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Navigating Public Health in a Hotter Malaysia

Wan Amirah Wan Usamah

Khazanah Research Institute

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Author's email address: **Amirah.Usamah@krinstitute.org**

Executive Summary

This working paper explores the potential risks rising temperatures bring to Malaysia's public health. The summary of its findings and the respective policy considerations is as follows:

1. **Globally, rising temperatures can have detrimental effects on public health.** Warmer temperatures have been found to increase the risk of heat-related illnesses, worsen non-communicable diseases, and increase the risk of vector-borne diseases.

2. **Malaysia's combination of high temperatures and humidity places an added vulnerability towards heat-related illnesses**. At the current average maximum temperature, Malaysia's heat index shows high exposure to heat exhaustion, heat cramps, and increased risks of heat stroke. As both average mean and maximum temperatures increase, the risk of heat-related illnesses will also increase.

3. **Beyond heat-related illnesses, warmer temperatures can worsen other health issues for Malaysians.** Non-communicable diseases such as ischemic heart disease, respiratory diseases, and diabetes can also worsen as temperatures rise. Additionally, increased transmission of vector-borne diseases such as dengue is likely under warmer temperature scenarios.

4. **Vulnerability towards heat-induced health issues is not equal across all Malaysians.** Variability among local climates, age-related vulnerabilities among children and the elderly, as well as working in specific sectors can place an added risk of heat-related illnesses or other health conditions worsened by heat.

However, despite the certainty that temperatures will rise in the next few decades, there are gaps in the mention of measures for managing heat-related illnesses and other heat-induced health conditions. To overcome the vulnerabilities and gaps highlighted in this paper, this paper suggests the following policy considerations:

1	Develop a Heat-health Action Plan
2	Enhance monitoring systems on heat-induced health conditions
3	Design heat-sensitive public infrastructure and facilities
4	Adapt decent work practices for current and future high temperatures

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1. Introduction

As the world grapples with increasingly urgent challenges driven by climate change, it is imperative that we contextualise the changing climate within Malaysia's ecosystem – particularly with regard to rising temperatures. Located near the equator, Malaysia's tropical climate has often been characterised as being 'hot and humid'. While high temperatures are seemingly not new to Malaysians, it is important to illustrate just how 'hot' things have been going, how much 'hotter' they may get, as well as the specific public health challenges Malaysia could face due to these increasing temperatures.

The necessity to focus on rising temperatures in regard to public health

Since the beginning of the 20th century, the global annual average temperature has been on the rise at increasingly alarming rates. Even more worryingly, the past decade has been marked by 'record highest temperatures' whereby several countries around the world have reached new historical maximum temperatures. In fact, 2023 has been recorded as the hottest year in the past 174 years observational period. Malaysia, too, is not excluded from this phenomenon, recording a rise of 1.4°C within the past few decades.

Rising heat is not only a matter of discomfort. High temperatures pose various health risks and increased challenges within the healthcare sector. Higher temperatures have also been found to increase the intensity and frequency of hot extreme events, such as droughts and heatwaves, which may then exacerbate the social risks brought on by heat. However, despite rising heat being an issue that most Malaysians can relate to, identification and management of the impacts of rising temperature and extreme heat events on different economic sectors have largely been side-lined within national climate policy. Thus, this paper aims to bring to light some of the challenges Malaysia could face as global temperatures increase, particularly in the context of health.

Objective and paper outline

Given the rising importance of identifying, addressing, and managing risks that are brought on by higher temperatures, this paper attempts to highlight the risks of hotter temperatures to Malaysia's public health. Utilising a compilation of international and local research previously conducted on this topic, this paper serves to establish a comprehensive and contextualised relationship between rising temperatures and public health vulnerabilities in the case of Malaysia.

To explore this topic further, Section 2 begins by examining global temperature patterns and projections, as well as the correlation between health and high temperature. Next, Section 3 contextualises current international findings into the exposure and health vulnerabilities specific to Malaysia. This is further expanded in Section 4 with an added dimension on how exposure to heat-induced heat risk can vary by location, age, and occupation. Lastly, Section 5 explores potential monitoring and adaptation that can be implemented to reduce Malaysia's health vulnerabilities in this warming climate.

2. Higher temperatures and their risk to public health

The term climate change has often been synonymous with global warming from pre-industrial baseline, and indeed, the past three decades saw an increase of 1.2°C in the global average temperature[1]. Even more worrying, while the 2015 Paris Agreement resulted in an international goal of keeping global warming well below 2°C and preferably under 1.5°C, the latest estimates predict that we may exceed the 1.5°C threshold as soon as 2030[2]. Additionally, based on the current climate policies and pledges, global warming is projected to increase by 3.2°C, by 2100. The world is warming, and it is warming rapidly.

Exceeding the 1.5°C threshold can cause greater climate impacts such as deadlier hot spells, higher sea level rise, greater losses of biodiversity, and higher frequencies of extreme weather events[3]. Meanwhile, exceeding the 2.0°C threshold would mean that these climate risks can be at least two times worse than those projected for the 1.5°C threshold[4].

Rising temperatures also bring other extreme heat-related events, such as heatwaves and drought. This, in turn, could result in various health concerns exacerbated by climate change and higher temperatures. Furthermore, the rate at which the temperatures are rising is highly likely to contribute to the severity of these climate-induced public health risks.

Given the intertwined relationship between climate change, rising temperatures, as well as projected risks to health and well-being, this section aims to give a comprehensive background on the current climatology, future temperature projections, and the health vulnerabilities exposed in hotter environments. Section 2.1 will begin by discussing how temperatures have changed in the past decades, as well as the latest projections of temperature increases based on various emissions scenarios at both the global and regional scales. Next, Section 2.2 will illustrate how our body reacts to heat and what these rising temperatures imply for public health.

2.1. Global temperatures are rising

With a global mean surface temperature of 1.48°C above the 1850-1900 average temperature, 2023 was the warmest year in the 174-year observational record[5]. This rise was very close to the 1.5°C target set by the 2015 Paris Agreement and far surpassed the previous 'warmest years' joint record of 2016 (at 1.29°C) and 2020 (1.27°C).

This increase in global temperatures is not expected to stabilise anytime soon, with current projections showing that the temperature increase can range between 1.5°C to 4.4°C by 2100, depending on the global emissions scenario. This is further explained in the box article below.

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[1] Copernicious (2024)

[2] Ibid

[3] IPCC et al. (2023)

[4] Ibid

[5] Copernicious (2024)

Box 1: Emissions and temperature projection

The amount of greenhouse gases emitted into the atmosphere directly affects the Earth's energy balance and temperature. Greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) trap heat in the atmosphere, leading to global warming and climate change[6].

Thus, emission projections are central to understanding future changes in global temperature, according to the Intergovernmental Panel on Climate Change (IPCC). The IPCC assesses various scenarios of future emissions based on different socio-economic and technological pathways. These emission scenarios, which are called Shared Socioeconomic pathways (SSPs), represent different possible futures, ranging from low to high greenhouse gas emissions.

When emission projections indicate higher levels of greenhouse gas emissions, it implies that more heat-trapping gases will accumulate in the atmosphere, causing more warming. Conversely, lower emission projections suggest less warming.

There are currently five possible warming scenarios based on the latest IPCC report. Each scenario has its respective measure of radiative forcing (which is the measure of the heating effect as a function of greenhouse gas emissions) and the projected temperature increase in the near-, mid- and long-term. Some emission scenarios can have multiple radiative forcing, such as in the case of SSP1 which has radiative forcing 1.9 and 2.9. This is summarised in Table 2.1 below.

Table 2.1 Projected temperatures in the near-, mid-, and long-term, by emissions scenario

Scenario	Radiative forcing	Near-term, 2021–2040		Mid-term, 2041–2060		Long-term, 2081–2100	
		Best estimate (°C)	Very likely (°C)	Best estimate (°C)	Very likely (°C)	Best estimate (°C)	Very likely (°C)
SSP1	1.9	1.5	1.2–1.7	1.6	1.2–2.0	1.4	1.0–1.8
SSP1	2.9	1.5	1.2–1.8	1.7	1.3–2.2	1.8	1.3–2.4
SSP2	4.5	1.5	1.2–1.8	2.0	1.6–2.5	2.7	2.1–3.5
SSP3	7.0	1.5	1.2–1.8	2.1	1.7–2.6	3.6	2.8–4.6
SSP5	8.5	1.6	1.3–1.9	2.4	1.9–3.0	4.4	3.3–5.7

These different scenarios are determined by the level of emission increase or decrease in the coming years. A summary of the emissions target that needs to be met for each scenario is as below.

- SSP1-1.9: A very low emission increase and would require the world to achieve net-zero carbon emissions by 2050.
- SSP1-2.9: A low emission increase and would require the world to achieve net-zero carbon emissions by 2075.

[6] Bhatti et al. (2024)

- SSP2-4.5: An intermediate emission increase where carbon levels would stay at their current rising trajectory before decreasing in the second half of the century (2050 onwards)
- SSP3-7.0: There is a high emissions increase, where the carbon emissions will be double the current number by 2100
- SSP5-8.5: The emissions increase is very high, where carbon emissions will be double the current number by 2050

Regardless, it is important to note that all scenarios are projected to lead to global warming on or above 1.5°C in the near and mid-term, with some scenarios also showing an increase of 2.0 and above in the mid-term.

Aside from the rise in temperatures, the frequency and intensity of hot extremes and heatwaves have increased since 1950. Hot extremes are defined as maximum daily temperatures that were exceeded on average once during a 10-year period and once during a 50-year period[7]. The frequency and intensity of these hot extremes will continue to increase in almost all regions regardless of global warming stabilising at 1.5°C[8]. The intensity of these hot extremes will be dependent on the level of warming, at least doubling at a 2°C warming and quadrupling at 3°C[9].

The frequency and intensity of these hot extremes would lead to a rise in the number of hot days and hot nights, while the length, frequency, and intensity of heatwaves will increase over most land areas. The definitions of hot days, hot nights, as well as the different types of heatwaves are broken down into further detail in Table 2.2.

Table 2.2 Terms and definitions of hot days, nights, and types of heatwaves

Terms	Definitions
Hot days	Where an average of 83.54 or more days a year exceed 35°C
Hot nights	Where an average of 83.54 or more nights a year exceed 90th percentile minimum temperatures
High heatwave frequency	When an average of 4.5 or more occur per year
High heatwave duration	Where an average heatwave event lasts 4.7 days or longer
High heatwave severity	Where the average heatwave event is 2°C or more above the local 15-day average
Extreme high temperatures	Number of days in which maximum daily temperature is above an absolute threshold such as 35°C or a relative threshold (temperature is at 90th percentile or higher of the maximum daily temperature base period)

Source: UNICEF (2023)

Global warming can also lead to changes in low-likelihood, high-impact extremes (LLHI events). LLHI events are, as the name suggests, climate events that occur very rarely and are often not anticipated but result in severe climate impacts. These LLHI events are often described as

[7] IPCC (2022)

[8] ibid

[9] ibid

‘extreme extremes’, ‘unprecedented’ or even ‘very unusual’. Examples of these LLHI events regarding heat at different global warming scenarios can be found below (Table 2.3).

Table 2.3 Examples of changes in low-likelihood high-impact extreme conditions at different global warming levels

	+1℃ (present-day)	+1.5℃	+2℃	>+3℃
Risk ratio of annual hottest daytime temperature (TXx)	1	3.3	8.2	Not assessed
Probability of ‘extreme extremes’ hot days with 1/1000 probability	About 20 days over 20 years in most locations	About 50 days in 20 years in most locations	About 150 days in 20 years in most locations	About 500 days in 20 years in most locations (3℃)
Increase in days exposed to dangerous extreme heat measured in the Health Heat Index (HHI)	Not assessed, baseline is 1981–2000	1.6 times higher risk of experiencing heat >40.6	2.3 times higher risk of experiencing heat >40.6	Around 80% of land area exposed to dangerous heat, tropical regions 1/3 of the year (4°C)

Source: IPCC (2022)

While the probability of LLHI events is hard to measure, particularly as we now live in a non-stationary climate, it is important to highlight the degree of severity of the above events to properly implement adaptation measures. Furthermore, at the current pace of global warming, even extreme events that have a low probability of happening in the present climate can occur more frequently in the future and thus have a higher change of ‘historically unprecedented’ events happening.

Regional climate risks: Southeast Asia

While the global warming levels discussed earlier (at 1.5°C, 2°C, 3°C) are the global mean response to the total emissions, the regional climate response may vary. With regard to warming, the risks brought on by rising temperatures are felt unequally across the world. Table 2.4 summarises the projected increase in annual average temperatures across the different subregions based on two warming/emission scenarios.

Table 2.4 Annual average temperature in world subregions in 1995 and projected increases by 2025 and 2085 (℃)

Region	Subregion	Mean annual temperature	Increase under 1.5℃ global warming scenario (RCP2.6)		Increase under 2.7℃ global warming scenario (RCP6.0)	
		1981-2010	2025	2085	2025	2085
Africa	Northern Africa	23.7	1.2	1.5	1.1	3.1
	Central Africa	24.5	1.2	1.3	1.0	3.0
	Eastern Africa	23.6	1.0	1.1	0.9	2.7

	Southern Africa	19.5	1.1	1.2	0.9	3.0
	Western Africa	27.6	1.1	1.3	1.0	3.0
Americas	Caribbean	25.5	1.0	1.0	0.7	2.1
	Central America	22.4	1.0	1.1	0.8	2.6
	South America	21.1	1.0	1.1	0.8	2.5
	North America	-4.5	1.6	2.1	1.6	4.4
Asia and the Pacific	Eastern Asia	6.3	1.3	1.7	1.2	3.2
	South-East Asia	25.6	0.8	1.0	0.8	2.2
	Pacific Islands	21.8	1.0	1.2	1.0	2.6
	Southern Asia	20.5	1.1	1.4	1.0	3.0
Europe and Central Asia	Northern Europe	3.8	1.5	1.8	1.5	3.3
	Southern Europe	13.5	1.2	1.6	1.1	2.8
	Western Europe	9.7	1.2	1.5	1.2	2.9
	Eastern Europe	-4.6	2.0	2.4	1.8	4.8
	Central Asia	7.8	1.8	1.8	1.6	3.8
	Western Asia	11.5	1.2	1.5	1.1	3.1

Source: IPCC (2022)
Note: South-East Asia estimated are highlighted in orange

Given the temperature projections for Southeast Asia, some climatic events are characterized as virtually certain – indicating that regardless of actions to decrease emissions, these events are unavoidable. Regarding climate events, one of the major concerns for the SEA region is hot extremes. Table 2.5 shows that the frequency of hot extremes is *virtually certain* to increase at various global warming levels.

