the country has been experiencing significant warming over the last few decades – minimum temperatures are increasing at a faster rate than maximum temperatures. Future projections show that tropical, humid areas will be much more exposed to deadly heat stress than higher latitudes, meaning that Indonesia will experience more frequent, longer and more intense heat episodes under multiple scenarios. According to Indonesia's Meteorology, Climatology and Geophysical Agency (Badan Meteorologi, Klimatologi, dan Geofisika, BMKG), the highest maximum temperature recorded in July 2022 was 38.8 °C for the city of Makassar and 35–36.5 °C for the Java and Nusa Tenggara regions, where the maximum temperatures were 32–33 °C in 2012.

Since 2023, PMI in collaboration with the American Red Cross has been implementing a programme focusing on the issue of extreme heat. The programme's objective is to reduce the impacts of extreme heat in two cities in Indonesia (Medan and Surabaya) with a focus on enhancing the national, provincial and city-level government capacity, in partnership with PMI, to anticipate, prepare for and respond to extreme heat impacts. It also aims to provide information to individuals and households to help them prepare for and protect themselves from the impacts of extreme heat.

As extreme heat is not yet well-recognized by many people and stakeholders in Indonesia, the project has studied public perceptions of climate change in general and extreme heat in particular in two locations, Medan (North Sumatra Province) and Surabaya (East Java Province). This has provided a helpful overview of public perception as a basis for upcoming project activities related to extreme heat.

1. SCOPE OF THE STUDY

Heat risk perception can be explained as a subjective assessment of the probability of high temperatures occurring and the level of concern about the consequences (Slovic, 1987). Considering that there are limited available studies related to heat phenomena in Indonesia, especially in urban areas, these heat perception studies have the objective of exploring the **knowledge, attitudes, practices and perceptions** of different at-risk groups regarding extreme heat in heat-prone areas of two cities, Medan (North Sumatra Province) and Surabaya (East Java Province). The combined results of these studies provide an overview of how communities think and go about their daily activities during periods of extreme heat; how the heat influences community life in the cities; and how communities prefer to receive information on and warnings of periods of extreme heat.

The two studies, conducted in Medan and Surabaya, covered all administrative sub-districts (*kecamatan*). Medan has 21 sub-districts and Surabaya has 31 sub-districts. The studies gathered community knowledge, practices and attitudes towards climate change and extreme heat, which includes details on:

- 1. demography and socioeconomic status:** sex, age, education, occupation.
- 2. knowledge:** understanding of climate change and extreme heat and any previous heat-related experience.
- 3. attitudes:** towards climate change and extreme heat.
- 4. practices:** self-protective activities taken during periods of extreme heat.
- 5. risk perception:** of how climate change and extreme heat impacts health, livelihoods, social and environmental issues.
- 6. communication:** sources of information and feedback channels.
- 7. adaptation strategies:** people's expectations to reduce the impacts of extreme heat.

These studies involved participants from the following five target groups:

- 1. community members:** people/households who live in informal settings/heat hotspots
- 2. outdoor workers:** people who work as farm labourers, construction workers, street vendors, small business owners, drivers, etc.
- 3. pregnant women**
- 4. youth:** students at school (mixed junior high/high school/university)
- 5. vulnerable people:** older people (60+ years old), people with chronic diseases/co-morbidity factors, people with disabilities.

2. SCOPE OF STUDY AREA – MEDAN

Medan, the capital of North Sumatra Province, is the fourth-largest metropolitan centre in Indonesia with more than 2 million people. Medan has a tropical climate with generally high temperatures, high humidity and significant rainfall throughout the year. Average daily temperatures typically range between 24–33°C, with relatively small seasonal variation compared to subtropical regions. Humidity levels frequently exceed 75–85 per cent, which intensifies thermal discomfort, particularly during periods of extreme heat. Because Medan lies close to the equator, it experiences fairly uniform daylight hours year-round, contributing to stable but persistently warm conditions. During dry seasons and certain weather patterns, the city frequently records heat well above typical seasonal averages. In recent years, temperatures in Medan have soared to extremes – daily maximums have reached 38°C, with regular observations of heat in the mid-30s °C, which far exceed average conditions for the region.

Urbanization also influences local weather patterns. Rapid development, dense built-up areas and limited green open space contribute to causing urban temperatures to remain elevated, particularly at night, reducing cooling relief after sunset. Combined with high humidity and limited wind circulation in some neighbourhoods, these factors increase heat stress and heighten vulnerability to extreme heat events, especially among outdoor workers and residents in densely populated settlements.

3. STUDY METHODOLOGY

Each Heat Perception Study was carried out based on several key criteria, considering heat spots in each city (Medan and Surabaya) as well as heat-vulnerable groups. The quantitative data collection was conducted in all sub-districts using cluster sampling at village level (kelurahan). The qualitative data collection, on the other hand, was conducted through focus group discussions (FGDs) by grouping the city areas into five sub-district clusters and inviting representatives of each sub-district to participate.

Quantitative analysis uses a mixed sampling technique due to the differentiation into five target groups. The sample size was determined using a formula with a 95 per cent confidence level and a 5 per cent margin of error, except for the pregnant women and disabled groups, which were determined using judgment sampling (Figure 1). The calculated sample size was then distributed proportionally to each sub-district based on its population.

Figure 1: The formula used to calculate sample size.

The sample size n and margin of error E are given by

$$x = Z \left(\frac{c}{100} \right)^2 r(100 - r)$$

$$n = \frac{Nx}{((N-1)E^2 + x)}$$

$$E = \sqrt{\frac{(N-n)x}{n(N-1)}}$$

where N is the population size, r the fraction of responses and Z the critical value for the confidence level c .

Respondents were selected from each household using a structured process. Each respondent had to be a household member and at least 18 years old. An alternating gender pattern was then applied – female in the first household, male in the second, female in the third, and so on. If no eligible person of the required gender was available, the balance was corrected in the next household. This method resulted in nearly equal gender distribution across the sample. A predetermined route through the village was also followed to identify and select the sampled households, as shown in the illustration below (Figure 2).

Figure 2: An example of a route used in a sub-district to interview households.



A descriptive analysis is used as a statistical method to summarize, organize and present numerical data, describing the characteristics of a population. The purpose is to summarize numerical data to explore its patterns and variability. While it does not explain relationships or causes, these studies also use the chi-square analysis as the statistical approach to examine patterns in categorical data which focuses on counts or frequencies – how often something occurs in different categories. The purpose of this analysis was to determine whether the observed categorical data differs significantly from the expected patterns.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

The chi-square method compares what we observe *with what we would expect* if there was no effect or relationship. The difference between the two is quantified using the chi-square statistic.

In this formula, **O** represents the observed frequency, and **E** represents the expected frequency. The larger the discrepancy between the observed and expected values, the larger the chi-square statistic becomes. A large chi-square value suggests that the differences are unlikely to have occurred by random chance alone.

Qualitative analysis is used to gain an in-depth understanding of people’s experiences, perceptions, attitudes and behaviours. The qualitative data were collected through FGDs from representatives of each sub-district, both in Medan and Surabaya, which were divided into five clusters. Each cluster consisted of 4–5 sub-districts. Each sub-district was asked to nominate five representatives from the target groups: residents of informal settlements, outdoor workers, older people (60+ years old), pregnant women and people with disabilities as well as students (both school and university level).

4. LIMITATION OF THE STUDY

This Heat Perception Study for Medan acknowledges some limitations. First, the assessment of heat perception relied primarily on self-reported responses, which are inherently subjective and may be influenced by individual tolerance levels, recent experiences, health conditions or recall bias. Factors such as age, gender, occupation, health status, acclimatization, cultural background and personal tolerance influence how heat is experienced and reported. As a result, perceived heat does not always correspond directly with measured temperature or heat index values.

Second, this Heat Perception Study limits the scope to the most vulnerable groups, including residents of informal settlements, outdoor workers, older people, people with disabilities, pregnant women and youth and does not cover other urban groups that might also be impacted by the extreme heat. The third limitation relates to the data collection that was conducted during an early hot period, which limited the ability to capture seasonal variations, long-term adaptation patterns or differences between typical and extreme years.

CHAPTER 2: THE CASE OF MEDAN

1. DEMOGRAPHICS AND GENERAL INFORMATION

This survey includes 1,238 respondents from 21 sub-districts of Medan. The demographics and socioeconomic profiles of the respondents covers different factors, including gender, age, education level and monthly income. The aim was to ensure that the data collected accurately represented the population of Medan, enabling the survey results to effectively reflect public perceptions regarding extreme heat in the city.

Table 1. Respondents' characteristics

		Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
GENDER	Male	28.34%	54.46%	38.75%	0.00%	52.38%	31.46%	38.53%
	Female	71.66%	45.54%	61.25%	100.00%	47.62%	68.54%	61.47%
AGE	Youth	17.91%	19.31%	0.00%	18.89%	23.81%	100.00%	30.77%
	Adult	74.06%	75.00%	8.75%	81.01%	57.14%	0.00%	52.50%
	Older people	8.02%	5.69%	91.25%	0.00%	19.05%	0.00%	16.72%
EDUCATION	None	1.60%	0.74%	5.00%	0.00%	23.81%	0.00%	2.18%
	Primary	32.97%	19.06%	60.01%	24.44%	45.24%	29.56%	31.42%
	Secondary	61.76%	67.08%	27.50%	57.78%	19.05%	61.50%	57.43%
	Higher	3.74%	13.12%	7.50%	17.78%	11.90%	8.92%	8.96%
INCOME PER MONTH	Low	23.18%	21.08%	11.07%	2.42%	3.23%	16.48%	77.46%
	Medium	6.95%	10.50%	1.78%	1.13%	0.08%	0.73%	21.16%
	High	0.08%	1.05%	0.08%	0.08%	0.08%	0.00%	1.37%

The surveyed individuals consist of 61.47 per cent female respondents. In terms of age groups, a significant proportion consists of adults, comprising 52.50 per cent, followed by youth at 30.77 per cent and older persons at 16.72 per cent. The majority of respondents have completed secondary education, with 57.43 per cent finishing junior or senior high school. Additionally, 31.42 per cent of respondents have completed their primary education, while 8.96 per cent have completed higher education. A small portion of respondents (2.18 per cent) have never attended school, reflecting a relatively low illiteracy rate among those surveyed.

Most of the respondents (77.46 per cent) represent low-income groups. Respondents with middle-income levels comprised 21.16 per cent, while those in the high-income group accounted for 1.37 per cent. This highlights the socioeconomic background of the respondents, who are predominantly from lower-middle-income households.

It is interesting to note that most (71.66 per cent) of the female respondents live in informal settlements. Furthermore, 61.25 per cent of the women respondents are aged 60 or older. This survey specifically focused on different groups of women who are vulnerable to extreme heat.

The socioeconomic distribution among the respondents indicates that 19.31 per cent of outdoor workers are youth, while 5.69 per cent are older people. Outdoor workers are often associated with informal jobs – such as street vendors, daily wage earners and construction labourers – which are often low-paying, high-risk and lack social protection.

Regarding education, 45.24 per cent of respondents with disabilities have completed primary education, while 23.81 per cent have never attended school. This aligns with a report from the World Bank (2021), which states that people with disabilities are three times more likely to be out of school compared to the general population, especially in low-income areas. Barriers such as accessibility issues, social stigma and limited inclusive education policies are major factors that hinder this group from accessing formal education. However, it is notable that most residents of informal settlements (61.76 per cent) as well as outdoor workers (67.08 per cent) are among the respondents to have completed their secondary education.

