

HEAT PERCEPTION STUDY FOR SURABAYA, INDONESIA

October 2025

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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

Indonesian Red Cross (PMI)

ACKNOWLEDGEMENTS

The publication of this Heat Perception Study for Surabaya was led by PMI and was a collaborative effort involving multiple individuals and institutions. The author would like to express its sincere appreciation to all parties whose technical and institutional support made this study possible.

In particular, our thanks go to PMI national headquarters for its leadership, strategic coordination and substantive review of the study. Our appreciation also extends to PMI East Java and PMI Surabaya for their active roles in conducting the surveys at city level and for contributing context-specific insights that strengthened the overall analysis, including the research team from Wijaya Kusuma University, Surabaya for facilitating the data collection process together with PMI Surabaya volunteers.

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 Mr. M. Fitri Rahmadana as a contributing writer, and for his 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 Surabaya.

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 adaptation of climate change, 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.

Given this alarming growth in extreme heat days, a household survey was conducted in Surabaya 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 1,505 respondents (60 per cent women and 40 per cent men) across 31 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 analysis can be used to inform the design of extreme heat preparedness programmes, including strategies and activities that are tailored to the characteristics and needs of these different at-risk groups.

This report highlights similarities and disparities in the groups' knowledge, attitudes and practices towards extreme heat. It found that 65 per cent of the respondents were earning less than the equivalent of 50 US dollars (USD) per month – well below the basic cost of living of 160 USD per month. This translates into having little to no disposable income with which to prioritize self-protective actions in response to the increasing heat in the city. This was particularly evident among older people (66 per cent) and people with disabilities (76 per cent) who are the groups most vulnerable to the effects of extreme heat.

Across all groups, 40 per cent of respondents spend more than ten hours per day outdoors, while outdoor workers constitute 50 per cent of respondents. This suggests that occupational exposure is a major driver of heat-related vulnerability and should be prioritized in adaptation strategies.

Even though nearly 80 per cent of the respondents had experienced unusual and uncomfortably hot weather in the city and acknowledged an increase in temperature in recent years, 93 per cent did not consider heat to be dangerous. Respondents' perception of heat-related risks was high at 71 per cent, but awareness of its consequences was low with only 30 per cent stating that it could lead to death. This points to a large perception gap in heat being considered a major hazard that impacts health and well-being. Education and income levels influence this knowledge as those with higher levels of education and income are more likely to have better awareness of the dangers of extreme heat.

All occupation groups reported experiencing periods of prolonged heat. However, heat appears to be normalized among farmers and fisherfolk, with around 50 per cent of respondents in both groups not perceiving recent increases in temperature as unusual, due to their routine, long-term exposure. This normalization may mask escalating heat risks and reduce the urgency of adaptive and/or self-protective responses.

Almost 70 per cent of respondents across all groups believed that heat stress can be prevented; although this knowledge was notably lower among people with disabilities. This gap between uncertainty and preventability can delay self-protective actions, increasing the risk of dehydration, heat exhaustion and heat-related illness on extremely hot days. Importantly, awareness does not always translate into protective behaviour – only 17 per cent said that they 'always' adapt their behaviour on hot days, while around half reported doing so 'sometimes' with the remainder reporting 'no change'. This inconsistency suggests that many people are exposed to avoidable heat-related health risks. This is particularly the case for people with disabilities who may face heightened vulnerability due to barriers in accessing cooling resources, information and support.

Institutional engagement during extreme heat events appears to be almost non-existent. The near-absence of reported assistance-seeking from government bodies, non-governmental organizations or humanitarian actors points to limited awareness of support mechanisms, inadequate outreach by institutions and disconnections between vulnerable people and formal support systems.

Almost three-quarters (72 per cent) of respondents acknowledge that early warnings can be life-saving, but there is a lower behaviour change response to these warnings (65 per cent). This could stem from the fact that 19 per cent of respondents receive warnings only on the day itself, leaving very little time to take self-protective action, with almost 60 per cent receiving no warning at all. There is also a content gap where messages emphasize temperatures, not duration, health risk or recommended protective actions. In short, the survey found that existing warning systems are not responsive enough for heat. Communication is poorly tailored to vulnerable groups and arrives too late to enable early action.

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

- 1. Recognize heat as a disaster risk and not as temporal and episodic:** It is important to recognize extreme heat as a disaster risk in national and local disaster frameworks to facilitate the inclusion of heat in government plans and budgets as well as in the development of social, economic and welfare programmes.
- 2. Incorporate heat within health systems:** Linking heat levels and alerts to health systems' preparedness and response protocols is necessary to mitigate heat-health impacts. Other initiatives should include training primary care and community health workers to recognize heat-health impacts and prepositioning water points and shaded rest areas, especially for outdoor workers during periods of extreme heat.
- 3. Make heat risk communication and early warnings actionable:** Heat risk communication and early warnings need to be action-oriented with messaging tailored to different groups of people. There also needs to be multi-stakeholder participation in developing heat thresholds and triggers, like those that already exist for other hazards.
- 4. Improve heat literacy with a focus on higher risk groups:** Older people and people with disabilities are at the highest risk during periods of extreme heat, yet are the least likely to be aware of the dangers or change their behaviour on hot days. Community-based heat-risk education focusing on simple, practical and relevant information should be arranged. Civil society actors, especially PMI, can lead these efforts, working closely with the city government and other relevant departments to take this forward.



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 (Surabaya and Medan) 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, Surabaya (East Java Province) and Medan (North Sumatra 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, 2015). 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, Surabaya (East Java Province) and Medan (North Sumatra 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 Surabaya and Medan, covered all administrative sub-districts (*kecamatan*). Surabaya has 31 sub-districts and Medan has 21 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 – SURABAYA

Surabaya is the capital of East Java, which is the second of largest urban area in Indonesia. This vast metropolitan area – home to more than ten million people – consists of 31 sub-districts (*kecamatan*). The city experiences a tropical climate characterized by consistently high temperatures and humidity. Seasonal variations can bring unusually high heat, especially during transitional periods in April and October when daytime heat has peaked above 36°C, with heat indices feeling closer to 40°C during extreme events.

A combination of factors contributes to Surabaya's extreme heat conditions. Rapid urbanization and densely built environments contribute to increasing heat stress for the city's residents, especially in central areas with limited green spaces. Climate drivers such as El Niño and warming sea surface temperatures further enhance dry, hot spells, making the heat more severe and prolonged than typical tropical weather patterns.

The impacts of extreme heat in Surabaya are felt socially, economically and in individuals' health and productivity, prompting public health advisories on limiting outdoor activities and encouraging increased hydration. High temperatures increase risks of dehydration, heat exhaustion and heatstroke, particularly among children, older people, outdoor workers and those without adequate cooling options.

3. STUDY METHODOLOGY

Each Heat Perception Study was carried out based on several key criteria, considering heat spots in each city (Surabaya and Medan) 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 2). 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. The 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. 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 is to determine whether the observed categorical data differ significantly from the expected patterns. 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:

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

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 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, in Surabaya and Meda, 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 Surabaya 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 SURABAYA

2.1. DEMOGRAPHICS AND GENERAL INFORMATION

The survey for Surabaya included 1,505 respondents from 31 sub-districts, providing a comprehensive representation of the population's perceptions and experiences of extreme heat in the city. The data collected covers a wide range of demographics, including gender, age, occupation, socioeconomic background, region and vulnerabilities. Understanding the distribution of these characteristics among the respondents helps to interpret and analyse the findings more effectively.

Table 1. Demographic overview of the survey

CATEGORY		Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
GENDER	Male	14.4%	76.6%	35.8%	0.0%	52.6%	38.5%	40.3%
	Female	85.6%	23.4%	64.2%	100.0%	47.4%	61.5%	59.7%
AGE	Youth	10.6%	14.9%	0.0%	30.1%	33.3%	98.9%	28.5%
	Adult	80.1%	74.8%	3.6%	69.9%	51.3%	1.1%	52.8%
	Older people	9.2%	10.3%	96.4%	0.0%	15.4%	0.0%	18.7%
	None	4.7%	5.7%	13.5%	0.0%	20.5%	0.0%	5.8%
EDUCATION	Primary	32.2%	42.2%	57.0%	16.8%	50.0%	30.9%	37.8%
	Secondary	55.3%	47.5%	25.4%	67.3%	28.2%	58.0%	49.2%
	Higher	7.8%	4.6%	4.1%	15.9%	1.3%	11.1%	7.2%
INCOME PER MONTH	Low	62.4%	54.4%	78.8%	34.5%	87.2%	85.1%	65.3%
	Medium	34.8%	42.9%	20.2%	60.2%	12.8%	13.4%	32.3%
	High	2.8%	2.8%	1.0%	5.3%	0.0%	1.5%	2.4%

A demographic overview of the survey indicates that out of 1,505 respondents, the majority were female (59.7 per cent), followed by adults (52.8 per cent). Most adult respondents had received either a primary or secondary education (87 per cent), with only 5.8 per cent lacking any formal education. Of this latter group, older people (13.5 per cent) and people with disabilities (20.5 per cent) were the most likely not to have received a formal education. Although nearly half of the respondents had completed secondary education (49.2 per cent), a significant number of respondents aged over 60 years (57 per cent) as well as people with disabilities (50 per cent) in Surabaya had attained only primary-level education.