Table 2.5 Likelihood of extreme climate events for Southeast Asia at different global warming levels

	Observed	1.5℃	2℃	4℃
Hot extremes	High confidence (likely) increases	High confidence (very likely) increases	High confidence (extremely likely) increases	High confidence (virtually certain changes) increases
Heavy precipitation	Medium confidence decreases	High confidence increases	High confidence (likely) increases	High confidence (extremely likely) increases
Agricultural/ecological drought	Low confidence	Low confidence	Low confidence	Low confidence
Hydrological drought	Low confidence	Low confidence	Low confidence	Low confidence

Source: IPCC (2022)

2.2. High temperatures and its relation to public health

As the world gets warmer due to climate change, several health concerns are projected to increase. A 2022 report by the IPCC found that "climate-related illnesses, premature deaths, all forms of malnutrition, as well as threats to both mental health and wellbeing are increasing"[10]. Among the risks discussed in the report, heat-related morbidity and mortality, as well as a rise in climate-sensitive food-borne, waterborne, and vector-borne diseases, are among the public health concerns that are worsened by rising temperatures[11].

[10] IPCC (2022)

[11] Ibid

To further explore how rising temperatures could impact public health, this subsection opens with an explanation of the biological processes that occur during exposure to warmer environments. This is then followed by a breakdown of heat-related illnesses that may occur if the surrounding temperature is higher than our ability to cool. It also explores how heat can impair certain body functions, particularly for individuals with non-communicable diseases. Lastly, this subsection investigates how warmer temperatures may lead to a rise in various climate-sensitive diseases.

Rising heat stress and incidences of heat-related illnesses

Heat is a critical and growing threat to human health, and as global temperatures rise, instances of heat stress can become increasingly common. Heat stress refers to when the heat received is more than what the body can tolerate without suffering physiological impairments[12]. For our survival, the body needs to maintain a relatively constant core body temperature of around 36°C to 38°C[13] . Any temperatures above or below that can be hazardous for human health.

Thermoregulation is a process that maintains a steady internal body temperature despite changes in the external environment. The core body temperature needs to remain relatively stable at 37°C, and thus, thermoregulation ensures that the body can prevent the loss of excess heat on a cool day or release body heat on warmer days.

In addition to temperature, moisture has also long been understood as an element of heat stress. How a person feels heat is dependent on their ability to regulate their internal body temperature and, thus, their ability to release excess heat via evaporation (sweating). If local moisture conditions are high, it can reduce the effectiveness of evaporation, causing the body to store more heat[14]. Hence, heat stress is maximised during instances of both high temperatures and high humidity.

However, there are physical limitations in our body's ability to manage heat[15]. In cases where the heat strain taken on by the body is beyond the individual's ability to cool, it can trigger dangerous physiological responses or pathways. The inability to cope with this heat load can then result in medical conditions referred to as heat-related illnesses (HRI).

HRIs can range in severity, with heat stroke being the most severe and potentially fatal. The spectrum of heat-related illnesses and their respective symptoms is summarised in Table 2.6.

Table 2.6 Summary of the spectrum of heat-related illnesses and their associated symptoms

Severity	Heat-related illness	Symptoms
Mild	Heat Edema	• Swelling of the hands and feet-may develop in unacclimatized individuals exposed to a hot environment. • Appears in a few days of exposure to a hot environment

[12] Buzan and Huber (2020)

[13] Ibid

[14] Ibid

[15] Milman (2021)

Mild	Prickly heat	• Appearance of rashes normally throughout covered areas of the body • Itchiness • Repeated heat exposure may lead to chronic dermatitis
Mild	Heat cramps	• Painful spasms develop in limb and abdominal muscles (calves, thighs and shoulders) subjected to intensive work and fatigue. • It occurs in individuals sweating profusely and only drinking water or using hypotonic solutions. • Limited in duration and muscle groups • Body temperature hardly rises
Mild	Heat tetany	• Hyperventilation (shortness of breath) • Experience numbness, tingling (paresthesia), or muscle spasms
Mild	Heat syncope	• Transient loss of consciousness (fainting) • High cardiovascular stress and reduced cardiac output • Frequent pallor, blurring of vision, dizziness and nausea • Mild dehydration • Common in non-acclimatized elderly
Moderate	Heat exhaustion	• Headache, Nausea, Vomiting • Malaise, Dizziness • Muscle cramps • Moderate hyperthermia (temperature less than 40°C or normal) • Severe dehydration • May progress to heat stroke if it fails to improve with treatment
Severe	Heat stroke	• Extreme body temperature (above 40 °C) leads to damage to cellular structures and the thermoregulatory system, with a high risk of mortality. • Experience confusion, delirium, and/or seizures • Kidney and/or liver failure • Hot, dry skin with cessation of sweating

Source: MOH (2016)

The risks and severity of HRI are heavily influenced by environmental conditions. Higher temperatures and humidity are often associated with an increased risk of HRI. At the same time, the exposure risks of HRI can vary by age, weight, physical fitness, and medical condition (which will be further explored in Section 4).

Warmer temperatures and its effects on other health issues

The impact of higher temperatures on public health is not only limited to heat-related illnesses. Hotter temperatures can exacerbate a range of health conditions, particularly those that are sensitive to heat or exacerbated by dehydration[16]. Some of the health conditions that can worsen in hotter temperatures include:

[16] Mora et al. (2017)

Table 2.7 Health conditions that are worsened in hotter temperatures

Respiratory Conditions	Hot weather can worsen symptoms of respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), and bronchitis. It can also lead to increased air pollution and the formation of ground-level ozone, which can irritate the airways and trigger respiratory symptoms.
Cardiovascular Conditions	Hot temperatures can strain the cardiovascular system, leading to increased heart rate, blood pressure, and workload on the heart. This can exacerbate symptoms in individuals with heart disease, hypertension (high blood pressure), and other cardiovascular conditions
Kidney Disease	Dehydration, which can occur more readily in hot weather, can strain the kidneys, and worsen symptoms in individuals with kidney disease. It can also increase the risk of kidney stones and urinary tract infections
Neurological Conditions	Hot weather can worsen symptoms in individuals with neurological conditions such as multiple sclerosis (MS), Parkinson's disease, and epilepsy. Increased body temperature can also lead to heat sensitivity and exacerbate symptoms such as fatigue, weakness, tremors, and seizures.
Diabetes	Dehydration and heat stress can lead to fluctuations in blood sugar levels, increasing the risk of hyperglycemia (high blood sugar) or hypoglycemia (low blood sugar) episodes
Skin Conditions	Increased sweating and humidity can irritate the skin and trigger flare-ups of skin conditions such as eczema and psoriasis.

Source: Author's compilation

Additionally, rising temperatures induced by climate change can exacerbate the spread and impact of vector-borne diseases by creating more favourable conditions for transmission. Warmer temperatures can impact vector-borne diseases by expanding and redistributing the burden of these diseases, shifting regions towards optimal transmission conditions for some parasites while pushing temperatures towards upper limits for other vectors and pathogens, ultimately increasing the risk of transmission[17]. Vector-borne diseases such as Dengue, Malaria, and Chikungunya are likely to worsen in warmer temperatures.

Climate change may also alter pathogens and host animal's behaviours, which could result in the emergence of novel diseases in new areas, more frequent and larger outbreaks, and longer or shifted seasons of transmission[18]. This, in turn, increases the exposure and vulnerability of the global human population towards these vector-borne diseases.

Furthermore, antibiotic and antimicrobial resistance are predicted to increase as a direct and indirect consequence of climate change[19,20]. Higher local temperatures have been associated with greater incidence of resistant infections as some common pathogens are now more resilient against antibiotics[21], which can negatively affect the treatment of these infections.

[17] IPCC (2022)

[18] Ibid

[19] "Antimicrobial Resistance and Climate Change" (2025)

[20] Wong (2024)

[21] MacFadden et al. (2018)

3. Malaysia's vulnerability to heat-related health issues

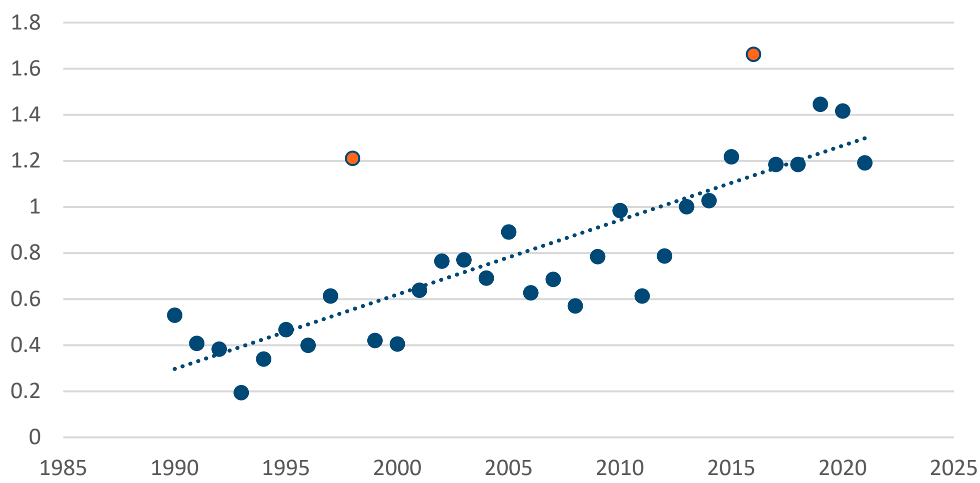
The adaptive capacity of Malaysians to regulate their body temperature across various forms of activities and to manage other heat-related health risks is essential in facing climate change. Thus, it is crucial to explore the various ways rising temperatures and extreme heat events can affect health in Malaysia's current and future environment. The section begins by discussing Malaysia's temperature gains, projections, and other climate factors that can influence heat (subsection 3.1). Next, it looks at public health concerns that can be worsened by heat. Particularly looking at heat-related illnesses in Malaysia (subsection 3.2) and the influence of heat on noncommunicable diseases and other vector-borne diseases (subsection 3.3).

3.1. Malaysia's temperature is increasing and trending upwards

Keeping the variance of temperature gains in mind, it is then important to contextualise how Malaysia's own climatic patterns have evolved in the past few decades. Overall, Figure 3.1 shows that Malaysia has faced increasing annual surface temperature in the past three decades. Particularly, from 2013 onwards, Malaysia's surface temperature has been at least 1°C higher than the average surface temperature during the 1951-1980 period. Concurrently, both Malaysia's minimum and maximum temperatures have increased, which is in line with the findings from the IPCC report, which predicted there would be an increase in hot extremes in the Southeast Asia region.

It is also worth noting that the annual surface temperature change was significantly higher during 1998 and 2016 (marked in orange), which reported a 1.21°C and 1.66°C temperature gain, respectively. One of the greatest influences on Malaysia's temperature is the ENSO's El Nino phase, which tends to result in higher average temperatures and decreased precipitation. 1998 and 2016 were among the years in which Malaysia experienced an El Nino phase and, thus, explains the sharp rise in temperature gain in its adjacent years. Further details on ENSO are described in Box 2.

Figure 3.1 Malaysia's annual surface temperature change, 1951-2021

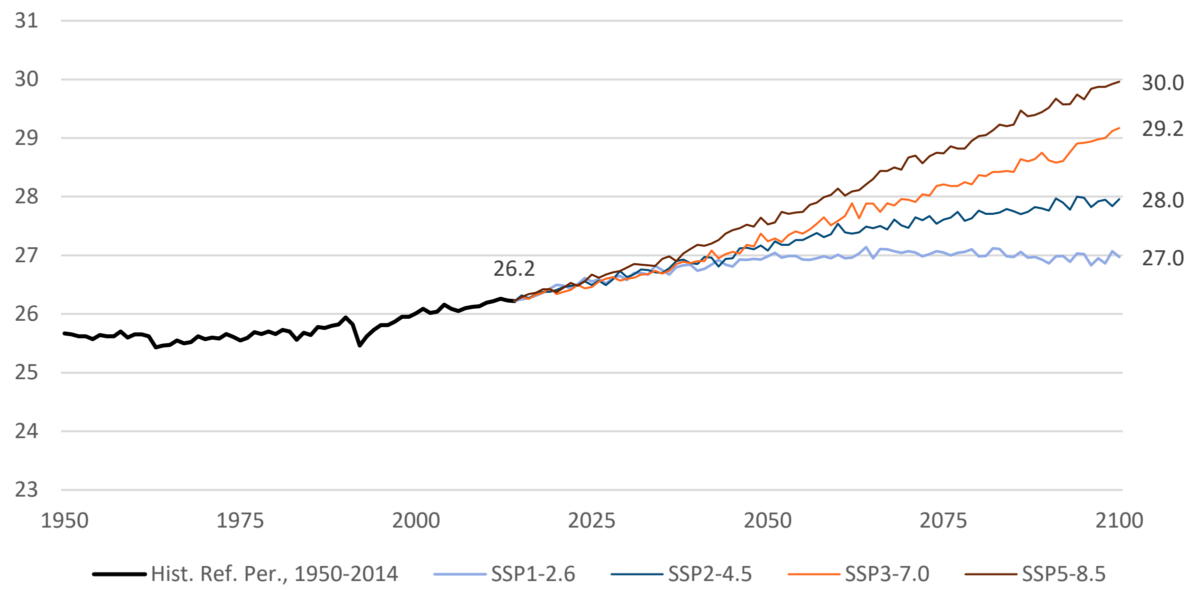


Data source: World Bank (2023)
Note: Points highlighted in orange were years with strong El Nino events

In addition to Malaysia's past temperature increase, IPCC models projects that Malaysia's mean temperature will increase regardless of the emission scenario (see Figure 3.2). Even under the most positive emissions scenario, where global emissions will reach net-zero by 2050 (SSP1-2.6), Malaysia's average mean temperature will still increase to 27.0°C, by 2100. Meanwhile, if the total emissions continue to increase, Malaysia could face mean temperatures between 29.2°C, – 30.0°C, by 2100.