In addition, 77.46 per cent of respondents reported to be earning less than IDR 2,000,000 (approximately USD 118) per month. This income level is well below the national poverty line and is internationally categorized as being part of the working poor – those who, despite being employed, still cannot meet their basic needs. According to the Organisation for Economic Co-operation and Development (OECD, 2019), this group is highly vulnerable to economic pressures, such as inflation, job loss or natural disasters, due to their limited financial resources or inadequate social protection.

The survey teams primarily targeted different groups of people who were identified at assessment workshops in the two cities as being at highest risk during periods of extreme heat. The demographic and socioeconomic distribution of survey respondents highlights this.

Table 2. Community vulnerability and resilience

		Informal settlement dwellers	Outdoor worker	Older people	Pregnant women	People with disabilities	Students	Total
DURATION OF WORKING OUTDOORS	< 4 hours	22.46%	4.95%	43.13%	31.11%	59.52%	36.15%	23.34%
	4–8 hours	39.84%	44.80%	27.50%	33.33%	23.81%	56.34%	41.92%
	8–10 hours	21.93%	34.41%	12.50%	15.56%	14.29%	6.10%	21.57%
	> 10 hours	15.78%	15.84%	16.88%	20.00%	2.38%	1.41%	13.17%
HEALTH CONDITION	No health condition	91.98%	94.55%	78.75%	100.00%	69.05%	98.12%	91.68%
	Existing chronic illness	8.02%	5.45%	21.25%	0.00%	30.95%	1.88%	8.32%
HEALTH INSURANCE	Yes	59.09%	65.35%	68.13%	66.67%	47.62%	56.81%	61.79%
	No	40.91%	34.65%	31.88%	33.33%	52.38%	43.19%	38.21%
DISTANCE FROM HOSPITAL	< 10 minutes	48.93%	52.48%	55.00%	46.67%	57.14%	56.34%	52.34%
	10–15 minutes	39.84%	35.15%	36.25%	40.00%	35.71%	33.80%	36.67%
	> 15 minutes	11.23%	12.38%	8.75%	13.33%	7.14%	9.86%	10.99%

	Informal settlement dwellers	Outdoor worker	Older people	Pregnant women	People with disabilities	Students	Total
Air conditioning	39.30%	44.31%	47.50%	44.44%	33.33%	54.93%	44.67%
Savings	19.25%	39.85%	27.50%	35.56%	21.43%	37.09%	30.78%
Gold	2.06%	6.47%	9.20%	11.32%	4.65%	3.85%	5.22%
ASSET OWNERSHIP							
Vehicles	55.01%	66.96%	39.08%	64.15%	25.58%	44.02%	54.44%
Land	3.86%	4.91%	10.92%	5.66%	0.00%	5.56%	5.37%
Others	0.26%	0.22%	0.00%	0.00%	0.00%	0.43%	0.22%
No assets	38.82%	21.43%	40.80%	18.87%	69.77%	46.15%	34.75%

Further analysis indicates that 20 per cent of pregnant women work more than 10 hours a day. Prolonged working hours, especially under hot and stressful conditions, pose serious risks to maternal health. The extreme heat can be linked to pregnancy complications, including preterm birth and low birthweight.² Additionally, pregnant women are particularly susceptible to dehydration and extreme heat can worsen this condition.³

Furthermore, 16.88 per cent of respondents aged 60 years and over still work more than 10 hours per day. This situation reflects the economic pressures faced by older people, especially in the informal settlements. Prolonged outdoor work in high temperatures can lead to dehydration, heat exhaustion and other heat-related illnesses – risks that are especially dangerous for older people.

The analysis also reveals that 15.78 per cent of informal settlement dwellers work more than 10 hours per day. They often endure exploitative working conditions, have limited bargaining power and face minimal opportunities for upward economic mobility (UN-Habitat, 2020). Additionally, 15.84 per cent of outdoor workers have reported working more than 10 hours a day, which suggests an imbalance between their physical workload and the body's ability to recover. According to the World Health Organization (WHO, 2021), this imbalance is a significant contributor to occupational stress, reduced productivity and higher rates of illness. This issue is particularly pronounced among the urban poor, who are more vulnerable to environmental stress and excessive labour demands.

According to the survey findings, approximately 8.3 per cent of respondents report chronic health conditions, while the remaining 91.7 per cent state that they have no known illnesses. Although the majority of participants appear to be in good health, the presence of chronic conditions among certain groups – such as older people, people with disabilities and residents of low-income and informal settlements – indicates potential health vulnerabilities that require further attention. According to Indonesia's Health Research and Development Agency (Badan Penelitian dan Pengembangan Kesehatan, RISKESDAS) 2018, the most reported chronic diseases in the country include hypertension (34.1 per cent), diabetes mellitus (2 per cent), stroke (10.9 per 1,000 people), chronic kidney disease (3.8 per cent) and ischemic heart disease, along with other cardiovascular problems.

In urban settings like Medan, hypertension and diabetes are particularly prevalent, often linked to sedentary lifestyles, high salt intake, stress and limited access to preventive health services. A study by Khoe *et al.* (2020) found that urban poor populations in Indonesia, including those in North Sumatra, face higher risks of chronic conditions due to barriers in accessing primary healthcare and limited adherence to treatment (Khoe *et al.*, 2020).

Moreover, research by Istiqomah *et al.* (2022) shows that low-income urban households in Medan often delay or avoid medical treatment due to medical expenses, which can worsen chronic illness outcomes over time.

2 <https://www.cdc.gov/heat-health/hcp/clinical-overview/heat-and-pregnant-women.html>
3 <https://pmc.ncbi.nlm.nih.gov/articles/PMC9300488/>

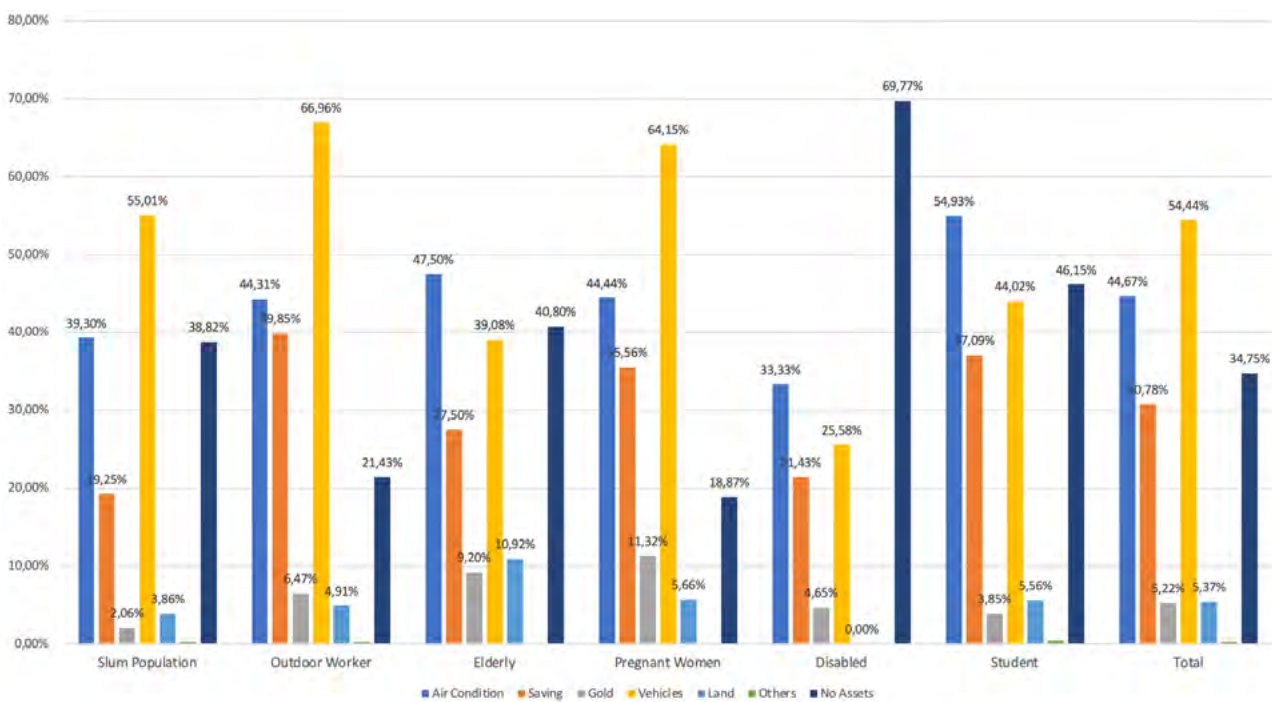
While the survey sample cannot represent the entire population of Medan, these findings provide valuable insights into the health risks faced by vulnerable communities in the city and how extreme heat can exacerbate the stress these communities already face.

However, it is worth mentioning that, in Indonesia, most city residents are covered by National Health Insurance (Jaminan Kesehatan Nasional, JKN), which BPJS Kesehatan, a government agency responsible for healthcare, manages. For low-income families, including many residents of informal settlements, the insurance premium is fully subsidized by the government, meaning they do not have to pay anything out of pocket to join the programme.

Additionally, a few cities in Indonesia have established their own local health insurance programmes to assist those who are not yet covered by BPJS or who face challenges in accessing national health insurance. These city-level insurance programmes are also typically funded by the city government and aim to fill gaps, especially for informal workers or those who have recently moved to the city and are not yet registered.

When individuals become sick, they can use this insurance to receive treatment at community health centres (*puskesmas*) or hospitals that partner with BPJS or the local scheme. While there are occasional complaints about long waiting times or limited services, the existence of insurance – especially for the residents of informal settlements – is a significant step towards improving health access for vulnerable groups.

Figure 3. Asset ownership



It is widely believed that the assets owned by households significantly influence a community's ability to cope with climate shocks and socioeconomic pressures. Asset liquidity determines how quickly vulnerable groups can prepare, respond to, or adapt to extreme heat and climate-induced hazards, especially in large cities that are increasingly exposed to these risks.

Survey findings indicate that only 30.78 per cent of respondents hold financial savings, which serve as a crucial buffer during times of crisis. Financial savings among the residents of informal settlements and people with disabilities are among the lowest at 19.25 per cent and 21.43 per cent respectively, underscoring their higher vulnerability compared to other groups. In contrast, the financial capacity of outdoor workers and students is notably better, at 39.85 per cent and 37.09 per cent respectively. Limited savings restrict a household's ability to take adaptive measures during extreme heat – such as buying fans, accessing healthcare, relocating temporarily

or reducing work hours. As Moser and Satterthwaite (2008) emphasize, financial capacity is directly linked to the adaptive ability of poor urban households, especially when facing climate-related stressors like heatwaves.

On the other hand, access to air conditioning (AC), which is believed to be the easiest solution to beat the heat, remains a luxury for many. Only 39.3 per cent of the residents of informal settlements own an AC unit.

Gold, traditionally regarded as a liquid and inflation-resistant asset, is owned by only 5.22 per cent of respondents. It indicates a general lack of non-cash wealth that could be accessed and utilized quickly in emergencies.

Interestingly, vehicle ownership is relatively high at 54.44 per cent, especially among outdoor workers (66.96 per cent) and pregnant women (64.15 per cent). This likely reflects work-related mobility needs but may also serve as a potential asset in the event of a crisis. Only 25.58 per cent of persons with disabilities own a vehicle, highlighting significant mobility limitations that could worsen their vulnerability during disasters (World Bank, 2021).

Land ownership – an important indicator of long-term resilience and housing security – is generally low. Among the residents of informal settlements, only 3.86 per cent own land, and none of the respondents with disabilities reported owning land.