Most respondents reported limited economic resources; specifically, 65.3 per cent indicated that they belong to low-income households, with the majority earning less than 500,000 Indonesian rupiahs (IDR) (USD 29.50) per month. This income profile aligns with the respondents' employment status – the majority of the women were housewives, while most of the men worked informally. Only 6.45 per cent of respondents had formal jobs.

A critical insight from the study is the sharp disparity between household income levels reported by respondents and the average cost of living in Surabaya. Official data from the East Java Bureau of Statistics (BPS Jawa Timur) indicates that the average monthly household expenditure in Surabaya is approximately IDR 2,602,456 (USD 153.87). This means that most of the study participants earn less than 20 per cent of what is typically required to meet basic living costs in the city.

Table 2 summarizes respondents' vulnerability and resiliency profiles, which may hinder or help them to cope with extreme heat.

Table 2. Community vulnerability and resilience

CATEGORY		Informal settlement dwellers	Outdoor worker	Older people	Pregnant women	People with disabilities	Students	Total
ASSETS OWNERSHIP	Gold	13.9%	11.3%	14.3%	14.4%	3.6%	11.6%	12.4%
	Vehicles	57.6%	59.6%	42.2%	58.9%	33.7%	49.2%	53.8%
	Land	9.2%	9.0%	14.3%	8.9%	6.0%	5.1%	9.0%
	Others	0.7%	0.4%	3.2%	2.1%	1.2%	0.3%	1.0%
	No assets	18.5%	19.7%	25.9%	15.8%	55.4%	33.8%	23.8%
SAVINGS	Have	50.4%	45.6%	34.2%	57.5%	24.4%	53.1%	46.6%
	Don't have	49.6%	54.4%	65.8%	42.5%	75.6%	46.9%	53.4%
AIR CONDI-TIONING	Have	97.6%	97.7%	95.9%	99.1%	96.2%	98.1%	97.5%
	Don't have	2.4%	2.3%	4.1%	0.9%	3.8%	1.9%	2.5%
DURA-TION OF WORKING OUTDOORS	< 4 hours	28.8%	5.3%	35.8%	46.0%	48.7%	28.6%	25.2%
	4-8 hours	22.9%	42.9%	23.3%	13.3%	30.8%	53.8%	33.8%
	8-10 hours	17.7%	36.9%	16.6%	11.5%	10.3%	15.3%	21.9%
	> 10 hours	30.5%	14.9%	24.4%	29.2%	10.3%	2.3%	19.1%
HEALTH CONDITION	No health condition	80.4%	86.5%	58.5%	84.1%	6.4%	90.8%	77.6%
	Existing chronic illness	6.6%	5.5%	14.0%	0.0%	0.0%	0.4%	5.3%
HEALTH INSURANCE	Yes	89.1%	78.7%	87.6%	92.9%	82.1%	83.6%	84.9%
	No	10.9%	21.3%	12.4%	7.1%	17.9%	16.4%	15.1%
DISTANCE FROM HOSPITAL	< 10 minutes	55.8%	58.0%	53.9%	50.4%	55.1%	57.3%	56.0%
	10-15 minutes	38.5%	35.3%	39.4%	38.9%	41.0%	39.3%	38.0%
	> 15 minutes	5.7%	6.7%	6.7%	10.6%	3.8%	3.4%	6.0%
WATER ACCESS DURING HEAT	Yes	80.4%	80.5%	83.4%	77.9%	73.1%	79.4%	80.1%
	Sometimes	12.1%	12.6%	5.2%	13.3%	14.1%	14.1%	11.9%
	No	7.6%	6.9%	11.4%	8.8%	12.8%	6.5%	8.0%

Over half of the respondents (53.4 per cent) reported that they do not have any savings. The lack of a personal financial safety net may cause self-protective behaviours to be deprioritized or ignored altogether, leaving these groups of people vulnerable during extreme heat events.

However, a significant portion of pregnant women (60.2 per cent) came from households with a medium income (IDR 2–5 million per month) and 57.5 per cent of them reported having some savings. This suggests that pregnant women may have better financial resources than other vulnerable groups. This may encourage pregnant women to take more self-protective measures in hot weather to protect themselves and their unborn child(ren).

In addition to savings, some respondents owned other assets, such as vehicles (53.8 per cent), gold (12.4 per cent) and land (9 per cent). Vehicle ownership helps communities to be more mobile and respond quickly in an emergency. Over three-quarters of the respondents (77.6 per cent) stated that they do not have any health conditions. Most respondents also had health insurance (84.9 per cent) and lived within 15 minutes of the hospital (94 per cent). This suggests that the majority of those surveyed would have rapid access to health services in the event of heatstroke, for example, indicating some degree of preparedness for extreme heat events.

Access to water is another key self-protective measure. While most respondents (80.1 per cent) have access to water during high heat, the remaining almost 20 per cent lack consistent access, with 12.8 per cent of people with disabilities having no access to water during periods of extreme heat. This is particularly concerning as hydration is a critical self-protective measure against heat and heat-related illnesses. This disparity suggests a need for targeted interventions for vulnerable people, especially those with disabilities whose physical limitations may prevent them from accessing water even when it is available.

As shown in Table 2, a significant number of people living in informal settlements (30.5 per cent) and pregnant women (29.2 per cent) work outdoors for over 10 hours per day. These groups of people are more vulnerable than others to the impacts of extreme heat, due to their prolonged exposure to high temperatures while working outdoors.

2.2. KNOWLEDGE OF AND ATTITUDES TO EXTREME HEAT

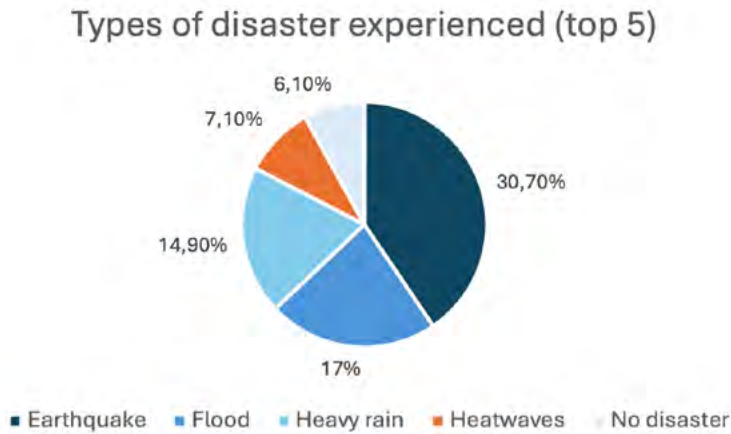
Table 3 shows that 71.3 per cent of respondents reported being aware of the term ‘climate change’ with a majority (58.6 per cent) attributing rising temperatures to a changing climate – demonstrating a good understanding that hotter weather is one of the consequences of climate change. Older people (48.7%) and people with disabilities (43.6 per cent) were less aware of climate change; while a small proportion of outdoor workers stated that climate change is causing temperatures to rise in the city.