However, as Malaysia only contributes a small fraction of global emissions, and thus is unlikely to limit warming through the reduction of its own emissions alone. Thus, Malaysia's capabilities in facing rising temperatures lie largely in its ability to adapt nationally to the various temperature increase scenarios. Concurrently, climate negotiations with countries that produce higher emissions may have greater impact in limiting temperature rise. Hence, Malaysia should prepare to adapt for higher warming scenarios whilst simultaneously strategically negotiating with other countries at the UNFCCC for the best mitigation outcomes to reduce warming of global temperatures.

Figure 3.2 Malaysia's average mean temperature projections based on different emission scenarios, 1950-2100,(℃)



Data source: World Bank (2023)

Aside from Malaysia's observed temperature gains in the past few decades, Malaysia's weather patterns are influenced by the monsoon season as well as the El Nino-Southern Oscillation (ENSO). Typically, ENSO's effect on Malaysia leads to drier than usual conditions during El Nino and wetter than usual conditions during La Nina[22]. As a result, there are slight annual, seasonal, and monthly variations in Malaysia's temperature and precipitation, with some days and months being much hotter than others.

[22] Tan et al. (2021)

Box 2: ENSO and its effects on Malaysia's climate

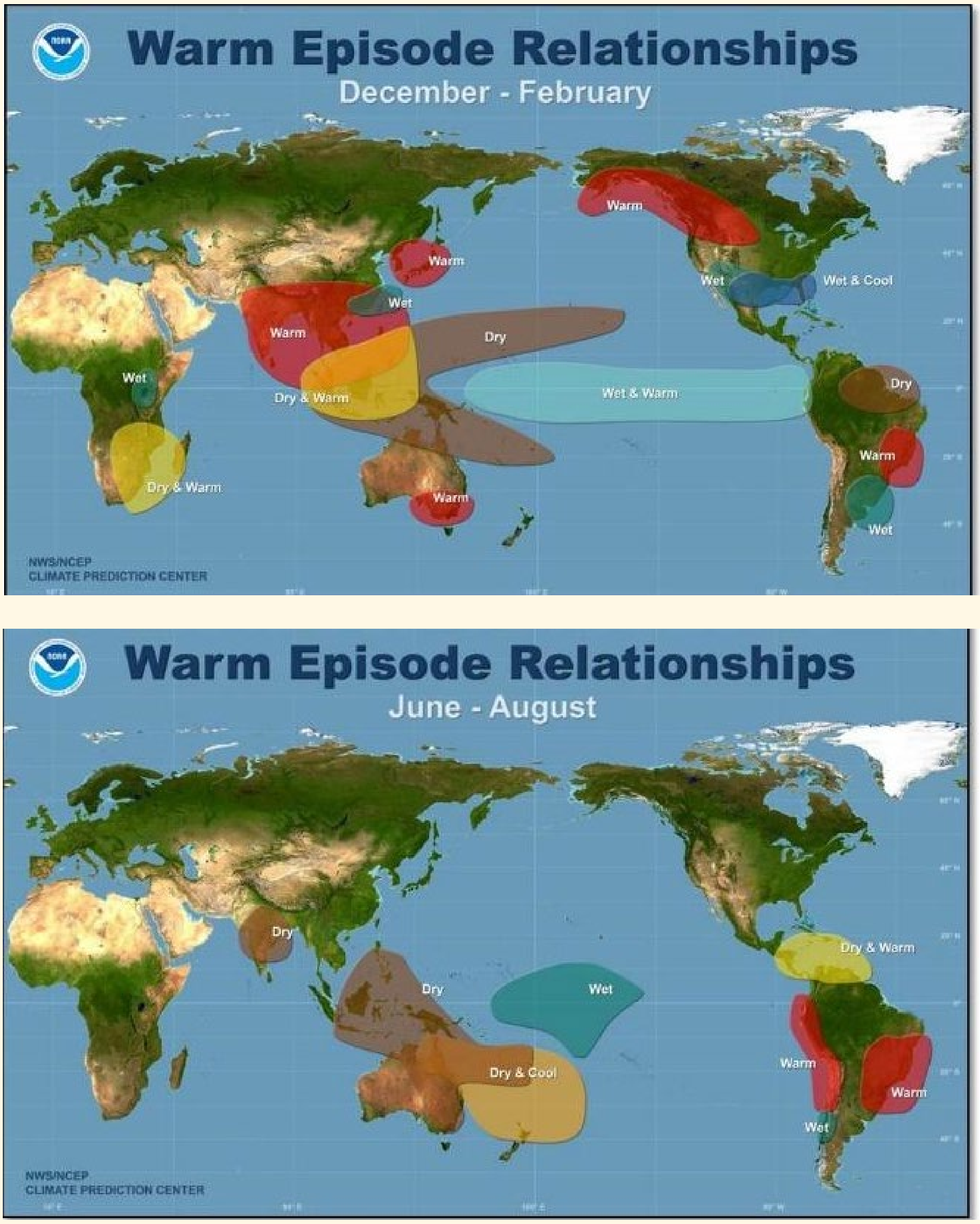
El Nino-Southern Oscillation (ENSO) refers to the periodic fluctuation that occurs every two to seven years. ENSO involves the variation in sea surface temperature (El Nino)[23] and atmospheric air pressure above the equatorial Pacific Ocean (Southern Oscillation)[24]. ENSO is considered a teleconnection[25] phenomenon, whereby ENSO's alterations result in weather changes in most parts of the world. Thus, ENSO has an influence on atmospheric circulation, temperature patterns, and precipitation abnormalities in various regions across the globe[26].

ENSO oscillates between phases of El Nino, La Nina and Neutral. These phases are determined by the Southern Oscillation Index (SOI) and the Oceanic Nino Index (ONI). SOI is the oldest ENSO index, which measures the normalized surface pressure between Tahiti and Darwin[27]. Meanwhile, ONI measures 3-month running means of Sea Surface Temperatures (SST) in a central Pacific region defined as Nino 3.4[28].

El Nino and La Nina represent the contrasting stages of ENSO, whereby the typically cool waters of the equatorial eastern Pacific Ocean undergo a warming phase (El Nino) or a cooling phase (La Nina), surpassing their expected temperature conditions (Neutral). During the El Nino stage, the atmospheric pressure is higher in Darwin and lower in central Pacific, which causes the SOI to read as positive. A positive SOI reading means the winds are weakened or may even reverse direction. When this happens, the warm water in the western Pacific sloshes back toward the eastern Pacific, near South America. Meanwhile, during La Nina, the winds get stronger than usual, pushing even more warm water toward the western Pacific. This makes the water near South America cooler than usual.

[23] "WMO Update: Prepare for El Niño" (2023)
[24] National Centre for Environmental Education
[25] Fountain (2023)
[26] Mock (2014)
[27] McGregor and Ebi (2018)
[28] Glantz and Ramirez (2020)

Figure 3.3 Global map of ENSO affected regions



Source: NOAA (2024)

ENSO largely influences the climate variability over Malaysia and the greater Southeast Asian region interannually[29]. During an El-Nino event, the usual westward trade winds weaken and reverse, bringing warm water from the Western Pacific to northern South America[30] , causing this region to be warmer than usual. The combination of accumulated water, changes in air pressure, and wind speed causes drastically increased rainfall in South America, while Indonesia, Malaysia, the Philippines, and Australia experience reduced rainfall and droughts [31] [32].

Additionally, the Southeast Asian climate exhibits variations within a single season as well as from year to year due to the Madden-Julian Oscillation (MJO)[33]. Both MJO and ENSO result in significant changes in tropical convection, large-scale circulation, and global weather patterns. Despite being completely different weather phenomena, the ENSO and MJO influence one another[34]. On one hand, an intensified MJO has the potential to activate westerly wind bursts, thus triggering the onset of El Nino[35,36]. On the other hand, strong eastward MJO can result in the abrupt weakening of El Nino events[37,38].

Table 3.1 Episodes of El Nino and La Nino by intensity, 1951-2022

El Nino				La Nina		
Weak	Moderate	Strong	Super	Weak	Moderate	Strong
1951-52	1963-64	1957-58	1982-83	1950-51	1955-56	1973-74
1952-53	1986-87	1965-66	1997-98	1954-55	1970-71	1975-76
1953-54	1987-88	1972-73	2015-16	1964-65	1998-99	1988-89
1958-59	1991-92			1967-68	1999-00	
1968-69	2002-03			1971-72	2007-08	
1969-70	2009-10			1974-75	2010-11	
1976-77	2014-15			1983-84	2020-21	
1977-78	2018-19			1984-85	2021-22	
1979-80				1995-96		
1994-95				2000-01		
2004-05				2011-12		
2006-07						

Source: NOAA (2024)

As seen in Table 3.1 above, Malaysia has had alternate cycles of El Nino and La Nina at varying intensities. From the past El Nino events recorded below, 2015-2016 recorded a very strong El Nino event, which is when the sea surface temperature on critical parts of the Pacific Ocean

[29] Tangang et al. (2012)
[30] Khor et al. (2021)
[31] Khor et al. (2021)
[32] US Department of Commerce (n.d.)
[33] Tangang et al. (2020)
[34] Li et al. (2023)
[35] Lau and Chan (1988)
[36] Bergman, Hendon, and Weickmann (2001)
[37] Takayabu et al. (1999)
[38] Miyakawa et al. (2017)

warmed up to at least 2°C above normal[39]. In comparison, a moderate El Nino experiences a warming of between 1-1.5°C, while a strong El Nino has a warming of at least 1.5°C. It was during the 2015-2016 El Nino event Malaysia saw a large increase in the number of days that exceeded 35°C.

While the ENSO itself is a national phenomenon, climate change may exacerbate the impacts of ENSO. For example, climate change can cause the El Nino period have more prolonged and extreme hot and dry conditions. Meanwhile, rising ocean temperature – which can hold more heat with increase evaporation rate and melting glaciers – can result in more severe extreme weather events, particularly during La Nina or monsoon seasons.

Humidity, an amplifier of Malaysian heat

As mentioned in Section 2.2 earlier, humidity is an important component in discussing how the human body responds to the current air temperature. Thus, in addition to temperature, measurements such as the Heat Index or Wet Bulb Globe Temperature (WBGT) can be used to estimate the combined heat effects of temperature and moisture. While both are used as a guideline for determining a safe threshold for heat exposure, they may have different use-case scenarios. A summary of the differences between these measurements is listed below (Table 3.2).

Table 3.2 Summary of the heat index and wet bulb globe temperature indicators

Heat Index	Wet Bulb Globe Temperature
Calculated by ambient temperature and humidity level	Calculated by ambient temperature, humidity level, wind speed, sun angle, and cloud cover
Formulated mainly for shady areas	Formulated for areas in direct sunlight
Often known as the 'real feel temperature'	Often used as a guide to manage workload in direct sunlight
Scales are usually higher than the ambient/dry bulb temperature	Scales are usually lower than the ambient/dry bulb temperature

Source: NOAA (2024)

Table 3.3 shows the relationship between temperature and relative humidity, using the heat index as the metric on how our body 'feels' the temperature to be. For example, when the temperature is at 30°C with a relative humidity of 50%, the person is likely to experience the temperature as 31°C. However, at the same 30°C temperature but with a relative humidity of 65%, the person would experience temperature conditions of 34°C. This illustrates that higher relative humidity causes the temperature to feel warmer despite both having the same air temperature.

[39] NOAA

The heat felt at these various combinations of temperature and humidity then leads to different vulnerabilities towards heat-related illnesses. Table 3.4 highlights the range of heat index levels and their corresponding risk levels.

Table 3.3 Heat health index at varying air surface temperature and relative humidity, (℃)

Relative Humidity	Temperature (℃)															
	27	28	29	30	31	32	33	34	36	37	38	39	40	41	42	43
40%	27	27	28	29	31	33	34	36	38	41	43	46	48	51	54	58
45%	27	28	29	31	32	34	36	38	40	43	46	48	51	54	58	
50%	27	28	29	31	33	35	37	39	42	45	48	51	55	58		
55%	27	29	30	32	34	36	38	41	44	47	51	54	58			
60%	28	29	31	33	35	38	41	43	47	51	54	58				
65%	28	29	32	34	37	39	42	46	49	53	58					
70%	28	30	32	35	38	41	44	48	52	57						
75%	29	31	33	36	39	43	47	51	56							
80%	29	32	34	38	41	45	49	54								
85%	29	32	36	39	43	47	52	57								
90%	30	33	37	41	45	50	55									
95%	30	34	38	42	47	53										
100%	31	35	39	44	49	56										

Source: NOAA (2024)

Table 3.4 Risk categories of heat index readings

Heat Index	Category	Description
27-32	Caution	Fatigue is possible with prolonged exposure and activity. Continuing activity could result in heat cramps.
32-41	Extreme Caution	Heat cramps and heat exhaustion are possible. Continuing activity could result in heat stroke
41-54	Danger	Heat cramps and heat exhaustion are likely; heat stroke is probable with continued activity
>54	Extreme Danger	Heat stroke is imminent.

Source: NOAA (2024)

On average, Malaysia's relative humidity ranges between 65%RH to 95%RH[40]. Given our country's high relative humidity, it is an important element when discussing the effect of rising temperatures on Malaysians. At 65% RH, temperatures between 30-32°C result in a heat index of 34-39°C, of which the risk is categorised as extreme caution. At a temperature of 33°C with the

[40] However, the range of relative humidity can vary by month and location.

same relative humidity, the heat index is at 42°C, and the risk category is at 'danger', where heat cramps and heat exhaustion are likely, while heat stroke is probable with prolonged activity. Thus, in the current climate, Malaysia is already vulnerable to heat-related illnesses.