The most significant finding is that more than one-third (34.75 per cent) of all respondents own no assets at all. This issue is particularly severe among persons with disabilities, 69.77 per cent of whom lack any form of assets. Without basic assets, an individual's capacity to survive, recover and adapt can be very challenging.

2. KNOWLEDGE OF EXTREME HEAT

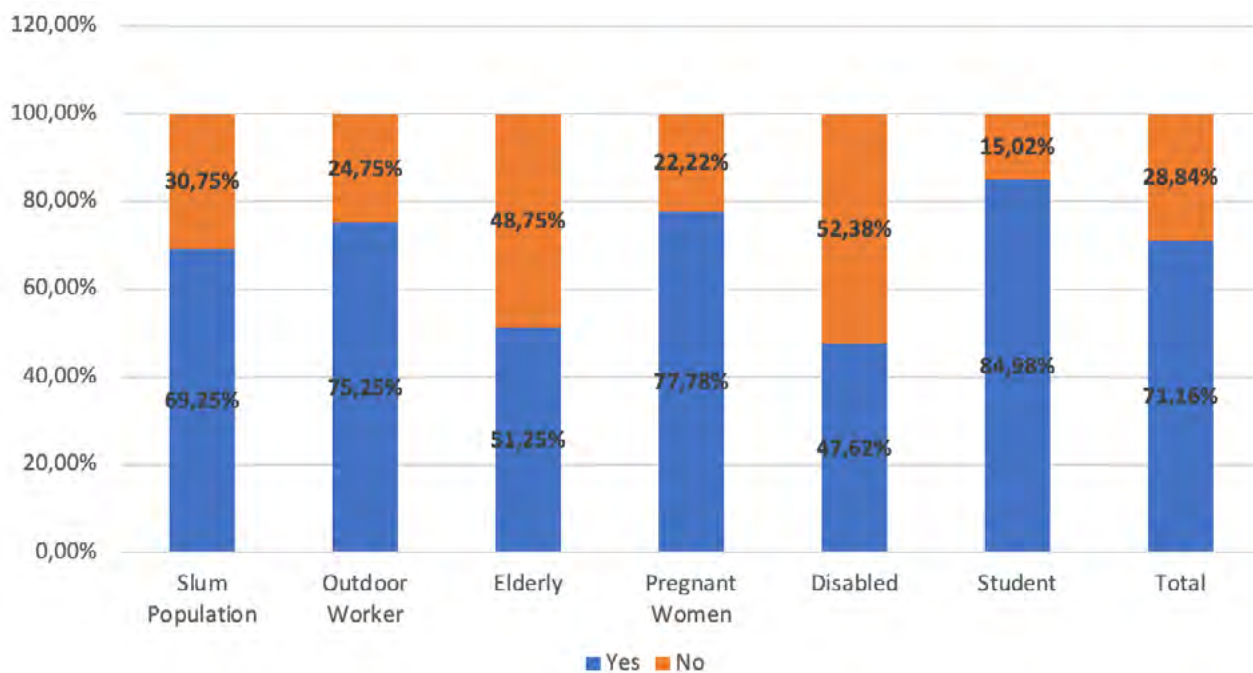
Overall, 71.16 per cent of respondents have reported hearing of climate change. However, nearly one-third of the population still lacks basic awareness, highlighting a significant knowledge gap. Among all groups surveyed, students have demonstrated the highest awareness of climate change, with a rate of 84.98 per cent. Pregnant women have followed this at a rate of 77.78 per cent, and outdoor workers at 75.25 per cent. Students may have a better awareness due to greater access to education and information. In contrast, pregnant women and outdoor workers may be aware of the effects of climate change, as they experience its direct impact. Table 3 reveals several noteworthy findings about the level of awareness of climate change among vulnerable groups.

Table 3. Ever heard of a phenomenon called 'climate change'?

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Yes	69.25%	75.25%	51.25%	77.78%	47.62%	84.98%	71.16%
No	30.75%	24.75%	48.75%	22.22%	52.38%	15.02%	28.84%
P-Value	0.364	0.032	4.49E-09	0.406	0.001	1.53E-06	NA

Residents of informal settlements have demonstrated a relatively high level of awareness about climate issues, with 69.25 per cent stating their awareness of the topic. They may have greater knowledge of climate change and its impacts, as they are often exposed to extreme weather conditions such as extreme heat and floods. This presumption is supported by a study from Nairobi, which found that residents of informal settlements recognize climate risks due to their daily lived experiences. They face issues such as heat stress and respiratory problems.

Figure 4. Ever heard of a phenomenon called 'climate change'



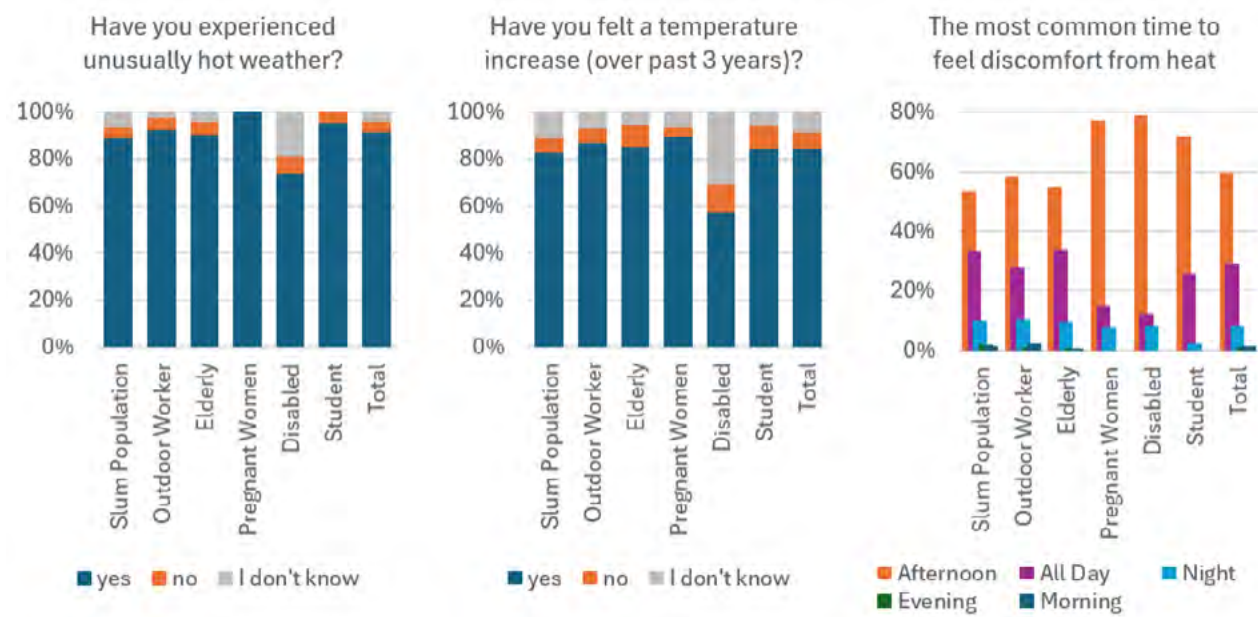
People with disabilities along with older adults have reported the lowest levels of awareness about climate change, with 47.62 per cent and 51.25 per cent respectively. This indicates a significant information gap that affects groups that should be prioritized in climate education initiatives. According to the United Nations Office for Disaster Risk Reduction (UNDRR, 2015), people with disabilities and older adults often encounter physical, technological or social barriers that hinder their access to information.

Table 4. Experience of hot weather

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Experienced unusual or uncomfortable hot weather							
Yes	88.50%	92.08%	90.00%	100.00%	73.81%	95.31%	90.95%
No	4.81%	5.20%	5.63%	0.00%	7.14%	4.69%	4.93%
I don't know	6.68%	2.72%	4.38%	0.00%	19.05%	0.00%	4.12%
P-Value	0.012	0.222	0.892	0.098	3.12E-06	0.004	NA
Felt an increase in temperature for the last 3 years							
Yes	82.62%	86.39%	85.00%	88.89%	57.14%	84.04%	83.76%
No	6.15%	6.44%	9.38%	4.44%	11.90%	9.86%	7.43%
I don't know	11.23%	7.18%	5.63%	6.67%	30.95%	6.10%	8.80%
P-Value	0.089	0.213	0.215	0.622	4.87E-07	0.124	NA

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Morning	1.6%	2.3%	0.7%	0.0%	0.0%	0.0%	1.4%
Afternoon	53.4%	58.5%	55.1%	77.5%	79.2%	72.1%	60.1%
Evening	1.9%	1.1%	0.7%	0.0%	0.0%	0.0%	1.1%
Night	10.0%	10.3%	9.6%	7.5%	8.3%	2.2%	8.6%
All day	33.0%	27.8%	33.8%	15.0%	12.5%	25.7%	28.9%
P-Value	0.017	0.176	0.478	0.156	0.095	5.10E-05	NA

Figure 5. Experience of hot weather



As shown in Figure 5, the majority of respondents across all vulnerable groups reported experiencing unusually hot or uncomfortable weather, and perceived an increase in temperature, over the past three years (83.76 per cent). A consistent temporal pattern also emerges, with most respondents identifying the afternoon as the period of greatest heat discomfort (60.1 per cent).

Overall, 90.95 per cent of respondents indicated that they had experienced unusually hot or uncomfortable weather, reflecting a strong public perception of temperature anomalies. This pattern is consistent with global trends of rising extreme temperatures and heatwaves reported by the Intergovernmental Panel on Climate Change (IPCC, 2021). The highest prevalence of reported heat exposure was observed among pregnant women (100 per cent), students (95.31 per cent) and outdoor workers (92.08 per cent), suggesting that groups with heightened physiological vulnerability or prolonged outdoor exposure may be more sensitive to temperature changes. The Chi-squared test further indicates that students and outdoor workers are significantly more likely to report experiencing hot weather.

Pregnant women (77.5 per cent) and persons with disabilities (79.2 per cent) most identified the afternoon as the period of time with the greatest discomfort. In contrast, a substantial proportion of older people (33.8 per cent) and residents of informal settlements (33 per cent) reported discomfort throughout the entire day, likely reflecting sustained exposure linked to inadequate ventilation and limited access to cooling facilities. The Chi-squared test confirms that the residents of informal settlements are significantly more likely to experience heat discomfort throughout the day, whereas students are most affected during the afternoon.