Table 3. Summary of respondents’ knowledge of extreme heat

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Have you ever heard of a phenomenon called 'climate change'?							
Yes	79.2%	63.8%	51.3%	77.0%	56.4%	87.8%	71.3%
No	20.8%	36.2%	48.7%	23.0%	43.6%	12.2%	28.7%
P-Value	1.3E-04	2.0E-04	4.0E-10	0.380	0.012	7.0E-10	NA
What do you think are the causes of high temperatures in your city?							
Climate change	63.8%	56.2%	53.9%	59.3%	61.5%	56.5%	58.6%
Overcrowding and overbuilding	26.0%	31.2%	30.1%	28.3%	32.1%	31.7%	29.5%
Other	5.7%	6.7%	13.5%	7.1%	6.4%	7.6%	7.4%
Deforestation	2.1%	4.1%	1.0%	2.7%	0.0%	1.1%	2.3%
Urbanization	2.4%	1.8%	1.6%	2.7%	0.0%	3.1%	2.1%
P-Value	0.101	0.033	0.008	0.990	0.397	0.411	NA

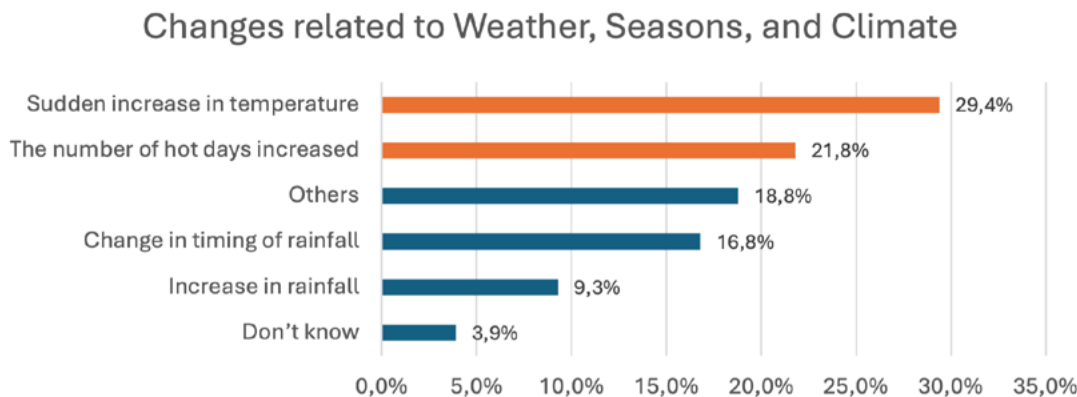
CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
What types of disaster has your community experienced in the past two years (top 5)							
Earthquake	35.0%	28.4%	27.7%	32.7%	30.3%	29.4%	30.7%
Flood	15.1%	17.7%	15.4%	16.9%	15.8%	19.5%	17.0%
Heavy rain	15.5%	13.9%	10.3%	16.0%	13.9%	17.5%	14.9%
Heatwave	5.2%	6.7%	10.0%	8.3%	8.5%	8.2%	7.1%
No Disaster	5.5%	7.2%	13.2%	6.8%	4.2%	2.1%	6.1%
P-Value	0.080	0.661	0.000	0.995	0.876	0.031	NA
Have you ever experienced unusual or uncomfortable hot weather in your city?							
Yes	91.7%	85.6%	77.7%	86.7%	78.2%	94.3%	87.5%
No	5.7%	11.9%	16.1%	12.4%	11.5%	5.3%	9.6%
I don't know	2.6%	2.5%	6.2%	0.9%	10.3%	0.4%	2.9%
P-Value	0.005	0.124	3.7E-05	0.251	2.9E-04	0.001	NA
Have you felt an increase in temperature over the past few years in your city?							
Yes	90.3%	85.8%	78.2%	93.8%	85.9%	86.6%	86.8%
No	5.2%	8.7%	15.5%	5.3%	7.7%	3.8%	7.4%
I don't know	4.5%	5.5%	6.2%	0.9%	6.4%	9.5%	5.7%
P-Value	0.046	0.447	1.7E-05	0.041	0.957	0.001	NA
When's the most common time to feel discomfort due to hot weather?							
Not relevant	9.7%	14.2%	21.8%	6.2%	14.1%	13.4%	13.2%
Morning	0.7%	1.1%	0.5%	0.0%	0.0%	0.4%	0.7%
Daylight	36.9%	34.9%	36.3%	39.8%	30.8%	33.2%	35.5%
Daylight	51.1%	49.3%	40.9%	52.2%	55.1%	50.8%	49.5%
Afternoon	0.2%	0.2%	0.0%	0.9%	0.0%	0.0%	0.2%
Evening	0.7%	0.2%	0.5%	0.9%	0.0%	1.5%	0.7%
Midnight	0.2%	0.0%	0.0%	0.0%	0.0%	0.4%	0.1%
Dawn	0.5%	0.0%	0.0%	0.0%	0.0%	0.4%	0.2%
P-Value	0.087	0.803	0.001	0.143	0.435	0.729	NA

Figure 3. Types of disaster experienced in the past two years



However, the analysis highlights a significant gap between awareness of extreme heat as a phenomenon and its recognition as a climate-related hazard. Only 7.1 per cent of respondents consider heatwaves to be a hazard that they have experienced in the past two years. In comparison, 30.7 per cent reported experiencing earthquakes, 17 per cent have faced floods, and 14.9 per cent have encountered heavy rain, making these the top three hazards reported.

Figure 4. Observed changes related to the weather, seasons and climate



A follow-up question indicates that many respondents recognize the physical discomfort caused by rising temperatures, even if they do not consider extreme heat to be a ‘disaster’. When asked about observed changes in the weather, seasons and climate, the majority attribute these changes to increased heat. Specifically, 29.4 per cent reported a sudden increase in temperature, while 21.8 per cent noted an increase in the number of hot days, as illustrated in Figure 3. This trend is consistent among all vulnerable groups.

Furthermore, Table 3 shows a striking 87.5 per cent of respondents reported experiencing unusually hot or uncomfortable weather. This was consistent across age, gender, education, occupation and vulnerable groups, demonstrating the broad-based nature of heat exposure in Surabaya. However, residents of informal settlements (91.7 per cent) and students (94.3 per cent) were the most affected by the unusually hot weather. Overall, 86.8 per cent of respondents believe that temperatures have been rising over time. But residents of informal settlements, pregnant women and students reported the most frequently that they had faced extremely hot weather in the past few years. Respondents experienced the most discomfort from hot weather from around noon to early afternoon.

The data show that, while residents experience extreme heat, they do not perceive it as a natural hazard that may cause critical impacts on human health and livelihoods. This gap in acknowledging the potential risks of extreme heat is also reflected at national level. According to Law No. 24/2007 on Disaster Management, disasters in Indonesia are categorized as:

- Natural disasters, such as earthquakes, tsunamis, volcanic eruptions, floods, droughts, typhoons, and landslides.
- Non-natural disasters, such as technological failure, modernization failure and epidemics.
- Social disasters include social conflicts between community groups and terrorism.

Heatwaves or extreme heat are not explicitly included in the list of recognized disaster types. This gap presents a challenge in mobilizing systematic early warning systems, emergency responses and long-term adaptation strategies that target heat-related risks.