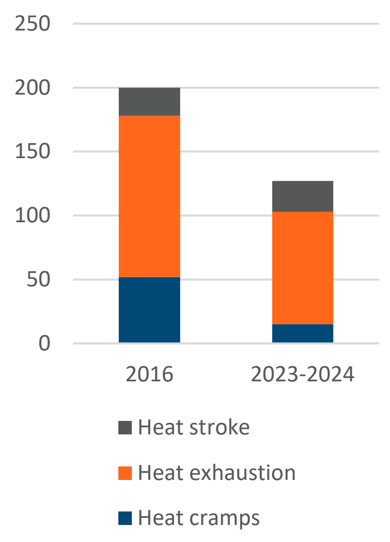
3.2. Past and future exposure to heat-related illnesses in Malaysia

Previous incidences of heat-related illnesses in Malaysia

Malaysia's combination of high temperatures and high humidity exposes its people to heat-related illnesses. This risk further increases during the El Nino phase when Malaysia is likely to experience higher average temperatures. During the 2015-2016 El Nino, it was reported that there were 200 cases[41] of heat-related illnesses, of which 2 were fatalities resulting from heatstroke.

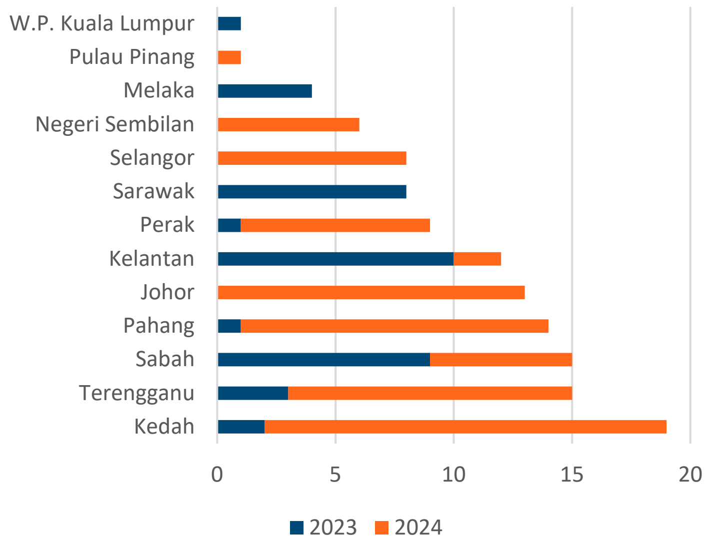
In the 2023-2024 El Nino occurrence, there has been a total of 127 cases of heat-related illnesses reported of which 5 were fatalities (2 fatalities in 2023, 3 fatalities in 2024)[42]. Among the 127 reported cases, 11.8% (15 cases) were for heat cramps, 69.3% (88 cases) were for heat exhaustion, and the remaining 18.9% (24 cases) were due to heat stroke. While the 2015-2016 El Nino occurrence recorded a higher number of cases, the recent El-Nino period proved to be more deadly as it recorded higher instances of heat stroke and fatalities.

Figure 3.4 Total number of heat-related illnesses reported, by type, 2016 and 2023-2024



Source: NADMA (2024), Malaysiakini (2023), The Star (2016)

Figure 3.5 Total number of heat-related illnesses reported, by state, 2023-2024



Source: NADMA (2024), MalaysiaNow (2023)

[41] Breakdown of the cases: 52 cases (26%) of heat cramps, 126 cases of heat exhaustion (63%) and 22 were due to heat stroke (11%).

[42] As of June 2024

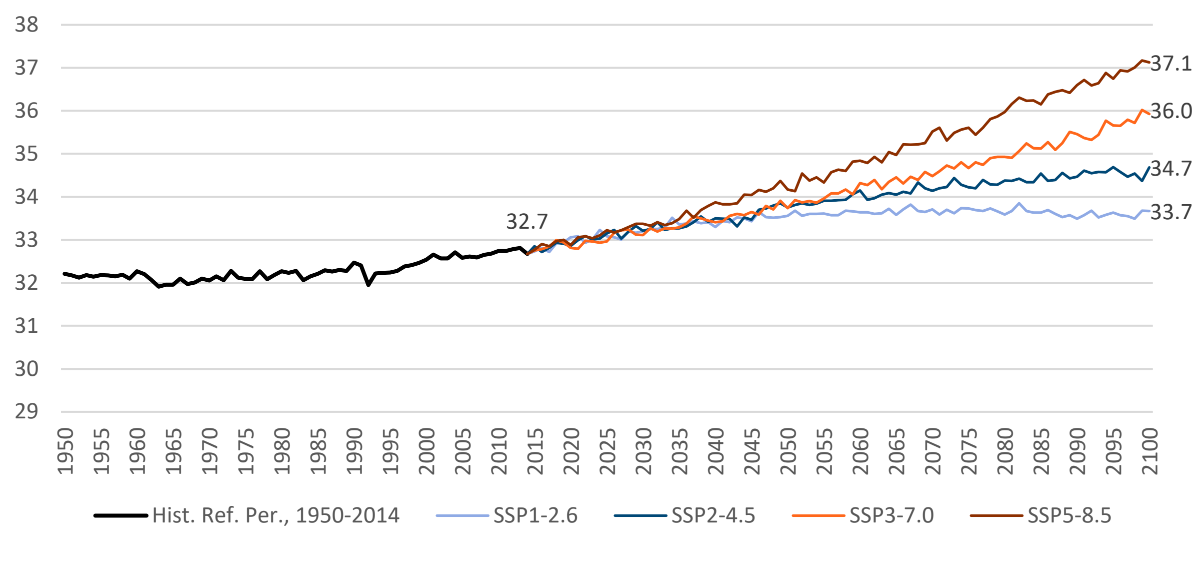
When breaking down by state, Kedah reported the highest number of heat-related illnesses, with a total of 19 cases (Figure 3.5). This is then followed by Terengganu and Sabah, both having 15 cases each. There are also several states that recorded a high number of heat-related illnesses in 2023 but had no cases in 2024, and vice versa. An example of this is Johor, which recorded 13 cases only in 2024, or Sarawak, which had 8 cases in 2023 but no reported cases in 2024.

However, aside from the aforementioned years above, the public reporting of heat-related illnesses in Malaysia has been notably lacking. While Malaysia experienced a moderate-intensity El Nino event in 2018-2019, there were no mentions if there were any incidences of heat-related illnesses during that period. It is also unclear whether there were any reports of heat-related illnesses during the La Nina years as well. The unavailability and inconsistency of the reports on heat-related illnesses indicates Malaysia's low reporting and lack of surveillance on these issues.

Future vulnerabilities to heat-related illnesses

Malaysia's projected temperature increase is also expected to be accompanied by higher maximum temperatures (Figure 3.6) as well as having more days in which the average temperature exceeds 30°C or 35°C (Figure 3.8). Whilst the intensity of the temperature increase is dependent on the world's emissions scenario, even the most positive outlook (SSP1-2.6) projects that Malaysia's average maximum temperature will increase. At SSP2-4.5, which is if global emissions will begin decreasing in 2050, Malaysia may experience an average maximum temperature of 34.7°C compared to its current average of 32.7°C.

Figure 3.6 Malaysia's average maximum temperature projections based on different emission scenarios, 1950-2100, (℃)

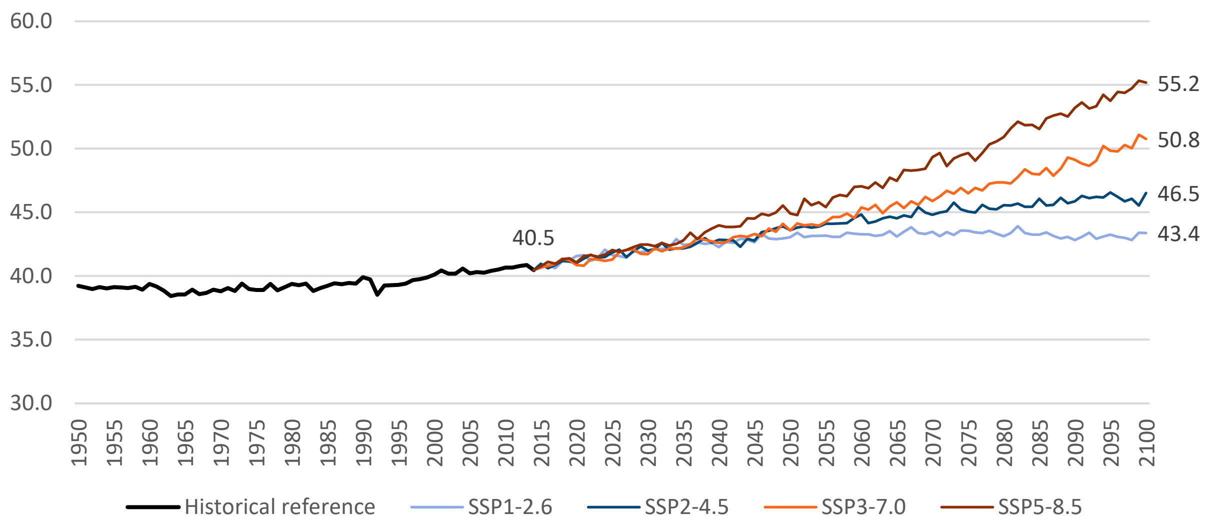


Data source: World Bank (2023)

Concerningly, when accounting for Malaysia's relative humidity, the realities of the temperature gain may be a lot more dire (Figure 3.7). Looking at a 65% relative humidity, which is the lower end of Malaysia's relative humidity, an average maximum temperature of 32.7°C equates to a heat index of 40.5°C –of which the risk category of heat-related illnesses is at extreme caution.

However, with the SSP1-2.6 and SSP2-4.5 emissions scenario, the average maximum heat index can reach 42.8°C and 46.5°C, respectively, by 2100. Both heat indexes place the risk category of heat-related illnesses in *Danger*, which is the heat index range where heat cramps and heat exhaustion are likely, while heat stroke is probable with continued activity. In the worst-case scenario, where emissions keep increasing and doubling by 2050 (SSP5-8.5), Malaysia's average maximum heat index can reach 55.1°C by 2100, placing a much higher risk of heat stroke.

Figure 3.7 Heat index for projected average maximum temperature, at 65% humidity, by warming scenarios, 1950-2100, (℃)



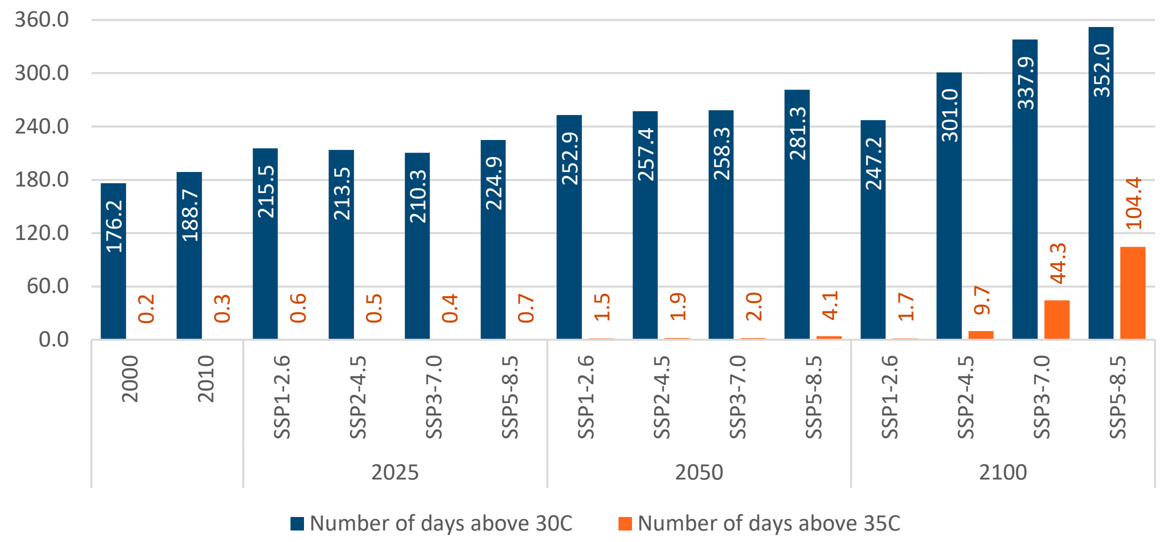
Data source: World Bank (2023)

On top of having higher maximum temperatures, Malaysians are also more likely to face more hot days (when average temperatures exceed 30°C) and extreme hot days (when average temperatures exceed 35°C). Again, when accounting for humidity, this places the risk of heat-related illnesses at 'extreme caution' for days that are above 30°C and 'danger' for days above 35°C.

It is also important to note that Figure 3.8 only provides an average estimate of the number of days in that period. Previous instances of moderate, strong, and super El Nino have shown that the number of days that exceed 35°C greatly increases compared to other years[43]. Thus, it is also likely that future El Nino events may also lead to a greater number of days exceeding 35°C being experienced in that year.

[43] Tan et al. (2021)

Figure 3.8 Projected number of days with temperature above 30℃ and 35℃, by warming scenario, for 2025, 2050 and 2100



Data source: World Bank (2023)

The combination of having higher maximum temperatures as well as an increased frequency of hot days indicates that Malaysians will be exposed to higher levels of heat stress in the future. Additionally, the recent IPCC report found that globally, the rising global temperature is likely to place an added stress on the healthcare system. Thus, it is important to track and monitor who, where, and how different communities in Malaysia are exposed to heat-related illnesses to better prepare for future higher temperatures.

3.3. Other Malaysian public health concerns worsening in warmer temperatures

Rising temperatures impacts on noncommunicable diseases

In Malaysia, noncommunicable diseases (NCDs) have become the leading cause of death and disease burden[44]. As highlighted in the earlier Section 2.2, rising temperatures are not only a concern for heat-related illnesses, but they can also worsen a myriad of other health conditions[45]. Particularly, higher temperatures have been shown to adversely impact cardiometabolic[46] and respiratory conditions[47]. Furthermore, warmer temperatures and heat stress can induce or intensify respiratory diseases[48].