Figure 6. Opinion on causes of high temperatures

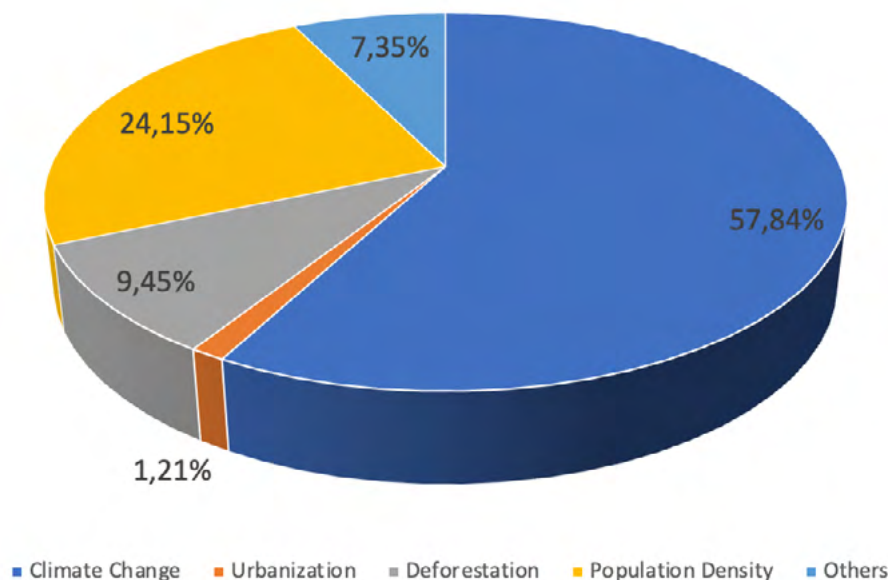


Table 5. Opinion on causes of high temperatures

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Climate change	61.50%	56.44%	51.88%	60.00%	50.00%	59.62%	57.84%
Urbanization	0.53%	1.49%	1.88%	0.00%	2.38%	1.41%	1.21%
Deforestation	9.09%	9.65%	8.13%	11.11%	2.38%	11.74%	9.45%
Population density	21.39%	26.73%	29.38%	24.44%	23.81%	20.19%	24.15%
Others	7.49%	5.69%	8.75%	4.44%	21.43%	7.04%	7.35%
P-Value	0.282	0.343	0.319	0.865	0.005	0.500	NA

Table 5 show public perceptions of the leading causes of rising temperatures. A total of 57.84 per cent of respondents from all vulnerable groups attributed the increase in temperatures to climate change. Additionally, some groups also linked rising temperatures with factors such as population density and deforestation.

Among respondents, those from vulnerable groups – including residents of informal settlements (61.5 per cent), pregnant women (60 per cent) and students (59.62 per cent) – report that climate change is the primary cause of rising temperatures. This trend indicates a growing public awareness of climate change and its impact on daily life.

However, people with disabilities (50 per cent) are the group with the lowest proportion of respondents recognizing climate change or deforestation as significant causes. This lower level of awareness may be due to limited access to information or a lack of engagement with environmental issues in their daily lives.

Local factors such as population density were also mentioned by 24.15 per cent of respondents as a cause of rising temperatures, with the highest responses coming from the older people (29.38 per cent) and outdoor workers (26.73 per cent). This suggests an understanding that urban spatial planning and dense environments can worsen heat effects, especially in the context of urban heat phenomena, where areas with many buildings absorb and retain more heat.

KEY FINDINGS:

- The reported experiences of hot weather vary among different groups. Residents of informal settlements and students are more likely to report experiencing hot weather, while people with disabilities are less likely to report having encountered hot weather or temperature increases.
- Residents of informal settlements tend to suffer from heat throughout the day, whereas students are most often affected in the afternoon.
- People with disabilities are less likely to report experiencing uncomfortably hot weather or an increase in temperature. This suggests that people with disabilities may be unaware of the rising heat-related risks. In contrast, students appear to be more aware of these risks.
- People with disabilities are also less likely to attribute these issues to climate change or deforestation, instead naming other causes of extreme heat more frequently.



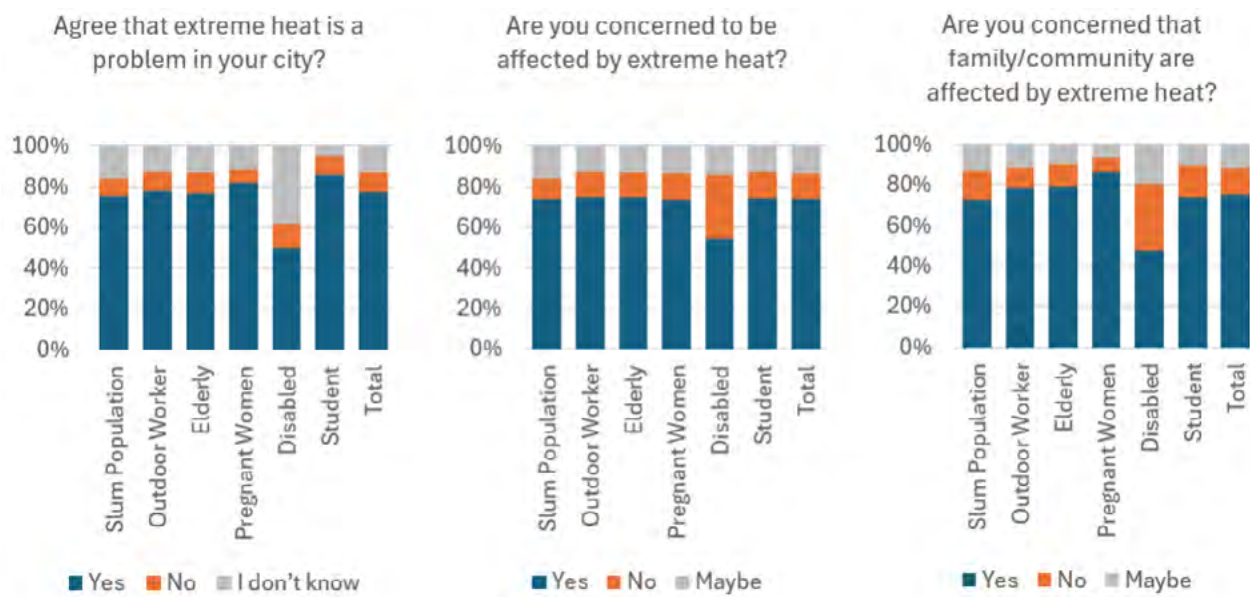
3. EXTREME HEAT IMPACTS AND VULNERABILITY

This section presents key findings that reflect how vulnerable groups in Medan perceive the impacts and risks of extreme heat

Table 6. Perception of extreme heat impacts

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Do you agree that extreme temperatures are a problem in your city?							
Yes	75.67%	77.97%	76.88%	82.22%	50.00%	85.92%	77.71%
No	8.29%	9.90%	10.00%	6.67%	11.90%	9.39%	9.29%
I don't know	16.04%	12.13%	13.13%	11.11%	38.10%	4.69%	13.00%
P-Value	0.097	0.740	0.943	0.742	2.68E-06	3.54E-04	NA
How bad do you think the heat is in your city right now?							
Normal	6.15%	5.94%	8.75%	6.67%	11.90%	7.04%	6.79%
Mild	1.60%	0.74%	2.50%	0.00%	0.00%	1.41%	1.29%
Moderate	48.66%	44.55%	40.00%	62.22%	57.14%	44.60%	46.28%
Severe	43.58%	48.76%	48.75%	31.11%	30.95%	46.95%	45.64%
P-Value	0.599	0.295	0.166	0.149	0.145	0.959	NA
Are you concerned about the risk of heat-related extremes that could affect you?							
Yes	74.06%	75.00%	75.00%	73.33%	54.76%	74.18%	73.83%
No	9.89%	12.87%	11.88%	13.33%	30.95%	13.62%	12.60%
Maybe	16.04%	12.13%	13.13%	13.33%	14.29%	12.21%	13.57%
P-Value	0.063	0.587	0.933	0.988	0.001	0.753	NA
Are you concerned about heat-related risks that could affect your family or your community?							
Yes	72.46%	78.71%	78.75%	86.67%	47.62%	74.18%	75.28%
No	15.24%	10.15%	11.88%	6.67%	33.33%	15.49%	13.49%
Maybe	12.30%	11.14%	9.38%	6.67%	19.05%	10.33%	11.23%
P-Value	0.311	0.052	0.546	0.194	5.89E-05	0.609	NA
Do you think a person can die due to heat exposure?							
Yes	34.76%	41.34%	36.88%	28.89%	11.90%	33.33%	35.95%
No	24.60%	18.32%	18.13%	20.00%	28.57%	26.76%	22.05%
Maybe	27.81%	30.45%	30.63%	46.67%	28.57%	30.99%	30.29%
I don't know	12.83%	9.90%	14.38%	4.44%	30.95%	8.92%	11.71%
P-Value	0.327	0.016	0.485	0.073	7.86E-05	0.185	NA

Figure 7. Perception of extreme heat impacts



Respondents from all vulnerable groups, including residents of informal settlements (75.67 per cent), outdoor workers (77.97 per cent), older people (76.88 per cent), pregnant women (82.22 per cent) and students (85.92 per cent) all agree that extreme heat is a significant problem in their city. Overall, 77.71 per cent of respondents acknowledge that extreme heat has become a significant issue. This aligns with findings by Green *et al.* (2022), which noted that urban poor communities are particularly vulnerable to extreme heat conditions.

However, persons with disabilities have shown the lowest level of awareness of the dangers of heat, with only 50 per cent recognizing it as an issue and 38.10 per cent indicating that they 'don't know'. This suggests possible barriers to understanding and accessing climate-related information, consistent with findings from the World Health Organization (WHO, 2015), which emphasize that people with disabilities often encounter obstacles in obtaining inclusive communication and information.

Regarding perceptions of the severity of current temperatures, most respondents rated extreme heat as 'moderate' to 'severe', with 45.64 per cent of respondents considering it 'severe'. Pregnant women predominantly describe it as 'moderate' (62.22 per cent), while students (46.95 per cent) and residents of informal settlements (43.58 per cent) rate it as 'severe'. This indicates differing heat perceptions based on daily activities and living environments. As noted by Smith and Rivera (2022), people's perceptions of extreme heat are influenced by their lived experience.

On the issue of being affected by extreme heat, over 73 per cent of respondents expressed concern about themselves, their families and their communities. Pregnant women expressed the highest level of concern (86.67 per cent) about the adverse impacts of extreme heat on their family or community, likely reflecting their increased sensitivity to the safety of children and families in high-risk situations. In contrast, people with disabilities exhibit the lowest level of concern (47.62 per cent).

Finally, regarding exposure to extreme heat that could result in death, only 35.95 per cent of respondents recognized that a person could die from exposure to extreme heat. Awareness of this risk is particularly low among people with disabilities (11.90 per cent) and pregnant women (28.89 per cent), even though both groups are physiologically more vulnerable to heat stress (Kovats & Hajat, 2008). This highlights a significant gap in heat-health literacy, where public perception does not align with the scientifically established medical risks associated with exposure to extreme heat.

Figure 8. Do you think the effects of heat can be prevented?