Heat experience and risk perception

Table 4. Perception of extreme heat

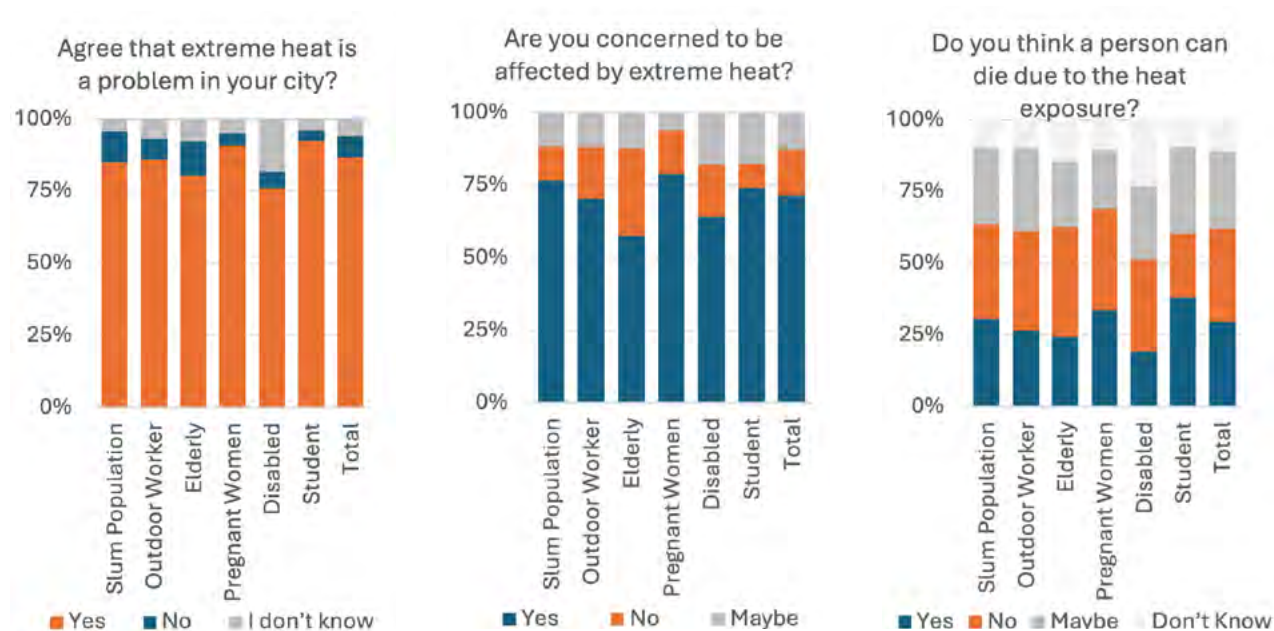
CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Do you agree that extreme temperatures are a problem in your city?							
Yes	85.1%	85.9%	80.5%	90.7%	75.9%	92.3%	86.7%
No	10.4%	7.2%	11.6%	4.2%	5.7%	3.6%	7.3%
I don't know	4.5%	6.9%	7.9%	5.1%	18.4%	4.1%	6.0%
P-Value	0.007	0.637	0.026	0.436	1.99E-05	0.009	NA
How bad do you think the heat is in your city right now?							
Normal	6.2%	4.4%	9.4%	2.0%	3.8%	2.1%	4.6%
Mild	2.7%	4.7%	3.1%	0.9%	6.7%	2.7%	3.3%
Moderate	55.8%	47.9%	56.4%	40.5%	55.6%	37.0%	48.0%
Severe	35.3%	43.0%	31.0%	56.6%	34.0%	58.2%	44.2%
P-Value	5.7E-05	0.353	4.4E-05	0.019	0.169	1.1E-05	NA

While the survey suggests that most respondents do not recognize extreme heat as a 'disaster', a significant majority (86.7 per cent) believe that extreme heat is a concern for Surabaya. Among the different groups surveyed, students (92.3 per cent), older people (80.5 per cent) and the residents of informal settlements (85.1 per cent) expressed greater concern about extreme heat than the other groups. What's more, the majority of respondents described extreme heat in Surabaya as 'moderate' to 'severe'. Notably, more than half of pregnant women and students perceive extreme heat as 'severe' in the city.

Table 5. Level of concern and risk–fatality perception

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Are you concerned about extreme heat-related risks that can affect you?							
Yes	76.6%	70.4%	57.5%	78.8%	64.1%	74.0%	71.4%
No	11.6%	17.7%	30.1%	15.0%	17.9%	8.4%	15.7%
Maybe	11.8%	11.9%	12.4%	6.2%	17.9%	17.6%	12.8%
P-Value	0.011	0.367	2.3E-08	0.077	0.277	2.5E-04	NA
Can a person die due to heat exposure?							
Yes	30.7%	26.6%	24.4%	33.6%	19.2%	38.2%	29.6%
No	33.1%	34.6%	38.3%	35.4%	32.1%	22.1%	32.4%
Maybe	26.5%	28.9%	22.8%	20.4%	25.6%	30.2%	26.8%
Don't Know	9.7%	9.9%	14.5%	10.6%	23.1%	9.5%	11.1%
P-Value	0.702	0.202	0.045	0.404	0.003	1.5E-04	NA

Most respondents (71.4 per cent) were concerned about the extreme heat-related risks they face, with no significant differences by age, gender or occupation. Residents of informal settlements (76.6 per cent) and students (74 per cent) were the most concerned about the risk of extreme heat. While more than half of the older people surveyed (57.5 per cent) expressed concern about heat-related risks, a significant portion (30.1 per cent) expressed no concern. This suggests that most respondents recognized that extreme heat has certain risks that may affect their lives; but, in general the people of Surabaya are uncertain about the fatal risk associated with extreme heat.

Figure 5. Risk perception

There were mixed responses regarding the mortality risk of extreme heat (see Table 5). The number of respondents who believed that a person can die from heat exposure was 29.6 per cent. While 32.4 per cent of respondents thought that exposure to heat could not cause mortality, most respondents were unsure, either perceiving it as 'maybe' (26.8 per cent) or 'do not know' (11.1 per cent).

By comparison, a notable percentage of students (38.2 per cent) were aware that heat can be fatal. This suggests that students have greater awareness of the risk of extreme heat than other population groups. In contrast, many older people (38.3 per cent) and people with disabilities (32.1 per cent) understood that a person cannot die due to heat exposure. Table 5 also highlights that a significant proportion of pregnant women (35.4 per cent) believe that extreme heat cannot lead to mortality, despite most pregnant women reporting the risk as 'moderate' (50.4 per cent). This is particularly concerning given robust evidence that high ambient temperatures during pregnancy are associated with a range of adverse health outcomes, including stillbirth or foetal death, premature birth, dehydration, gestational diabetes and pre-eclampsia (Lakhoo *et al.*, 2025).

The survey findings also indicate that there are clear patterns linking knowledge of heat-related health risks to education and income variables. The two cross-tabulation tables (Tables 6 and 7) show a positive pattern between the two variables: the higher the education and income levels, the higher the percentage of respondents who answered 'yes' to mortality risk due to extreme heat. This shows that respondents with higher levels of education and income are more likely to have better awareness of the dangers associated with extreme heat.

Table 6. Cross-tabulation table of education level with knowledge of extreme heat fatality risk

MORTALITY DUE TO HEAT	EDUCATION				Total
	None	Primary	Secondary	Higher	
a. Yes	22.99%	21.79%	32.43%	56.88%	29.63%
b. No	29.89%	39.02%	29.59%	19.27%	32.43%
c. Maybe	22.99%	25.66%	28.92%	22.02%	26.84%
d. Don't know	24.14%	13.53%	9.05%	1.83%	11.10%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

Table 7. Cross-tabulation table of income level with knowledge of extreme heat fatality risk

MORTALITY DUE TO HEAT	INCOME			Total
	Low	Medium	High	
a. Yes	27.16%	33.95%	38.89%	29.63%
b. No	34.59%	27.78%	36.11%	32.43%
c. Maybe	27.37%	26.75%	13.89%	26.84%
d. Don't know	10.89%	11.52%	11.11%	11.10%
Total	100.00%	100.00%	100.00%	100.00%

Furthermore, Table 8 highlights that 53.09 per cent of respondents reported experiencing unusually hot weather multiple times per year. Discomfort from heat is mostly reported during the day at 13:00–16:00 (49.5 per cent), which is the hottest part of the day. This is a common experience across different genders, age groups, education levels and vulnerable groups.

Table 8. Experience of unusual heat per occupation

OCCUPATION	HOW OFTEN DO YOU EXPERIENCE UNUSUAL HEAT?					Total
	Do not experience it	a. Less than once a year	b. Once a year	c. Multiple times per year	d. Year-round	
a. On pension / retirement pay	11.3%	7.5%	17.0%	45.3%	18.9%	100.0%
b. Business owner	19.3%	1.1%	28.4%	43.2%	8.0%	100.0%
c. Employee at private company	14.3%	3.6%	12.5%	50.0%	19.6%	100.0%
d. Government employee	9.8%	2.0%	9.8%	56.9%	21.6%	100.0%
e. Informal job (street vendor, delivery driver, etc.)	14.0%	5.1%	8.0%	58.7%	14.2%	100.0%
f. Farmer	50.0%	0.0%	0.0%	50.0%	0.0%	100.0%
g. Fisherfolk	50.0%	0.0%	0.0%	25.0%	25.0%	100.0%
h. Labourer	15.7%	10.0%	25.7%	37.1%	11.4%	100.0%
i. Housewife	10.5%	7.7%	11.6%	55.7%	14.6%	100.0%
j. Driver	40.0%	20.0%	20.0%	20.0%	0.0%	100.0%
k. Student	12.0%	9.6%	11.2%	50.2%	16.9%	100.0%
Total	13.16%	6.71%	12.29%	53.09%	14.75%	100.00%

There are, however, important nuances across different occupation groups. As indicated in Table 8, 50 per cent of fisherfolk and farmers, along with 40 per cent of drivers, say they do not experience unusual heat, despite their high potential vulnerability to extreme temperatures. This might be attributed to their prolonged exposure to extreme heat, which increases their tolerance levels while decreasing their sensitivity to risk.