Over the past decade, ischaemic heart disease, which can worsen in higher temperatures, has been the top medically-certified cause of death[49] (Table 3.5). Additionally, among the ten

44 MOH (2023)

45 Baharom et al. (2021)

46 Ibid

47 D'Amato et al. (2014)

48 Ibid

49 Except in 2021, where the lead cause of medically certified cause of death was due to COVID-19 infections

principal medically certified causes of death include various health conditions that can worsen with heat, such as cerebrovascular diseases (such as stroke, aneurysm, or carotid artery diseases), chronic lower respiratory diseases, and diabetes.

Among non-medically certified causes of death, a majority is attributed to old age. Those who are elderly (aged 65 and above) are also more vulnerable to heat-related illnesses, and this is further explored in Section 4.2. There are also a few NCDs that were identified to be among the ten principal causes of non-medically certified deaths, such as diabetes, ischaemic heart disease, and asthma – all of which can be aggravated by heat stress. Thus, as temperatures are projected to rise, the strain NCDs have on healthcare resources is also likely to increase unless proper climate-health policies are in place.

Table 3.5 Malaysia's ten principal causes of death, medically certified and non-medically certified, 2015-2022, (%)

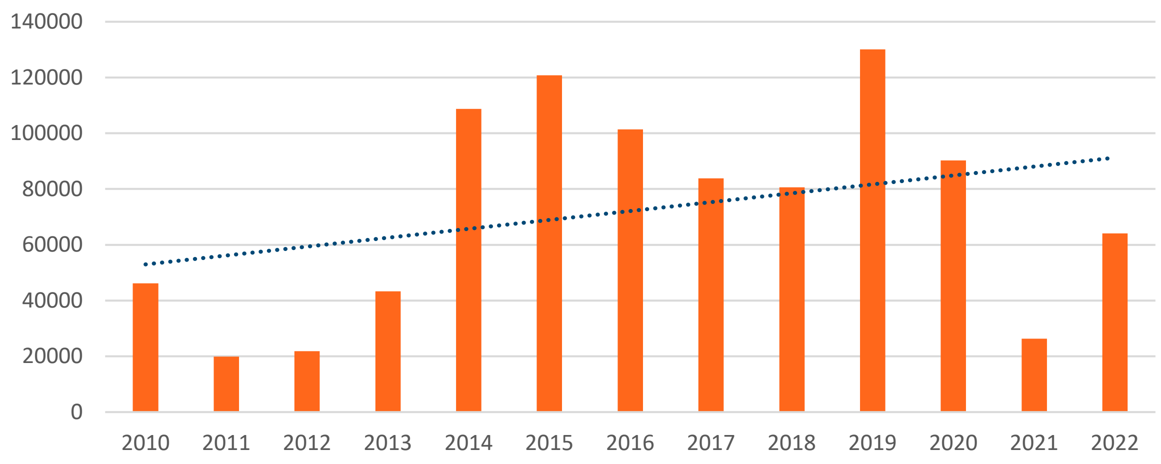
	2015	2016	2017	2018	2019	2020	2021	2022
Medically certified								
Ischaemic heart diseases	13.7%	13.2	13.9	15.6	15.0	17.0	13.7	16.1
Pneumonia	12.6	12.5	12.7	11.8	12.2	11.4	11.1	13.3
Cerebrovascular diseases	7.0	6.9	7.1	7.8	8.0	8.3	6.5	7.2
COVID-19 infection (due to)							19.8	4.2
Transport accidents	5.2	5.4	4.6	3.7	3.8	2.9	1.9	3.2
Malignant neoplasm of trachea, bronchus and lung	2.2	2.2	2.3	2.4	2.4	2.5	1.7	2.1
Chronic lower respiratory diseases	1.6	1.8	2.0	2.6	2.1	2.1	1.5	1.8
Malignant neoplasm of the colon, rectum and anus	1.3	1.4	1.6	1.8	1.7	2.0	1.4	--
Hypertensive diseases	-	-	1.3	1.9		1.9	1.7	1.7
Diabetes mellitus	-	-	-	2.5	1.8	2.0	1.8	1.7
Malignant neoplasm of breast	1.3	1.5	1.7	1.7	1.7	1.8	-	1.5
Liver diseases	1.7	1.7	1.6	-	1.5	-	-	-
Non-medically certified								
Old age 65 years and over	50.4	50.2	49.6	46.8	47.5	45.4	44.4	44.5
Hypertension	2.7	2.7	3.1	3.9	3.7	3.8	4.9	4.9
Diabetes mellitus	3.0	3.0	3.2	3.5	3.1	3.1	3.2	3.3
Cerebrovascular diseases	2.5	2.6	2.6	2.7	2.6	2.4	2.3	2.6
Ischaemic heart diseases	1.8	1.9	1.7	1.7	1.6	1.3	1.2	1.3
Colon, rectum and anus cancer	0.9	1.0	1.1	1.0	1.1	1.1	1.2	1.2
Trachea, bronchus and lung cancer	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Asthma	2.2	2.1	1.9	1.9	1.7	1.0	1.0	1.1
Liver cancer	0.8	1.0	0.9	0.8	0.8	0.8	0.9	0.9
Breast cancer	0.7	0.8	0.9	0.8	0.8	0.9	0.9	0.9

Note: For those with '-', this cause was not listed as the top ten principal cause of death for that year
Source: MOH (various years)

The challenge of dengue in the Malaysian context

Another public health concern that is brought on by rising temperatures is the rise in vector-borne diseases such as dengue, malaria, and chikungunya. Particularly, dengue has been a high public health concern for Malaysia, and cases have been dutifully tracked. Figure 3.9 shows the reported cases of dengue over the past decade. Noticeably, the two years with the highest number of reported dengue cases were in 2019 (130,101 cases) and 2015 (120,836 cases). Recent years have also shown that the number of reported dengue cases has been trending upward.

Figure 3.9 Total number of dengue cases reported in Malaysia, 2010-2022



Source: MOH (various years)

Various literature exploring the relationship between dengue and temperature has found that rising minimum temperatures can lead to an increase in dengue cases. Higher temperatures shorten the incubation period of Aedes mosquitos, leading them to mature at a faster rate thus exponentially increasing their population[50] [51].

Hence, as temperatures increase, the rising population of Aedes mosquitos may translate into an increase in dengue cases in Malaysia. This is further supported by Wang et al., which highlighted a notable increase in dengue fever in the next century under the SSP2-4.5 and SSP5-8.5 emissions scenario[52] where the projected mean temperature is at 27.0°C and 30.0°C, respectively, by 2100. In their paper, they estimated that peal dengue fever will rise from 487 cases per day in 2030 to 668 cases per day in the 2090s (1.37 times) under the SSP2-4.5 emissions scenario[53].

The current persistence of dengue, among other communicable diseases, continues to put pressure on the country's public health functions, such as outbreak response mechanisms and

[50] Cheong et al. (2013)
[51] Hii et al. (2016)
[52] Wang et al. (2023)
[53] Ibid

treatment capacity[54]. Thus, if not managed well, the increase in dengue cases driven by the rise in temperature can place a significant burden on the public health sector and may require growing resources to eliminate Aedes mosquito breeding grounds.

4. Compounding vulnerabilities in facing rising temperatures

While all Malaysians will experience warmer temperatures because of climate change, the degree to which they are vulnerable to heat-related health issues can vary. The health risks of Malaysians to rising temperatures is dependent on their exposure, sensitivity, and adaptive capacity (see Box 3). Thus, this section explores how certain demographic characteristics are more exposed to heat-stress compared to others. Particularly, it will cover how the location (section 4.1), age (section 4.2), and occupation (section 4.3) can all have varying health risks in hotter conditions.

Box 3: Defining climate risks

A complex climate risk model that incorporates several aspects of climatic impacts, vulnerabilities, and adaptive capacities was used in the most recent report from the Intergovernmental Panel on Climate Change (IPCC)[55]. The dynamic interplay among climate-related hazards, the susceptibility of natural and human systems, and their exposure to those hazards is what creates climate risk.[56]. Table 4.1 below provides definitions for exposures, vulnerabilities, and dangers.

Table 4.1: Definitions of hazards, exposures, and vulnerability as outlined in the IPCC report

Hazard	Current and future climate conditions. These conditions will determine the likelihood of an area being affected by extreme events (e.g. heatwaves or flooc or slow-onset events (e.g. sea-level rise).
Exposure	The presence of people, livelihoods, species, or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultu assets in places and settings that could be adversely affected
Vulnerability	The propensity to be adversely affected. It encompasses two main elements: • Sensitivity: The degree of which one is affected by climate variability • Adaptive capacity: The ability to adapt to potential damage or respond accordingly to climate events

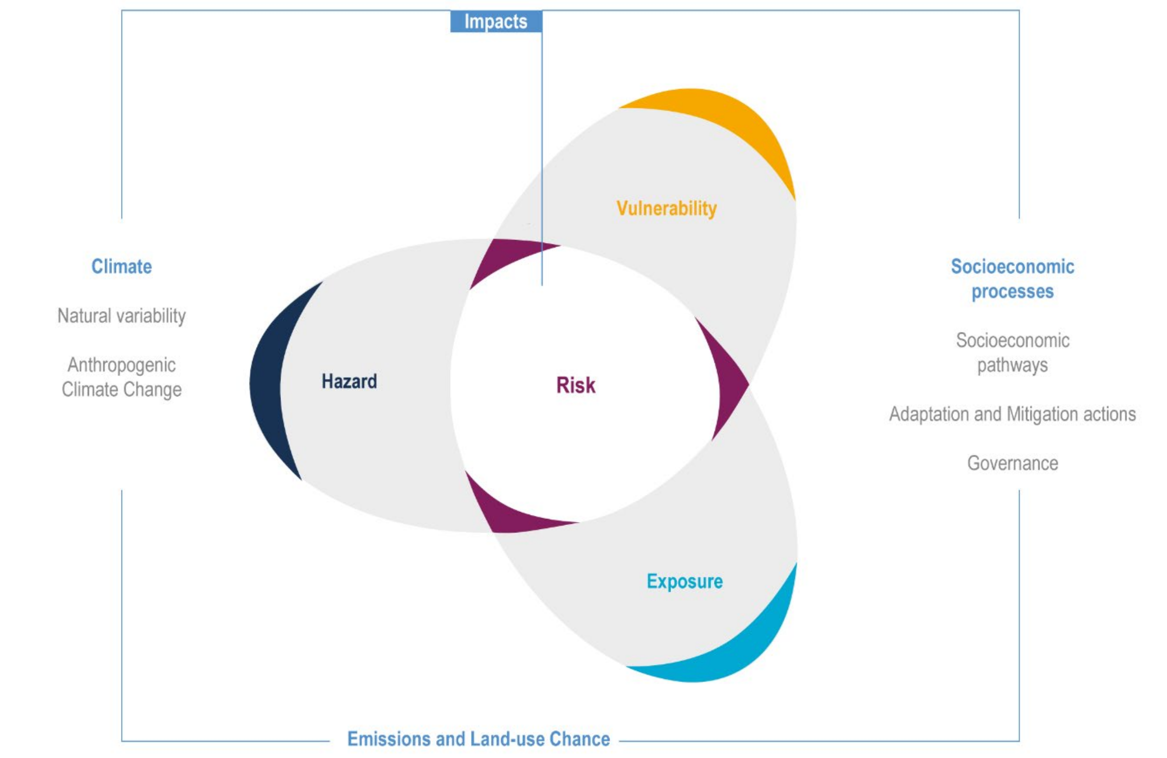
Source: IPCC (2022a)

The interdependence of several systems, including environmental, social, and economic ones, is highlighted by the IPCC model of climate risk (see Figure 4.1), which shows how changes in one area can have an impact on others[57]. It also emphasises how the effects of climate change can range greatly among various systems, social groupings, and industries. Due to their innate sensitivity or limited ability to adapt, certain industries, geographical areas, and communities may be more susceptible to climate[58]. As a result, groups and regions with greater

[54] MOH (2023)
[55] IPCC (2022)
[56] Ibid.
[57] IPCC (2022)
[58] Ibid.

vulnerabilities face higher risks from climate change, even when they are exposed to equivalent threats.

Figure 4.1 The IPCC model of climate risk



Source: Extracted from IPCC (2022a)

Identifying vulnerable areas and mapping socially vulnerable communities is essential in developing the overall climate risk landscape. The intersectionality between socioeconomic and climatic elements further highlights that managing climate risk is not only a scientific concern but a social one. Hence, climate adaptation should not be limited to managing hazards but must equally improve the adaptative capacity of affected communities.

4.1. Local climate variability within Malaysia

While Section 3.1 breaks down the past and future projections of mean temperatures at the national scale, it is important to highlight that temperature variability also exists within Malaysia itself. The differences in both temperature and climate, depending on where one is in Malaysia, are known as local climates.

Geographical characteristics such as hilly reliefs, proximity to the coasts, availability of rivers, lakes, and diversity of soil-vegetative cover can all influence mean temperatures and relative humidity[59]. There are also different kinds of local climates, the most prominent being urban, island and forest climate, which are further expanded in Table 4.2 below.

[59] Kobysheva (1989)

Table 4.2 Definition of local climate types

Urban local climate	Urban climate is influenced by buildings, streets, industry, and transport, leading to higher temperatures (urban heat island), reduced evaporation, and disturbed atmospheric circulation (urban breeze).
Island local climate	Island climate is influenced by the heat balance differences between land and water, leading to coastal breezes, especially in tropical regions. Temperature and humidity are greatly influenced by the heat properties of land and water. Meanwhile, rainfall patterns (precipitation) are dependent on the temperature of currents washing on the island.
Forest local climate	Forest climate, particularly in broad-leaved forests, is shaped by the upper surface of leaves and the ground surface. The soil temperature in forests is much lower in the summer / warmer temperatures compared to open country spaces.