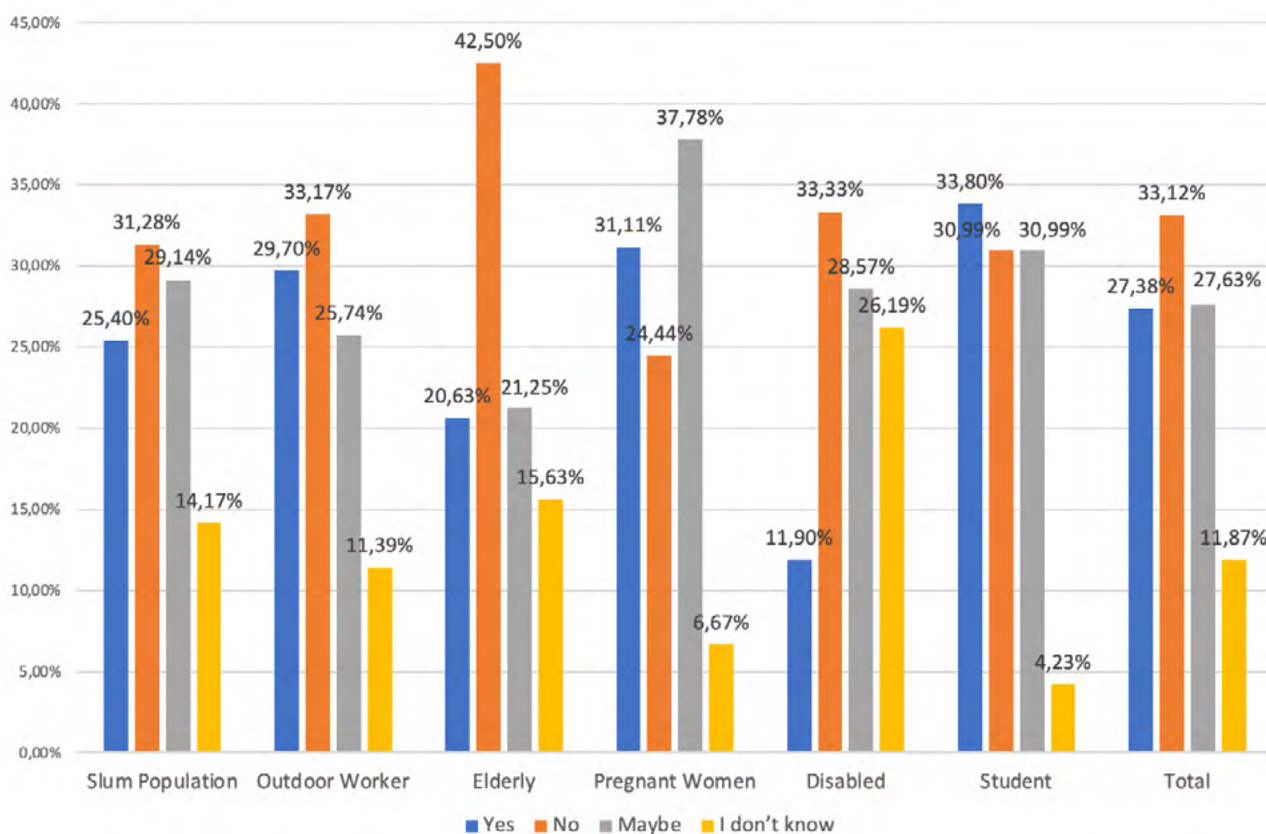


Table 7. Do you think the effects of heat can be prevented?

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Yes	25.40%	29.70%	20.63%	31.11%	11.90%	33.80%	27.38%
No	31.28%	33.17%	42.50%	24.44%	33.33%	30.99%	33.12%
Maybe	29.14%	25.74%	21.25%	37.78%	28.57%	30.99%	27.63%
I don't know	14.17%	11.39%	15.63%	6.67%	26.19%	4.23%	11.87%
P-Value	0.246	0.558	0.005	0.250	0.010	4.50E-04	NA

Several important findings emerge regarding community perceptions of mitigating the impacts of extreme heat. Overall, only 27.38 per cent of respondents believe that the effects of extreme heat can be prevented. In contrast, 33.12 per cent answered 'no', 27.63 per cent replied 'maybe', and 11.87 per cent said that they did not know. These figures suggest that, while some people see the potential for prevention, many remain uncertain or unaware of actionable mitigation strategies.

Among all groups, students are the most optimistic, with 33.80 per cent believing that the impacts of heat can be mitigated. Conversely, people with disabilities are the least optimistic, with only 11.90 per cent believing in the possibility of preventing heat impacts. This may reflect limited access to information on inclusive climate adaptation (WHO, 2011).

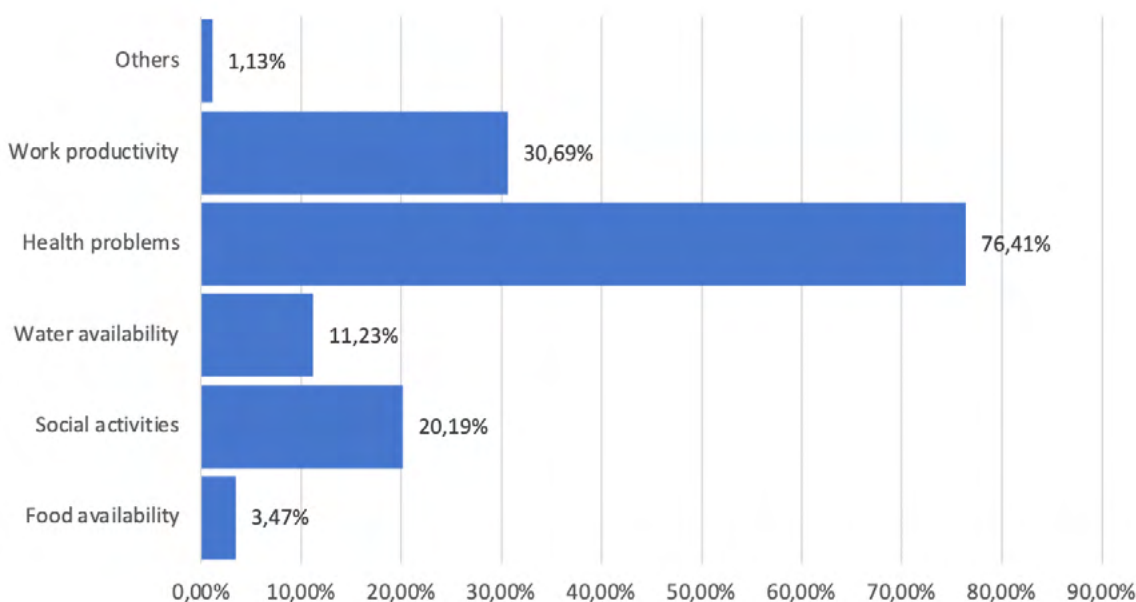
Older people also tended towards pessimism, with 42.50 per cent believing that heat impacts cannot be prevented. This attitude may stem from a physical limitation to taking self-protective action, limited knowledge of climate change and limited access to reliable information. Research by Chenco *et al.* (2022) indicates that older people

often underestimate their risk from extreme heat, despite being particularly vulnerable to its effects. These findings underscore an urgent need for age-sensitive education strategies and improved communication tailored to older people's specific information needs.

Pregnant women exhibit high levels of uncertainty, with 37.78 per cent indicating that they do not receive adequate or precise information about heat-related risks and self-protective measures. Meanwhile, outdoor workers and residents of informal settlements express moderate optimism (29.70 per cent and 25.40 per cent, respectively), although significant portions of both groups remain pessimistic.

These results suggest that it is essential to strengthen community-based education and advocacy programmes that build people's trust in the possibility of mitigating heat impacts, through behavioural change initiatives and targeted policy interventions.

Figure 9. The impact of heat in your daily life



Heat-related health issues are the most reported impact of extreme temperatures, with 76.41 per cent of respondents across the groups reporting illnesses caused by heat. This figure is significantly higher than the other heat impact categories and indicates that extreme heat directly affects physical well-being, particularly among vulnerable groups. Common heat-related illnesses include fatigue, dehydration, heatstroke and respiratory issues. Diniz *et al.* (2020) highlight that hot weather consistently increases rates of morbidity and mortality, especially among older people and those with pre-existing health conditions.

Table 8. Impact of heat on your daily life

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Health problems	88.1%	87.8%	87.9%	92.3%	86.2%	84.2%	87.4%
Food availability	4.2%	4.3%	2.8%	2.6%	3.4%	4.3%	3.9%
Work productivity	34.1%	44.9%	24.1%	33.3%	17.2%	29.9%	35.1%
Social activity	25.5%	17.6%	21.3%	35.9%	10.3%	29.9%	22.9%
Others	0.9%	0.9%	3.5%	2.6%	0.0%	1.1%	1.3%
P-Value	0.630	1.23E-04	0.004	0.558	0.195	0.085	NA

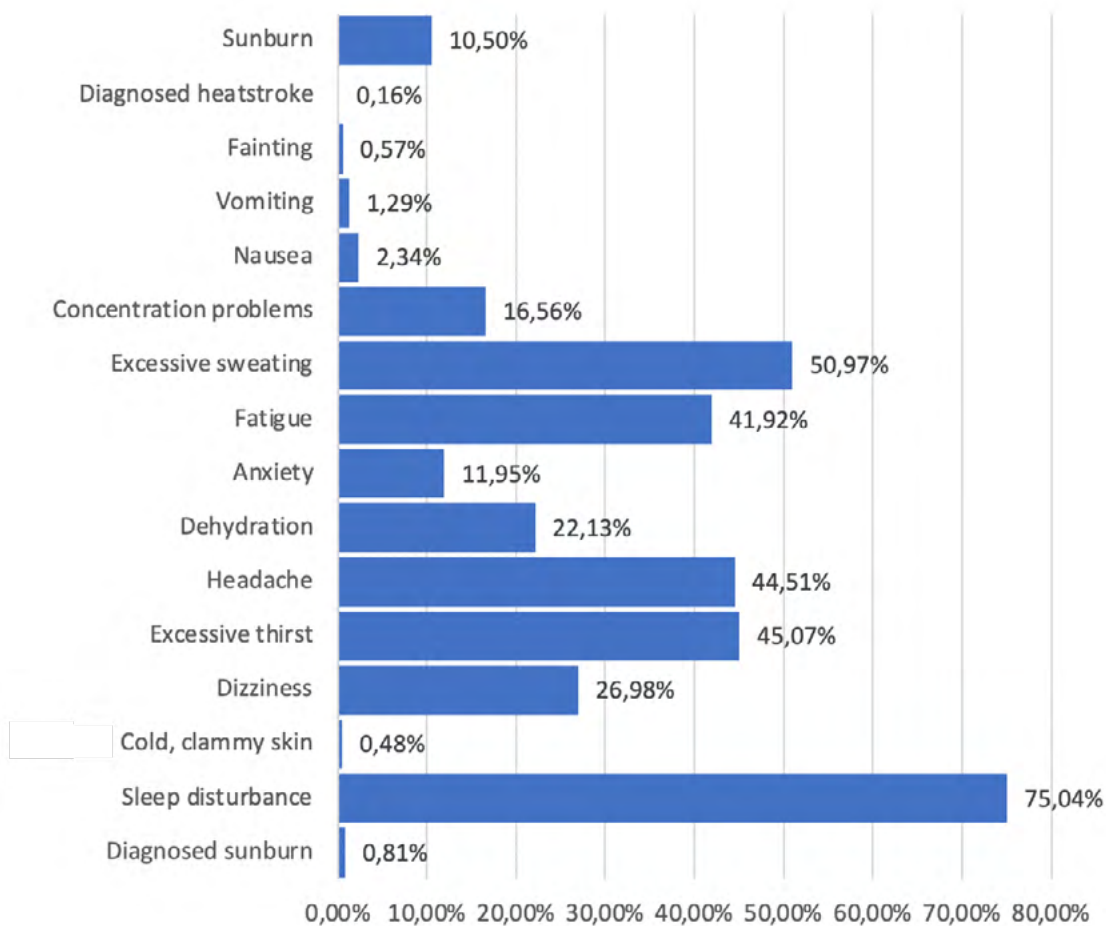
Work productivity is also significantly affected, with 30.69 per cent of respondents reporting that extreme heat disrupts their performance and efficiency. Outdoor workers (44.9 per cent) who are directly exposed to extreme heat primarily report a decline in work productivity. This, coupled with health issues resulting in income loss, impacts their ability to afford daily essentials such as food, water and healthcare. The International Labour Organization (ILO 2019) highlights that heat-related reductions in labour significantly contribute to economic vulnerability among low-income workers, especially in tropical and developing regions where access to cooling mechanisms and labour protection is limited.