In contrast, a significant proportion of respondents involved in business or employed by the government along with informal workers such as street vendors and those in retirement, reported experiencing unusual heat multiple times a year. Similarly, 50 per cent of farmers reported encountering unusual heat several times each year.

The perceived experience of extreme heat can significantly influence individuals' attitudes and concerns about its risks. As illustrated in Table 9, 75 per cent of fisherfolk reported not being worried about heat-related risks, while 50 per cent of farmers responded 'maybe'. This suggests that there may be limited awareness among them of the symptoms of heat stress, or that these extreme conditions are being normalized. Notably, fisherfolk appear to be the least aware of the risks associated with extreme heat. To gain a better understanding of these occupational contexts, further in-depth observations or interviews are recommended.

Table 9. Level of concern about the risks of extreme heat across different occupations

ARE YOU CONCERNED ABOUT THE EXTREME HEAT-RELATED RISKS THAT CAN AFFECT YOU?				
OCCUPATION	YES	NO	MAYBE	Total
a. On pension / retirement pay	66.04%	22.64%	11.32%	100.00%
b. Business owner	68.18%	27.27%	4.55%	100.00%
c. Employee at private company	78.57%	14.29%	7.14%	100.00%
d. Government employee	72.55%	11.76%	15.69%	100.00%
e. Informal job (street vendor, delivery driver, etc.)	68.67%	17.56%	13.78%	100.00%
f. Farmer	50.00%	0.00%	50.00%	100.00%
g. Fisherfolk	25.00%	75.00%	0.00%	100.00%
h. Labourer	65.71%	14.29%	20.00%	100.00%
i. Housewife	74.52%	15.63%	9.85%	100.00%
j. Driver	53.33%	26.67%	20.00%	100.00%
k. Student	74.70%	7.23%	18.07%	100.00%
Total	71.43%	15.75%	12.82%	100.00%

KEY FINDINGS:

- Among at-risk groups, older people and people with disabilities seem to be less aware of the dangers posed by extreme heat. They are the least likely to agree that extreme heat is a problem in their area; least concerned about being affected by it; and least likely to believe that extreme heat can be fatal.
- This relatively low level of risk perception among older people and people with disabilities suggests that information campaigns targeting these groups could be particularly effective.
- Students and residents of informal settlements show a greater awareness of the dangers of extreme heat than other vulnerable groups, with students demonstrating a heightened understanding of its potential severity along with the possibility that it can prove fatal to vulnerable people.
- Overall, as education and income levels rise, so does the percentage of respondents who acknowledge the risk of mortality due to extreme heat.

2.3. EXTREME HEAT IMPACTS AND VULNERABILITY

Table 10. Extreme heat impacts

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Which areas of your life are affected by the heat?							
Community social issues	7.3%	3.9%	3.5%	8.2%	5.4%	5.7%	5.7%
Electricity supply	6.3%	5.9%	12.5%	3.9%	7.3%	4.8%	6.2%
Food availability	6.1%	5.7%	4.6%	3.3%	6.0%	6.5%	5.7%
Health issues	42.0%	40.6%	46.9%	47.3%	45.1%	36.8%	41.3%
Other	0.7%	0.5%	2.3%	0.2%	3.5%	1.5%	1.0%
Social activities	11.4%	7.7%	9.7%	10.9%	9.2%	15.9%	11.2%
Water availability	9.5%	6.1%	6.9%	9.6%	4.1%	10.7%	8.4%
Work productivity	16.7%	29.6%	13.5%	16.7%	19.4%	18.1%	20.4%
P-Value	0.327	9.3E-07	3.6E-04	0.457	0.200	0.069	NA

Health issues emerged as the most cited impact of extreme heat as shown in Table 10 (41.3 per cent). This was followed by a decline in work productivity (20.4 per cent) and disruption to social activities (11.2 per cent). This pattern is similar across all groups of respondents. These findings align with extensive literature documenting the multi-dimensional impact of heatwaves – not only on physical health but also on economic performance and social behaviour (WHO, 2021)..

Among all respondents, older people (46.9 per cent), pregnant women (47.3 per cent) and people with disabilities (45.1 per cent) expressed greater concern about their health during periods of extreme heat. The Chi-squared test confirms that outdoor workers and older people primarily report health issues stemming from extreme heat. Notably, outdoor workers (29.6 per cent) comprise the most significant proportion of respondents who identified work productivity as being impacted by extreme heat.



Table 11. Negative health impacts during extreme heat

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Negative health impacts during extreme heat (multiple answers)							
Profuse sweating	34.5%	36.5%	30.7%	33.6%	38.4%	30.0%	33.8%
Fatigue	14.4%	15.7%	15.0%	12.7%	10.8%	13.1%	14.2%
Sleep disturbances	15.5%	11.7%	17.7%	16.1%	17.8%	11.6%	13.9%
Dizziness	11.3%	10.5%	12.4%	13.2%	14.0%	11.1%	11.4%
Headache	9.1%	8.4%	7.9%	10.5%	9.2%	9.6%	9.1%
Concentration issues	5.7%	5.8%	4.3%	1.1%	3.5%	9.0%	5.9%
Dehydration	3.0%	3.4%	2.8%	5.3%	2.2%	4.9%	3.7%
Sunburn	1.6%	5.3%	3.3%	1.9%	0.3%	5.4%	3.6%
Anxiousness	2.9%	1.9%	2.8%	0.9%	2.9%	3.4%	2.6%
Cool and clammy skin	1.2%	0.3%	1.3%	0.3%	0.3%	0.7%	0.7%
Nausea	0.2%	0.4%	0.5%	3.4%	0.0%	0.4%	0.6%
Fainting (passing out)	0.3%	0.0%	1.0%	0.0%	0.0%	0.7%	0.3%
Diagnosed heatstroke	0.3%	0.1%	0.3%	0.2%	0.0%	0.2%	0.2%
Vomiting	0.0%	0.0%	0.0%	0.8%	0.6%	0.1%	0.1%

Overall, respondents reported multiple heat-related symptoms – profuse sweating (33.8 per cent), fatigue (14.2 per cent), sleep disturbances (13.9 per cent) and dizziness (11.4 per cent) being the most common. Although these symptoms can signal progression towards heat stress, heat exhaustion or heat stroke, only 0.2 per cent of respondents reported being diagnosed with heat stroke. The implication here is that people often endure warning signs without seeking timely medical care – either due to a lack of awareness or the normalization of discomfort. The International Federation of Red Cross and Red Crescent Societies (IFRC, 2017) emphasizes the importance of raising public awareness of the early symptoms of heat stroke – such as dizziness, cramps and confusion – and the need to seek medical help promptly when these symptoms persist or worsen. It is worth noting that, in the survey, there are no significant differences in the reported health impacts across the different groups of vulnerable people.

KEY FINDINGS:

- Health issues have been reported as a significant impact of extreme heat, followed by a decrease in work productivity.
- Overall, there is a lack of awareness about heat-related illnesses and their symptoms across the vulnerable groups.
- There are no significant differences in the reported health impacts across different vulnerable groups.