Source: Kobysheva (1989)

District differences in temperature and relative humidity

Distinctions of the local climate then translate to different levels of mean minimum and maximum temperatures as well as mean relative humidity between states and districts in Malaysia. This is shown in Table 4.3, which records the mean minimum and maximum temperatures as well as mean relative humidity (RH) across districts in Malaysia for the years 2019 and 2022. The data reveals notable differences between these two years, influenced by distinct climatic phenomena: 2019 experienced El Niño conditions, whereas 2022 was characterized by La Niña conditions. Generally, the tables show a trend towards higher temperatures and lower relative humidity in 2019, which is typically seen during El Nino.

Comparing districts across different states, notable differences in maximum and minimum temperatures can be observed. In Kedah, Alor Setar experienced higher maximum temperatures of 33.3°C in 2019 compared to 32.2°C in 2022, while Pulau Langkawi saw its maximum temperatures drop from 32.5°C to 31.8°C. The minimum temperatures in these districts also exhibited similar trends of minor decreases or stability, indicating that while some areas experience significant changes, others remain relatively stable.

There were also several districts that had a mean maximum temperature of 33.5°C in 2019, an El Nino year for Malaysia. Places like Temerloh, Pahang and Kuala Kangsar, Perak, recorded a mean maximum temperature of 33.9°C and 33.6°C, respectively, in 2019, the two highest among the districts below. These districts are also among those that have consistently exhibited higher temperatures compared to others.

While there are several districts which had a mean maximum temperature exceeding 32.5°C (highlighted in orange) in 2019, there are only a few that exceeded that threshold for both 2019 and 2022. For instance, Subang, Selangor; Jerantut and Temerloh in Pahang; as well as the districts in Perak and Perlis, had persistently higher temperatures. Additionally, districts such as Kapit and Sri Aman, both in Sarawak, showed both high mean maximum temperatures and relative humidity. This may indicate they experience higher HHI, given the higher relative humidity, which may result in them feeling the high temperatures at greater intensity.

Conversely, Cameron Highlands in Pahang had the lowest mean temperatures and highest relative humidity, given its high altitude. These variations underscore the diversity in climatic conditions across different regions, influenced by geographical and environmental factors.

Table 4.3 Mean minimum, maximum temperature, and relative humidity of districts, 2019 and 2022, (℃)

State	District	2019			2022		
		Mean min temp	Mean max temp	Mean RH	Mean min temp	Mean max temp	Mean RH
Johor	Batu Pahat	24.1	32.5	80.2	24.2	32.0	83.1
	Kluang	23.9	32.3	79.9	23.8	31.7	83.4
	Mersing	24.1	32.5	Def.	24.1	31.5	83.9
	Senai	24.0	32.7	84.9	23.9	32.2	83.6
Kedah	Alor Setar	24.5	33.3	82.4	24.1	32.2	83.0
	Pulau Langkawi	25.8	32.5	78.7	25.5	31.8	78.4
Kelantan	Gong Kedak	24.2	32.0	80.4	23.9	31.3	84.6
	Kota Bharu	24.5	31.9	79.7	24.1	31.0	83.5
	Kuala Krai	23.2	33.0	Def.	23.4	32.3	86.2
Melaka	Melaka	24.5	32.5	76.6	24.2	31.6	80.8
Negeri Sembilan	Kuala Pilah	23.1	32.2	80.9	23.2	31.9	84.7
Pahang	Jerantut	23.4	33.5	84.7	23.7	32.7	84.4
	Cameron Highlands	15.7	22.6	87.4	15.8	22.4	88.1
	Kuantan	23.8	32.5	82.4	23.8	31.9	82.8
	Muadzam Shah	23.5	33.0	80.7	23.6	32.2	82.1
	Temerloh	23.8	33.9	81.8	23.7	32.9	83.2
Perak	Ipoh	24.3	33.4	78.3	24.1	33.1	77.3
	Kuala Kangsar	23.9	33.6	80.7	23.4	32.5	82.5
	Sitiawan	24.4	33.1	81.6	24.2	32.7	81.1
Perlis	Chuping	24.2	33.4	81.4	24.3	32.7	84.0
Pulau Pinang	Bayan Lepas	25.5	32.7	76.2	25.5	32.2	76.1
	Butterworth	24.7	32.4	78.6	24.4	31.5	82.9
Sabah	Keningau	22.2	32.6	80.2	22.3	31.3	83.3
	Kota Kinabalu	24.5	32.8	78.7	23.9	31.8	83.0
	Kudat	24.4	31.2	81.2	24.4	30.6	84.7
	Ranau	20.6	30.3	80.3	21.0	30.0	83.1
	Sandakan	24.5	31.7	80.9	24.5	31.2	84.0
	Tawau	23.7	32.1	82.0	23.6	31.4	84.9
Sarawak	Bintulu	24.0	32.0	86.0	23.7	31.7	Def.
	Kapit	24.2	33.4	86.1	23.7	32.5	85.8
	Kuching	24.1	32.5	84.0	23.6	31.8	86.3
	Limbang	23.7	33.3	84.0	23.7	32.4	84.1
	Miri	24.0	31.7	84.4	23.8	31.1	85.4

	Mulu	23.3	33.5	85.1	23.0	32.4	88.3
	Sibu	23.7	32.6	85.2	23.3	31.8	85.5
	Sri Aman	23.4	33.2	85.2	23.3	32.5	86.6
Selangor	KLIA Sepang	24.8	32.9	77.2	24.3	32.2	80.7
	Petaling Jaya	25.5	33.5	71.8	Def.	Def.	Def.
	Subang	24.9	33.6	79.1	24.7	32.9	77.2
Terengganu	Kerteh	23.9	31.4	85.5	23.9	31.1	85.4
	Kuala Terengganu	24.8	31.9	81.1	24.6	31.1	84.8
WP Labuan	Labuan	25.2	31.7	79.7	24.6	31.0	84.0

Note: The districts listed above is limited to those reported by DOSM, temperatures exceeding 32.5℃ is highlighted in orange
Note: Def. Refers to mixing values
Source: DOSM (2023)

The urban heat island effect

On top of the district temperature differences, urbanization can also influence the intensity of heat felt. The urban heat island (UHI) effect is a phenomenon where urban areas experience higher temperatures than their rural surroundings[60]. Previous studies investigating the UHI effect in selected Malaysian cities found that the heat island intensity can range between 2-7°C[61]. This temperature difference is most noticeable when winds are weak and during the evening after sunset. The factors that affect the UHI are explained further in Table 4.4 below.

Table 4.4 Summary of factors affecting urban heat islands

Surface albedo	Urban structures, such as buildings and roads, are often made from materials that have a lower albedo compared to natural landscapes, thus, these materials absorb more solar radiation and retain heat rather than reflecting it back into the atmosphere.
Heat absorption and retention	Concrete, asphalt, and other building materials used in urban areas have high thermal mass, meaning they absorb heat during the day and release it slowly at night, which keeps temperatures higher for longer periods compared to rural areas.
Lack of vegetation	Urban areas typically have less vegetation than rural areas. Plants and trees cool the air through a process called evapotranspiration, where water is evaporated from the soil and transpired from plant leaves, reducing air temperatures. The relative scarcity of vegetation in cities limits this cooling effect.
Waste heat	Cities produce a lot of waste heat from vehicles, industrial processes, air conditioners, and other energy use. This waste heat adds to the ambient temperature.
Modified wind patterns	The tall buildings and narrow streets of urban areas can reduce wind speeds. Wind normally helps to disperse heat and bring cooler air from the surroundings; however, in urban environments, the wind is often not strong enough to offset the heat generated.

[60] Deilami, Kamruzzaman, and Liu (2018)
[61] Kasniza Jumari et al. (2023)

Reduced sky view factor	The presence of tall buildings limits the amount of sky that can be seen from ground level, which reduces the area through which heat can radiate to space during the night.

Source: Deilami, Kamruzzaman, and Liu (2018)

Though the city's local climate is heavily influenced by the manmade construction in its environment, it can also be divided into smaller microclimate types. Urban design choices such as the width of streets, green planting, and elements of the building construction all contribute to the creation of these microclimates. This, in turn, can reduce the impact of UHI and the warming felt by those who live in these urban areas.

4.2. Age-related vulnerabilities in facing heat stress

Higher heat stress vulnerabilities among infants and children

Infants and children have different physiological characteristics when compared to adults and thus are more uniquely affected by heat stress. This is particularly notable among younger-aged children, especially those who are under the age of five. This, in turn, leaves them more vulnerable to both short- and long-term effects when exposed to conditions with higher temperatures.

Table 4.5 Summary of infant and children's physiological characteristics that expose them to higher heat stress vulnerabilities.

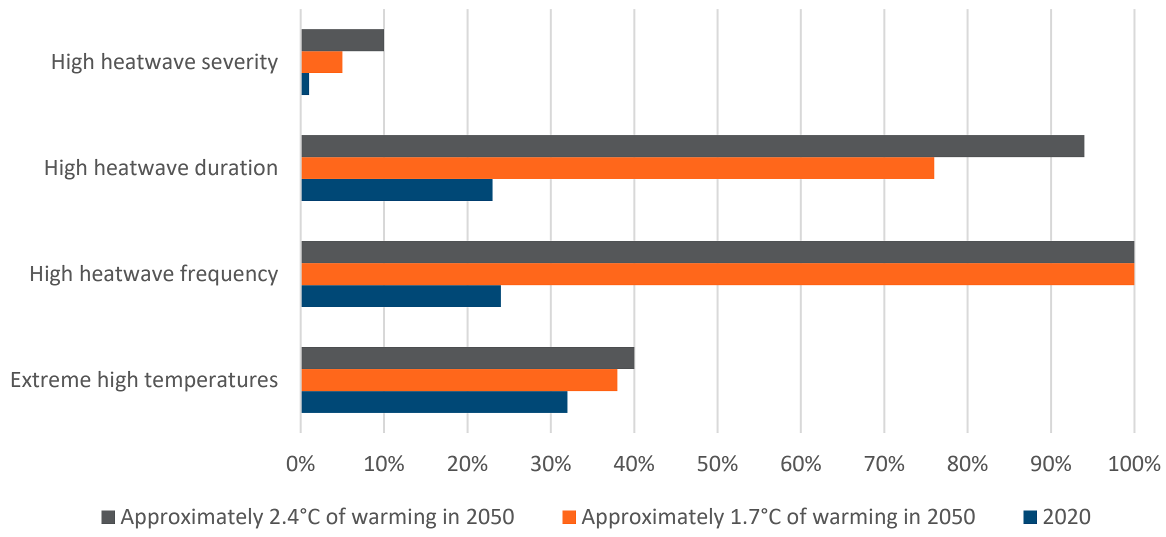
Higher heat production	Because they have more internal heat to begin with and move less economically per given activity, children produce more heat per kilogram of weight than adults do.
Greater body surface area	Younger children have a higher surface-area-to-mass ratio. This can lead them to absorb more heat from the environment, depending on their body and fitness levels. Conversely, this may be useful for heat dissipation in other environments.
Lower levels of sweat production	Children have a lower rate of sweating than adults do because of a lower sweat rate per gland, and they begin sweating at a higher body temperature.
Under-developed bodily systems	Infants experiencing heat stress are likely less capable of fighting off the symptoms, as they have under-developed sweat glands and less capacity for regulating their temperature independently. They also have a developing immune system, which potentially further diminishes their capability. In addition, heat stress in pregnant mammals was observed in recent studies to impair the immunological function of the offspring, further hindering the offspring's ability to regulate extra heat.

Slower adjustments to changes in weather	Infants and young children adapt to a hot environment more slowly than adults do, typically requiring 10–14 days to achieve adequate acclimatization. Similarly, when exercising, children and adolescents require 10–14 days to become acclimated, compared to 7 for adults with comparable activity per day.
Poorer practice of fluid replenishment	If not appropriately supervised, children are more likely to inadequately replenish fluid losses during prolonged exercise.

Source: UNICEF (2023)

Rising global temperatures lead to increased exposure and risks children towards heat stress. A 2021 UNICEF report found that by 2050, almost every child in the world (totalling nearly 2.2 billion) will be exposed to high heatwave frequency compared to only 24% of children in 2020. Currently, approximately 559 million children are exposed to high heatwave frequency, while 624 million children are exposed to at least one of the other three high heat measures (Figure 4.2).

Figure 4.2 Percentage of children worldwide affected by different heatwave measurements and projections based on various emission scenarios



Source: UNICEF (2023)

It is also worth noting that the effects of rising temperatures are not felt equally around the world. Infants who are from Africa, Western Pacific, and South-East Asia are exposed to more person-days of heatwaves compared to other geographical groups[62]. Furthermore, given that Malaysia's average and maximum temperatures are projected to increase within the next few decades, it is expected that this will lead to a rise in exposure and vulnerability of Malaysian children to heat stress.

[62] UNICEF (2023)

As of 2022, children (defined by DOSM as those aged 0-14) make up a total of 23.2% of Malaysia's population[63]. Among them, 31.5% of children were under the age of 5, while another 34.1% were aged between 5-9[64]. During the 2023-2024 El Nino event, a total of six young children (those 12 years and below) and 25 teenagers (those aged between 13-18) were reported to have heat-related illnesses (Table 4.6).

Table 4.6 Total number of heat-related illnesses and fatalities reported, by age group, 2023-2024

Age group	2023		2024	
	Reported HRI	Fatalities	Reported HRI	Fatalities
Children	3	2	3	1
Teenagers	9		16	
Adult	25		67	2
Elderly	2		2	
Total	**39**	**2**	**88**	**3**

Source: NADMA (2024), MalaysiaNow (2023)[65]

Despite only having six cases of HRI among young children, three of them resulted in fatalities. All three of these mortalities recorded were among children under the age of 5[66]. This underscores the added vulnerability children face in managing heat stress compared to adults.

Lower capabilities in managing heat stress among the elderly.

On the opposite end of the spectrum, those who are elderly (people who are aged 60 years and older) are also more vulnerable to heat stress compared to younger-aged adults. Those who are elderly are less adaptive to temperature changes and are unable to adjust to the increase in temperatures well[67].

Several physiological studies on the health of older individuals found that the ability to sense heat, take appropriate behaviour, and the body's ability to regulate core body temperature (such as sweating) during heat exposure may be compromised as they get older[68]. Additionally, those who are elderly are also more likely to have chronic medical conditions and take prescription medication, which may impair the body's ability to regulate heat[69].