Social activities are also impacted, with 20.19 per cent of respondents reporting a decrease in participation in social events during periods of extreme heat. This indicates that high temperatures not only affect physical well-being but also disrupt people’s social lives and impact mental well-being. These findings align with those of Clayton *et al.* (2017), who note that climate change, including extreme heat, can lead to social isolation and a decline in the quality of interpersonal relationships.

Water availability is another concern, with 11.23 per cent of respondents expressing anxiety about access to clean water during extreme heat. Calero *et al.* (2022) stated that high temperatures can affect the quality and quantity of both surface and drinking water, increasing the risk of microbial contamination.

Overall, the findings demonstrate that extreme heat has a multidimensional impact on people’s lives, with the greatest affects seen in health and work productivity. Adaptation efforts to extreme heat should, therefore, involve interventions on public health, worker protection and strengthening water and social systems.

Figure 10. Physical and mental impacts of hot weather



Among the surveyed health impacts of extreme heat, sleep disturbance emerged as the most frequently reported outcome across vulnerable groups, with 75.04 per cent of respondents indicating difficulty sleeping during peak heat periods. This pattern is linked to elevated nighttime temperatures, inadequate household ventilation and limited access to cooling resources such as electric fans. These findings align with evidence from Obradovich *et al.* (2017), which demonstrates that rising nighttime temperatures are associated with significant reductions in both sleep duration and quality, with disproportionate effects observed among older people and low-income populations.

Table 9. Physical and mental impacts of hot weather

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students
Sleep disturbances	77.0%	75.7%	75.6%	80.0%	78.6%	68.1%
Fatigue	43.9%	43.3%	35.6%	33.3%	26.2%	45.5%
Anxiety	13.1%	12.1%	15.0%	11.1%	7.1%	8.5%
Concentration problems	13.9%	20.3%	8.1%	13.3%	4.8%	23.5%
Headache	46.3%	42.1%	46.3%	42.2%	26.2%	48.8%
Excessive thirst	40.9%	47.5%	41.3%	46.7%	33.3%	52.6%
Excessive sweating	48.1%	55.4%	45.0%	51.1%	21.4%	57.7%
Dehydration	20.3%	22.8%	14.4%	24.4%	9.5%	31.9%
Dizziness	31.0%	24.0%	24.4%	20.0%	7.1%	32.9%
Sunburn	6.4%	14.1%	6.3%	6.7%	7.1%	15.5%
Nausea	1.1%	2.0%	2.5%	11.1%	2.4%	3.3%
Vomiting	0.8%	0.5%	2.5%	6.7%	2.4%	1.4%
Cold and clammy skin	0.8%	0.2%	0.0%	0.0%	0.0%	0.9%
Fainting	0.3%	0.7%	0.0%	0.0%	0.0%	1.4%
Diagnosed sunburn	0.5%	1.0%	0.6%	2.2%	2.4%	0.5%
Diagnosed heat stroke	0.0%	0.2%	0.0%	0.0%	0.0%	0.5%

Other commonly reported heat-related health issues include excessive sweating (50.97 per cent), excessive thirst (45.07 per cent) and headaches (44.51 per cent). These symptoms indicate how the body responds to extreme heat by trying to regulate its temperature. Respondents (22.13 per cent) also reported dehydration. This highlights a significant risk of fluid imbalance, particularly in situations where access to clean water and shaded areas is limited.

Many respondents (41.92 per cent) also report that fatigue – a symptom closely linked to prolonged heat exposure and limited rest – is another heat-health issue they encounter during the peak heat days. Kjellstrom *et al.* (2016) noted that heat-related fatigue is a major contributor to reduced work capacity, particularly among outdoor workers.

However, 26.98 per cent and 16.56 per cent of respondents report dizziness and difficulty concentrating, respectively, suggesting that extreme heat affects not only physical well-being but also cognitive function. In addition, nearly 12 per cent of respondents report experiencing anxiety.

KEY FINDINGS:

- Health issues are the primary and most significant impact of extreme heat.
- Sleep disturbance is the most reported impact of extreme heat.
- Other prominent health impacts are excessive sweating, fatigue, headache and excessive thirst.
- The other two major impacts of extreme heat - reduced work productivity and social activity - also have a significant influence on people's lives.
- The effect on work productivity varies by group. While older people report a lower-than-average impact on productivity, outdoor workers experience a higher-than-average impact.
- Among all vulnerable groups, people with disabilities are less aware of the risks associated with extreme heat. They are less likely to recognize it as a problem, to be concerned for themselves or their families and communities, and to believe that heat can be deadly.
- This relatively low level of risk perception among people with disabilities suggests that information campaigns specifically targeting them could be effective.
- In contrast, outdoor workers and students tend to be more aware of heat risks compared to the average population.
- Students see heat as a significant risk, while outdoor workers are more inclined to believe that heat exposure can be fatal.
- Older people and those with disabilities are less likely to think that the impacts of extreme heat can be prevented.
- Students are more likely to consider that the impacts of extreme heat can be prevented.



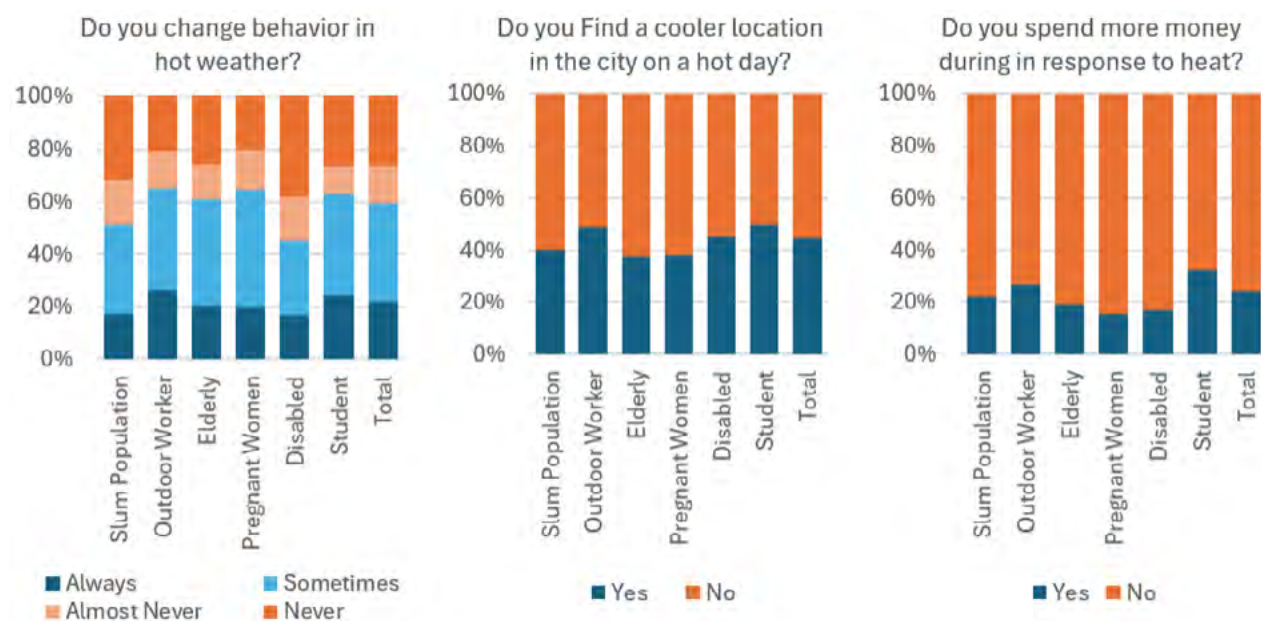
4. ADAPTATION STRATEGIES AND BARRIERS

Survey findings on adaptation strategies and barriers to coping with extreme heat indicate that behavioural change to address the dangers of heat, among the different groups, is limited. Only 22.1 per cent of respondents consistently report changing their behaviour during hot weather, while 37.2 per cent state they adjust what they do occasionally.

Table 10. Adaptation strategies and barriers

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Changing behaviour in hot weather							
Always	17.4%	26.5%	20.6%	20.0%	16.7%	24.4%	22.1%
Sometimes	33.7%	38.4%	40.0%	44.4%	28.6%	39.0%	37.2%
Almost never	17.1%	14.1%	13.8%	15.6%	16.7%	9.9%	14.4%
Never	31.8%	21.0%	25.6%	20.0%	38.1%	26.8%	26.4%
P-Value	0.001	0.008	0.883	0.677	0.275	0.214	NA
Asking for help from government agencies or NGOs or PMI during the summer							
Yes	0.0%	0.2%	0.6%	0.0%	0.0%	0.0%	0.2%
No	100.0%	99.8%	99.4%	100.0%	100.0%	100.0%	99.8%
P-Value	0.872	1.000	0.610	1.000	1.000	1.000	NA
Spending more money during the summer to beat the heat							
Yes	21.9%	26.5%	19.4%	15.6%	16.7%	32.4%	24.5%
No	78.1%	73.5%	80.6%	84.4%	83.3%	67.6%	75.5%
P-Value	0.193	0.283	0.131	0.215	0.310	0.004	NA
Having access to water during high temperatures							
Yes	54.3%	53.0%	61.3%	73.3%	35.7%	60.6%	55.9%
Sometimes	18.7%	21.5%	13.8%	11.1%	16.7%	17.8%	18.5%
No	27.0%	25.5%	25.0%	15.6%	47.6%	21.6%	25.6%
P-Value	0.714	0.141	0.201	0.056	0.003	0.262	NA
Finding a cooler location in the city on a hot day							
Yes	40.1%	48.5%	37.5%	37.8%	45.2%	49.8%	44.3%
No	59.9%	51.5%	62.5%	62.2%	54.8%	50.2%	55.7%
P-Value	0.061	0.042	0.078	0.460	1.000	0.089	NA

Figure 11. Adaptation strategies and barriers



Over 40 per cent of respondents rarely or never change their behaviour to cope with extreme heat – likely because many do not perceive themselves at risk or lack awareness of self-protective actions (Kell *et al.*, 2022). Persons with disabilities (38.1 per cent) and residents of informal settlements (31.8 per cent) are the groups who most reported that they never change their behaviour to cope with the increasing heat. The Chi-squared test analysis also showed that residents of informal settlements are less likely to change their behaviour or find a cool location in hot weather. In contrast, outdoor workers are the most likely to change their behaviour during periods of extreme heat.

A more concerning finding is that almost all respondents (99.8 per cent) had never sought assistance from institutions such as the government, NGOs or PMI during extreme heat days. This lack of help-seeking can be attributed to several factors, including a lack of awareness, stigma, insufficient information about available resources and distrust of formal institutions. Mees *et al.* (2016) emphasize the importance of building communication and trust between citizens and institutions to enable stronger collective adaptation to climate impacts.

In terms of economic expenses, 75.5 per cent of respondents report no additional spending to cope with extreme heat. Only 24.5 per cent reported spending extra money to cope with the heat, with students (32.4 per cent) leading the way. Limited prioritization of heat adaptation as an urgent need, or a lack of awareness about the negative impacts of heat, may be behind the non-prioritization of coping mechanisms.

Only 55.9 per cent of respondents have full access to adequate clean drinking water during high temperatures. The remainder faced restrictions: 18.5 per cent have access only sometimes, and 25.6 per cent have no access at all. People with disabilities are particularly vulnerable, as 47.6 per cent of disabled respondents reported having no access to water during periods of extreme heat. In contrast, 73.3 per cent of women confirmed that they have access to water on hot days.

Respondents indicating that they actively seek cooler places in the city on hot days numbered 44.3 per cent; the lowest rates reported among older people (37.5 per cent) and pregnant women (37.8 per cent) – the two groups most at risk during extreme heat. This may be due to physical limitations that restrict their ability or willingness to travel, making it challenging for them to leave their homes or familiar surroundings – even when those places are uncomfortable. As a result, they may remain in overheated environments despite the associated health risks.