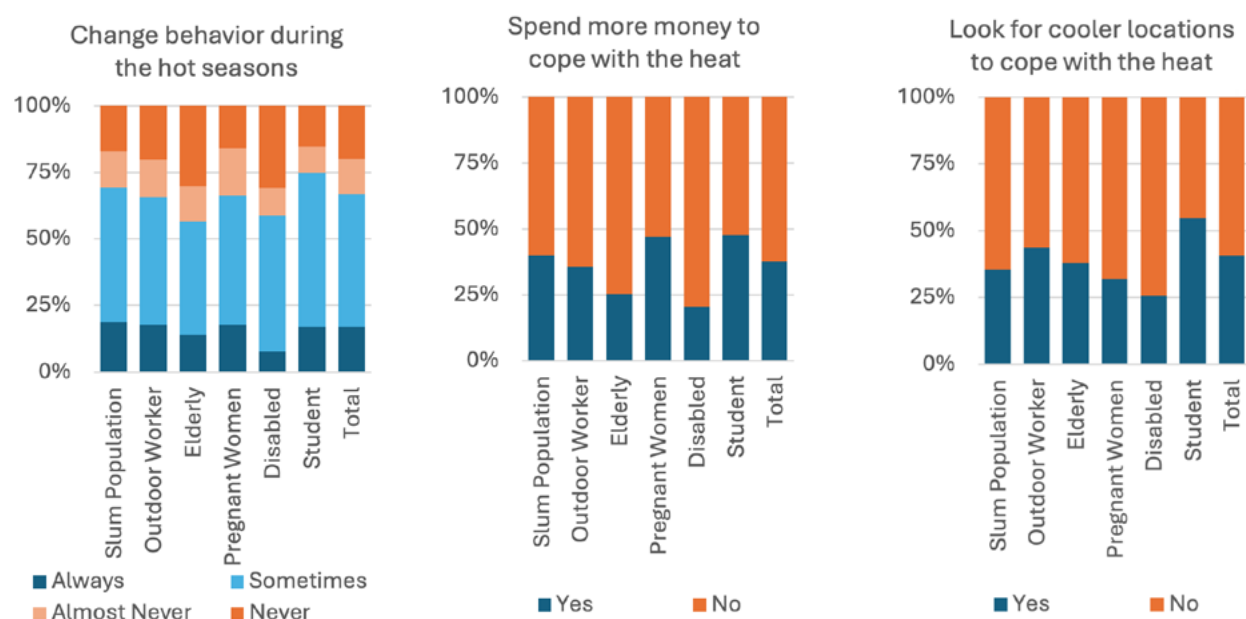
2.4. ADAPTATION STRATEGIES AND BARRIERS

The survey findings indicate that 67.3 per cent of respondents from most of the vulnerable groups believe that heat-related fatigue or illness can be prevented. However, more than half of the people with disabilities expressed uncertainty about whether heat exhaustion could be prevented; specifically, 15.4 per cent do not believe it can be prevented, 19.2 per cent responded with 'maybe' and another 19.2 per cent answered 'don't know'. Among all groups surveyed, students, residents of informal settlements and older people primarily believe that heat exhaustion or illness can be avoided.

Table 12. Adaptation practices to cope with the heat

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Believe that heat exhaustion/sickness can be prevented							
Yes	68.3%	70.2%	64.2%	71.7%	46.2%	67.6%	67.3%
No	8.0%	5.5%	9.8%	5.3%	15.4%	2.7%	6.8%
Maybe	18.0%	17.7%	12.4%	9.7%	19.2%	21.0%	17.1%
Don't know	5.7%	6.7%	13.5%	13.3%	19.2%	8.8%	8.8%
P-Value	0.043	0.140	0.008	0.060	1.6E-05	0.013	NA
Change behaviour during the hot season							
Always	18.7%	17.7%	14.0%	17.7%	7.7%	16.8%	16.8%
Sometimes	50.6%	47.9%	42.5%	48.7%	51.3%	58.0%	50.0%
Almost never	13.7%	14.2%	13.5%	17.7%	10.3%	9.9%	13.3%
Never	17.0%	20.2%	30.1%	15.9%	30.8%	15.3%	19.9%
P-Value	0.292	0.745	0.002	0.416	0.022	0.018	NA
What types of disaster has your community experienced in the past two years (top 5)							
Earthquake	35.0%	28.4%	27.7%	32.7%	30.3%	29.4%	30.7%
Flood	15.1%	17.7%	15.4%	16.9%	15.8%	19.5%	17.0%
Heavy rain	15.5%	13.9%	10.3%	16.0%	13.9%	17.5%	14.9%
Heatwave	5.2%	6.7%	10.0%	8.3%	8.5%	8.2%	7.1%
No Disaster	5.5%	7.2%	13.2%	6.8%	4.2%	2.1%	6.1%
P-Value	0.080	0.661	0.000	0.995	0.876	0.031	NA
Seek assistance from government or NGO or PMI to cope with the heat							
Yes	1.2%	2.5%	0.5%	0.0%	0.0%	2.3%	1.5%
No	98.8%	97.5%	99.5%	100.0%	100.0%	97.7%	98.5%
P-Value	0.652	0.076	0.362	0.328	0.512	0.407	NA
Spend more money to cope with the heat							
Yes	40.0%	35.6%	25.4%	46.9%	20.5%	47.7%	37.7%
No	60.0%	64.4%	74.6%	53.1%	79.5%	52.3%	62.3%
P-Value	0.280	0.304	2.2E-04	0.045	0.002	3.0E-04	NA
Look for cooler locations to cope with the heat							
Yes	35.5%	43.8%	37.8%	31.9%	25.6%	54.6%	40.7%
No	64.5%	56.2%	62.2%	68.1%	74.4%	45.4%	59.3%
P-Value	0.011	0.135	0.423	0.058	0.008	7.4E-07	NA

Figure 6. Adaptation practices to cope with the heat



The tendency to believe in the impacts of extreme heat influences respondents' behaviour during hot weather. Overall, 60.8 per cent of respondents reported that they change their behaviour 'always' or 'sometimes' when temperatures rise. Among the 19.9 per cent who stated that they 'never' change their behaviour, the most significant responses come from people with disabilities (30.8 per cent) and older people (30.1 per cent). This may be influenced by their lack of awareness of the potential fatality of extreme heat. Conversely, 58 per cent of students reportedly changed their behaviour during hot weather.

It's also noteworthy that only 1.5 per cent of respondents seek assistance from institutions, such as government agencies, nongovernmental organizations or PMI, to cope with extreme heat.

Overall, the survey results indicate that people's perceptions of and attitudes to extreme heat influence their responses to it. This justifies efforts to strengthen people's awareness of extreme heat-related risks and encourage adaptive behaviours, especially among vulnerable groups such as outdoor workers and pregnant women as well as those found to be least aware of the dangers, including older people and people with disabilities.

Only 37 per cent of respondents reported spending more money to cope with extreme heat. Among these, students (47.7 per cent) and pregnant women (46.9 per cent) comprise the largest groups. Most respondents (59.3 per cent) do not look for cooler locations to manage extreme heat; however, 54.6 per cent of students indicate that they do look for cooler places when temperatures rise. This may indicate that schools and public spaces for students are perceived to be safer or more accessible compared to those used by other vulnerable groups.

Limited adaptation practices and constraints

While a significant proportion of respondents reported changing their behaviour in hot weather, further analysis reveals that these changes tend to be minimal and inconsistent. Figure 7 illustrates that the most reported coping mechanisms among respondents were increasing fluid intake and using fans or air conditioning. Although these measures are standard first-line protections, they may not be adequate for prolonged or intense heat exposure, particularly for outdoor workers. Importantly, visiting parks or green spaces is among the least adopted strategies, despite evidence that green areas provide effective passive cooling and psychological relief (Bowler *et al.*, 2010).

Figure 7. Protective measures taken by respondents (multiple answers)



According to research on urban planning in Surabaya, the city has over 100 green spaces, including 11 major parks, which help to reduce urban temperatures by approximately 2–3°C. However, the distribution of parks is uneven, with central and western districts (formal housing) having more public parks than the densely populated informal settlements (*kampung*) in the eastern districts of the city, where green open space constitutes only about 7.14 per cent of the land area (Rini *et al.*, 2014). Many vulnerable residents live in areas with limited access to shaded or cool public spaces, which decreases their likelihood of seeking out parks, especially during hot weather. The limited use of green spaces may also result from cultural habits; daily routines typically do not include visits to parks, and there may be a lack of widespread understanding of the connection between green spaces and heat adaptation. Further site observations are needed to gain a deeper understanding of these findings.

Economic constraints also shape behaviour. A significant proportion of respondents (62.3 per cent) reported not spending extra money to cope with extreme heat, except among higher-income households (Table 12). In low-income households, adaptive investments such as buying light-coloured and loose-fitting clothing, accessing shaded rest areas or visiting air-conditioned malls may be deprioritized due to essential needs such as food and school expenses. Other respondents reported using extra funds during the hot season for items like cool drinks or ice, paying higher electricity bills for air conditioning or fans, and purchasing medications.

IFRC (2017) emphasizes that effective adaptation requires not only physical and financial capacity but also the psychological acceptance of risk as well as clear, actionable guidance. Without these, even individuals with access to resources (such as pregnant women with medium incomes and savings) may not adopt heat-appropriate behaviours.

Table 12 also reveals that only 16.8 per cent of respondents ‘always’ change their behaviour during hot weather. In addition, 98.5 per cent of respondents do not seek assistance from government or nongovernmental organizations at times of peak heat, indicating both a lack of outreach from these institutions and low demand from the people they serve for external support; perhaps due to the perception that such help is unnecessary for dealing with heat. This means that, while many people are aware of the need to adapt, they often make only the bare minimum of effort – such as increasing fluid intake or turning on a fan – rather than making more comprehensive or sustained behavioural changes. One likely reason is the underestimation of heat as a serious or potentially fatal risk.