Currently, 7.3% of Malaysia's population is above 65 years of age, and this share is projected to increase in the next few decades. Thus, the increased vulnerability of the elderly population to heat stress is a matter of public health concern as Malaysia is an ageing nation heading to become an aged nation by 2035, which is when 15% of the population is above the age of 60.

[63] DOSM (2022)

[64] ibid

[65] "Health Ministry Records 39 Heat-Related Cases" (2023)

[66] The children fatalities are- 2023: , 2024: 1 boy aged 3, Kelantan

[67] Ryti and Jaakkola (2023)

[68] Ibid

[69] Ibid

KRI's previous report on social health determinants also found that while Malaysians are living longer, they are doing so in poor health[70]. This is further supported by the 2023 Health White Paper which found that this demographic incurs two to three times the medical costs compared to the general population[71]. Even more concerning, the paper found that Malaysia is not equipped to provide adequate long-term care for its senior citizens[72].

The rising proportion of senior citizens is likely to result in an increase in NCDs and demand for specialised geriatric care, thus placing an additional burden on the health care system[73]. Concerningly, higher temperatures may amplify the demand and burden of Malaysia's future health care system further as these medical conditions worsen with heat.

4.3. Heat stress as an occupational hazard

Higher temperatures are an obstacle to decent work conditions.

Working in high temperatures can pose occupational health hazards, limiting a worker's physical abilities, work efficiency, and overall productivity[74]. Prolonged exposure to excessive heat can lead to health issues and heat-related illnesses such as heat-exhaustion or heat stroke. Meanwhile, labour productivity tends to decrease when temperatures exceed 24–26°C, and at 33–34°C, a worker engaged in moderate-intensity tasks experiences a 50% reduction in work capacity[75].

Aside from exposure to heat stress and heat-related illnesses, working in high temperatures could lead to an increased risk of injury[76]. Some examples of these risks specific in hotter work environments include sweaty palms, safety glasses fogging up, feelings of light-headedness, and a decline in the cognitive function responsible for reasoning, which could then lead to additional risks[77]. Workplaces with inadequate ventilation and an absence of cooling systems can further exacerbate occupational hazards that are associated with heat[78]. Meanwhile, certain protective clothing may restrict sweat evaporation and thus limit the worker's ability to cool themselves.

Table 4.7 Factors contributing to heat stress

Environmental factors	Job-specific factors
• Air Temperature • Air Velocity • Radiant Temperature • Relative Humidity	• Clothing • Health Condition • Acclimatisation • Hydration • Metabolic Heat • Work Rate (Light/Moderate/Heavy

[70] KRI (2020)
[71] Health White Paper
[72] Ibid
[73] Ibid
[74] Internationale Arbeitsorganisation (2019)
[75] Ibid
[76] Ibid
[77] Ibid
[78] ibid

Source: ILO (2019)

Given the risk of working with a high degree of heat stress, there are both international and national standards that have been issued that specify the maximum recommended heat exposure levels as well as the prescribed rest periods. One of the tools utilised is the wet bulb globe temperature (WBGT) which is a composite temperature metric consisting of temperature, humidity, wind speed, and solar radiation. This then provides a comprehensive measure of the environmental heat stress as it gives an indicator of the heat load on the human body.

Measurements recorded on the WBGT are then used to inform the intensity and duration of work that can be done safely or with a low risk of injury. For example, at as WBGT reading of 30.0°C, light intensity work at any allocation of work is safe for an acclimatized worker, but heavy and very heavy intensity work can only be done at a work/rest allocation of 0-25% (Table 4.8). However, at the same WBGT reading, non-acclimatized workers are only safely able to do light work at 0-25% work-rest allocation.

Table 4.8 WBGT thresholds , (℃)

Allocation of Work in a Work/Rest Cycle	Acclimatized				Action Limit (Unacclimatized)			
	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
75-100%	31.0	28.0	--	--	28.0	25.0	--	--
50–75%	31.0	29.0	27.5	--	28.5	26.0	24.0	--
25-50%	32.0	30.0	29.0	28.0	29.5	27.0	25.5	24.5
0-25%	32.5	31.5	30.5	30.0	30.0	29.0	28.0	27.0

Source: ACGIH (2022)

Additionally, the clothing worn by the worker can also limit their safe working thresholds. Depending on the material of the clothing, the reading of the WBGT will then be corrected to better reflect safe exposure levels for the workers, as summarised in Table 4.9. In the case of when the WBGT reading is at 28.0°C, workers wearing an SMS polypropylene coverall have a corrected WBGT of 28.5°C (additional 0.5°C), those in polyolefin coveralls have a corrected WBGT reading of 29.0°C (additional 1.0°C), and so on. Thus, the work intensity and work/rest allocation should be adjusted accordingly based on these corrected WBGT readings and risk levels.

Table 4.9 Correction of TLV for Clothing

Clothing Type	WBGT Correction (°C)
Work clothes (long sleeve shirt and pants)	0
Cloth (woven material) coveralls	0
SMS (Spunbonded - Meltdown - Spunbonded) polypropylene coveralls	+ 0.5
Polyolefin coveralls	+ 1
Double-layer woven clothing	+ 3

Limited-use vapour-barrier coveralls	+ 11

Source: ACGIH (2022)

However, as temperatures continue to rise due to climate change, workplaces may need additional cooling facilities or infrastructure or may need to maintain low WBGT levels. Meanwhile, in outdoor conditions where there may be limited options for cooling, increased frequency of breaks or adaptive clothing for cooling may be needed to comply with international standards and ILO guidelines or codes of practice.

Sectors at higher vulnerability to heat stress

While workers in all sectors are exposed to these risks, certain economic sectors and occupations have heightened risks due to their nature of work, particularly in industries where workers are exposed to high temperatures and physical exertion[79]. These include industries reliant on outdoor labour, such as agriculture, construction, landscaping, and forestry, as these workers endure prolonged exposure to direct sunlight and high temperatures, as well as have high physical demands of tasks like fieldwork, building construction, and land clearing.

Exposure and vulnerability to heat stress can also persist in indoor working environments as well. Certain manufacturing processes, including foundries, steel mills, and glass production, generate significant heat in indoor environments due to the heat generated from machinery[80]. Without adequate cooling systems or ventilation, indoor temperatures can escalate, heightening the risk of heat stress and heat-related illnesses among workers.

Aware of the higher exposure to heat stress in certain sectors and industries, Malaysia's Department of Occupational Health and Safety (DOSH) has compiled a few examples of workplaces, activities, and typical adjusted WBGT (Table 4.10). From the examples below, it can be observed how certain industries have a much higher adjusted WBGT, pushing a majority of these workers into conditions that have a high risk of exposure to heat-related illnesses.

Additionally, as temperature increases, the typical adjusted WBGT is likely to increase in these workplaces unless additional cooling infrastructure or initiatives are put in place. Examples of these could include having air-conditioned spaces, increased air flow, or cooling vests. However, depending on the sectors and industrial activity, not all may have the same cooling solution. Thus, it is important to identify workplaces that currently have a high adjusted WBGT and may also have difficulties in reducing the heat load or require a unique cooling solution. This can then better prepare the industries on ways to manage and keep their WBGT at a safe level in future warmer temperatures.

[79] Internationale Arbeitsorganisation (2019)

[80] Ismail et al. (2020)

Table 4.10 Examples of workplaces and activities that are exposed to high heat stress

Sector	Example of Workplaces	Activities	Adjusted WBGT (℃)
Manufacturing	Glass and rubber manufacturing plants, chemical plants, conventional and nuclear power plants	Foundries and smelting operations, metal refining, support activities for oil and gas operations. Boilers, sterilisers and furnaces operations.	Rubber: 30.4 - 35.3 Premix Plant: 27.08 - 31.1 Oil and Gas: 27.8 - 32.9 Aluminium/Metal: 31.9 - 33.1 Casting: 28.8 - 33.1 Foundry: 30.2 - 40.9 Ceramic: 29.1 - 35.3 Coating: 31.04 - 34.8 Sawmill: 31.3 - 34.7
Mining and Quarrying	Limestone and granite quarries. Gold and bauxite mining.	Blasting, loading, site clearing, hauling and crushing	
Construction	Building and residential construction	Tunnelling, brick laying, bar bending, plastering, painting	Bricks: 26.8 - 30.0
Agriculture, Forestry and Fishing	Palm oil plantations, paddy fields	Farming, logging, harvesting, seeding, animal feedings	Palm Oil Mill: 32.3 - 36.7
Utilities	Gas processing plant, water processing plants, power plants	Heavy work under hot sun, cleaning	
Transport, Storage and Communication	Depot, telecommunication substation	Mail delivery, manual handling, vehicle maintenance and cleaning, substation maintenance, cable installation	
Wholesale and Retail Trades	Warehouse	Stock transfer and replenishment, Manual handling	
Hotels and Restaurants	Bakeries, commercial kitchen, confectioneries	Cooking, bread/cake baking	Confectioneries: 30.2 - 31.6
Finance, Insurance, Real Estate and Business Services	Laundries, Landfills, Waste-water treatment plants, office building	Dry cleaning, drying and pressing (ironing), domestic waste collection and segregation, cleaning/painting of exterior building	
Public Services and Statutory Authorities	Training centre (outdoor), federal/ state road, government hospital	Field Training, Fire-fighting, road-traffic control, clinical waste collection	

Source: DOSH (2016)

Informal sectors face added vulnerability to heat-related occupational hazard

Though there are guidelines for safe working conditions in warm temperatures, the implementation of these measures is limited to those who are formally employed. Thus, informal work arrangements can compound the vulnerability of workers to heat stress occupational hazards by limiting access to protective measures, healthcare, and training, as well as exacerbating economic pressures to continue working in unsafe conditions[81].

Informal work arrangements can exacerbate vulnerability to heat stress occupational hazards in several ways, as described in Table 4.11below.

Table 4.11 Factors of informal employment that can worsen heat stress

Limited access to protective measures	Workers in informal arrangements may have limited access to protective measures against heat stress. This includes access to personal protective equipment (PPE) like cooling vests, hats, and sunglasses, as well as access to shaded rest areas or cool drinking water.
Lack of regulation and enforcement	Informal work sectors often lack formal regulations and enforcement mechanisms to ensure safe working conditions, including protection against heat stress. Employers may not be required to provide adequate breaks, hydration stations, or training on recognizing and managing heat-related illnesses.
Lack of awareness and training	Workers in informal arrangements may not receive adequate training or information about the risks of heat stress and how to prevent it. This can result in a lack of awareness about the importance of staying hydrated, taking breaks in shaded areas, and recognizing early signs of heat-related illness.
Limited healthcare access	Informal workers may have limited access to healthcare services, making it difficult to seek medical attention for heat-related illnesses or access preventive care. This can exacerbate the severity of heat-related illnesses and increase the risk of long-term health consequences.
Economic pressures	Informal workers may face economic pressures to continue working in hazardous conditions, including extreme heat. This can lead to workers ignoring symptoms of heat stress and risking their health to earn a livelihood.
Inadequate living conditions	Informal workers often face inadequate living conditions, including a lack of access to safe housing with adequate ventilation and cooling systems. Living in overcrowded or poorly ventilated spaces can exacerbate the effects of heat stress on workers' health, making them more susceptible to heat-related illnesses.

Source: Sverdlik et al. (2024)

[81] Sverdlik et al. (2024)

In Malaysia, 8.6% (1.3 million workers) of those who are working in non-agriculture sectors are doing so in the informal sector[82] (employment with unregistered firms). When accounting for those working in the informal sector, including agriculture, the share increases to 13.3% (2.0 million persons).

Of those in informal employment, the majority are doing so in the services sector (812 thousand persons) (Table 4.12). However, there are also a significant number of those who are informally employed in the agriculture (700 thousand persons), manufacturing (200 thousand persons) and construction sectors (238 thousand persons). These are all sectors that are highly exposed to heat stress and are potentially increasingly vulnerable as temperatures increase.

Table 4.12 Breakdown of those who are informal employment (non-agriculture), by sector, 2019

Sector	Number of persons ('000)	Proportion (%)
Manufacturing	200.4	16.0
Construction	237.7	18.9
Services:	812.2	64.6
Wholesale and retail trade; repair of motor vehicles and motorcycles	262.4	20.9
Transportation and storage	44.9	3.5
Accommodation and food and beverage service activities	223.4	17.8
Administrative and support service activities	80.2	6.4
Human health and social work activities	113.3	9.0
Other services industries	87.9	7.0
Others	5.9	0.5
Total	1,256.2	100.0

Source: DOSM (2020)

Another growing concern is occupational safety and health (OSH) among Malaysians working in the p-hailing sector, particularly motorcycle and e-bicycle riders. On top of the increasing number of fatalities and injuries associated with accidents among delivery drivers, they are also exposed to several OSH hazards. Some of the hazards associated with p-hailing are smoke from other vehicles, direct and prolonged exposure to UV rays, and extreme environments and temperatures, among others.

Additionally, those who are working in this p-hailing sector also find themselves working long hours and face exhaustion due to a lack of rest. This, along with prolonged exposure to hot temperatures and high humidity, places them at an added risk of developing heat-related illnesses, particularly if they are not able to take frequent breaks due to delivery deadlines. Thus, this highlights how informality can exacerbate heat stress and heat-related illnesses among workers.

[82] DOSM (2022)

5. Managing public health in a hotter Malaysia

5.1. Lack of heat-health measures in current adaptation policies

Given the findings discussed throughout this paper, heat is a growing concern for Malaysia. Despite the almost certainty that temperatures will keep increasing in the coming century[83], planning on how to manage the effects of warmer temperatures is still largely absent. Rather, mentions of managing public health challenges brought on by climate change in several government policies remain broad, with little to no mention of temperature rise.

Table 5.1 Policies mentioning the intersection of health and climate change

Policy Document	Ministry	Initiative / strategy
National Policy on Climate Change	NRES	• Conduct systematic reviews and harmonise existing legislation, policies and plans, taking into account and proposing relevant balanced adaptation and mitigation measures, which includes public health • To incorporate measures, including mobilising financing and technical assistance in areas including public health • To establish and implement a national R&D agenda on climate change in various areas, including public health services and delivery
Dasar Pembandaran Negara Kedua	KPKT	• Highlights the formation of a healthy and low carbon city • Measures include the increase of parks and recreation in towns
Green Technology Master Plan Malaysia 2017-2030	NRES	• The development of green cities to lower carbon emission and improve quality of life
National Environmental Health Action Plan (NEHAP)	MOH	• Aims to put sustainable environment and health at the centre of development that will result in sustainability and improvements in environmental quality, enhancement of public health, and ensure the health of the future generations in the region • Areas of concern within environmental health include climate change • To evaluate, manage, and control the impact of environmental factors on health on a long-term basis
Dasar Keselamatan Negara, 2021-2025	MKN	• Highlights a need for actions to manage public safety health, particularly for bio security threats • Outline measures on pandemic management and health safety, management of national disasters, food safety, and mental health • Identified climate change as a potential threat to national security, with an emphasis on climate disasters

Source: Author's compilation

Of the above policies, the NEHAP was the most comprehensive in outlining the appropriate strategies needed to manage challenges in the intersection of environment and health. While

[83] IPCC (2022)

climate change has been identified as one of their areas of focus, most of its emphasis has been on Dengue, Malaria, as well as food- and water-borne diseases. However, a recent focus group discussion by the NEHAP technical working group has found climate change adaptation strategies and neglected health issues to be a growing priority.

Table 5.2 List of top ten environmental health issues for Malaysia based on the magnitude and severity of issues

Rank	Challenge
1	Children environmental health
2	Vector-borne diseases
3	Contamination of drinking water sources and emerging water pollutants
4	Urban health issues
5	Climate change adaptation strategies and neglected health issues.
6	Food safety and contamination issues
7	Human exposure to pesticides and other environmental chemicals
8	Zoonotic diseases
9	Exposure to ionising and non-ionising radiation
10	More rigorous efforts to identify sources and means to reduce PM2.5 and ozone levels in Malaysia to assess the disease burden related

Source: Hashim et al. (2023)

With regard to the management of heat-induced public health challenges, a few guidelines and adaptation measures have been developed. Though the coverage of measures regarding vector-borne diseases is comprehensive, little attention has been placed on adaptation measures regarding heat stress and heat-related illnesses. Rather, the clinical guidelines released by MOH in 2016 are limited to the treatment response, while MOHR's heat-stress management pertains to safe working practices at different levels of heat and humidity.

Table 5.3 Current measures and guidelines on heat-related health concerns

Heat stress and heat-related illnesses
• Clinical Guidelines on Management of Heat Related Illness at Health Clinic and Emergency and Trauma Department, 2016 (MOH) • Guidelines on Heat Stress Management at Workplace, 2016 (MOHR)
Vector-borne diseases
• National Dengue Strategic Plan (2015-2020) • UNITEDengue: a cross border network on dengue surveillance information • Dengue Virus Surveillance System (DVSS): an early warning system for emergency preparedness • The National Malaria Elimination Strategic Plan (2011-2020) • Member of Asia Pacific Malaria Elimination Network (APMEN)
Food and water-borne diseases
• Member of the Global Salmonella-Survey Network

Source: Author's compilation

5.2. Discussion and policy recommendations

Rising temperatures and a warmer climate can exacerbate various public health concerns in Malaysia and increase exposure towards heat-related illnesses. To overcome these vulnerabilities and the gaps identified, this paper brings forward four policy recommendations.

Policy recommendation 1: Develop a Heat-health Action Plan

As temperatures increase in Malaysia due to climate change, **developing a heat-health action plan becomes imperative to manage heat-related impacts, particularly on health**. Such a plan is essential for protecting public health and reducing the adverse effects of extreme hot days and heat waves, which can lead to serious illnesses and increased mortality. It can also lead to operational disruption for businesses, particularly those that are dependent on labour or in sectors with high heat exposure.

A comprehensive heat-health action plan should encompass preparation, response, and recovery strategies at national, regional, and local levels. This multi-tiered approach ensures that all aspects of heat management are addressed, from immediate emergency responses to long-term urban planning and public health policies. Such a plan could include early warning systems, public education campaigns, heatwave response protocols, timely public and medical advice, and improvements to housing and urban planning. **Special attention should be given to protecting vulnerable populations, such as the elderly, children, and those with pre-existing health conditions.**

While heat action plans should cover various sectors, prioritizing health can be an effective starting point. Malaysia's existing NEHAP touches on climate change but is primarily focused on vector-borne and water-borne diseases. This indicates a gap in addressing heat-specific health issues, which can be just as critical. A dedicated heat-health action plan would fill this gap, providing targeted measures to prevent heat-related illnesses and deaths. This should also include measures to manage other serious illnesses, such as cardiovascular illnesses that can worsen in higher temperatures. Additionally, **investing in modelling capacity and expertise of local researchers on projected heat-health related issues can also better inform policy** and the development of heat-health action plans.

Developing an effective heat-health action plan requires inter-ministry coordination due to the cross-cutting nature of the issue. Heat and health intersect various portfolios, including health, environment, urban planning, and social services. Coordinated efforts among these ministries can ensure a holistic approach to managing heat risks. Collaborative strategies can leverage resources and expertise across different sectors, leading to more comprehensive and effective interventions. By prioritizing health and fostering inter-ministry cooperation, Malaysia can develop a robust heat-health action plan that not only addresses immediate health risks but also builds long-term resilience to the growing challenges posed by climate change.

Policy recommendation 2: Enhance monitoring systems on heat-induced health conditions

Enhanced monitoring of heat-related illnesses, hospital admissions, and mortality rates is essential to understand the full impact of extreme heat events. Monitoring systems for heat-induced health conditions are crucial for improving public health responses in Malaysia, where rising temperatures due to climate change pose significant health risks. By closely tracking these health outcomes, healthcare providers can identify trends and patterns that might not be immediately apparent, allowing for a more proactive approach to managing heat-related health issues. This comprehensive data collection should include information from both public hospitals and private healthcare providers to ensure a complete picture of the population's health.

Moreover, it's important to monitor admissions and mortality rates for patients with pre-existing conditions that can be exacerbated by heat, such as cardiovascular diseases, respiratory conditions, and diabetes. These individuals are particularly vulnerable during heat waves, and their health outcomes can provide early warning signs of broader public health threats. Tracking this data daily and at the district level can reveal correlations between temperature spikes and health impacts, enabling more precise and localized interventions. This granular data helps highlight Malaysia's overall vulnerability to heat while mapping out specific populations or neighbourhoods that are at higher risk.

The benefits of such a monitoring system extend beyond immediate health responses. **The data collected can inform public health interventions, identify high-risk populations, and evaluate the effectiveness of heat mitigation strategies**. For instance, if certain districts show a higher incidence of heat-related illnesses, targeted public health campaigns and resource allocation can be directed to those areas. Additionally, tracking incidences of heat-induced health conditions by occupation can highlight sectors where workers are more vulnerable to temperature increases. This data can serve as a foundation for developing a comprehensive heat-health action plan.

Policy recommendation 3: Design heat-sensitive public infrastructure and facilities

As temperatures increase, a major challenge in dealing with extreme heat is the reliance on air conditioning, which may not be accessible to all. Socioeconomically disadvantaged households often cannot afford the cost of air conditioning, making it increasingly necessary to provide public cooling spaces that do not require very little spending. Hence, **increasing access to cooling centres, especially in socioeconomically disadvantaged areas, ensures that vulnerable populations have refuge from the heat and may be lifesaving in extreme heat events.**

Malaysia's planning standard should also be amended to better reflect projected climate risks and hazards. Currently, Malaysia's planning standard used by planning authorities are largely based on population requirements. However, for areas with high heat exposures, particularly in urban dense areas, the development of planning standards to include allocations for green spaces and required cooling centres can reduce the vulnerability of Malaysians to heat-stress and resilient against extreme heat. This is also in line with Malaysia's 4th National Physical Plan strategies and key actions, which includes increasing the number of green areas as spaces for social interaction.

Furthermore, the cooling capacity of public schools is another critical consideration. Current building codes in public schools focus on ventilation, but it may not suffice as temperatures rise. Thus, new standards should include effective cooling solutions to ensure that the school environments remain comfortable during heat waves. This is vital for students' health, well-being, and academic performance.

Overall, **developing heat-sensitive public infrastructure and facilities in Malaysia is crucial to enhancing resilience against extreme heat**. This includes designing and retrofitting buildings, public spaces, and transportation systems to withstand higher temperatures. Measures such as natural shading, increased access to cooling centres, and improved urban planning to reduce heat islands can significantly mitigate the adverse effects of extreme heat. By addressing these issues, Malaysia can develop infrastructure that protects public health and enhances the resilience of communities to heat stress.

Policy recommendation 4: Adapt decent work practices in current and future high temperatures

Adapting decent work practices to the rising temperatures in Malaysia is essential to protect workers and maintain productivity in a warming climate. Higher temperatures can create unsafe working conditions, which may result in some work environments where the Wet Bulb Globe Temperature (WBGT) exceeds safe thresholds. Additionally, **there is a growing need to review and evaluate existing standards and laws under the Occupational Safety and Health Act 1994 and the Employees' Social Security Act 1969 to adequately address heat and climate stress** across the various projected temperature scenarios.

Identifying unsafe and heat-vulnerable workplaces early on is essential for implementing necessary cooling measures – particularly if some of these workplaces require unique cooling solutions. **Firms too should be proactive in identifying the risks of their workers being exposed to heat stress and thus take appropriate measures.** Furthermore, the feasibility of climate insurance schemes to protect against heat-related risks for both people and business should be explored as it can help to cushion income shocks brought on by extreme climate events.

Extending social protection and educational campaigns to informal workers is increasingly important. Informal workers, who often lack the protections afforded to those in formal employment, are especially vulnerable to heat-related illnesses. Providing them with information on safety thresholds and proper work practices can help reduce heat-related health issues. **Additionally, agricultural work practices need to be evaluated and adapted to ensure that field workers are not exposed to dangerous heat levels**.

As temperatures increase, ensuring that labour policies address heat-related risks will be a growing challenge. Thus, **establishing a dedicated task force to oversee the development and implementation of these policies is crucial.** This task force can focus on planning for future heat-related impacts on labour, ensuring that all sectors are prepared to handle higher temperatures and other climate-related issues, which is vital for safeguarding workers' health and maintaining decent working conditions. Furthermore, continued compliance with established heat-stress management guidelines is also critical, as existing regulations must be enforced and updated regularly to reflect the increasing heat risks.

6. Conclusion

This working paper began with the objective of highlighting the potential risks rising temperatures bring to Malaysia's public health. Reviewing various forms of international and national literature on this topic, this paper contextualised these scientific findings regarding Malaysia's exposure and demographics to better understand its vulnerabilities. The key findings identified in this paper are as follows:

1. **Globally, rising temperatures can have detrimental effects on public health.** Warmer temperatures have been found to increase the risk of heat-related illnesses, worsen non-communicable diseases, and increase the risk of vector-borne diseases.

2. **Malaysia's combination of high temperatures and humidity places an added vulnerability towards heat-related illnesses**. At the current average maximum temperature, Malaysia's heat index shows high exposure to heat exhaustion, heat cramps, and increased risks of heat stroke. As both average mean and maximum temperatures increase, the risk of heat-related illnesses will also increase.

3. **Beyond heat-related illnesses, warmer temperatures can worsen other health issues for Malaysians.** Non-communicable diseases such as ischemic heart disease, respiratory diseases, and diabetes can also worsen as temperatures rise. Additionally, increased transmission of vector-borne diseases such as dengue is likely under warmer temperature scenarios.

4. **Vulnerability towards heat-induced health issues is not equal across all Malaysians.** Variability among local climates, age-related vulnerabilities among children and the elderly, as well as working in specific sectors can place an added risk of heat-related illnesses or other health conditions worsened by heat.

However, despite the certainty that temperatures will rise in the next few decades, there are gaps in the mention of measures for managing heat-related illnesses and other health conditions that can worsen with heat in the current climate and health-related national policies. To overcome the vulnerabilities and gaps highlighted in this paper, this paper suggests the following policy recommendations:

1	Develop a Heat-health Action Plan
2	Enhance monitoring systems on heat-induced health conditions
3	Design heat-sensitive public infrastructure and facilities
4	Adapt decent work practices for current and future high temperatures

Limitations and future work

While this paper aims to be as comprehensive as possible when outlining Malaysia's public health vulnerabilities in a warmer future, it serves only as a beginning and a call to action. A large understanding of the health risks induced by higher temperatures is based on international literature on this topic or smaller-scale studies conducted by local researchers. We have yet, at a national scale, begin to identify communities whose health is highly vulnerable to temperature increases. This may be in part due to the limited availability and granularity of data that could enable such assessments.

Additionally, discussions of what rising temperatures can mean for Malaysia are not only limited to public health. Rather, the impacts of warmer temperatures also extend to issues on food security, energy demand, the cultivation of commodities, as well as economic productivity, among others. While they are beyond the scope of this current paper, these areas are also potential challenges for Malaysia's future well-being when thinking of rising temperatures.

Despite this, research work on these topics is scattered and often overlooked when planning for Malaysia's climate adaptation measures. Thus, future research is needed to evaluate these other areas of concern to ensure that all of Malaysia's climate risk and vulnerabilities are accounted for in the development of Malaysia's National Adaptation Plan and future Malaysia Plans.

Concluding remarks

The past decade has marked various instances of 'record highest temperatures' as several countries, Malaysia included, faced their highest maximum temperature. This is expected to worsen as various emissions scenarios project that the average maximum temperature is likely to increase in the next few decades. On top of the higher frequency of heat waves and extreme heat events, higher temperatures can pose various health risks to Malaysians. This is not only limited to concerns of heat-related illnesses but also extends to noncommunicable diseases and vector-borne diseases, both of which are exacerbated by heat.

It is also important to note that the risk of heat-induced health concerns is not equal, and some communities are more vulnerable to them than others. Hence, it is imperative that early action and proper identification of these communities are taken to build the resilience of Malaysians against these heat-induced health concerns.

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