KEY FINDINGS:

- Residents of informal settlements and people with disabilities are less likely to change their behaviour in hot weather.
- Outdoor workers are more likely to change their behaviour and seek out cool locations during hot weather.
- Students tend to spend more money when temperatures rise.
- Pregnant women are more likely to have access to water, while people with disabilities are less likely to have such access.
- The low level of personal heat adaptation measures is most common among groups with the least knowledge and awareness of heat risk. This suggests that campaigns aimed at increasing awareness could enhance community resilience to heat through heat adaptation measures.



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5. EARLY WARNING, ALERT MESSAGING AND COMMUNICATION CHANNELS

The importance of weather forecasts and access to weather information among vulnerable populations reveals a complex pattern and highlights existing disparities in both perception and access.

Table 11. Importance of weather information

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
The importance of weather forecasts							
Very important	9.9%	13.6%	9.4%	8.9%	4.8%	12.7%	11.3%
Important	61.8%	61.9%	63.1%	71.1%	52.4%	67.1%	62.9%
Not important	28.3%	24.5%	27.5%	20.0%	42.9%	20.2%	25.8%
P-Value	0.295	0.193	0.663	0.511	0.025	0.119	NA
Consulting weather forecast information							
Yes	37.7%	48.8%	29.4%	37.8%	26.2%	52.6%	42.4%
No	62.3%	51.2%	70.6%	62.2%	73.8%	47.4%	57.6%
P-Value	0.032	0.002	4.85E-04	0.627	0.045	0.001	NA
Sources of weather forecast information (multiple answers)							
Word-of-mouth	44.1%	37.6%	50.6%	40.0%	50.0%	33.8%	41.1%
Public information	3.2%	4.5%	2.5%	2.2%	2.4%	7.0%	4.1%
Television	34.2%	34.7%	43.1%	31.1%	11.9%	26.3%	33.3%
Social media	51.9%	64.1%	25.6%	64.4%	35.7%	79.8%	57.2%
Radio	1.6%	1.0%	0.0%	2.2%	0.0%	0.5%	1.0%
WhatsApp	2.9%	5.4%	0.0%	2.2%	2.4%	11.3%	4.8%
Others	3.2%	4.0%	5.6%	4.4%	9.5%	3.8%	4.1%
P-Value	0.072	0.373	2.83E-10	0.890	0.024	5.69E-09	NA

The majority of respondents across all vulnerable groups stated that weather forecasts are ‘important’ or ‘very important’. Pregnant women (71.1 per cent), followed by students (67.1 per cent) and outdoor workers (61.9 per cent) expressed the importance of weather forecasts. However, a significant portion of respondents, especially people with disabilities (42.9 per cent), do not consider weather forecasts to be important in reducing the risks of extreme heat. This suggests that, while most people recognize the value of weather information, some groups remain less aware of its benefits or underestimate its value, likely due to limited access to weather information or low climate literacy (Boonyabanha *et al.*, 2019).

The differences in behaviour when looking for weather information are significant. Only 42.4 per cent of all respondents reported actively seeking weather forecasts. Among the various groups, students are the most active, with 52.6 per cent reporting that they look for weather information. In contrast, older people (70.6 per cent) and people with disabilities (73.8 per cent) exhibited the lowest levels of information-seeking behaviour. Overall, more than half of the respondents are not proactively seeking weather updates, indicating a broader behavioural change challenge. This underscores the necessity of improving not just access, but also the relevance, urgency and clarity of the messages issued. These findings align with those of Singh and Bajaj (2020), who find that structural and perceptual barriers can hinder timely access to critical information, even when platforms are widely available.

Sources of weather information also vary significantly across groups. Social media platforms, such as Instagram and Facebook, are the most common sources overall (57.2 per cent) particularly among students (79.8 per cent) and pregnant women (64.4 per cent). Conversely, only 25.6 per cent of older people accessed weather information through social media; instead, they tended to rely on informal channels such as word-of-mouth (50.6 per cent) as well as television (43.1 per cent). This illustrates a generational divide in information access, with younger people more digitally connected while older adults rely on traditional media and local social networks. This pattern is supported by Anderson *et al.* (2021) who stress the importance of community-based approaches to reach older adults to mitigate climate risk.

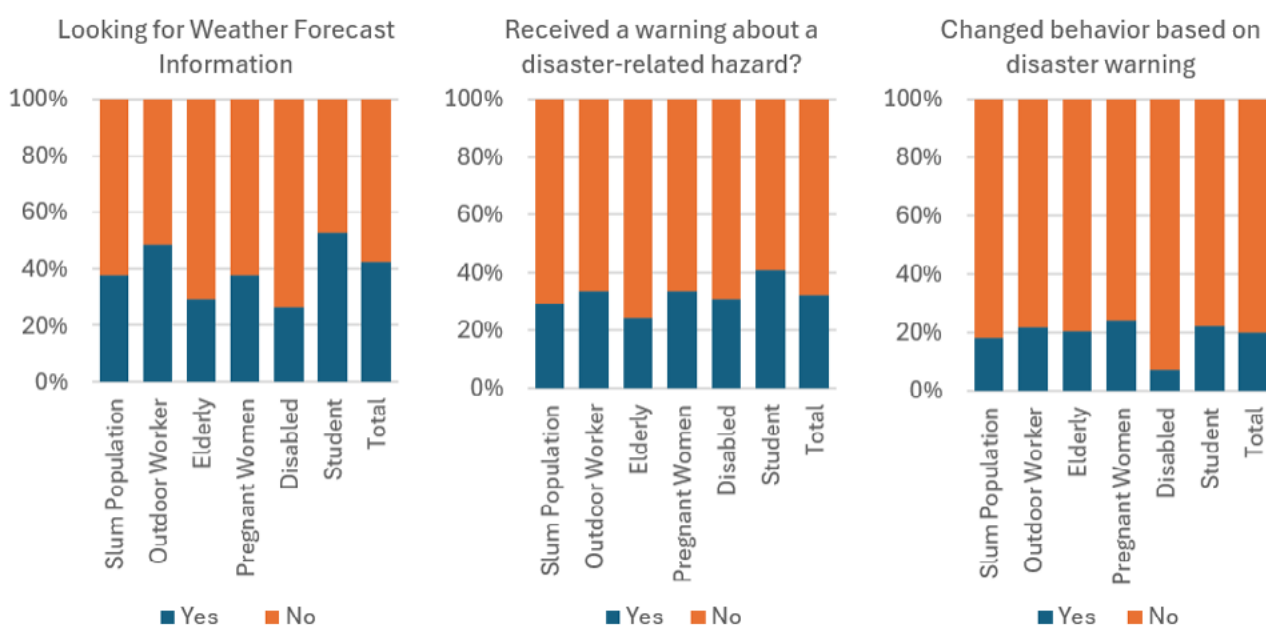
Radio and WhatsApp are the least used channels, with only 1.0 per cent and 4.8 per cent of total responses, respectively. Furthermore, trust in official public information sources, such as government announcements, is very low at 4.1 per cent, indicating the limited reach of official communication systems among vulnerable populations. Government communication is usually slower than other sources to reach the audience due to internal protocols on issuing information.

There are two key aspects of disaster preparedness – whether respondents ever receive disaster warnings, and whether they change their behaviour in response to the warnings. The survey data provides a clear understanding of how well early warning systems reach vulnerable groups (see Table 11) along with their effectiveness in encouraging behaviour change (see Table 12).

Table 12. Response to weather information

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Ever received a warning about a disaster-related hazard?							
Yes	29.1%	33.4%	24.4%	33.3%	31.0%	40.8%	32.1%
No	70.9%	66.6%	75.6%	66.7%	69.0%	59.2%	67.9%
P-Value	0.166	0.521	0.032	0.982	1.000	0.003	NA
Changed your behaviour based on disaster warnings?							
Yes	18.2%	21.5%	20.6%	24.4%	7.1%	22.1%	20.1%
No	81.8%	78.5%	79.4%	75.6%	92.9%	77.9%	79.9%
P-Value	0.299	0.428	0.946	0.583	0.053	0.492	NA

Figure 12. Response to weather information



The majority of respondents (67.9 per cent) across all vulnerable groups reported never receiving a disaster-related warning. Older people (75.6 per cent) and residents of informal settlements (70.9 per cent) are the most affected by this lack of communication; a finding supported by the Chi-squared analysis.

Several factors may contribute to this. Many older people do not use smartphones or social media regularly – now common platforms for quickly communicating warnings and information. Similarly, residents of informal settlements often lack access to internet, television and radio services, making it difficult for them to receive timely alerts. Additionally, many informal settlements are not formally registered and are therefore often excluded from formal government systems or benefits. Consequently, they may be excluded from automated warning systems. Digital literacy and education levels also affect this issue – people from low-income backgrounds and older age groups may not fully understand the messages or know how to respond effectively. Even when information is available, trust issues or a lack of relevance can mean that people ignore the messages, especially if they are not delivered clearly or locally.

The United Nations Office for Disaster Risk Reduction (UNDRR, 2022) highlights that early warning systems often fail to reach high-risk groups due to communication and social inequalities. Additionally, the International Federation of Red Cross and Red Crescent Societies (IFRC, 2022) states that older people and residents of informal settlements are frequently overlooked in disaster planning, leaving them less protected and prepared.

Interestingly, students make up the largest percentage of respondents (40.8 per cent) who reported receiving a warning, showing that younger people have better access to digital technology and social media. Anderson *et al.* (2021) found that younger people tend to receive risk information more effectively because of their higher digital literacy.

The effectiveness of existing warning systems in prompting behaviour change remains limited. Only 20.1 per cent of all respondents indicated that they changed their behaviour after receiving a warning. Among people with disabilities, this percentage is just 7.1 per cent – the lowest among all groups surveyed. This indicates that receiving information alone is not enough. The ability to respond is also influenced by factors such as mobility, access to resources and trust in the information provided (Twigg, 2015). Additionally, many respondents may be unaware of the actions to take upon receiving a warning, highlighting a gap between knowledge and preparedness. This points to a need for improved message content and clarity; warnings should provide clear, actionable advice tailored to diverse needs and abilities.

In contrast, pregnant women (24.4 per cent) and students (22.1 per cent) show higher rates of behaviour change after receiving disaster warnings. This implies that, beyond access to information, factors like risk perception and adaptive capacity also play a critical role in how people respond to warnings. Pregnant women may perceive a higher risk due to concern for their own health and the well-being of their unborn child, which increases their motivation to take self-protective action. Similarly, students with better access to formal education and disaster-related information, increase their awareness and understanding of risks, helping them make informed decisions. These findings underscore that timely action relies not only on receiving the warning but also on individuals' perception of the threat and their ability to act upon it.

Table 13 provides an important insight into awareness of extreme heat among vulnerable groups. It focuses on two aspects – whether respondents have ever checked a weather forecast relating to heat/increasing temperatures; and whether they had ever received a specific warning about increasing temperatures. Overall, the data reveals a generally low level of alertness, even though these vulnerable groups are the most affected by extreme heat.