These findings align with contemporary research which highlights that limited heat risk literacy coupled with a low perceived threat from extreme heat significantly reduces the likelihood of individuals seeking care – even when such services exist. A representative survey in Germany (2023) found that many people actively checked the weather forecast during heatwaves, but this did not necessarily lead to self-protective actions. This means that people may have the information (knowledge) but still fail to act if they do not believe the heat poses a real danger to them (attitude); unless people perceive heat as personally dangerous, they are unlikely to act – even if they have additional funds, insurance and access to healthcare. Without heat literacy, people are unlikely to recognize the need to seek help or spend more money on self-protective measures. Infrastructure alone is insufficient unless paired with education, outreach and behavioural nudges.

KEY FINDINGS:

- Amongst at-risk groups, older people and people with disabilities are the least likely to change their behaviour or to spend money on self-protective actions during the hot season. In contrast, students and pregnant women are more inclined to adjust.
- The low level of adaptation strategies is most common in groups that are less knowledgeable about the risks of heat. This suggests that awareness-raising campaigns could enhance community resilience to heat risks by encouraging the adoption of mitigation strategies.
- Knowledge of self-protective and adaptive measures for extreme heat are inadequate among vulnerable groups.
- Heat risk education is widely needed, particularly on methods to reduce the impacts of extreme heat.

2.5. EARLY WARNING, ALERT MESSAGING AND COMMUNICATION CHANNELS

Most respondents (72.4 per cent) acknowledged the importance of checking weather forecasts, indicating a general recognition of the potential value of early warning systems. However, the perception of the importance of weather forecasts does not consistently translate into proactive behaviour, as 58.7 per cent of respondents do not check weather updates. While 85 per cent of students indicated the positive importance of the weather forecast, a significant proportion (37 per cent) of older people do not consider weather forecasts to be an important tool.

Table 13. Attitude versus practices on checking the weather forecast

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
How important is it for you to know what weather is forecast?							
Very important	16.1%	13.8%	12.4%	15.9%	9.0%	24.4%	16.0%
Important	55.6%	59.2%	50.8%	48.7%	55.1%	61.1%	56.4%
Not important	28.4%	27.1%	36.8%	35.4%	35.9%	14.5%	27.6%
P-Value	0.899	0.243	0.007	0.135	0.098	2.6E-08	NA
Do you check the weather forecast?							
Yes	40.0%	39.7%	21.2%	43.4%	38.5%	60.7%	41.3%
No	60.0%	60.3%	78.8%	56.6%	61.5%	39.3%	58.7%
P-Value	0.535	0.440	2.1E-09	0.721	0.682	4.1E-12	NA

In the FGDs, some pregnant women stated that they do not actively seek information about the weather and perceived the heat as 'part of life' rather than a hazard. This indicates the normalization of heat which reduces the likelihood of taking active countermeasures (Zhang *et al.*, 2017; Sera *et al.*, 2021).

“I do not really seek out information about heat, because heat is just something you accept.” (PW1)

“No. If it’s hot, then it’s hot.” (PW2)

“No, because I stay at home the whole day.” (PW3)

Students (60.7 per cent) were the only group with a majority who actively checked weather forecasts, possibly due to higher digital literacy, more routine exposure to information platforms, and more structured daily activities that are sensitive to seasonal changes. This aligns with previous findings that youth are typically more adaptable and responsive to emerging risks when timely information is provided (Sharma *et al.*, 2022).

The IFRC (2017) emphasizes that early warning systems need to be trusted and able to issue timely and actionable information to effectively influence individual and community behaviour. The current pattern in Surabaya indicates that existing systems are not fully used or trusted, nor are they perceived as relevant to everyday decision-making.

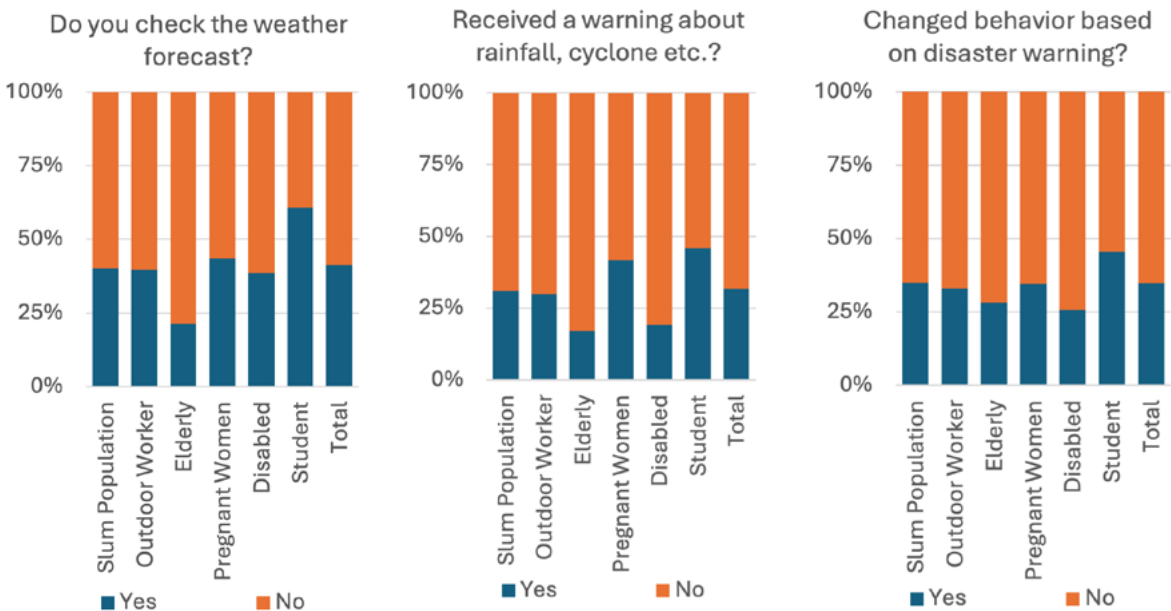
Table 14. Types of alert messaging and respondents’ actions

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Do you ever receive alerts or warnings for hazards such as heavy rainfall, cyclones etc.?							
Yes	44.0%	39.2%	18.1%	49.6%	28.2%	57.3%	41.2%
No	56.0%	60.8%	81.9%	50.4%	71.8%	42.7%	58.8%
P-Value	0.190	0.349	5.5E-12	0.075	0.023	9.4E-09	NA
Do you ever receive an alert or warning about extreme heat?							
Yes	31.0%	30.0%	17.1%	41.6%	19.2%	45.8%	31.7%
No	69.0%	70.0%	82.9%	58.4%	80.8%	54.2%	68.3%
P-Value	0.752	0.414	4.6E-06	0.025	0.021	1.0E-07	NA
If yes, how many days before the hot period did you receive this information?							
Do not receive alerts	56.0%	60.8%	81.9%	50.4%	71.8%	42.7%	58.8%
A week before	1.4%	1.4%	1.0%	0.9%	0.0%	3.4%	1.6%
A few days before	11.1%	11.9%	4.1%	11.5%	14.1%	18.7%	12.0%
One day before	7.8%	7.8%	3.6%	8.8%	7.7%	11.1%	7.9%
On the same day	23.6%	18.1%	9.3%	28.3%	6.4%	24.0%	19.7%
P-Value	0.197	0.852	5.7E-10	0.155	0.023	5.5E-08	NA
Did or would you change your behaviour based on such alerts?							
Yes	34.8%	32.8%	28.0%	34.5%	25.6%	45.4%	34.7%
No	65.2%	67.2%	72.0%	65.5%	74.4%	54.6%	65.3%
P-Value	1.000	0.356	0.044	1.000	0.109	8.0E-05	NA

In Indonesia, the primary agency responsible for disseminating hazard-related early warnings is BMKG. It provides early warnings for a range of natural hazards, including extreme weather, earthquakes, tsunamis and floods. However, warnings for heatwaves are not yet formally included in the system. BMKG typically issues warnings through multiple channels: official website, SMS messages, social media (Twitter, Instagram, Facebook), television, radio, mobile apps such as Info BMKG and in coordination with local government agencies. Information usually includes the hazard type and location, expected time and duration, severity level, geographic coverage and recommended self-protective actions.