Table 13. Hot weather information

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Have you ever checked a weather forecast relating to heat/increasing temperatures?							
Yes	22.5%	29.2%	16.3%	15.6%	19.0%	39.0%	26.3%
No	77.5%	70.8%	83.8%	84.4%	81.0%	61.0%	73.7%
P-Value	0.049	0.126	0.003	0.134	0.362	6.32E-06	NA
Have you ever received a warning about increasing temperatures?							
Yes	20.9%	26.2%	17.5%	17.8%	21.4%	33.8%	24.3%
No	79.1%	73.8%	82.5%	82.2%	78.6%	66.2%	75.7%
P-Value	0.073	0.304	0.040	0.388	0.795	0.001	NA

Significantly, 73.7 per cent of respondents indicated that they never check the weather forecast for warnings of heat or rising temperatures. Among these, older people (83.8 per cent), pregnant women (84.4 per cent) and people with disabilities (81.0 per cent) are the least likely to do so. This is particularly alarming because these groups are more vulnerable – both physiologically and socially – to extreme heat. The tendency not to check the weather forecast may be due to low weather literacy, limited access to media, or a belief that high temperatures do not pose a serious risk (Sheridan & Allen, 2018).

Conversely, students are the most proactive group, with 39 per cent having checked hot-weather forecasts. Overall, however, only 24.3 per cent of all respondents had ever received a warning of extreme heat, with students again reporting the highest rate of receiving heat warnings (33.8 per cent) and older people (17.5 per cent) and pregnant women (17.8 per cent) reporting the lowest. These findings highlight a significant gap in the reach and effectiveness of early warning systems, particularly for the populations at most significant risk.

Table 14. Information gap

	Information you receive	Useful information
Maximum temperature	17.45%	13.59
Minimum temperature	3.74%	2.34
Humidity level	1.21%	0.89
How long the heat lasts	6.06%	35.22
What actions to take	5.35%	26.17
How to protect family and friends	0.81%	7.51
Other	0.16%	4.28

Table 14 illustrates a significant gap between the types of heat-related information that people receive and those they consider helpful in protecting themselves from the risks of extreme heat. This highlights a significant challenge in heat risk communication – not only in delivering information but in ensuring that it is relevant, actionable and easy to understand.

Most respondents report receiving more technical information, such as maximum temperatures (17.45 per cent) and the duration of heatwaves (6.06 per cent). Only a small proportion receive guidance on what actions to take (5.35 per cent) or how to protect family and friends (0.81 per cent). This suggests that the information being communicated is focused too heavily on meteorological data, rather than on the practical advice or adaptive actions that are critical for vulnerable groups, who may struggle to interpret the technical information.

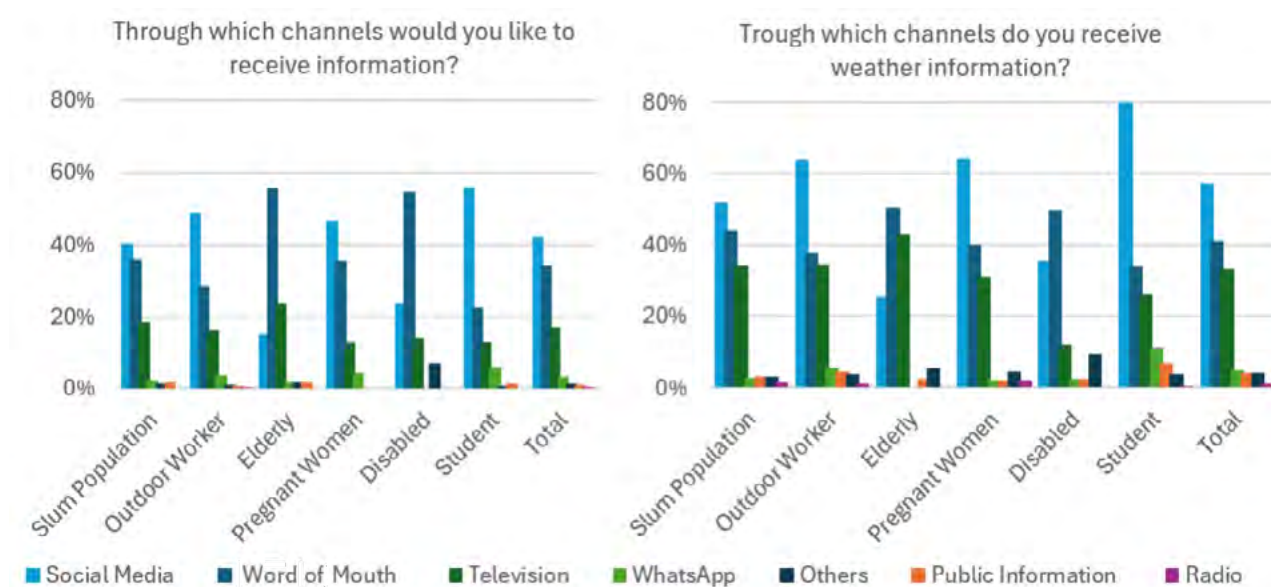
When asked what kind of information they found the most useful, respondents ranked information about the expected duration of heat (35.22 per cent), the self-protective action they can take (26.17 per cent) and how they can protect others (7.51 per cent) as more important than maximum or minimum temperatures. Effective risk communication must therefore include actionable messages, not just technical detail (Maibach *et al.*, 2016).

The lack of guidance on what to do during extreme heat events, despite its critical importance, illustrates that many early warning systems in Indonesia, including in Medan, are not action-oriented. The extremely low percentage of respondents receiving information on how to protect their family and friends (0.81 per cent) also suggests that community-based approaches to risk communication have not yet become the norm. Research by Ebi & Semenza (2008) indicates that knowledge of collective protection activities can significantly enhance community resilience during heatwaves, especially in densely populated and vulnerable urban areas.

Table 15. Effective information channels

	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Word-of-mouth	35.8%	28.7%	55.6%	35.6%	54.8%	22.5%	34.4%
Public information	1.6%	0.7%	1.9%	0.0%	0.0%	1.4%	1.2%
Television	18.4%	16.3%	23.8%	13.3%	14.3%	13.1%	17.2%
Social media	40.4%	49.0%	15.0%	46.7%	23.8%	55.9%	42.2%
Radio	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.2%
WhatsApp	2.4%	3.7%	1.9%	4.4%	0.0%	6.1%	3.4%
Others	1.3%	1.0%	1.9%	0.0%	7.1%	0.9%	1.4%
P-Value	0.638	0.005	9.7E-12	0.912	0.001	2.7E-05	NA

Figure 13. Effective information channels



Overall, the most trusted and widely used sources of information are social media and word-of-mouth. Formal channels such as public announcements, radio and television show lower levels of trust. These findings suggest that, although multiple communication channels exist, factors such as accessibility, social proximity and the speed of information delivery play crucial roles in effective communication, particularly for vulnerable groups.

Social media is the dominant communication channel (42.2 per cent), especially among students (55.9 per cent) and outdoor workers (49.0 per cent). This reflects the high level of digital technology penetration among young people and active workers, who often have access to smartphones and internet connections. Social media is not only fast and easily accessible, but it also enables the sharing of viral, community-based messages. It plays a crucial role in risk and disaster communication, especially for generations already familiar with digital platforms (Sutton *et al.*, 2013).

Nonetheless, informal word-of-mouth communication remains highly prominent, particularly among older people (55.6 per cent), people with disabilities (54.8 per cent), and residents of informal settlements (35.8 per cent). This suggests that direct social networks and personal interactions remain a primary source of information for groups that may face limitations in accessing technology or developing digital literacy. This finding supports arguments by Wisner *et al.* (2004), who emphasized the importance of local social networks in disaster information dissemination, especially in areas underserved by formal systems.

Television still plays a moderate role, accounting for 17.2 per cent of communication methods, with older people (23.8 per cent) and residents of informal settlements (18.4 per cent) being the most frequent users. This suggests that traditional media remains relevant, particularly for older people or those living in areas with limited internet access. However, official public information sources – such as bulletin boards, banners or government announcements – are used by only 1.2 per cent of respondents, while radio use is almost non-existent (0.2 per cent).

WhatsApp shows limited overall use (3.4 per cent), but its usefulness is somewhat more notable among students (6.1 per cent) and pregnant women (4.4 per cent), indicating its growing potential as a supplementary communication tool in these specific groups.

KEY FINDINGS:

- **People with disabilities are less likely to consider weather forecast information to be important or actively seek it out. When they do, they tend to rely more on word-of-mouth and less on social media.**
- **Residents of informal settlements and older people are less likely to search for weather forecast information, while outdoor workers and students are more inclined to do so.**
- **Older people rely more on word-of-mouth and television and less on social media, while students greatly rely on social media to access weather information.**
- **Older people are less likely to seek out or receive weather forecasts and early warning messages. Additionally, they are less inclined to act on these warnings. Conversely, students actively seek this information and respond to warnings.**
- **The effectiveness of existing warning systems in prompting behavioural change remains limited.**
- **The groups that are least aware of, and concerned about, heat risks are also the ones that receive the least advanced information. An information campaign to raise awareness of heat risks could help inform more vulnerable community members about upcoming extreme heat events, enabling them to prepare accordingly.**
- **Outdoor workers and students prefer to receive heat-related information through social media, while older people and people with disabilities prefer word-of-mouth over social media for communication.**

6. RECOMMENDATIONS

This Heat Perception Study for Medan reveals widespread exposure to extreme heat and limited adaptation, particularly among vulnerable groups such as informal workers, pregnant women, older people, and people with disabilities. While many respondents recognize the discomfort of rising temperatures, few perceive extreme heat as a serious risk and behaviour change remains inconsistent. Based on these findings, the following actions are recommended.

- 1. Strengthen community heat preparedness and behaviour change:** It is critical that community-based heat preparedness activities in informal settlements and among high-risk groups (older people, people with disabilities, pregnant women, outdoor workers) be scaled up to improve heat literacy and corresponding actions. Prioritize practical actions such as hydration, rest breaks, use of shade, and identifying cool spaces. The role of PMI volunteers will be instrumental in scaling this action.
- 2. Urban planning and social protection must integrate a heat lens:** For a long-term approach to addressing heat, the impacts of rising temperatures must be mainstreamed into city development plans. Urban planning should seek to expand green spaces, advocate for low carbon emissions technology especially in transportation, and establish accessible cooling centres in high-risk areas of the city. Anticipatory heat action can also be linked with national or local social protection schemes for low-income households and vulnerable groups.
- 3. Improve early warning systems with simple, practical and cost-effective actions:** Ensure that warnings of extreme heat reach the most vulnerable through channels that are commonly used (community networks, television, local leaders). Messages must be clear and straightforward, and include practical, cost-effective actions that people can follow to mitigate the effects of heat.
- 4. Embed heat response within public health services:** Primary healthcare facilities are critical for local responses and community outreach to high-risk groups before and during extreme heat events. A heat action plan for the health sector that links to a wider city-level Heat Action Plan can capture this. Coordination between health, social welfare and disaster management departments led by the city government is also recommended.
- 5. Strengthen protection for outdoor and informal workers:** As outdoor and informal workers are at very high risk from extreme heat, heat-sensitive labour guidelines should be developed and implemented. Provisions and services such as access to drinking water, shaded rest areas and rest breaks during peak heat hours should be part of these guidelines. Advocacy and engagement with different trade associations to promote safe work practices during extreme heat should be carried out.

These recommendations are intended to support local and national stakeholders, including government agencies, health services and civil society, in building a more inclusive and evidence-based response to extreme heat. Importantly, they highlight that technology and early warning systems alone are not enough. To truly protect vulnerable people, it is essential to communicate risks clearly, involve affected groups in planning and encourage everyday actions that reduce heat risks. This also means investing consistently in public awareness, community networks and preparedness programmes that help people understand, respond to and recover from extreme heat.

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