These multiple channels, message types and end-users results in an uneven distribution of information. For example, SMS Blast can only be received by people whose phone numbers are listed in the BMKG database. The Info BMKG mobile app can only be accessed by smartphone users who have downloaded the app. Television and radio broadcasts are typically used for severe weather alerts. WhatsApp groups for local updates are unofficial and mainly accessed by local government and volunteers. Therefore, despite this multi-platform approach, the system's effectiveness is influenced by local infrastructure, digital literacy and the extent of local government engagement in translating and sharing the alerts appropriately for different community groups.

Figure 8. Access to weather forecasts and early warnings



The survey results show that more than half of respondents (68.3 per cent) had never received alerts related to extreme heat, while 58.8 per cent had never received alerts for any other type of hazard (such as earthquakes or floods). When alerts are received, they often arrive on the same day as the hazard, which limits the time available to take self-protective action. Nonetheless, most respondents (65.3 per cent) reported never changing their behaviour based on the extreme heat alerts.

Several factors may explain why only 31.7 per cent had received alerts of extreme heat. First, the digital divide, such as lack of access to smartphones, the internet or social media, may prevent some individuals, particularly older people and people with disabilities, from receiving digital alerts. Second, variability in local government engagement and community-level dissemination (e.g., via village heads, community leaders, or RT (*Rukun Tetangga*/Neighbourhood Unit) and RW (*Rukun Warga*/Community Unit) structures can lead to inconsistent outreach. Moreover, when alerts are received on the same day as the hazard, it suggests the warning system might be operating in a reactive rather than an anticipatory manner, especially for short-onset events such as heatwaves.

The assessment report from the National Agency for Disaster Management (Badan Nasional Penanggulangan Bencana, BNPB) and the United Nations Office for Disaster Risk Reduction (BNPB & UNDRR, 2020) highlights these gaps in Indonesia's early warning capabilities, especially in warning dissemination and communication. These patterns point to a critical need for localized, timely and tailored communication, especially for slow-onset hazards like extreme heat, which are often under-recognized.

Table 15. Information gaps (multiple answers)

TYPES OF INFORMATION	Information received?	Other helpful info
Maximum temperature	40.28%	31.63%
How long the heat will last	20.28%	18.50%
What measures to take to protect yourself from the heat	13.18%	17.82%
Minimum temperature	14.60%	14.51%
Humidity level	7.11%	6.18%
How to protect my family and friends	4.36%	9.64%
Other	0.19%	1.71%
Total	100.00%	100.00%

Effective early warning requires not just the dissemination of hazard data (e.g., maximum temperatures), but also clear communication of the personalized risk alongside recommended self-protective actions. However, most messages received by the respondents focus on technical details like maximum and minimum temperatures (40.3 per cent and 14.6 per cent, respectively), while only a small portion of respondents (20.3 per cent) received information about the duration of the heatwave. Notably, 17.8 per cent of respondents specifically asked for more practical information to be provided about what self-protective actions they can take, while 9.64 per cent of respondents want to receive information about how to protect their family and friends.

This highlights a critical gap in the 'last mile' of risk communication, where technical warnings are not being translated into simple, actionable and easy-to-understand advice. As emphasized by the World Meteorological Organization (WMO, 2015) and in IFRC, 2017, simply providing weather data is insufficient for effective community response. Communities need to receive practical advice alongside the alert, such as what actions to take, how to stay safe and where to seek help. Without this, even timely alerts may not lead to self-protective behaviour.

Table 16. Effective communication channels for weather information

CATEGORY	Informal settlement dwellers	Outdoor workers	Older people	Pregnant women	People with disabilities	Students	Total
Where do you look for weather information? (multiple answers)							
Social media	215	224	22	75	25	216	777
Word-of-mouth	195	207	101	38	39	76	656
TV	158	128	81	37	31	50	485
WhatsApp	60	57	8	23	11	61	220
Other	37	41	15	13	5	25	136
Public display	29	31		10		34	104
Radio	10	11	9	1	1	2	34
Newspapers	2	9	2			2	15
Total	706	708	238	197	112	466	2427
P-Value	0.515	0.102	1.2E-23	0.094	0.026	2.1E-21	NA

The findings indicate that social media (32 per cent) is the primary source of weather information for most respondents, followed by word-of-mouth (27 per cent) and television (20 per cent). However, there are notable variations across vulnerable groups:

- Older people and people with disabilities primarily access weather information through word-of-mouth (family, neighbours, community leaders) followed by television.
- Students and younger people rely more heavily on social media platforms such as Facebook and Instagram.

These patterns suggest that risk communication strategies must be differentiated. Multi-channel, multi-format communication is essential to ensure that early warnings are not only delivered but also understood and acted upon by different groups of people. For older people and people with disabilities, community-based outreach via trusted intermediaries – such as family members, community leaders or local health workers – remains one of the most effective strategies to raise awareness and encourage self-protective actions. Recent studies have demonstrated that social connections often serve as key resources for building resilience, especially in the face of extreme heat events. For instance, Kovats *et al.* (2020) found that older adults frequently rely on their immediate social networks for information, assistance and emotional support during heatwaves. These findings suggest that simply disseminating information through formal channels may not be sufficient; tailored communication through trusted networks is essential to translate knowledge into risk perception and action, particularly among vulnerable groups. For students and younger people, real-time social media alerts, engaging infographics and local influencer partnerships could significantly enhance reach and impact.

KEY FINDINGS:

- **Older people and people with disabilities are less likely to seek out or receive weather forecasts and early warning messages. They are also less likely to act on these warnings. In contrast, students tend to seek out this information and respond proactively.**
- **Overall, groups with the lowest awareness of and concern about heat risks are often the least well-informed in advance of a period of hot weather. Implementing an information campaign to raise awareness about heat risks could significantly increase the proportion of vulnerable communities that are aware of the dangers of extreme heat, allowing them to prepare effectively.**
- **Social media is the most effective communication channel for disseminating heat-related information to students and younger people, while word-of-mouth remains the preferred method for reaching older people.**
- **It is recommended that heat early warning communication includes guidance on self-protective measures, alongside meteorological details such as maximum and minimum temperatures.**

2.6. RECOMMENDATIONS

This Heat Perception Study for Surabaya reveals widespread exposure to extreme heat with limited adaptation among vulnerable groups including residents of informal settlements, outdoor workers, older people, pregnant women, people with disabilities, and students. 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:

First, extreme heat should be formally recognized as a disaster risk within Indonesia's national and local disaster management frameworks. BMKG, BNPB and local governments need to integrate heatwaves into contingency planning, early warning systems and public health preparedness. Recognizing heat as a recurrent hazard would support more consistent mobilization of resources and coordinated response mechanisms.

Second, public education and awareness campaigns and heat risk communication must be strengthened to improve heat-health literacy. These campaigns should highlight the serious health risks of extreme heat, particularly the dangers it poses to maternal health as well as to older adults and outdoor workers. Efforts should focus on increasing public understanding of the early symptoms of heat stress, heat exhaustion and heatstroke, and include practical, easy-to-follow self-protective measures and first aid responses. Communication must be designed to be accessible across literacy levels, languages and digital access gaps. This includes using communication materials in simple, visual formats (infographics, videos, voice messages) to reach the widest audience.

Third, targeted socialization efforts are needed for high-risk groups. Outdoor workers in heat-sensitive occupations – such as farmers, fisherfolk and drivers – should be provided with specific advice on self-protective measures and first aid protocols; adapting their work routines to ensure regular breaks in the shade; staying hydrated; identifying the early onset of heat illness; and knowing when to seek help.

Fourth, Indonesia's early warning systems must evolve to include formal alerts for extreme heat. BMKG should adopt Impact-based Forecasting approaches that do not only share weather data but also explain what actions to take, when and where. These warnings should be disseminated through diverse, community-friendly channels, including social media, SMS, radio, television and community networks (see below).

Fifth, leverage community-based structures and social capital. Activate trusted local networks such as youth volunteers, community health workers, RT/RW leaders and religious groups to act as messengers and educators for heat-related health information and emergency response. Community engagement should remain central to this process, enabling participatory approaches to heat preparedness and ensuring that no vulnerable group is left behind. Pregnant women and people with disabilities may also be reached through community-based mechanisms such as RT/RW leaders, *Posyandu* (Integrated Community Health Posts), health volunteers and family members.

Sixth, public infrastructure to support heat adaptation must be improved. Local government and urban service providers should prioritize the availability of cooling spaces and clean drinking water, particularly in informal settlements, markets and public transport hubs. Employers of outdoor workers should be encouraged or required to provide shaded rest areas and emergency first-aid supplies during hot weather.

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 communities, 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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This study was supported by:

