Extreme Heat and Covid 19: The Impact on the Urban Poor in Asia and Africa

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For further information, see www.coolinfrastructures.com

Executive Summary

This report presents the results of a large scale, multi country survey that was intended to understand the effects of COVID-19 on heat exposure, perceptions of heat and vulnerability for low-income urban residents in southeast Asia, south Asia, and west Africa. Across these regions, this report shows that COVID-19 amplified the existing vulnerabilities of low-income urban communities in Pakistan, India, Indonesia and Cameroon to heat.

The study was funded by the UK's Economic and Social Research Council / Global Challenges Research Fund (as part of a multi-country study on 'Cool infrastructures') with additional support from the Scottish Funding Council's Global Challenges Research Fund.

The survey data includes responses from 4564 low-income urban residents across 4 cities in India, Pakistan, Cameroon and Indonesia, collected via mobile phone in July and August 2020. Our analysis includes four detailed, city level case studies that analyse this data against the backdrop of national and city specific measures to prevent the transmission of COVID-19.

Our analysis shows how pandemic response created different magnitudes of disruption to everyday practices and sources of vulnerability and exposure to heat, that were highly context specific. Responses to the pandemic undermined residents' abilities to stay cool or otherwise manage heat stress in low-income areas. The survey reveals high levels of exposure to heat as the result of poor-quality housing, and vulnerability as a result of limited affordability, reliability, and access to, electricity and water for low-income communities.

These findings indicate the need to substantively reframe how we understand and respond to heat-health risk. The impact of COVID-19 offers an important reminder that heat-health is impacted whenever levels of vulnerability and exposure to heat increase; not only when exceptional heat events take place. Accordingly, heat-health warning and response systems should identify risk not only as a result of changes in the magnitude of the hazard but must also monitor and respond to significant changes in vulnerability and exposure.

In response, we identify seven priority areas for policy action, based on the survey data and analysis. These address behaviour; gender; water; electricity; shelter and shade; social protection; data and information.

Summary of Survey Data and Key Findings

- >90% of survey respondents were aged 18-49 and 42% were women.

- One in five respondents described themselves as street vendors of goods and services. Just under a fifth of described themselves as either self-employed or employed in waged labour.

- Over one third of respondents live in what the UN identifies as overcrowded conditions, and three quarters live in homes with a roof made from metal or concrete.

- Over half of all respondents reported a decrease in income since the onset of the COVID-19 pandemic.

- A quarter of all survey respondents reporting that they have had to make do with reduced electricity access during the COVID-19 pandemic; and decreased access to electricity was correlated with a *significant increase* in the likelihood that people experienced thermal discomfort in the home.

- Specific vulnerabilities to domestic heat exposure – including those related to building materials, access to electricity and water, and gender – were accentuated by measures to prevent the transmission of COVID-19, including confinement, lockdown, and social distancing.

- There is a statistically significant increase in experiences of thermal discomfort and in symptoms of heat related illnesses during the COVID-19 pandemic, even in regions that did not experience higher than usual surface temperatures at the time of the survey.

- Reductions in water intake during the COVID-19 pandemic were closely correlated with more severe symptoms of heat related illness. Respondents whose water intake had reduced since the pandemic were more than 3 times more likely to report experiences of blurred vision than those whose water intake had increased.)

- Reports of an increase in physical conflict/violence during the COVID-19 pandemic were more than twice as likely (OR 2.10) amongst those who also reported an increased experience of thermal discomfort.

1 Introduction

1.1 Heat and COVID-19: Risks, Responses and Research

As COVID-19 spread around the world in 2020, it overlapped with the recurrent hazard of extreme heat. That year, an estimated 431.7 million people worldwide experienced a heatwave event during the 2020 COVID-19 Pandemic.[1] This included over 145 million people in East Asia and the Pacific, 73 million in Sub Saharan Africa and 33 million in South Asia.

The methods for dealing with an epidemic and dealing with extreme heat are not always compatible, creating conflicts and contradictions in public health advice and confusion for individuals about the best courses of action in their everyday lives. Some measures to prevent the transmission of COVID-19 have risked exacerbating the vulnerability and exposure of some populations to heat stress.

These risks have disproportionately affected people living in informal, low-income households in high density cities across parts of South, Southeast Asia and Africa. In some cities, social distancing measures contradicted the guidance enshrined in urban heat action plans designed to ensure that members of the public had access to public cooling and hydration infrastructures. Meanwhile, local lockdowns risked restricting highly vulnerable socio-economic demographic groups to hot, poorly ventilated housing during the hottest times of the year.

The limited availability of data, however, has made a deeper, localised understanding of this nexus of heat with COVID-19 very challenging. Whilst policy makers understood the potential contradictions between measures to limit exposure to COVID-19 and measures to limit exposure to extreme heat, there was little empirical evidence on which to base new approaches. In early 2020, many international, national and regional health agencies, including International Federation of the Red Cross and Red Crescent member societies, were working at full capacity with no bandwidth to undertake new research.

The research on which this report is based was specifically designed to fill this gap in knowledge. Based on a large-scale, remote survey of 4564 low-income residents across 4 cities in India, Pakistan, Cameroon and Indonesia, the research details how measures to prevent the transmission of infectious disease effected access to basic infrastructures for cooling homes and bodies, and people's experience of extreme heat during the COVID-19 pandemic.

1 Walton, D. and van Aalst, M. (2020) *Climate Related Extreme Weather Events and COVID-19.* IFRC Climate Centre, p18

1.2 Who is This Report for?

The study provides substantial new data on the direct as well as indirect impacts of the COVID-19 pandemic, thermal comfort and heat-related illness, in Jakarta (Indonesia), Hyderabad (India), Karachi and Hyderabad (Pakistan) and Douala (Cameroon). These cities are home to very large or rapidly growing low-income populations dealing with extreme heat.

Alongside data on heat exposure and symptoms associated with heat-related illness, the report supplies supplementary data points on access to electricity, water, food, health services, as well as income and food intake during the COVID-19 pandemic, that will be of use to policy makers and researchers.

The report is intended for use by governmental and non-governmental organisations in these cities and countries as they work to fine-tune policy and programme responses to the COVID-19 pandemic and avoid heat-related health impacts. Its broader findings are intended to be of use to inform interventions in urban areas facing similar challenges across Sub-Saharan Africa, South Asia and South East Asia.

1.3 How is This Report Structured?

The report includes:

- A detailed summary of the intersecting risks between COVID-19 and heat-health (Section Two)
- A detailed description of the survey method used to collect data; as well as the quantitative and qualitative methods used to analyse it (Sections Three and Four)
- A detailed, comparative analysis of the datasets which highlights the trends, differences and key takeaway messages (Section Five)
- Case studies for 4 cities which highlight the key findings (Sections Six, Seven, Eight and Nine)
- A summary discussion of broader take-away lessons, gaps in research and considerations for how to manage heat and covid simultaneously as the pandemic continues (Section Ten)
- A set of accompanying documents: including survey tools and open access to all raw datasets (Appendices)

2 Pandemic Management and Heat Management: Compound Risks

2.1 Urban Heat-Health in a Pandemic

The novel coronavirus "COVID-19" was identified in Wuhan China in late 2019, and rapidly spread, with a global pandemic declared by the WHO on 11th March, 2020. While there was much to be learnt about the virus, it was commonly accepted that it was communicable through airborne droplets emitted from an infected person. To break the chains of transmission, public health and other authorities enacted various measures. These included physical distancing indoors and outdoors, ventilating indoor spaces, and 'lockdown' measures that reduced the frequency with which people could leave their homes or limited the locations they could visit. A second set of measures revolved around increasing hygiene, through mask wearing and washing hands as well as goods and surfaces. While necessary to prevent transmission of the virus, these measures put immense social and economic on populations across the globe. The effects were felt most immediately by low-income populations, and highlighted pervasive inequalities in vulnerability and exposure, particularly in relation to loss of income, overcrowding, and inability to maintain food and water intake.

In early 2020, concerns about the compound effect of Covid-19 measures and exposure to extreme heat were raised by international health authorities and experts.[2] With little available data, there were fears that measures to protect against the pandemic could prove as deadly than the virus itself, particularly in countries where urban poverty overlapped with a lack of access to infrastructures for cooling.

Among those expected to be at the forefront of this nexus of heat and pandemic risk were people living in high-density urban environments across the global tropics, from Southeast Asia to South Asia and sub-Saharan Africa. The risks were expected to be particularly high for residents in urban neighbourhoods where a combination of poorly insulated housing materials, little ventilation, and limited access to public services for electricity, water, as well as public green space, significantly amplified the effects of heat. Indoor air temperatures in these locations is routinely higher than the peak recorded day time temperatures outside by several degrees.[3]

In cities across the Global South, neighbourhoods fitting this description are often characterised by policy makers as 'informal settlements' or labelled by urban authorities as 'slums'. Yet, the residents of these neighbourhoods are not homogeneous. They can be low income and income poor, as well as aspiring or lower middle class. Residents of these neighbourhoods have diverse, heterogenous income positions. These income disparities create differential patterns of access to critical

2 https://ghhin.org/heat-and-covid-19/

3 Dapi, L. N., J. Rocklöv, G. Nguefack-Tsague, E. Tetanye and T. Kjellstrom (2010). "Heat impact on schoolchildren in Cameroon, Africa: potential health threat from climate change." *Global Health Action* 3(1): 5610.

infrastructures for cooling, including electricity, water and green space. They also have a material impact on the composition of homes and domestic environments, as well as investments in technologies and appliances through which people seek to achieve a desired level of thermal comfort.

As a result, the effects of heatwaves and COVID-19 can be unevenly distributed across households within the same neighbourhood.

In these contexts, measures to reduce the risks of infection through lockdowns and restrictions on movement were expected to introduce severe limits on people's capacity to cool down; either by limiting their access to cool communal or public places, or by imposing limits on their ability to pay for essential, and heat-managing, goods and services, including electricity, water and food. The combined effect of heat, COVID-19 pandemic response measures, income poverty, and population density on infection rates was unclear. But what was clear, was that public health institutions, local authorities, and national governments were facing unprecedented challenges.

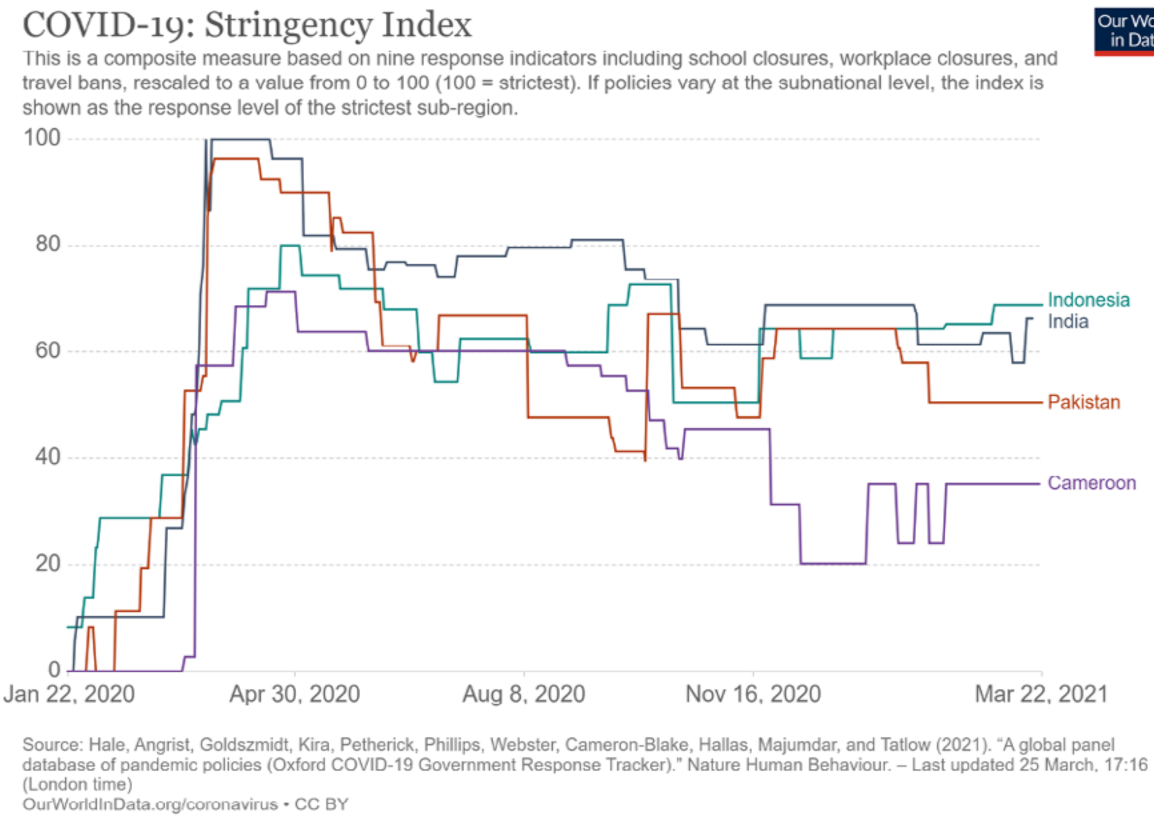
2.2 Dealing with Contradictory Public Health Policies:

In many cases, the immediate public health response to COVID-19 contradicted the guidelines and actions plans drawn up by urban authorities to manage heatwaves and heat-health risks.

Major public health responses to COVID-19 – from travel bans, and lockdowns, to workplace and school closures – were focused primarily on limiting social contact and the confinement of both the sick and the healthy. By contrast, urban heat action plans (like those drawn up by urban authorities across South Asia) prior to the pandemic hinged on increasing access to public facilities, from public cooling centres to public water facilities; all measures that also, inadvertently, increased social contact. For example, where emergency cooling centres may have been a vital intervention for alleviating the risk of heat stress during a heat wave, during the COVID-19 pandemic they now risked exposing people to infection.

Information provided to heat action planners and urban authorities directly addressed these contractions, advising that efforts to increase access to cooling during the pandemic would depend on national laws and the ability of staff to maintain physical distances. Authorities were encouraged to ensure that measures to reduce the transmission of COVID-19 would also address access to cooling. Examples included, frequently disinfecting high-frequency touch-points such as public drinking-water taps or distributing face masks to those using public water facilities. Meanwhile, in the absence of adequate ventilation and air conditioning, urban authorities were advised to encourage residents to consider low cost or low-tech cooling measures – including dampening clothing.

Since January 2020, the stringency of measures to present the transmission of COVID-19 varied country-by-country, and evolved rapidly over time as governments have responded to public health experts and political pressures (See Table XX). Our survey and country specific analyses locate the responses of urban residents within this rapidly changing policy environment.



3 Research Methodology:

3.1 Survey Development

This report is based on a survey of 4400 urban residents living in four cities across India, Pakistan, Indonesia and Cameroon. The survey was intended as a rapid, multi-country response to the lack of data on heat-health during the 2020 COVID-19 pandemic, that sought to quickly gather data from a large sample of low-income urban residents.

The survey was carried out in Hyderabad, India; Karachi, Pakistan[4]; Jakarta, Indonesia; and Douala, Cameroon.

These four cities are critical global sites for research on heat and cooling. India, Pakistan and Indonesia are home to three of the nine largest low-income urban populations in the world currently facing heat related risks. Cameroon is home to two of the twelve fastest growing urban populations facing heat related risks in Sub Saharan Africa.

Across all four cities, a high percentage of urban residents live on low incomes with precarious access to energy, water and transportation grids. In each location, post-colonial patterns of urban growth, increasing population density, and pressures on infrastructures for water and energy are compounding the effect of 'urban heat islands', exacerbating the risks from heat for marginalised people, especially women, and shaping the social context in which people negotiate access to cooling.

Research across these cities allow us to identify the key factors that shape local cooling practices, highlight regional priorities, and compare urban contexts (like Karachi and Hyderabad) in which extreme heat is attracting urgent attention in the present and cities (like Jakarta, Yaounde) for which rising temperatures are considered a future risk.

The survey was co-designed by an international team of social scientists, engineers, and heat-health experts, with input and feedback from national societies of the International Federation of Red Cross and Red Crescent, via the Climate Centre, and the Kigali Cooling Efficiency Programme. Research teams with city specific expertise supplied specific input on the survey questions, language and terminology.

Due to national restrictions on travel and mobility because of the pandemic, the survey took place remotely, by mobile phone. The survey data was collected by an international company (GeoPoll) that was selected based on its experience and record of accomplishment, the presence of teams of trained data collectors in each country, and its ethical commitments to research participants. To generate data that would allow for

4 Due to an error in the survey implementation, the survey data for Karachi, Pakistan includes responses from a neighbouring city, Hyderabad. Separated by just 140km, Karachi and Hyderabad have different climatic conditions, population sizes and patterns of access to electrical and water infrastructure. However, they fall under the administered of the same provincial level government and therefore shared many commonalities in lockdown measures. As such, we have retained all of the results, and analysed them separately as appropriate.

statistically significant analysis and findings, we aimed for a minimum of 1000 respondents per city.

The survey was limited to 33 substantive questions, of which only two were open ended, to reduce the burden on respondents and to maximise the number of complete responses. Respondents were reimbursed for their participation with mobile phone credit. The survey was translated into Urdu, Pashtu, Hindi, French and Bahasa Indonesia, and back translated to ensure accuracy, and each in-country team was provided with two days training. We conducted a pilot study with 80 respondents in each country, to test the questions, and we made modifications to the survey as a result. In each city, we stipulated that at least one third of respondents should be women.

The final list of questions and their translations can be found in Appendix A.

3.2 Survey Description

The survey targeted low-income urban residents deemed at elevated risk of the compound effects of measures to prevent the transmission of COVID-19 and heat stress.

The survey questions were divided into three broad groups.

Initial 'Filtering Questions'

These questions were designed to identify residents of low-income urban neighbourhoods for the survey. Based on detailed prior knowledge of each urban context, these questions used several socio-economic characteristics as an index of socio-economic status and likely residential status. These questions included: occupation, sources of income, home ownership, type of housing, number of occupants, and material construction of homes, access to cooling technologies, electricity and water. The data gathered allows for analysis in terms of standard metrics, such as the number of inhabitants per room, to ascertain overcrowding (UN Habitat).

Cool Infrastructures

The survey included detailed questions on housing, energy and water infrastructures that were intended to identify correlations between building materials and types, thermal comfort and heat-related illnesses, both before and after the pandemic.

- **Housing** (including building type, size, construction materials, number of windows): Questions about housing these were intended to identify the thermal properties of the home, such as insulation and thermal mass, and the potential for cross-ventilation.

- **Electricity and Water** (including type of connection; formal or informal; and normal hours of availability): Access to power and water are essential for reducing vulnerability to heat stress. These questions were intended to establish a baseline to compared with changes during 2020 either as a direct result of the pandemic or because of income reductions.

- **Types of Cooling Equipment**, including those requiring a power or water supply (such as evaporative coolers).

COVID-19

Respondents were asked about changes since the pandemic began in relation to: time spent at home, income, food consumption, water use, electricity use and access to health services.

Thermal Comfort

A final set of questions were then asked about thermal comfort over various periods inside and outside the home and experiences of symptoms of heat stress and heat-related illness. Two open questions were asked to determine 1) normal practices of heat management, and 2) whether these changed because of the pandemic.

Respondents were asked to indicate how hot they felt conditions were both outside and inside their homes. This is useful data to tie to environmental conditions to develop a model of what environmental conditions produce tolerable as compared to intolerable conditions in practice, and the role played by housing materials and access to active cooling infrastructure in modulating this result.

Occurrences of heat-related symptoms respondents felt were recorded for the month prior to being surveyed, as a proxy for the pandemic lockdown experience. Respondents were then asked if they'd experienced these symptoms before to get a sense of how typical they were. Symptoms ranged from mild (such as feeling hot, thirsty, or having headaches) and progressed through concentration loss, fatigue and irritability to more severe heat illness (nausea, loss of consciousness) to symptoms typical of heat exhaustion and heat stroke.

Wellbeing

Finally, respondents were briefly asked about any changes in mental wellbeing, frequency of domestic violence and overall heat effects. The mental wellbeing question has been discarded from the analysis as it was phrased as a leading question. Further questions however include levels of physical violence (which includes domestic violence). A perceptual question regarding the overall impacts of heat was asked after both physical, mental and the violence questions were asked, with the intention that answers would therefore be more likely to reflect all of these aspects combined: "compared to this time last year how has heat affected you..." (more, less, about the same). In combination with other survey questions, the objective was to ascertain whether respondents identified more heat impacts during the survey period, as a result of either coronavirus measures or variations in seasonal extremes.

The data set has been made available for public use via a Github site [available at: https://github.com/Cool-infrastructures/COVID19-Heat] and is further described in section 4.0.

3.3 Survey Limitations

The data collection process, sample selection and analysis process all introduced several limitations to the research exercise.

Data collection took place between June and July 2020. During the data collection period, not all the cities we surveyed were affected by the same pandemic response measures and even where similar measures had been imposed, there was widespread variation in adherence.

During this data collection window, climatic conditions in each city also varied, with considerable differences in recorded outdoor surface air temperatures and humidity. Recorded outdoor air surface temperatures during the survey ranged from 27°C in Douala, Cameroon, to 42°C in Karachi, Pakistan, and the heat index across all four cities during the survey ranged from 26°C in Hyderabad, India to a high of 55°C in Karachi, Pakistan.

Our questions asked people to compare their experiences during the pandemic with experiences before the pandemic. The pre-pandemic time frame was much longer and could include multiple heat events – from seasonal high and low temperatures, to heatwaves. By contrast, the pandemic specific reporting period was much shorter.

This study did not set out to examine cultural attitudes to the rules and recommendations made by national governments/public health authorities, or people's own assessments of the level of health threat they faced from COVID-19. The levels of trust that people have in state authorities – as well as cultural attitudes to public health rules and local assessments of risk – are historically rooted in experiences of colonial and postcolonial medicine, as well as globalisation. These factors are highly likely to have shaped the outcomes we measured (for example, changes in time spent at home). As the dynamic of the pandemic shifted, these views and the actions of authorities may also have changed.

Finally, due to the ethical issues involved in the collection and storage of personal data, as well as the challenges, we opted not to collect locational data for respondents.

No survey of this nature can claim to be fully representative. However, our analysis of the responses from 4400 participants points towards several statistically significant patterns and common experiences from which we have extrapolated some overarching conclusions.

Since the survey was initiated and undertaken, a good deal has changed. Whilst our knowledge of the virus and its impacts on human health has increased considerably, we still know relatively little about the compound effects of COVID-19 on lives and livelihoods. In the urban contexts that this research was conducted, we cannot underestimate compound effects (e.g., mounting vulnerability because of consecutive months of economic losses at household level as well as collectively and institutionally.

3.4 Deployment

The survey took place over two phases between June and July 2020, with approximately 500 responses in each (for survey numbers and response rates, see below: Table XX). Calls for the surveys were made throughout the day, so across the dataset no bias is anticipated due to call time. These two phases allowed us to compensate for some of the rapid variations in both weather and pandemic response conditions, which were evolving rapidly.

Survey Numbers and Response Rates

City	Phase 1 dates *Completed responses*	Phase 2 dates *Completed responses*	Total survey responses
Karachi [and Hyderabad] in Sindh Province, Pakistan	June 27 – July 5 594	July 14-21 578	1172 [Karachi =875; Hyderabad = 297]
Hyderabad India	June 30 – July 7 *598*	July 14-18 *582*	1180
Jakarta, Indonesia	June 27 – July 8 *526*	July 14-27 *582*	1108
Douala, Cameroon	June 26 – July 2 *520*	July 14-20 *584*	1104

To identify participants, mobile phone numbers were randomly selected from lists of phone numbers generated for each context.

For all survey respondents, the initial questions of the survey were designed to ascertain whether the respondent was low income and likely to be living in an informal settlement. Participants who did not fulfil the initial filtering criteria were excluded from the survey. In Pakistan, Indonesia and Cameroon the filtering questions were an additional measure, as the phone numbers were sourced directly through network providers, enabling a stratified sampling method based on the availability of demographic data of phone users. In India, phone numbers were sourced through the Global System for Mobile Communications Association (GSMA) partnerships and, as such, had less information available, meaning the survey questions were primarily responsible for filtering potential interviewees.

Each survey was carried by a single interviewer, following a pre-determined script [see Appendix A]. For closed questions, the interviewer read out the options and recorded the answer directly as indicated by the respondent (no responses were recorded which did not fit in the preassigned options). For open ended questions, the interviewer asked the question and transcribed the response. In most instances, this transcription was highly truncated and abbreviated rather than verbatim, leading to noticeably short and often uninformative answers. We discuss the implications of this in more detail below (see, Qualitative Analysis, Section 4.3.1).

4 Methods: Analysis

4.1 Quantitative Analysis

Data Preparation and Simple Analysis

Answers to open questions have been cleaned, coded, and grouped within a common thematic coding framework. The answers to the open questions have been translated into English by the team members in the different countries. Temperature and humidity data was added, corresponding to the survey dates.[5] The Heat Index (HI) has been calculated and added to determine the incorporated effects. This data is freely available at: https://doi.org/10.7488/ds/2961

After cleaning the data, we performed exploratory analysis of the data with the Julia package StatsPlots (https://github.com/JuliaPlots/StatsPlots.jl). We generated grouped bar charts for most questions which showed the responses of each of the four countries in distinct colours. This enabled us to find general trends in the responses which have informed the further statistical as well as qualitative analysis. The Julia notebooks to generate the plots and the further statistical analysis are freely available at: https://github.com/Cool-infrastructures/COVID19-Heat

Addition of Heat Index

The environmental data on weather conditions at the time of the survey responses has been added to the data set. This provided a basic check as to the prevailing conditions on the days the survey was conducted to identify whether there were any extreme weather events to consider that might influence responses.

More detailed consideration of this data has not been used in the analysis given the enormous variation in heat across the urban landscape, which the Heat Index (drawn from airport weather stations) does not reflect. Furthermore, as we have no precise geographic data on the respondents, we cannot estimate their weather conditions or variance from the airport data on the day they were surveyed.

Due to the cost of accessing this data, we have sourced results from timeanddate.com which draws content from WMO recognised weather stations. As the necessary information to calculate more complex heat indices such as UTCI was not always available, we have limited our initial input of weather conditions to ambient temperature (T), relative humidity (RH) and a composite measure using the Heat Index (HI). By incorporating the effect of both temperature and relative humidity, HI is a representation of felt air temperature or apparent temperature.

5 Temperature and humidity data is sourced from www.dataandtime.com.

The weather conditions at the time of the surveys were as follows:

India – Hyderabad: maximum temperatures ranged between 27°C and 32°C with high humidity, meaning that the heat index ranged between 26°C and 41°C. Night-time lows in the same period ranged between 23-26 degrees with high humidity, and a HI of 24-28. While hot, these conditions did not meet the official definition of a heatwave in Hyderabad, which is 4.5°C to 6.4°C above average maximum daily conditions (or a severe heat wave if more than 6. 4°C) as recorded by at least two Meteorological stations on two consecutive days.

Pakistan – Karachi and Hyderabad (Sindh Province): Karachi experienced two heatwaves, with temperatures over 40°C on May 5-8, and May 17-22, about a month and a half before the survey. During the survey periods (late June – Mid July), the temperatures ranged between 34°C -42°C with high humidity, meaning the heat index ranged between 41.1°C and 55°. Night-time minimum temperatures were also very high, ranging from 29-31 degrees with Humidity ranging from 62-84%, resulting in a HI of 33 on one night and between 35 and 39 on the remaining 13 of the 14 survey days. The Karachi Heatwave Management Plan is sensitive to periods of extreme heat including high night time temperatures as significant for human health. However, there appear to not be formal thresholds beyond the WMO definition of a heatwave as "when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5 °C, the normal period being 1961-1990".

Indonesia – Jakarta: maximum temperatures ranged between 30°C and 34°C degrees with high humidity, meaning that the heat index ranged between 35°C and 41°C. Apart from low-intensity rainfall on the 16th and 17th of July, there was no rainfall. Night-time lows were between 25-27 degrees, with high humidity, resulting in a HI of 26°C -31°C. The conditions were typical of the time of year in which the survey took place, as average maximum temperatures for June and July was 32.71°C . As such, while hot, these conditions did not meet the official definition of a heatwave in Jakarta, which is: 5 or more consecutive days where the daily maximum temperature is statistically higher than the average maximum temperature by 5°C or more. This is the WMO definition, but it should be noted that in equatorial tropical regions, wide variations in temperature are highly unusual, but this does not mean that everyday conditions are not extreme.

Cameroon – Douala: maximum temperatures ranged between 27°C and 32°C with high humidity, meaning that the heat index ranged between 32.2°C and 39.8°C. Night-time minimum temperatures were cooler, ranging between 23-24°C, with 100% relative humidity, resulting in a relatively comfortable HI of 24-25°C. Douala as well as Cameroon more generally suffers from not only a lack of a heatwave definition and warning system, but also the data required to create one (Menang, 2017).

It should be noted that the general heat wave definition originally provided by the WMO has been widely critiqued, and in many countries replaced with definitions considered to be more appropriate to local meteorological context. Indeed in the 2015 WMO-WHO (2015) 'Heatwaves and Health: guidance on warning-system developing' does not even refer to the 5 days over 5 degrees definition at all. Instead, it notes heatwaves as characterised by 2 to 3 days of hotter than average conditions. Further, it observes that heatwaves can be hot and dry or hot and humid – which means that humidity is a critical factor to consider in the definition – and that the real significance of conditions is determined not by the magnitude of statistical deviation from the norm per se. Rather, the observation of the conditions in which significant impacts on human health occur should inform the development of the warning criteria or thresholds. It adds that even in the absence of abnormally hot conditions, average conditions when these are already extreme can present a threat to human health for exposed and vulnerable populations. Extreme heat information for chronic (seasonal or daily) exposure can be found, for example, via the ThinkHazard database.[6]

On the basis of such advice, the fact that no formal heatwaves were declared does not mean conditions should be dismissed as benign. On the contrary, the guidance suggests that better definitions of heatwaves and the development of locally appropriate warning criteria for each of the countries should be developed, based on heat-health outcomes. This report is not able to address such concerns, much less resolve them, but it does add to the evidence of heat-health impacts that can be used in developing more appropriate heat-health warning systems.

Epidemiological and Statistical Analysis

We computed the descriptive statistics for the demographic characteristics and all the variables. We grouped the entire data into appropriate categories viz., demographic characteristics such as personal details, electricity availability for cooling provisions, welfare facility, housing envelope materials, and methods to cope with the heat. To compare the difference in participants' perceptions of the impact of COVID and associated measures, we categorized heat-related adverse outcomes, social impacts, and behavioural impacts and determined the association between the participants' perception of thermal comfort and the co-variables before and during the COVID-19 pandemic.

We used chi-squares and analysis of variance (ANOVA) to determine the statistical significance of the differences between groups defined by each outcome in the demographic characteristics (age, gender, occupation, family size, electricity available cooling provisions, welfare, and building materials) and perception indicators (coping with the heat and heat-related health symptoms). For example, we group the perception of temperature inside the home into a hot category which contains all responses above 'Comfortable' and a cold category which contains the following responses: 'Comfortable', 'Slightly cool', 'Cool', 'Cold' 'Don't know' and 'Refused'. To apply the chi-squared test, we generate a contingency table which contains the number of occurrences of the answers to two characteristics or perception indicators. For example, when evaluating the number of occurrences of temperature perception and gender we get four numbers: females in the hot and cold categories, respectively, and males in the hot and cold categories, respectively. The result of the chi-squared provides a measure of the difference between the data and the hypothesis that the data is independent, i.e., the two characteristics or perception indicators are independent of each other. The larger the chi-square value, the stronger is the evidence that the two characteristics or perception indicators are associated.

To evaluate the effect of the pandemic (and lockdown) and to compare the difference in the participants' perception regarding health-related symptoms, social impacts, and behavioural change due to the pandemic, we used the univariate logistic regression model that assessed the influence of the independent variable on each binary outcome

6 https://thinkhazard.org/en/

(results expressed as Odds Ratio (OR) with a 95% confidence interval). We used a fixed model for covariates with a univariable p-value <0.05.

The Odds Ratio provides a measure how likely one outcome in one characteristic or perception indicator, e.g., participant in the hot category for temperature inside the home, if the participant is part of one category in a second characteristic or perception indicator, e.g., participant is female. For example, if the OR is 3, this means that the odds of females to perceive thermal discomfort are three times higher compared to the odds of the control group, i.e., males. On the other hand, if the OR is 0.5, their odds to perceive thermal discomfort would only be half compared to the odds of the control group. The Odds Ratio is statistically significant if the confidence interval doesn't include 1 because an Odds Ratio of 1 indicates that each category has the same odds.

We did not make any adjustments for multiple testing. We considered a two-tailed p-value smaller than 0.05 as statistically significant (2-sided tests). Missing values were excluded. The initial analysis was performed in SPSS (v16) and afterwards automated using Julia. The relevant Julia notebooks are available at: https://github.com/Cool-infrastructures/COVID19-Heat.

Hypotheses informing Epidemiological and Statistical Analysis

In each of the following city reports, two tables present data on the relationship between 1) demographic and residence characteristics of study participants and their relationship to perceived thermal comfort, and 2) the association between participants' perceived thermal comfort, heat-related illnesses, and their behaviour in the context of the pandemic. The hypotheses that inform the analysis in the tables are summarised below.

Table 1: Characteristics of respondents and their homes and association with perceived thermal discomfort during the pandemic/at the time of the survey?

In this table, responses from those who perceived thermal discomfort, assessed by responses of 'Very hot', 'Hot', Warm' and 'Slightly warm' were analysed for associations with characteristics of the household and the home.

Demographic and Household Characteristics

Age. As older age groups are commonly assumed to be more at risk of heat-related illness as a result of comorbidities and declining thermal regulation capability, we have assessed thermal comfort in relation to various ages (≥ 25 years/ <25 years; ≥ 30 years/ <30 years; ≥ 40 years/ <40 years and ≥ 50 years/ <50 years). As very few respondents were older than 60, we did not include a category to compare those under 60 with those older than 60.

Gender. Given that the daily practices shaping exposure to heat inside and outside the home, as well as the nature and type of exertion in the heat (for example, related to types of work) are strongly gendered, we examined association between gender and thermal comfort.

Occupation. Type of work is usually associated with exposure to heat stress and occupational heat strain. This was included as occupations may affect the level of heat acclimatization and tolerance of respondents in general, and in relation to the home environment if confined there during lockdown measures. The occupation classifications were divided into 4 main groups where each group was compared to all the others, to identify if any of these exhibited a significantly greater likelihood of thermal discomfort. However, different occupations are associated with different degrees of financial stability and income, and as such we also wanted to observe whether those in more or less secure forms of employment might be likely to experience different likelihoods of thermal discomfort. Each of the categories were also compared individually against each of the others.

- Paid labour, street sales, self-employed vs rest – assumed to be unlikely to experience additional thermal discomfort in the home as usually more exposed, but likely to have unreliable and possibly lower incomes leading to reduced ability to mitigate heat at home.

- Migrant remittances, help from family vs rest – there was no hypothesis as to how this would affect thermal comfort, but as it is a key source of income in South Asia it was crucial to include.

- Employed in private company or by government vs rest – the hypothesis was that salaried positions were more likely to support thermal comfort at home given stability of income, and the likelihood that such income was also higher than those in some categories.

- Homemaker, student, unemployed vs rest – as the category likely to spend the most amount of time at home, it was useful to test whether these respondents had high levels of thermal discomfort during the pandemic, as they were the likely to have experienced the least amount of change to their daily behaviours.

Total Residence Numbers, and Residents per Room. Overcrowding, or a high number of residents per room is associated with poverty and a potential indicator of decreased ability to manage thermal comfort. Resident per room was calculated by dividing the number of residents by the reported number of rooms. 3 people or more per room is the UN Habitat's [citation] definition of overcrowding. We also assessed whether there was a clearer relationship when the threshold was set at 4. As the survey did not collect information on the size of the rooms, and therefore cannot be used for more sophisticated assessments of overcrowding (including age/square meter) we also included the total number in the home as a stand-alone category.

Utilities

- **Electricity connection.** Types of connection were grouped into categories of informal connections versus formal, solar, generator or other. The hypothesis was that informal connections might be particularly unreliable.

- **Hours of electricity supply** (less than 21 hours, versus more than 21 hours). The hypothesis was that respondents with constant or near-constant power supply would be less likely to suffer thermal discomfort, while those with significant gaps in supply would have greater likelihood of thermal discomfort.

- **Fans vs Refrigerator and 'other'.** We hypothesised that those who had access to other cooling devices or refrigerators might exhibit less thermal discomfort, compared to fans which were the most widely available.

- **Drinking Water Supply.** Drinking water sources were grouped into four categories: Tanks (delivery of water by tankers for storage in smaller tanks at home); a shared public tap (often at the end of the street); Bottled water; Other (such as domestic wells/bores). Drinking water is crucial for maintaining hydration, which supports more effective thermal regulation. However, the source of drinking water shapes how reliable, accessible, and affordable it is. Furthermore, sources of water were differently affected by the pandemic. The hypothesis was that less reliable, accessible or affordable water was likely to shape dehydration and therefore likelihood of experiencing thermal discomfort. However, which water source is most vulnerable varies from country to country.

- **Water for household purposes.** Bathing to cool the body, and using water to cool the home through evaporation and in evaporative coolers are key strategies for reducing thermal discomfort. Given sources of water vary in their reliability, accessibility and affordability, we wanted to examine if an association was apparent between the type of household water source and the likelihood of thermal discomfort.

Building Envelope Characteristics

- **Building Material.** Different materials have different thermal properties, affecting thermal comfort. Given all components of the building envelope affects the conditions inside, this question assesses when at least one heat-conducting or heat retaining material is used in the floor, walls or roof, as opposed to when none are used.

- **Roofing material.**
    - As metal roofing is likely to absorb and conduct heat into the home, this is compared to cooler materials to see if it increases the likelihood of thermal discomfort.
    - As concrete absorbs and retains heat, keeping homes warmer at night, concrete roofing was also assessed against the coolest (natural materials) to see if it had an association with thermal discomfort.
    - Concrete was also compared to ceramics and clay; and metals and concrete as the two hottest materials were then compared to ceramic and clay.

- **Number of rooms.** Less than 2 rooms compared with 2 or more were analysed for association with thermal discomfort. More than 2 rooms was assumed to allow for cooking, which creates an additional heat source, to be located in another room, allowing for one room without additional heat exposure.
- **Ventilation.** Less than 2 windows was compared to 2 or more, the assumption being that with the door closed, 2 or more windows would allow for some degree of cross ventilation, and therefore reduced thermal discomfort, regardless of building material and door type.
- **Electricity usage, windows & people per room.** Those who had to use less electricity during the pandemic, and had either 1 window or fewer per home, or 4 or more people were examined for association with thermal discomfort. The hypothesis was that lack of cross ventilation and/or higher occupation levels might contribute to greater discomfort when families were likely to be confined to the home.
- **Cooling strategies.** Normal (pre-pandemic) strategies for coping with heat were compared for their association with thermal discomfort, the hypothesis being that some strategies may be more effective than others. These could be assessed in more detail, but as the main strategy to change as a result of the pandemic was the ability to go outside, we have assessed this, comparted to indoor strategies (fan use, ventilation, evaporative cooler), to see if there was a strong association with thermal discomfort, as going outside might indicate a particularly hot home.

Table 2: **Association between participants' perceived thermal comfort and heat-related illnesses (HRI) and everyday life.**

Perceived HRI symptoms during the pandemic and the association with thermal discomfort was assessed, as a correlation was predicted between a hot environment and symptoms this can cause.

- **Not all HRI symptoms had clear correlations.** A variety of sample symptoms associated with different severities of heat illness were included.
- **'Any one HRI symptom'** in the last month was also tested for association, as there are a wide variety of possible symptoms.
- **Heat affect.** Survey respondents were asked "Compared to this time last year, has heat affected you more or less?" This question was asked after respondents discussed heat-related illness, and any changes in physical violence and was deliberately broad in its framing. In examining for association with thermal discomfort during the survey period, the hypothesis was that there might be a correlation between greater impacts and greater thermal discomfort.

Impact of Pandemic on the Home and Everyday Life:

- Physical Conflict. An increase in physical conflict, a less offensive or taboo term for domestic violence, but also covering instances such as fighting between siblings, was hypothesised to be a potential outcome of thermal discomfort.
- Time spent at home. An increase in time at home (as opposed to a decrease in time at home was examined for an association with thermal discomfort to identify whether the pandemic lockdown measures may have contributed to the risk of associated heat impacts on health and wellbeing by increasing exposure to hot domestic environments and reducing the access to public, cool areas.
- Change in income levels. A loss of income (as opposed to an increase or steady income) during the pandemic was tested for association with thermal discomfort, as the hypothesis was that those with less income may be unable to afford sufficient power or water to keep them cool while at home.
- Change in eating habits and association with thermal discomfort. There is a relationship between eating enough, and having sufficient electrolytes and associated good health to support healthy thermal regulation and the ability to tolerate warm conditions. Eating less might have a relationship with thermal discomfort.
- Change in water intake. Unfortunately, this question did not differentiate between drinking water and water for household purposes. Both are useful in reducing vulnerability to heat, so it was hypothesised that there might be an association with thermal discomfort.

4.2 Qualitative Analysis

Open Questions

Two related open-ended questions were asked during the survey to ascertain peoples' habitual heat management strategies and whether and how these may have changed in relation to the pandemic response. Respondents were asked: *when it feels too hot in your home, what do you normally do* (Question 20)? *This was followed by: has the coronavirus pandemic changed what you do when it is hot* (Question 21)? *If they answered 'yes', they were then asked: how did the pandemic change what you do when it is hot? do you engage in different activities, do you use different technology/tools, go to different places, spend more or less time indoors/outdoors* (Question 22)?

In some instances, particularly in India and Pakistan, the respondents appear to have interpreted the final question as 'how the pandemic has changed your life in general?' This could be a consequence of the way it was phrased when translated (see Appendix A). Most of the responses focus on not having access to rice and daily items, having to focus more on hygiene measures and not having sufficient income. We have coded these in the online data set and reported on them in some of the case studies where relevant, as although they do not specifically relate to measures taken to address heat specifically, they demonstrate changes in practices that may afford incidental changes in exposure and vulnerability.

Regardless of content, the answers to the open questions were often only a few words. It seems the interviewers did not record the full answers and often used stock phrases, effectively informally coding answers and stripping out detail. This could not be redressed without re-running the entire survey. Nonetheless, the content does raise important points that would otherwise have not been clear.

Contextual Analysis

To better analyse the responses, contextual research was undertaken on the pandemic measures in each region. This has utilised available official information and credible media sources as well as academic literature where available. This is examined in the city case studies in section 5.0, and in the discussion in section 6.0.

Fig.1.: All-city coding of responses to "When it feels too hot in your home, what do you normally do?"

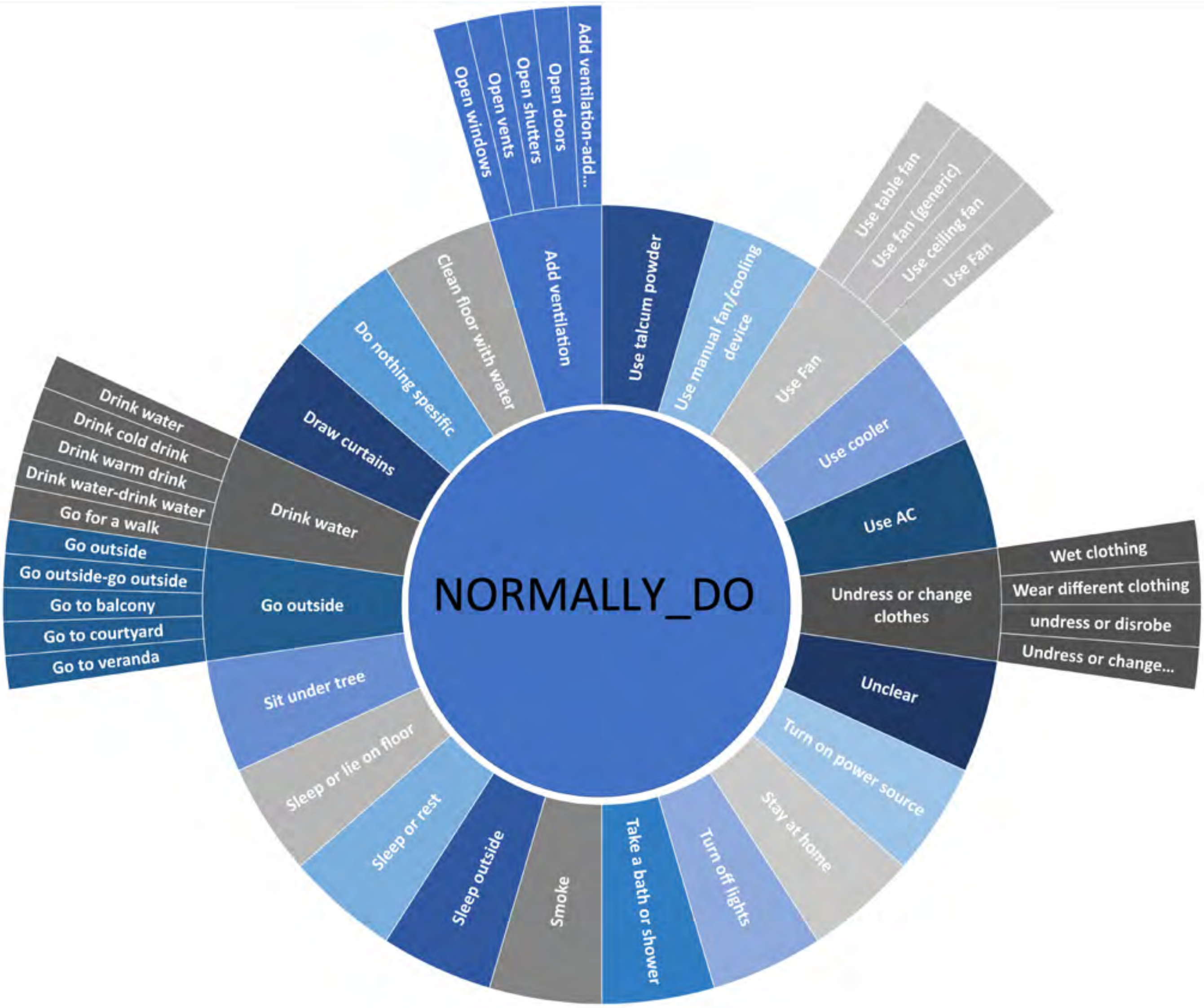
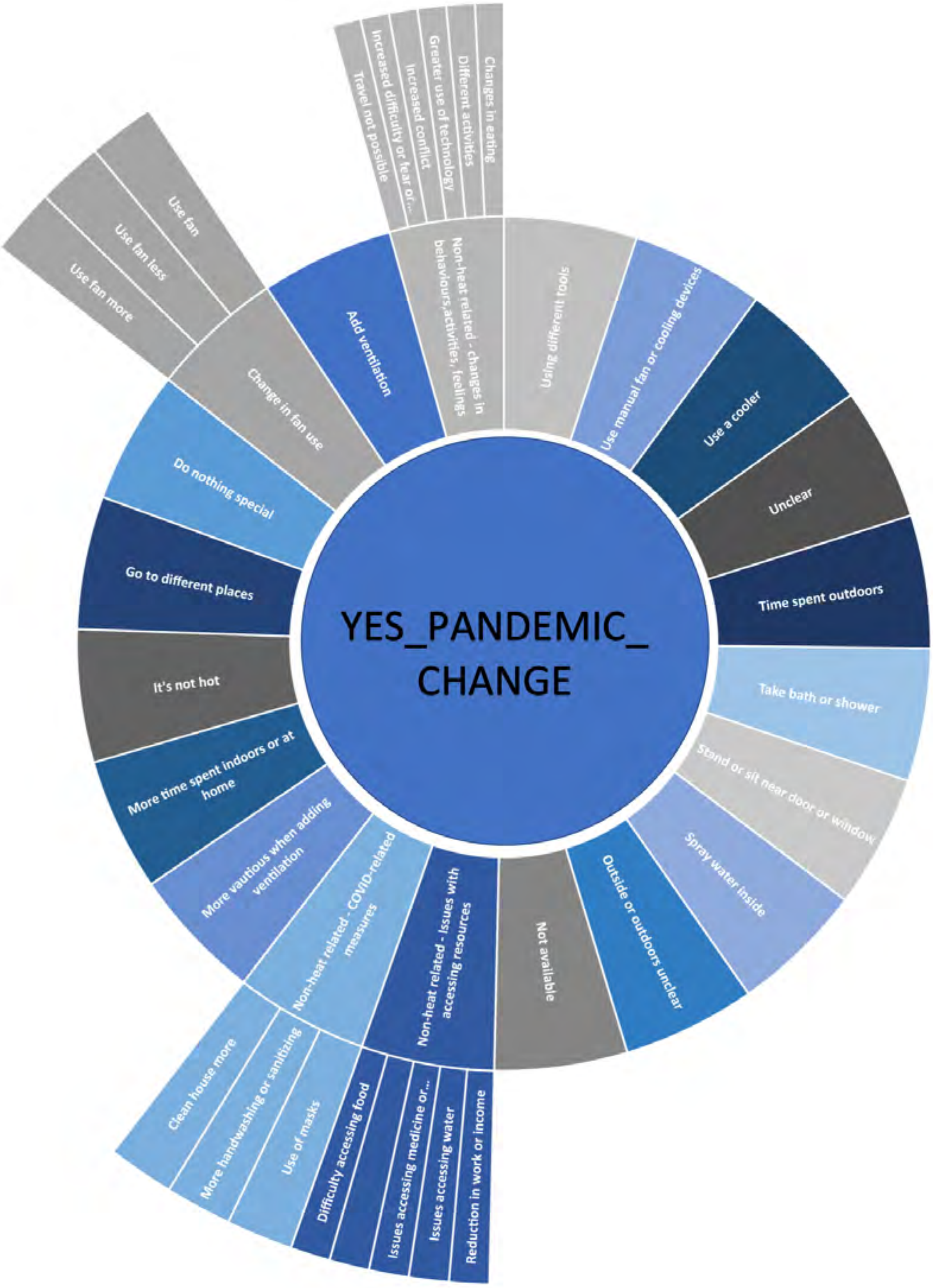


Fig.2.: All-city coding of responses to "How did the pandemic change what you do when it is hot?"



5 Case Study: Karachi, Pakistan

Summary

- The survey respondents from Pakistan (n=1172) comprise two cities, Karachi (n=875) and Hyderabad (n=297), both urban centres in the province of Sindh.

- Karachi experienced two heatwaves in May 2020, and was also under Covid-19 measures of 90%-60% potential stringency between May and July. The survey ran in late June to mid-July 2020.

- Those perceiving thermal discomfort had 3.8 times higher odds of experiencing at least one symptom of heat related illness than those who did not.

- 7% of respondents reported an increase in physical conflict in the home. Those reporting increased violence had 4.4 times higher odds of reporting thermal discomfort, indicating a strong correlation (OR: 4.4; CI: 1.1-18.3; p=0.25).

- The pandemic measures changed the kinds of cooling practices available to 9% of respondents. This group had 4.1 times higher odds of thermal discomfort compared to those whose cooling practices were unchanged.

- 63% of participants reported that heat affected them more over the month prior to the survey (which ran in late June to mid-July 2020) compared to the same time last year.

- The degree of change in time spent indoors during the pandemic was substantially differentiated across genders.

- None of the respondents had direct formal access to mains electricity supply. 28% of respondents reported decreased electricity access during the pandemic, while 38% reported no change and 34% reported increased access.

- Water usage also changed during the pandemic, with 23% of respondents reporting reduced water use; 35% reported no change; 42% reported increased usage.

- Heat mitigation strategies appear to be shaped by building type, and were differently affected by pandemic measures; respondents living in reinforced cement concrete homes were more likely to use fans while those living under galvanized iron roofs were more likely to go outdoors. The latter strategy was strongly affected by lockdown and quarantine requirements.

5.1 Timeline and Context

Timeline

29 January – Four Pakistani students studying in China tested positive for COVID-19
26 February – First two cases confirmed in Pakistan.
4 March – Screening measures implemented at major airports.
10 March – Sindh Government imposed temporary ban on marriage halls, banquets, tea stalls.
13 March – Most international flights stopped; universities and schools closed until 5 April.
18 March – First two deaths in Pakistan confirmed.
21 March – International flights suspended for 2 weeks; lockdown announced in Sindh for 14 days
24 March – Prime Minister (PM) approved Rs1.2 trillion economic relief package, particularly aimed at low-income groups needing access to food.
27 March – Public holidays extended till 5 April, markets and malls to remain closed till 10 April.
02 April – Government extended lockdown for another two weeks
10 April – International/ domestic flight operations suspended till April 21.
24 April – Government extended nationwide lockdown to 9th May
9 May – Lockdown lifted in an attempt to restart the economy, cases rose soon after.
18 June – Sindh government imposes smart lockdown on parts of Karachi deemed to be hotspots.
08 August – International flights resume as cases continue to decline.
10 August – Restaurants, cinemas and gyms reopen.
15 September – Schools started reopening in phases
01 October – Mini smart lockdown imposed in Karachi's Manghopir from 1st to 15 October as COVID-19 cases spike.

Key Survey data

Data collection 1	June 24,27-July 5
Data collection 2	July 14-21
Total number of Respondents: Gender distribution:	N = 1172 Women: 48%; Men: 52%

Weather conditions: During the survey periods, maximum temperatures ranged between 34° C– 42°C with high humidity. This resulted in an extreme Heat Index range: 41.1°C and 55°. Night-time minimum temperatures were also very high, ranging from 29°C – 31°C, with Humidity ranging from 62-84% (HI of 33°C – 39°C).

Heatwave: No heatwave declared during the survey period or in the month immediately prior. However, shortly before that, Karachi experienced two heatwaves (temperatures over 40°C) on May 5-8, and May 17-22.

Sources: Ministry of Health, NCOC, PM Office, Ministry of Education, Dawn News, Daily Jang.

The survey was undertaken to ascertain the relationships between heat, pandemic measures and health and wellbeing outcomes in the context of the complex interaction of changing vulnerability and exposure to heat stress as a result of the pandemic measures, particularly in low income households.

The survey took place in late June and mid July. All of the respondents (n=1172) were from urban areas in the province of Sindh. Most came from Karachi (n=875) and about a quarter came from Hyderabad (n=297).

In many respects, the cities are very different. Karachi is Pakistan's largest city, with an unofficial population of 25 million and a built environment. Hyderabad is Sindh's second largest city, with a population of 1.7 million. Low-income settlements in the two cities differ in terms of history, social demographics, dominant building material (brick in Hyderabad rather than concrete which is more common in Karachi), as well as water and electricity suppliers. Karachi is a coastal city. Weather patterns in the region have been changing, with Karachi becoming increasingly prone to extreme summers, as well as periods of high humidity. In May of 2020 it experienced two heatwaves with temperatures above 40°C. Hyderabad, lies 140km inland from Karachi, and has a year-round arid climate.

In some regards, these populations are very similar. Access to public health facilities is provided by the Sindh government in both cities, and as such study provides combined results for both two cities (n=1172). However, where relevant, such as in regard to electricity and water supply and use, results have been disaggregated for the purposes of analysis. The Covid-19 management measures introduced by both Federal and Provincial governments were also focused on Karachi. As such, where the results are disaggregated by city, most of the analysis refers to Karachi, as the larger city with a higher percentage of the survey responses.

Pandemic Measures

In Pakistan, the announcement and implementation of the lockdown policies and safety measures was not a linear process. The Federal Government was criticized for its slow response to halt the spread of the virus, and for downplaying its severity despite warnings from medical experts.[7] Yet there were also several instances when the Federal Government took unilateral decisions regarding lockdown policy, without consulting provincial level governments.[8]

The first case of COVID-19 in Pakistan was reported in Karachi on 26th February 2020 (Waris *et al.*, 2020). March saw the gradual shutdown of public life: on the 4th, the Federal Government had set up COVID-19 screening at the country's four major airports; on the 10th, the Government of Sindh issued a temporary ban on marriage halls, banquets, tea stalls and hotels; on the 13th, educational institutes were shut down. By March 18th, there were 302 COVID-19 cases reported across Pakistan and the first two deaths. On 20th March, the first death from COVID-19 in Sindh was confirmed and the next day, all international flights were suspended for two weeks. Following this, the Government of Sindh announced a 14-day lockdown.

7 See: Crisis Group, 2020

8 The Sindh Government had been in favor of a strict lockdown policy, at odds with the Federal Government's stance. A key contention was around the closure of mosques, garnering extensive resistance from religious clerics and the general population. In April and May, during Ramzaan, this manifested as physical conflicts outside mosques.

Federal Government interventions materialized in the form of a PKR 1.2 trillion (USD 6.08 billion) country-wide economic relief package for the poor. In Sindh, the Provincial Government quickly imposed measures to restrict movement between 8am to 5pm. In Karachi, the police and the paramilitary Rangers ensured compliance with restrictions.

In March 2020, the Federal Government started using cell phones to issue health advice and increase awareness of symptoms, claiming to have reached more than 113 million people across Pakistan (Warwick Business School, 2020). However, in Karachi's low-income neighborhoods, many people experienced difficulties following safety measures due to limited resources, space to maintain social distance and lack of access to clean water to maintain hygiene.

On 31st March, the Federal Government approved a USD $900 million economic relief package for 12 million poor families (Center for Global Development, 2020), which provided PKR 12,000 ($73 USD) to cover basic necessities for four months. With the onset of the Islamic holy month of Ramzaan, NGOs and philanthropists worked to increase provision of economic assistance and basic necessities to the poor.

In April 2020, the country remained in a lockdown, and non-essential travel was discouraged. The Government of Pakistan announced a loss of PKR 2.5 trillion (15.2 billion USD) due to the pandemic, and an estimated 12.3 million to 18.5 million people had become jobless. The Prime Minister announced the setting up of a Corona Relief Fund, requesting donations from Pakistanis in the country and abroad. In May 2020, with Eid al-Fitr marking the end of Ramzaan, the lockdown was lifted. The Sindh Government allowed mosques, shopping malls and other commercial centers to open across Karachi. However, by 21st May, COVID-19 cases had risen sharply to more than 48,000 across Pakistan, and 15,626 in Karachi.

By 18th June, a week before the survey commenced, the Sindh Government began to impose "smart lockdowns" in Karachi, closing neighborhoods deemed COVID-19 hotspots. This situation continued throughout the duration of the survey, and by August 2020, COVID-19 cases in Pakistan had started to decline, which the government claimed was the result of smart lockdowns. On 10th August, restaurants, cinemas and gyms were reopened throughout Pakistan, and the Federal Government issued orders for educational institutions and marriage halls to reopen from 15th September. A total of 89,667 COVID-19 cases were reported in Karachi by 4th October 2020 (Health Department Government of Sindh, 2020).

Weather Conditions

Covid-19 measures came into place just before Pakistan entered its summer season, raising the spectre of potential knock-on effects in vulnerability and exposure to heat.

Karachi is located on the coast of the Arabian Sea and in a low altitude, hot arid, subtropical desert climate. The city experiences a hot and humid climate all year round, barring a short, dry winter spell during January/February. It also experiences a few days of heavy monsoon rains every year. The average annual temperature is 25.9 °C with the highest average temperature 30 °C in June, which is the month the survey commenced. May is considered the driest month, with July receiving the most rainfall. On average, the city receives 194 mm of rainfall in a year.

However, Karachi's weather trends have been changing, with extreme summers and winters and periods of torrential rainfall. In 2015 the city faced the deadliest heat wave in over 50 years: the temperature rose to 45°C and led to over 1200 people losing their lives. The impact was largely on laborers working outdoors, homeless people (Imtiaz and Rehman, 2015) and low-income populations living in homes made from reinforced cement concrete and block masonry (the most pervasive building materials in the city) and with limited or no access to cooling. In 2018, during the month of Ramzaan, temperatures rose to dangerous levels and heat stroke wards were set up in hospitals to mitigate the risk of heat related deaths.

The survey occurred a month or so after two heatwave events. In May 2020, amid the COVID-19 lockdown, Karachi experienced two heatwaves with temperatures above 40°C, from May 5-8, and May 17-22. Conditions remained hot during the survey periods, when maximum daytime temperatures ranged between 34°C – 42°C in combination with high humidity. This resulted in Heat Index (HI) readings of 41.1°C – 55°C. Night-time minimum temperatures were also very high, ranging from 29°C – 31°C with humidity ranging from 62-84%, resulting in a HI of 33°C on one night and between 35°C and 39°C on the remaining 13 of the 14 survey days. Although very hot, these periods were not considered to be heatwaves.

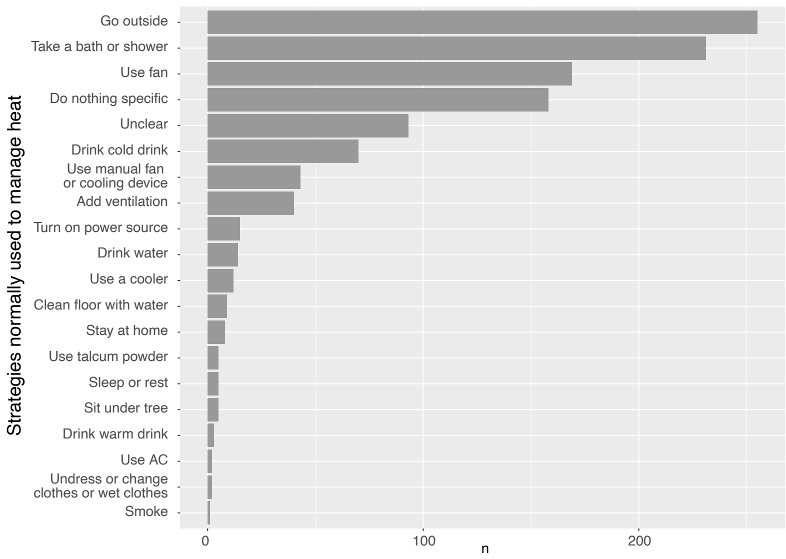


Fig.3.: Strategies normally used to manage heat at home in Sindh Province

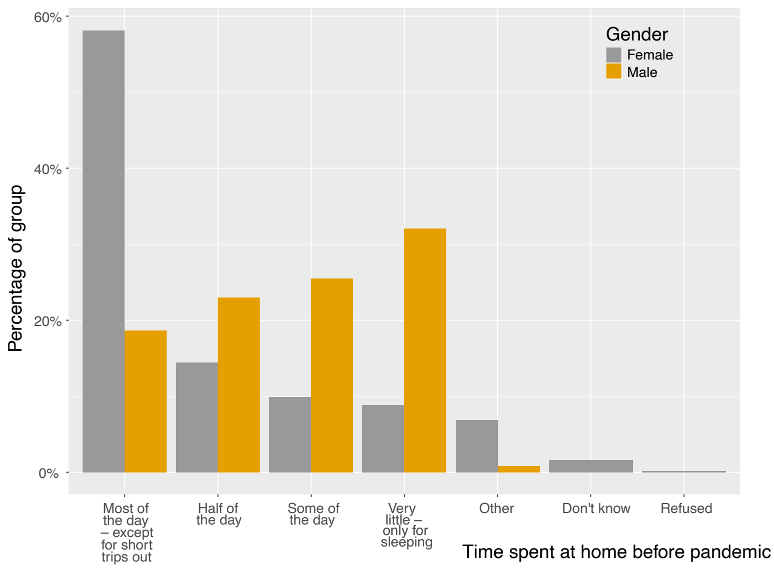


Fig.4.: Prior to the COVID-19/Coronavirus pandemic, how much time each day do you typically spend physically inside your home (expressed as percentage of responses by gender)

5.2 Overview of Survey Results

Pre-pandemic Cooling Strategies

In order to assess whether the pandemic affected the population's ability to manage heat exposure, respondents were asked what strategies they normally used to manage heat when it was too hot in their homes (Figure 3). The most common response was to go outdoors in order to escape heat within the house, followed by taking a bath or shower, at 22.9% or the use of active ventilation forms, such as electrical fans and room coolers. Some 15% intimated that they would sit and wait out the hot conditions by reducing their physical activity – effectively, choosing to 'do nothing'. 10.9% of the respondents chose passive ventilation techniques, such as opening windows, sitting on a veranda for air, or going onto the roof. 8.1% chose to drink a beverage for cooling the body, including cold water, cold milk, and also tea. A few (1%) chose to use water for cooling, such as by moistening clothes, or washing the floors.

Staying at Home – Time and Gender

Time spent at home provides evidence of the duration and potential exposure to heat in the domestic environment that respondents were likely to experience. Inversely, it also assists with calculating potential exposure outside of the home (such as while at work). Time at home also provides an indication of likely water and electricity needs and has implications for domestic relationships and domestic violence.

Before the onset of the pandemic, approximately 32% of men reported spending very little time in their homes, primarily using them for sleeping. Nearly 26% reported spending some part of the day inside. By contrast, almost 60% of women surveyed reported spending most of their day inside the house. This data reflects social obligations and gender

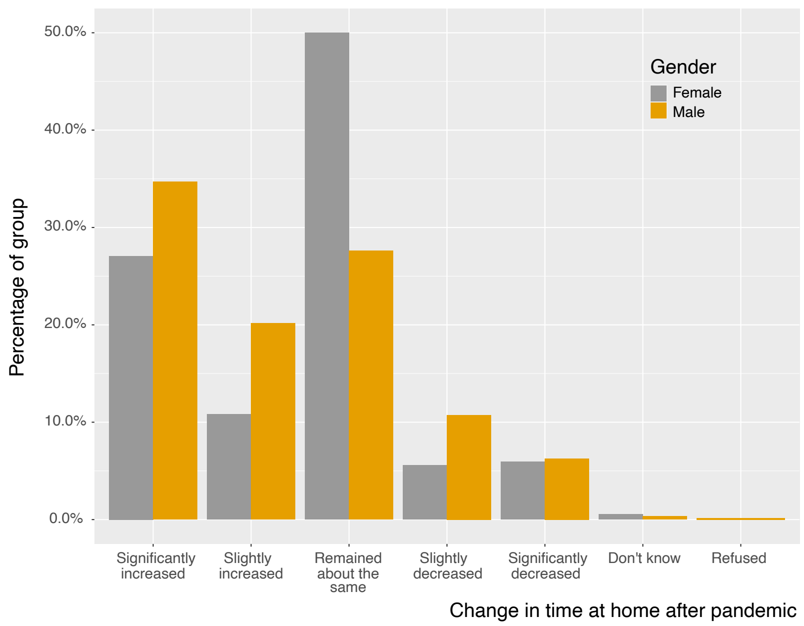


Fig.5.: "As a result of the COVID-19/Coronavirus pandemic, has the amount of time you spend inside your home… "(expressed as percentage of responses by gender)

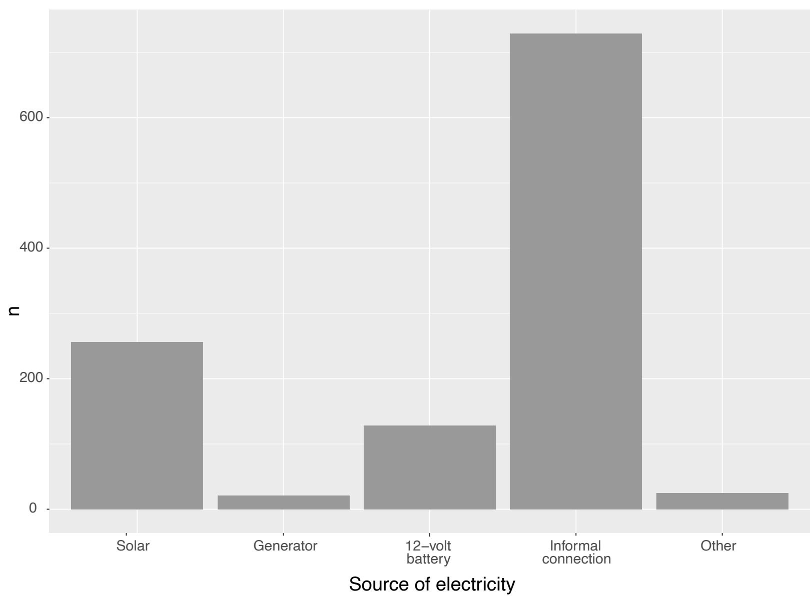


Fig.6.: Electric connections for respondents, Karachi and Hyderabad.

norms. Men often feel compelled to earn and, in the context of precarious labour arrangements and poor public transport that force people to spend a considerable amount of time commuting, invariably spend a substantial time outside of the house. Meanwhile, in the broader context of Pakistan's patriarchal society, women are expected to stay home and engaged in unpaid labour, such as tending to domestic duties or caring for family.

Changes in Time Spent at Home

The pandemic and its lockdown measures significantly altered patterns of time spent at home, but these were strongly differentiated across genders. Half of female respondents (50%) reported no change before and during the pandemic, while 38% reported increased time at home. By comparison, 26% of male respondents reported no change while 55% reported increased time at home.

Given higher rates of paid employment among male respondents, the significant increase in their time at home is likely to be either a direct consequence of the lockdown measures, or an indirect consequence due to job losses. Some female respondents also reported an increase in the amount of time they spent at home. This may indicate the smaller percentage of women who were employed outside of the home and were unable to work, or who were no longer able to visit friends/relatives/neighbours and engage in reduced shopping activities as a result of lockdown measures, or possibly quarantine requirements.

Changes in time outside of the home may also indicate a conscious change in everyday practices such as frequency of shopping and routine socializing. In the open-ended questions many commented on changes in availability of food, and some noted that they 'don't meet neighbours anymore' because of concerns regarding spreading the virus.

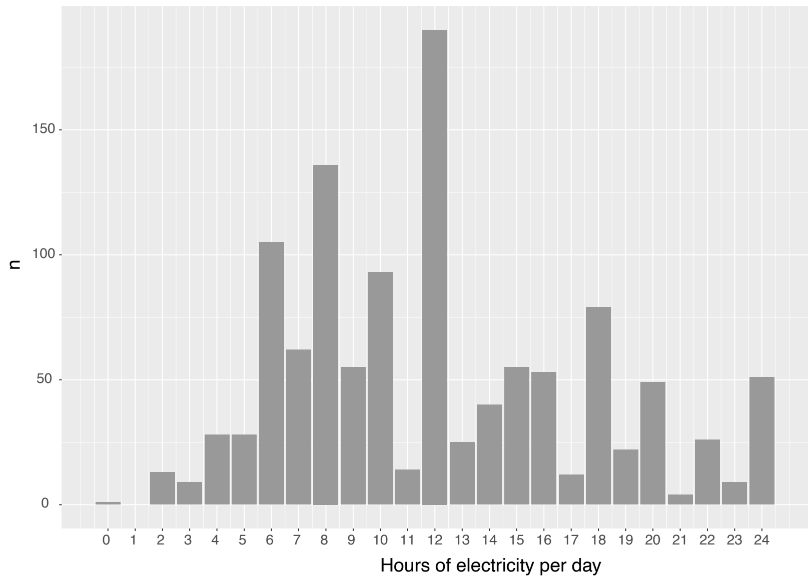


Fig.7.: How many hours of electricity the respondents receive at home, across all connection types, showing frequency of responses for hours of supply and cumulative percentages of hours of supply per percentage of respondents.

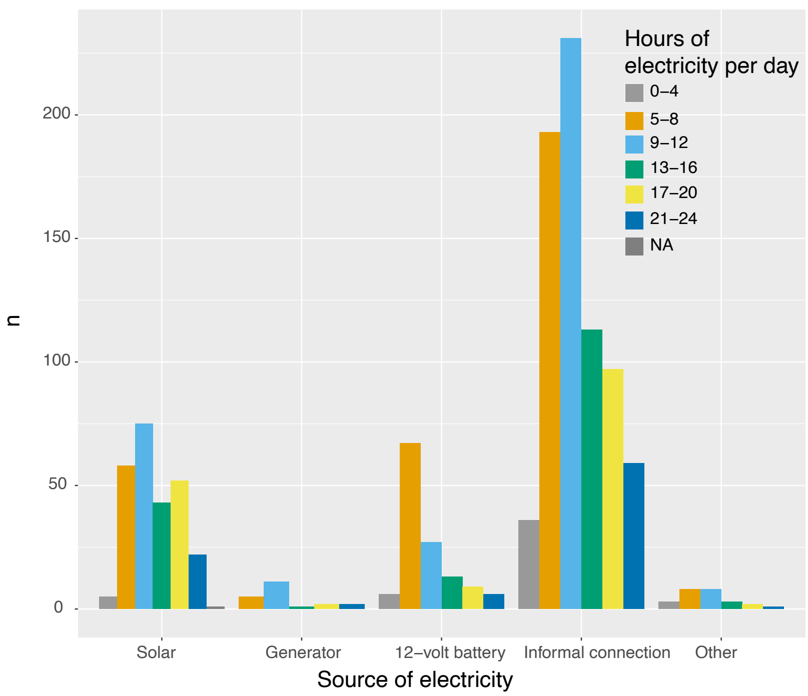


Fig.8.: Reliability of electricity supply by type, Pakistan.

Access to Electricity

None of the participants reported formal access to electricity directly from the utility company. A large number (63%) reported informal electricity connections. These could be of several types: either illegally connected to the mains line without paying bills (locally called *kunda*), which are practically free for the household; or accessing a formal connection through a neighbour and sharing their bill, which is a cheaper alternative to an individual formal connection. 22% reported using solar panels as a form of 'backup' supply, which helps run a few fans and bulbs during a power outage. 11% reported that their homes were running on 12-volt batteries, whereas very few (2%) had generators installed.

63% of respondents reported receiving 12 or fewer hours of electricity per day. Only 8% reported having electricity for 21 hours or more. Availability varies depending on the type of connection. For informal connections, supply tends to be around 12 hours per day. For the small number of respondents relying only on solar panels or batteries, 6 to 9 hours per day was more common.

These results reflect widespread shortfalls of electricity supply in the past few decades. The response has been scheduled power outages, or 'load shedding' measures, affecting residential consumers, and particularly those in low-income neighbourhoods who provide little cost recovery to electricity companies. Lack of reliability and high costs has also led to a significant number of low-income households to opt for alternative sources of energy such as DC batteries and solar panels.

The survey findings also clearly showed that the COVID-19 pandemic impacted on respondents' ability to use energy. 28% reported that they had to use less; 38.1%

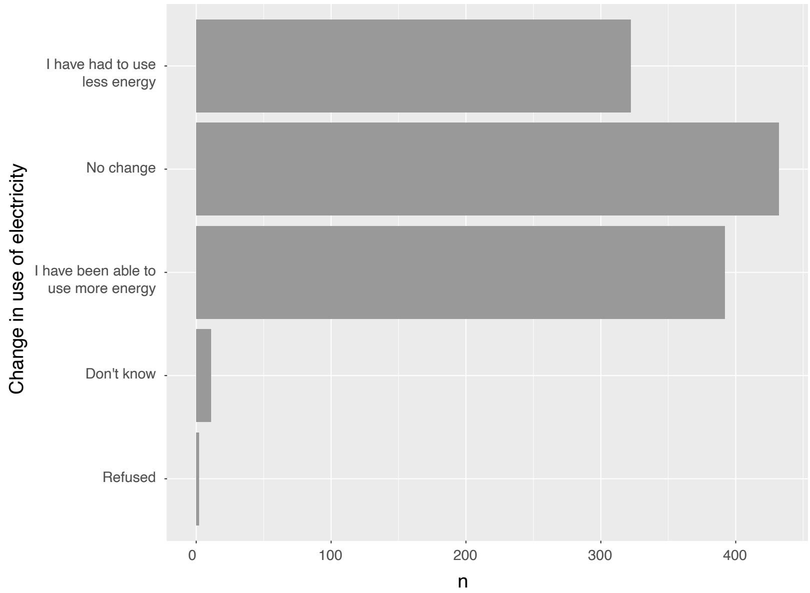


Fig.9.: Change in electricity usage as a result of the pandemic in Karachi and Hyderabad

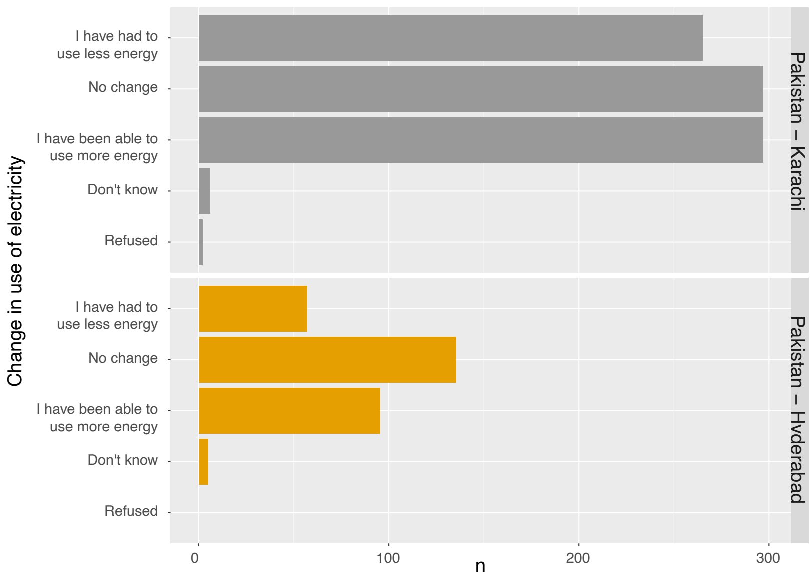


Fig.10.: Comparison between the change in electricity usage before and during the pandemic, for Karachi and Hyderabad

reported no change, and 33.9% reported increased ability to use energy. Given limited space, the question did not distinguish between changes in availability as a result of cost or provision. As such, the differences in responses concerning electricity usage during the pandemic, could indicate respondents' financial concerns.

When these results are examined in more detail, there appears to have been less change in Hyderabad, where 46.8% of the respondents reported no change in their electricity consumption pattern, compared to 34.6% in Karachi. Further, only 19.5% of respondents in Hyderabad reported using less electricity during the pandemic, whereas this was 30.4% in Karachi. These figures appear to reflect official and media reports, and suggest a more reliable or uninterrupted power supply in Hyderabad. The disaggregated data for both cities shows that low-income populations in Hyderabad were, nevertheless, better connected to the grid, and perhaps with more affordable access to electricity when compared to their counterparts in Karachi. In the event of a pandemic, when confined to their homes, the Hyderabad respondents may have been in a better position to cope with the compounding effects of indoor heat due to more stable or reliable power supply.

Finally, approximately one-third (33%) of those who reported increased time spent at home as a result of the pandemic also reported increased electricity consumption. In the absence of power outages or income loss, this positive relationship was anticipated, as residents offset the heat of the domestic environment by, for example, using fans. More detailed analysis of the data is needed to confirm whether income loss affected power use for those spending more time at home, but this would also need to be analysed in the context of further information about power outages to produce a definitive analysis.

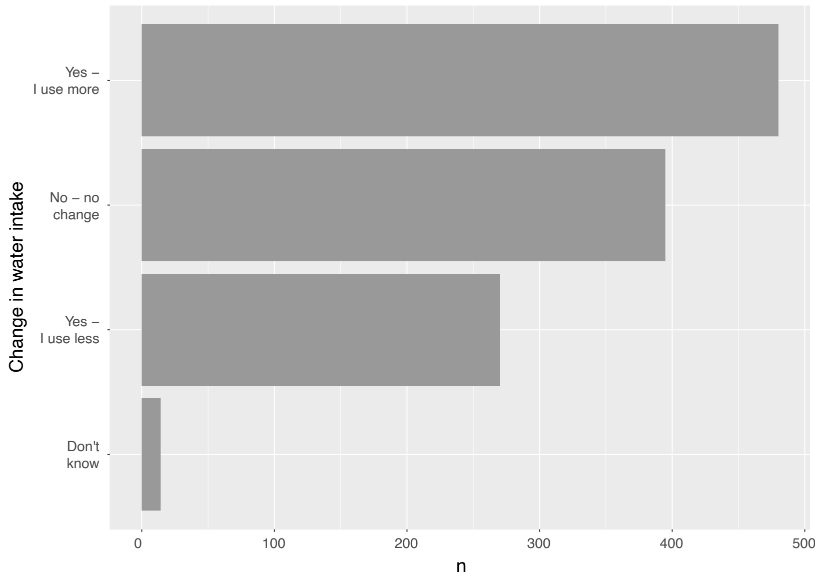


Fig.12.: Change in water intake as a result of the pandemic in Karachi and Hyderabad

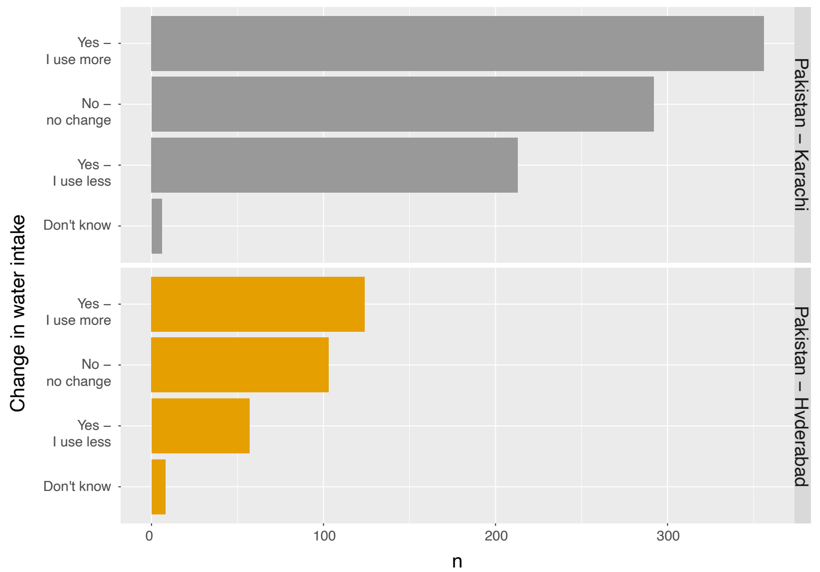


Fig.11.: Comparison between the change in water usage before and during the pandemic, for Karachi and Hyderabad

Water Usage

Across both cities, nearly 41.8% of the respondents reported increased water usage. Approximately 34.7% reported no change, and 23.5% reported that they had reduced water usage.

Against the backdrop of the pandemic, increased water usage might be linked to the increased concern for hand washing as a preventive measure to safeguard against the spread of the virus. However, considered in relationship to temperature data, increased water usage also appears to be related to the needs for cooling, bathing and hydration at a time when outside air temperatures were well above 30°C and people spent more time at home, confined in thermally challenging domestic environments.

Even though the trends are similar across both cities, there is a subtle difference. Some 19.5% of respondents from Hyderabad reported reduced water usage, whereas in Karachi this figure was higher at 24.5%. Based on this data, we can posit that low-income households in Karachi are more vulnerable when it comes to water access under conditions of economic hardship and/or confinement measures. Research on Karachi's low-income settlements shows that households often have to choose between purchasing water and food, or paying rent, and as such it is not uncommon for low-income households to compromise on water usage.[9]

Finally, out of those who reported an increased time spent at home (n=548) approximately 45% also reported increased water usage. Similar to the relationship between increased time indoors and increased electricity consumption in the last section, a causal relationship between the current two indicators (an increased time spent at home, and an increased water usage) cannot be derived only from the responses elicited in the survey. However, increased time at home and increased water intake are statistically significantly correlated (Chi^2 = 4.426, p-value = 0.0354, Odds ratio = 1.284, CI: 1.017-1.621).

9 See: 'Alternate water supply arrangements in peri-urban localities: awami (people's) tanks in Orangi township, Karachi', Ahmed, N. & Sohail, M., 2003, *Environment and Urbanization* 15 (2):33-42; 'Water Supply in Karachi: Issues and Prospects', Ahmed, N., 2008, Oxford University Press; 'Gender, global terror, and everyday violence in urban Pakistan', Mustafa, D., Anwar, N.H., & Sawas, A., 2019, *Political Geography* 69:54-64; 'Without water, there is no life': Negotiating everyday risks and gendered insecurities in Karachi's informal settlements', Anwar, N.H., Sawas, A., & Mustafa, D., 2020, Urban Studies, 57:1320-1337.

Electricity or Water? Building Materials and Cooling Practices

In resource limited households, with intermittent supplies of water and electricity, there is likely to be degree of some trade-off or strategic choices made around what types of cooling practices are the most available or affordable. Furthermore, they may have different levels of efficacy depending on other aspects of the home environment. The survey data for Karachi indicates that:

- People living in reinforced cement concrete structures are *more likely* to use fans to mitigate the effects of heat than to take a shower.
- People living in non-reinforced cement concrete structures (including semi-permanent materials such as bamboo and clay) almost universally opt for showers as a first response to mitigate heat.
- People with galvanized iron roofs prefer leaving the home and going outdoors above all other heat mitigation strategies, such as bathing or adding ventilation.

Further analysis is needed to examine whether these decisions are related to, among other things: the thermal mass and thermodynamics of the structures themselves; whether housing material is related to the options for cooling most readily available, for example the type of power or water supply; whether there is a relationship between housing type and ability to pay for these services; or what the relationship between housing materials and cooling practices reveal about class aspirations.

Plot-Level Density: Bodies and Cooling Practices in Karachi

Plot-level or room-level population density is an important indicator of electricity and water needs, as well as cooling practices. The survey data from Karachi suggests a further relationship between the density of occupants in a home and the use of electricity or water as a cooling strategy.

- In homes with a density of fewer than 2 people per room, the first response (24.8%) to mitigating heat was to add active ventilation, through electric or portable fans. By contrast, only 19.8% of the respondents chose to use water for bathing to cool themselves.[10]
- In homes with a density of between 2 and 4 people per room, the use of electricity for ventilation fell slightly (to 23.6%), and the choice to bathe rose slightly (to 22.7%).
- In homes with a density of more than 6 people per room, 52% of the people chose to bathe.

10 Further research is needed to understand this data. Perhaps, electric appliances/ventilation are experienced as less effective by people using them in densely populated spaces. Or, perhaps homes with a density of more than 6 people are less likely to own a fan or electrically powered cooling device.

5.3 Statistical Analysis of Heat-Health Exposure, Vulnerability and Impacts

The influence of the building envelope on the thermal load, and related perception of residents on thermal comfort, was assessed via questions related to building materials.

94% of respondents lived in homes made of building materials with high thermal absorptivity or conductivity (galvanized iron, sheet metal, reinforced concrete & t-girder). 6% of respondents lived in homes made primarily of materials (roofing, walls and floor) with low thermal absorptivity and natural materials, such as palm fronds, dried clay, bamboo, wooden shingles, ceramic tiles. Although these materials had properties to keep indoors cooler, their perceptions of thermal comfort were not statistically different during the month prior to the survey, and as such it seems these types of housing did not make residents less exposed or vulnerable to heat stress.

Across all types of housing, respondents reported experiencing various symptoms associated with heat stress during the survey period, such as: feeling hot (46%), confusion (30%), headache (22%), fatigue (17%), poor quality of sleep (9.2%), dizziness (2.7%), nausea (1.9%), fainting (0.9%), rash (0.9%) and vomiting (0.9%).

The data was analysed to determine whether thermal discomfort was in fact related to negative health outcomes in the forms of heat related illness (HRI) symptoms (see table 5.2 -1 below). A significant association between participants' perceiving thermal discomfort and experiencing heat-related symptoms was observed for HRI-s like confusion (X^2=6.65, p=0.001), fatigue (X^2=4.3, p=0.037), feeling hot (X^2=24.53, p<0.0001), feeling sweaty (X^2=36.78, p<0.0001), feeling thirsty (X^2=25.031, p<0.0) and irrational behaviour (X^2=5.46, p=0.019). For other HRI symptoms such as blurred vision, clammy skin, concentration loss, convulsions, fainting, poor quality of sleep, rash and vomiting, there was no association with perceived thermal discomfort.

As the spectrum of possible symptoms is wide, we also analysed the data for respondents having at least one of the following symptoms: feeling sweaty, feeling thirsty, headache, irrational behaviour, muscle cramps, muscle weakness or nausea. This had a strong positive association with perceived thermal comfort. The odds for these experiences were reported ~3.8 times higher among participants who perceived thermal discomfort (CI: 2.5-5.6; X^2=47.5, p<0.0001) than those who did not perceive thermal discomfort.

Table 1: Demographic and personal characteristics of the study participants and its association with perceived thermal comfort (n=1172)

	Respondents perceiving Thermal Discomfort N (%)	Chi-square, p-value (X^2)	Crudes Odds Ratio, 95% C.I.
Demographic characteristics			
Age (years) ≥ 25 years/ <25 years	632 (53)	5.432; 0.020	1.586; 1.073-2.343
Age (years) ≥ 30 years/ <30 years	385 (33)	2.654; 0.103	1.426; 0.929-2.189
Age (years) ≥ 40 years/ <40 years	129 (11)	0.531; 0.466	1.272; 0.665-2.434
Age (years) ≥ 50 years/ <50 years	33 (3)	1.773; 0.183	3.567; 0.483-26.333
Gender male vs female	541 (46)	3.8; 0.051	0.674; 0.453-1.003
Occupation Paid labour, street sales, self-employed vs rest	309 (26)	0.109; 0.742	1.077; 0.693-1.673
Occupation Migrant remittances, help from family vs rest	12 (1)	1.282; 0.258	NA; one group is empty
Occupation Employed in private company or by government vs rest	182 (16)	5.305; 0.021	0.587; 0.372-0.927
Occupation Homemaker, student, unemployed vs rest	491 (42)	1.625; 0.202	1.302; 0.868-1.954
Occupation Homemaker, student, unemployed vs employed in private company or by government	491 (42)	4.853; 0.028	1.739; 1.058-2.858
Total residence members ≥6 members vs <6 members	601 (51)	0.012; 0.913	1.022; 0.689-1.517
Residence per room ≥3 vs <3	710 (61)	0.067; 0.796	1.056; 0.699-1.595
Residence per room ≥4 vs <4	391 (33)	1.701; 0.192	1.324; 0.868-2.020

Welfare facilities			
Electricity connection informal vs solar, generator, other	663 (57)	2.652; 0.103	0.653; 0.390-1.094
Hours of electricity supply <21 hrs vs ≥ 21 hrs	980 (84)	0.796; 0.372	1.351; 0.696-2.622
Cooling interventions Fans vs refrigerator	973 (83)	0.154; 0.694	0.860; 0.405-1.824
Drinking water supply Tanks vs rest	310 (26)	2.379; 0.122	1.438; 0.904-2.287
Drinking water supply Shared tap vs rest	431 (37)	0.219; 0.642	1.100; 0.737-1.641
Drinking water supply Bottles vs rest	283 (24)	4.125; 0.042	0.656; 0.435-0.988
Drinking water supply Other vs rest	36 (3)	0.009; 0.922	0.949; 0.331-2.717
Water for household purpose Tanks vs rest	404 (34)	1.820; 0.177	0.764; 0.516-1.131
Water for household purpose Shared tap vs rest	590 (50)	1.312; 0.252	1.255; 0.850-1.853
Water for household purpose Other vs rest	66 (6)	0.133; 0.716	1.173; 0.497-2.770
Building envelope characteristics (poor vs good thermal properties)			
Building material ≥ 1 hot materials (concrete, metals, etc.) vs <1 hot materials	993 (85)	0.161; 0.6882	0.839; 0.355-1.981
Roofing material Metals vs natural materials (wood, palm, bamboo)	178 (15)	0.916; 0.339	0.487; 0.108-2.188
Roofing material Metals vs ceramic and clay	178 (15)	3.215; 0.073	1.981; 0.929-4.226
Roofing material Concrete vs natural materials (wood, palm, bamboo)	743 (63)	1.257; 0.262	0.449; 0.107-1.890
Roofing material Concrete vs ceramic and clay	743 (63)	3.745;0.053	1.826; 0.985-3.386
Roofing material Metals and concrete vs ceramic and clay	921 (79)	4.052; 0.044	1.854; 1.008-3.410
Wall Material	612 (52)	1.836; 0.175	0.753; 0.499-1.136

Concrete vs bamboo, palm and mud brick			
Floor Material Asphalt, cement vs natural materials, tiles	783 (67)	0.008; 0.928	1.021; 0.654-1.593
No of rooms <2 vs ≥2	128 (11)	0.492; 0.483	1.261; 0.659-2.413
Ventilation <2 vs ≥2 windows	246 (21)	1.819; 0.178	1.413; 0.853-2.340
Electricity usage, windows & people per room Use less electricity, ≤1 window & 4≥ people per room vs rest	645 (55)	2.819; 0.093	1.396; 0.944-2.064
Coping With Heat			
Normal cooling strategies Go outside vs use fan, ventilation, cooler	318 (27)	1.593; 0.207	1.420; 0.822-2.452

5.4 Pandemic Effects on Thermal Comfort, and Associations with Heat Related Illness and Aspects of Everyday Life

Table 2: Association between participants' perceived thermal comfort and Heat-related Illnesses (HRI), daily life and behaviour in the pandemic context (N=1172)

	Participants perceiving Thermal Discomfort N (%)	Chi-square, p-value (X^2)	Crudes Odds Ratio, 95% C.I.
Perceived Heat-Related Illness (HRI) symptoms (During Pandemic)*			
Confusion	333 (28)	6.648; 0.0099	1.874; 1.155 – 3.04
Fatigue	186 (16)	4.324; 0.0376	1.954; 1.028 – 3.714
Feeling hot	521 (44)	24.53, <0.0001	3.25; 1.99 – 5.31
Feeling sweaty	676 (58)	36.78, <0.0001	3.67; 2.35 – 5.71
Feeling thirsty	594 (51)	25.031; 0.0	2.804; 1.847 – 4.257
Irrational behaviour	67 (6)	5.461; 0.0195	7.489; 1.03 – 54.474
Any one HRI in past month	845 (72)	47.467; 0.0	3.792; 2.543 – 5.655
Affected more by heat compared to last year			
Affected by heat More vs less or the same	683 (58)	11; 0.0009	1.928; 1.301-2.856

Impact of pandemic on daily life and behaviour			
Physical Conflict More in last month vs before	79 (7)	5.057; 0.0245	4.429; 1.074 – 18.271
Time spent at home before pandemic Half or more of the day vs less than half	604 (52)	1.359; 0.2437	1.261; 0.853 – 1.863
Time spent at home during pandemic Increased vs same or decreased	496 (42)	0.005; 0.9415	1.015; 0.687 – 1.5
Change in Income levels during pandemic Decreased vs same or increased	748 (64)	2.233; 0.1351	1.371; 0.905 – 2.077
Access to Health Services during pandemic	682 (58)	4.367; 0.0366	1.516; 1.024 – 2.245
Harder vs same or easier			
Change in eating Habits during pandemic Eat less vs same or more	328 (28)	7.202; 0.0073	1.942; 1.187 – 3.176
Change in Water Intake during pandemic Use more vs same or less	448 (38)	4.28; 0.0386	1.545; 1.02 – 2.339
Changed what you do when hot Yes vs rest	107 (9)	6.55; 0.0105	4.079; 1.273 – 13.068

Note: *The following HRI during pandemic that did not have a significant association with the thermal discomfort: blurred vision, clammy skin, concentration loss, convulsions, dizziness, fainting, fatigue, poor sleep quality, rash, vomiting, headache, loss of consciousness, muscle cramps, muscle weakness, nausea.

Changes in Exposure and Thermal Discomfort

Around 63% of participants reported that heat affected them more during the previous month compared to the same time last year. There is statistical significance with perceived thermal discomfort (OR: 1.93; CI:1.3-2.9; p=0.0009).

However, the data does not support the analysis that this was a result of spending more time at home due to the pandemic. Among the 1172 study participants, ~52% who perceived thermal discomfort also reported that they had spent at least half the day at home, although no statistical significance was observed between the time spent at home and thermal discomfort. About 42% of respondents who perceived thermal discomfort spent more time at home during the pandemic but again no statistical significance was observed. It appears that the pandemic confinement measures did not increase thermal discomfort compared to normal. These figures combine housing types and gender. Further analysis differentiating among sub-categories is required to identify if these factors affect thermal discomfort.

At a broad level, gender and associated patterns of employment may be significant in explaining the lack of impact of staying at home. For most women time at home was largely unchanged, and therefore thermal discomfort remained similar. Conversely, for men, who experienced more significant increases in time at home, this may have meant they were avoiding conditions likely to expose them to more severe thermal discomfort as a result of working outdoors or in labour intensive roles (exogenous environmental heat, and endogenous exertional heat).

Changes to Vulnerability and Adaptive Capacity

In contrast to changing exposure, changes in vulnerability and adaptive responses as a result of pandemic measures did have a very significant impact thermal discomfort. About 9% of respondents reported that the pandemic changed what they do when it is hot and also experienced thermal discomfort. There is statistical significance between this and perceived thermal discomfort, with respondents who needed to change their behaviour having 4.1 times higher odds to perceive thermal discomfort to respondents who didn't change their behaviour (OR: 4.1; CI: 1.3-13.1; p=0.01).

It seems likely that such changes were not related to a reduced ability to use water or electricity. A large percentage (41%) of participants used more water during the pandemic. 38% used more water and reported thermal discomfort, which was statistically significant (OR: 4.3; CI: 1.02-2.3; p=0.038).[11] As such it seems likely that the ability to increase water intake was a response to thermal discomfort, and was not negatively affected by the pandemic with knock-on effects for vulnerability to heat. There was also no statistically significant correlation between those who reported having to use less water and the experience of thermal discomfort. About 28% of participants perceived that they had to use less electricity than before the pandemic, but there was no statistical significance with thermal discomfort.

As electricity and water use were unchanged, supported thermal comfort or not significantly associated with discomfort, the relationship between changing heat management behaviours and thermal discomfort appears to be related to another strategy. The most common behaviours in Pakistan not reliant on electricity or water were some variation of 'going outdoors' and/or 'sitting in the shade'. Such behaviours were heavily impacted by pandemic restrictions and therefore seem likely to be responsible for changes in thermal discomfort. Aside from inability to buy food and daily items, inability to go outside was one of the most frequently commented on in the open question about how the pandemic had affected heat management behaviour.

While income loss did not appear to be directly related to thermal discomfort, reduced food intake was. Around 70% of participants perceived a significant decrease in income levels during the pandemic and most of these perceived thermal discomfort (64% of respondents) but no statistical significance was observed.

By contrast, among the 30% of participants who reported that they ate less during the pandemic, there was statistical significance with thermal discomfort (OR: 1.9; CI: 1.2-3.2; p=0.007). The relationships between reduced food intake with thermal discomfort are complex. Hunger, starvation, and appetite affect body temperature and thermal

11 The question of whether those who used less water experienced more thermal discomfort is yet to be determined based on the data.

perception and lack of electrolytes can affect thermal regulation. However, heat exposure can also impair appetite, so the causal relationship may also be reversed. There is not enough physiological information in the survey to make a clear determination of the causal mechanisms, but these results indicate the need to further investigate this issue.

Access to Health Facilities

Participants (58%) also reported increased difficulties in accessing health services during the pandemic as well as thermal discomfort. This was statistically significant (OR: 4.4; CI: 1.02-2.2; X^2=4.37, p=0.036). This was a surprising result as no connection had been anticipated, as thermal discomfort is not itself a direct driver of seeking health care, although HRI's can be if severe enough, this may indicate that heat-health impacts in Pakistan were a source of people seeking access to health facilities. The relationships between these variables are worth investigating further, as 72% of respondents experienced at least one HRI in the previous month. However, most of these were milder symptoms. As such, an alternative explanation is that health-seeking behaviours enabled people to identify health care access was harder and exposed people to more heat and thus thermal discomfort (for example, when waiting outside medical centres in queues). This indicates a need for further research on the relationship between thermal discomfort and health-seeking behaviour, with implications for how epidemic and pandemic health care responses are managed, for example through the provision of additional shade in waiting areas.

Physical Violence and Heat in the Home

Overall, most of the respondents (93%) reported no increase in physical conflict. For the 7% who reported it did increase, there was a statistically significant relationship with thermal discomfort and their odds of perceiving this was 4.4 times higher (OR: 4.4; CI: 1.1-18.3; p=0.25).

Physical conflict inside the home also appears to be related to heat-mitigation strategies. For those who felt that physical conflict had not increased, or remained the same, their first response to heat mitigation behaviour has been bathing, which is also the first response across all other categories, or adding active/passive ventilation, which is generally the second response.

However, amongst the group that reported increased physical conflict, more people chose to go outdoors (33%) than to take a shower (24%) or add ventilation (13%) to mitigate the heat. This response patterning was also gendered, with male respondents more frequently choosing to 'go outdoors' as a first strategy, while female respondents more often chose to 'do nothing'.

Going outdoors was, regardless of physical conflict, a strategy more used by men than women, reflecting social norms around who is able to move freely and alone in public space. However, this gendering of cooling strategies in relation to physical conflict at home may also shed light on the relationship between internal/domestic environments that could potentially affect cooling behaviours and choices. It may be men are leaving the home to cool off both physically and mentally (if a perpetrator) or to cool off and escape a dangerous situation, if a victim. Further analysis is also needed to see if other cooling measures were in some way unavailable to these respondents that may have increased the likelihood that going outdoors was the best available option to them and whether that may have increased the likelihood of higher than usual levels of violence.

Those who reported increased physical conflict and chose to ‘do nothing’ (21%) were also predominantly women. This may indicate that, in addition to reduced freedom to go outside due to social norms, this choice of cooling strategy may also point to a wider sense of loss of autonomy and helplessness resulting from physical conflict inside the home. Since the overall number of responses for these relationships is low (only 81 reported conflicts, out of which 70 reported corresponding cooling behaviours), this relationship requires further investigated in future studies in order for strong causal pathways, and corresponding options for intervention, to be identified.

5.5 Conclusion

The survey has demonstrated vulnerability and exposure to heat as a function of building type, time at home, access to electricity and water prior to the Covid-19 pandemic measures. It has also shown that the pandemic measures dramatically changed the daily practices of respondents, and that some of these may have negatively affected their ability to manage heat. Change in time spent indoors during the pandemic was highly differentiated across genders, with the biggest change for men. Notably, there is no statistical significance observed between increased time indoors and increased thermal discomfort.

Changes in electricity and water consumption were widespread but this does not seem to have contributed to thermal discomfort. However pandemic measures changed the kinds of cooling practices available to 9% of respondents. This group had 4.1 times higher odds of thermal discomfort compared to those whose cooling practices were unchanged. Choice of cooling strategy seems to have been partly shaped by the materials from which the home was constructed, with householders with galvanized iron roofs more likely to go outdoors in preference to other cooling strategies, such as bathing or using fans, prior to the pandemic. Going outdoors was the strategy most affected by pandemic measures, and as such those living in homes with galvanised iron roofs present a key population sub-group who require additional cooling support during pandemic confinements. We also observed that densities affect heat mitigation strategies, this requires further research to verify the causal mechanisms, but indicates number of householders may be a good indicator for cooling strategy and associated vulnerabilities.

These findings have direct implications for how pandemic responses are designed, in order to avoid creating an inadvertent heat-health burden, and for heat wave preparedness. They also have broader implications for both formal urban planning and interventions into informal auto-construction practices, to identify materials and populations that can be supported to ensure their homes are less prone to overheating and more cooling options are available to them. Such matters become all the more urgent in the context of rapid urbanisation and the looming threat of run-away climate change.

6 Case Study: Hyderabad, India

Summary

- 1180 people completed the survey in Hyderabad, capital of Telangana state.
- During the survey period of late June to mid-July 2020, Hyderabad was under a nationally imposed lockdown, with measures at around 80% potential stringency in place.
- Weather conditions at the time were hot, but not extreme: maximum temperatures ranged between 27°C and 32°C with high humidity, meaning that the heat index ranged between 26°C and 41°C.
- 75% of participants reported thermal discomfort during the month preceding the survey.
- 48% of respondents changed how they managed heat as a result of the pandemic, and had 6.5 times higher odds of perceiving thermal discomfort.
- Informal electricity connections played a key role in enabling more than 90% of survey respondents to have reliable access to electricity (more than 19 hours a day).
- Despite almost universal informal electricity connections, 23% of respondents had to decrease electricity consumption during the pandemic.
- Water usage for bathing is notably absent as a low-technology heat-management strategy.
- Use of electric fans and going outdoors were the most widely cited heat-management strategies.
- Going outdoors is primarily a male heat-management strategy, indicating social norms and safety concerns may limit the options available to women.
- The pandemic significantly decreased incomes, access to food and health services. Under more severe weather conditions, this would likely compound negative health outcomes.

6.1 Timeline and Context

Timeline

March 2nd – First cases reported of COVID-19 reported in Hyderabad, alongside the earliest cases across India
March 22nd – 14-hour nationwide curfew implemented
March 24th – Cluster of further cases in Telangana reported; early hotspots in Kerala and Maharashtra identified
March 25th – Nationwide lock-down imposed until 14th April, prompting a mass movement of migrant workers from urban centres to rural areas
March 26th – Relief package announced by central government, particularly focusing on providing food
April 14th – Nationwide lockdown extended till 3rd May; later extended to 17th May; extended to 31st May
June 8th – Phased reopening across the country, but with varying responses from state governments, some of whom go on to enforce their own local lockdown measures
July 2nd – Central government announced greater easing of lockdown measures, allowing more economic activities to resume despite rising cases

Key Survey data

Data collection 1	June 30 – July 7
Data collection 2	July 14-18
Total number of Respondents: Gender distribution:	1180 Women: 36.5%; Men: 63.5%

Weather conditions: Maximum temperatures between 27°C and 32°C. Due to high humidity, the Heat Index (HI) ranged between 26°C and 41°C.

Night-time lows between 23-26°C with high humidity, and a HI of 24-28°C.

Local Heatwave definition: Not met.

Sources: Wire.in, IFPRI, Brookings Institution, The Hindu

Hyderabad is located on the Deccan plateau in South-Central India. It is India's 5th larget city, with a population of around 9 million. It is the capital city of the state of Telangana and an important hub for the Information Technology industry since the 1990s.

Hyderabad is located in a relatively arid region with summertime temperatures frequently rising above 40°C. At the time of the survey, day time maximum temperatures ranged between 27°C and 32°C. Combined with high humidity, this resulted in Heat Index (HI) ranges between 26°C and 41°C. Night-time lows offered only moderate relief, ranging from 23-26°C and a HI of 24-28°C. While hot, these conditions were not exceptional and did not meet the local definition of a heatwave.

The onset of the monsoon occurred, as predicted, on the 8th-9th June. While there are often water shortages in Hyderabad water during summer and complaints on water quality because of lower water levels, in the summer of 2020 this was less an issue, potentially due to the lockdown and the shutting down of numerous industries. Flooding is also often a concern during the rainy season but did not occur prior to or during the survey.

Hyderabad was put under full lockdown measures from the 25th of March. These were eased by the central government in early May. Hyderabad was not officially under lockdown over the period of the survey, though it was for several months prior to this. In many parts of the city, widespread fear of COVID-19, however, resulted in what were effectively voluntary lockdowns, as people chose to stay at home and keep businesses closed to reduce the risk of infection.

Formal and voluntary pandemic measures were of particular significance for the urban poor. At the time of the survey, there were no isolation centres for the general public, so sick patients were being told to stay at home unless they needed intensive medical attention. This has implications in poor urban areas, high density settlements, overcrowded and poorly ventilated housing, was a cause for concern in terms of COVID-19 transmission. Such conditions are also associated with limited availability or reliability of water and electricity supply, poor thermal insulation of building materials, and thus high vulnerability and exposure to heat stress in the home

Incomes were also severely disrupted. Intending to avert economic slowdown and take advantage of the relative absence of traffic, the government for the state of Telangana (of which Hyderabad is the capital) proactively pursued infrastructure-development projects during the period of the lockdown. This meant that bigger companies and much of the migrant labour force they employed continued working through the period of the lockdown. Smaller firms and the labour force typically employed by them, however, could not remain functional during the lockdown. The movement of migrant workers during the lockdown period in India, which has been fiercely debated, thus had regionally specific patterns in Hyderabad: as labourers from different parts of country typically work in specific segments of the economy, some enjoyed continual employment during the lockdown period while others struggled to find employment.

Many people remained indoors for the entire duration of the summer of 2020: on the one hand, this meant that many didn't experience the summer itself as very harsh because they were shielded from the outdoors. On the other hand, this also meant that many may have been exposed to heat stress at home. There may also have been impacs on overall health and fitness due to reduced food intake, exercise and reduced access healthcare for non-COVID related illnesses.

Given the complex interaction of changing vulnerability and exposure to heat stress as a result of the pandemic measures, particularly in low income households, the survey was undertaken to ascertain the relationships between heat, pandemic measures and health and wellbeing outcomes.

6.2 Overview of Survey Results

Electricity

The use of electricity, particualrly for powering fans, was the key means of heat management in Hyderabad. While most respondents have an informal electricity connection, this connection is fairly reliable; around 90% of respondents reported having electricity for 19 or more hours each day, and most for more than 22 hours per day.

In two open questions, respondents were asked (a) what they normally did to manage heat at home, and (b) whether this had changed as a result of the pandemic. The responses to the open questions were universally very short, likely more to do with the survey service than the respondents themselves. Most responses were recorded as answers of a few words, sometimes a sentence naming two or more strategies, so the results below are interpreted as the primary strategies used to combat heat rather than necessarily an exhaustive list.

The vast majority of respondents (59%) used an electric fan as their primary means of mitigating thermal discomfort, often in combination with other measures. This supports the correlation between reliable electricity access and improved thermal comfort identified in Table 1 below. However, despite access to relatively reliable electricity, it should be noted that 25% of respondents reported having to reduce their use of energy as a result of the Pandemic.

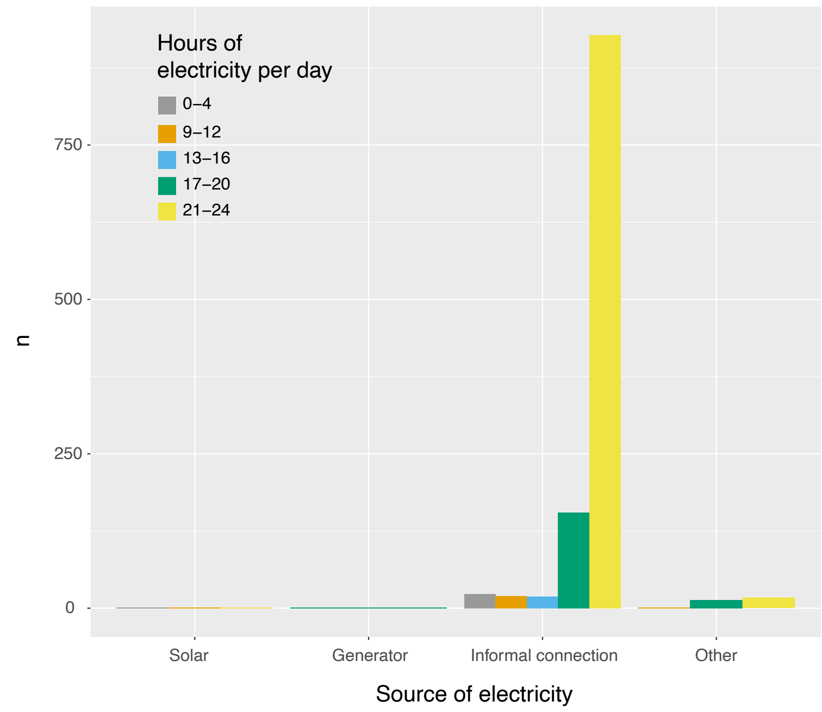


Fig.13.: Electricity source and reliability

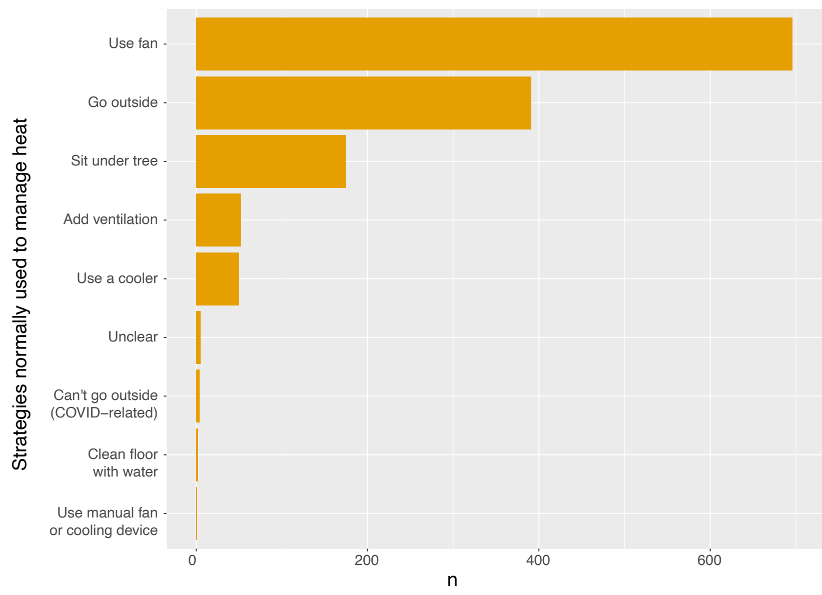


Fig.14.: Strategies normally used to manage heat

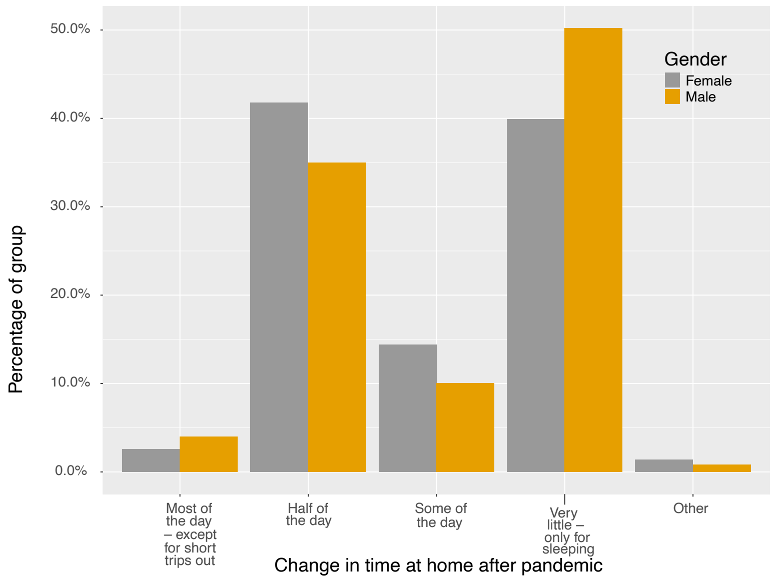


Fig.15.: Prior to the COVID-19/Coronavirus pandemic, how much time each day do you typically spend physically inside your home (expressed as percentage of responses by gender)

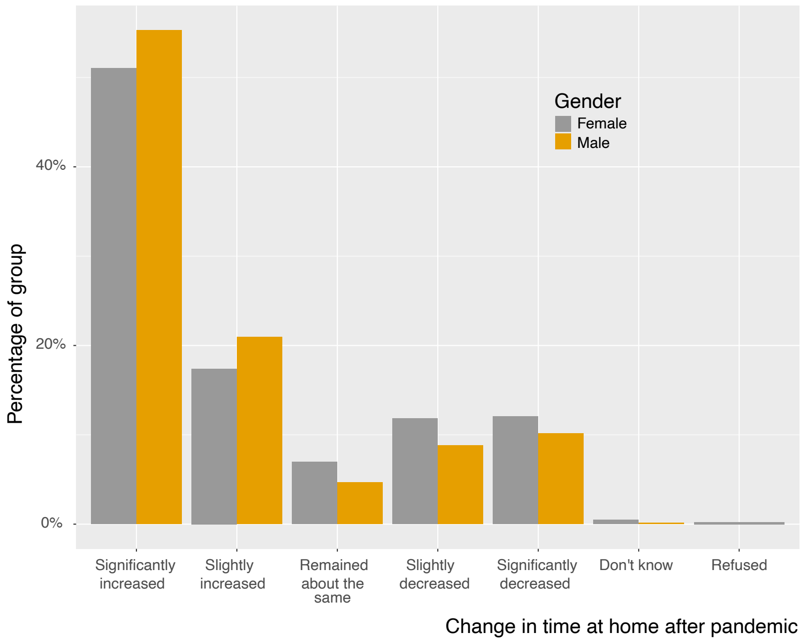


Fig.16.: "As a result of the COVID-19/Coronavirus pandemic, has the amount of time you spend inside your home…" (expressed as percentage of responses by gender)

Staying at Home

One of the key measures to manage the spread of the coronavirus was keeping people at home, either directly through lockdowns and curfews or indirectly through the cessation of work. In India, a major feature of the latter was the mass exodus of migrant workers from the cities to rural areas – the experience of these workers is unlikely to be captured in this survey data, as it focuses on urban residents. However, among those residents the increased pressure to stay at home is captured in the survey results, as is the quality of housing and the experience of thermal comfort and heat stress. Prior to the pandemic there was significant variation in the amount of time spent at home for both male and female respondents, although women spending more time at home over all. As a result of the pandemic measures, time spent at home significantly increased for over 50% of male and female respondents.

Regardless of gender, an increase of hours spent inside, when housing is hotter than outdoor conditions, increases the likelihood of thermal discomfort and the risk of heat stress. About 75% of respondents perceived thermal discomfort over the month prior to the survey. As indicated in the chart (Fig. X) of what people 'normally do' to manage heat at home, going outside was the second most common strategy (33%) of which sitting under a tree was almost exclusively the reason specified (in about half of these responses). Going outside was a strongly gendered option. Only 33 of the 394 respondents who mentioned going outside were female, and of these, a significant proportion spoke not about themselves as individuals, but about their husbands or family collectively performing this behaviour, saying "he" or "we" go outside. This raises deep questions about the agency of women to protect themselves from heat, and the gendering of heat management practices. Increasing ventilation (opening doors and windows) and using an evaporative cooler were the next most common but very low in percentage terms (about 4 % each). This may indicate infrastructural limitations (lack of windows, or high temperatures in outdoor environment) or lack of resources to purchase an evaporative cooler or its limited effectiveness in the hot and humid conditions typical during the survey period.

Over half of respondents (53%) noted changes as a result of the pandemic, although the majority of these focussed on challenges in accessing food or other daily necessities and were not specifically to do with heat. Of those that did, 83 respondents (13%) explicitly noted changes in the amount of time they could spend outdoors, presumably as a result of the lockdown and curfew although 8 people mentioned fear of being infected with/spreading the virus as the reason.

Water Usage

It is striking that there is an almost complete absence of the use of bathing (including washing, showering, wetting the body) to cool down reported by respondents in Hyderabad. Only one respondent mentioned this in response to strategies used during the pandemic to cool down. This is significantly different to the responses from other cities/countries surveyed. Hydrating or drinking to cool down was also not mentioned at all. It is unclear from the data but – given known water scarcity in Hyderabad – it seems very likely that it is connected to water availability.[12] Given apparently low water use, the fact that 23% of respondents noted they used even less water during the pandemic is of note. These results point to the need for further research to understand water use as part of heat management strategies in Hyderabad, and whether choice of strategy and its frequency of use is shaped by water availability, cost, or other considerations.

6.3 Thermal Comfort and Heat-Related Illness Symptoms

Using a chi-square and analysis of variance (ANOVA), a univariate logistic regression model to assess the influence of independent variables on each binary outcome (results expressed as Odds Ratio (OR) with a 95% confidence interval) and a fixed model for covariates with a univariable p-value <0.05, we found significant associations between thermal discomfort and the type of building materials used, ventilation and the number of residents in the home.

Demographics and Personal Characteristics

1180 complete survey responses that met the criteria for low-income residents in informal dwellings were collected and analysed. The mean age of the participants was 31.7 years (SD: 9.29). About three-fifths of the participants (n=749, 63.4%) were male; the majority were employed in low-income occupations (labour/wage, driver, agriculture/husbandry/fishing, business/self-employed, informal trade/street sales, migrant remittances) (n=1124, 95.2%) that did not provide a stable income. The remaining small percentage (n=56, 4.8%) were employed in jobs with stable incomes, such as government and private companies. No statistical significance was observed between the participant's perception of thermal comfort (Question 33, Temperature Inside Home: On average, over the past month, what has the temperature inside your home been like?) and age, gender, and occupation type. However, male participants had 1.2 times higher odds of reporting thermal discomfort than their female counterparts.

12 The likelihood that people would use water to cool down does not seem to have varied according to where the water comes from (its source).

Table 3: Demographic and personal characteristics of the study participants and its association with perceived thermal comfort (n=1180)

	Respondents perceiving Thermal Discomfort N (%)	Chi-square, p-value (χ^2)	Crudes Odds Ratio, 95% C.I.
Demographic characteristics			
Age (years) ≥ 25 years/ <25 years	687 (58)	0.102; 0.7497	0.949; 0.689 – 1.308
Age (years) ≥ 30 years/ <30 years	482 (41)	0.713; 0.3984	0.893; 0.686 – 1.163
Age (years) ≥ 40 years/ <40 years	163 (14)	0.116; 0.7337	0.944; 0.678 – 1.315
Age (years) ≥ 50 years/ <50 years	57 (5)	0.004; 0.951	0.984; 0.581 – 1.667
Gender male vs female	565 (48)	1.328; 0.2491	1.171; 0.895 – 1.532
Occupation Paid labour, street sales, self-employed vs rest	821 (70)	0.11; 0.7404	1.092; 0.65 – 1.836
Occupation Migrant remittances, help from family vs rest	36 (3)	0.148; 0.7009	0.884; 0.47 – 1.663
Occupation Employed in private company or by government vs rest	20 (2)	0.001; 0.9762	0.987; 0.413 – 2.358
Occupation Homemaker, student, unemployed vs rest	0 (0)	NaN; NaN	NaN; NaN – NaN
Occupation Homemaker, student, unemployed vs employed in private company or by government	0 (0)	NaN; NaN	NaN; NaN – NaN
Total residence members ≥6 members vs <6 members	97 (8)	1.483; 0.2233	1.325; 0.841 – 2.086
Residence per room ≥3 vs <3	724 (61)	0.441; 0.5066	1.12; 0.801 – 1.566
Residence per room ≥4 vs <4	332 (28)	0.991; 0.3196	1.149; 0.874 – 1.51
Welfare facilities			
Electricity connection informal vs solar, generator, other	851 (72)	0.0; 0.996	1.002; 0.464 – 2.163

Hours of electricity supply <21 hrs vs ≥ 21 hrs	373 (32)	1.946; 0.1631	1.21; 0.926 – 1.582
Cooling interventions Fans vs refrigerator	809 (69)	0.008; 0.927	0.977; 0.597 – 1.598
Drinking water supply Tanks vs rest	488 (41)	4.173; 0.0411	0.757; 0.579 – 0.99
Drinking water supply Shared tap vs rest	386 (33)	4.589; 0.0322	1.341; 1.025 – 1.754
Drinking water supply Bottles vs rest	1 (0)	0.621; 0.4307	0.345; 0.022 – 5.533
Drinking water supply Other vs rest	2 (0)	0.092; 0.7612	0.69; 0.062 – 7.637
Water for household purpose Tanks vs rest	247 (21)	0.493; 0.4827	1.112; 0.827 – 1.495
Water for household purpose Shared tap vs rest	627 (53)	0.351; 0.5536	0.915; 0.682 – 1.227
Water for household purpose Other vs rest	3 (0)	0.54; 0.4626	0.517; 0.086 – 3.109
Building envelope characteristics (poor vs good thermal properties)			
Building material ≥ 1 hot materials (concrete, metals, etc.) vs <1 hot materials	647 (55)	0.004; 0.9519	1.009; 0.75 – 1.357
Roofing material Metals vs natural materials (wood, palm, bamboo)	534 (45)	1.061; 0.303	0.857; 0.639 – 1.15
Roofing material Metals vs ceramic and clay	534 (45)	0.162; 0.6871	0.847; 0.377 – 1.903
Roofing material Concrete vs natural materials (wood, palm, bamboo)	44 (4)	0.24; 0.6244	0.856; 0.46 – 1.594
Roofing material Concrete vs ceramic and clay	44 (4)	0.112; 0.7375	0.846; 0.318 – 2.248
Roofing material Metals and concrete vs ceramic and clay	578 (49)	0.163; 0.6865	0.847; 0.378 – 1.9
Wall Material Concrete vs bamboo, palm and mud brick	51 (4)	0.02; 0.8885	1.041; 0.592 – 1.832

Floor Material Asphalt, cement vs natural materials, tiles	409 (35)	0.108; 0.7425	1.045; 0.804 – 1.358
No of rooms <2 vs ≥2	373 (32)	1.946; 0.1631	1.21; 0.926 – 1.582
Ventilation <2 vs ≥2 windows	409 (35)	0.856; 0.3549	1.132; 0.87 – 1.473
Electricity usage, windows & people per room Use less electricity, ≤1 window & 4≥ people per room vs rest	588 (50)	6.289; 0.0121	1.409; 1.077 – 1.844
Coping With Heat			
Normal cooling strategies Go outside vs use fan, ventilation, cooler	297 (25)	1.77; 0.1833	1.212; 0.913 – 1.609

Living Environment Characteristics

None of the 1180 participants owned their homes. About 41% (n=488) of participants lived in homes with less than two rooms with an average of 5 family members per house.

About 46% of these homes were poorly ventilated, with only one or no windows. Participants living in homes with poor ventilation perceived increased thermal discomfort (OR: 1.132; CI: 0.872-1.473) compared to those in well-ventilated homes, but this was not statistically significant.

97% of homes got their electricity supply through informal connections. The remaining 3% from alternate energy sources such as solar panels and generators. 92% of homes used ceiling fans or table fans for cooling themselves, and only 7% had refrigerators to provide additional cooling of food and drink. 25% of participants reported that during the COVID-19 pandemic, they used less energy. Tanks supplied drinking water in about 58% of homes and the rest from communal taps. For household activities including potential use for cooling, 28% of homes had supplied water and 72% from bottles and communal taps. Water supply type and availability did not draw any significant differences in participants' perceptions of thermal comfort (Table 1).

The influence of the building envelope on the thermal load and related perceptions of the residents on the thermal comfort was assessed via questions related to building materials. 26% of participants lived in homes made of materials (for roofing, walls and floor) with low thermal absorptivity and natural materials (e.g., palm fronds, dried clay, bamboo, wooden shingles, ceramic tiles), properties assumed to keep indoors cooler. Their perceptions of thermal comfort were not statisticially different from perceptions of participants (74%) whose homes were made of building materials with poor thermal properties (galvanized iron, sheet metal, reinforced concrete & t-girder).

Reports of thermal discomfort at home had 1.12 times higher odds among participants who sought respite under trees to beat the indoor heat, compared to those who used artificial coolers such as fans or evaporative coolers (Table 2). Yet people who reported that they usually went outside when it was too hot inside also had access to electric fans in their home. Furthermore, no significant association was noticed between the participant's perception of thermal discomfort and the mode of coping with the heat. This paradox suggests further analysis of the relationship between multiple variables is required. For example, leaving an overheating home rather than using electrical appliances may be due to fans being ineffective in these particular homes, due to building materials, an inconsistent electricity supply, lack of cooler air from outside to circulate, or because the type or size of fan is unable to produce enough air velocity to reach all the inhabitants in the room. Other explanations beyond the survey data may be that leaving the home is simply a common habit, or that it is supported by the added value of social engagement provided for by public spaces.

Table 4: Association between participants' perceived thermal comfort and Heat-related Illnesses (HRI), social lives and behaviour in the pandemic context (N=1180)

	Participants perceiving Thermal Discomfort N (%)	Chi-square, p-value (χ^2)	Crudes Odds Ratio, 95% C.I.
Perceived Heat-Related Illness (HRI) symptoms (During Pandemic)*			
Confusion	124 (11)	22.881; 0.0	3.993; 2.174 – 7.333
Fatigue	45 (4)	35.582; 0.0	0.287; 0.187 – 0.441
Feeling hot	271 (23)	44.642, 0.0001	3.5; 2.383 – 5.142
Feeling sweaty	96 (8)	7.404; 0.0065	2.068; 1.213 – 3.525
Feeling thirsty	140 (12)	10.153; 0.0014	2.024; 1.303 – 3.145
Irrational behaviour	293 (25)	10.508; 0.0012	1.639; 1.213 – 2.214
Any one HRI in past month	520 (44)	35.172; 0.0	2.221; 1.701 – 2.9
Affected more by heat compared to last year			
Affected by heat More vs less or the same	514 (44)	33.855; 0.0	2.189; 1.676 – 2.859
Impact of pandemic on daily life and behaviour			
Physical Conflict More vs less or the same	156 (13)	9.643; 0.0019	1.898; 1.26 – 2.86
Time spent at home before pandemic Half or more of the day vs less than half	257 (22)	190.992; 0.0	0.141; 0.105 – 0.19
Time spent at home during pandemic Increased vs same or decreased	626 (53)	7.066; 0.0079	0.655; 0.479 – 0.896
Change in Income levels during pandemic Decreased vs same or increased	734 (62)	260.507; 0.0	9.539; 7.092 – 12.83
Access to Health Services during pandemic Harder vs same or easier	667 (57)	10.181; 0.0014	0.569; 0.401 – 0.807
Change in eating Habits during pandemic Eat less vs same or more	156 (13)	11.501; 0.0007	2.044; 1.343 – 3.111
Change in Water Intake during pandemic Use more vs same or less	593 (50)	2.617; 0.1057	0.788; 0.59 – 1.052
Changed what you do when hot Yes vs rest	561 (48)	163.434; <0.0001	4.079; 1.273 – 13.068

Note: *The HRI symptoms during pandemic that did not have a significant association with the thermal discomfort were: blurred vision, clammy skin, concentration loss, confusion, convulsions, fainting, poor sleep quality, rash, vomiting.

Pandemic Implications for the Experience of Thermal Discomfort and HRIs

For the month prior to the survey, respondents reported experiencing various symptoms associated with thermal stress such as blurred vision (1.9%), clammy skin (2%), concentration loss (1.78%), confusion (2.3%), convulsions, such as muscle spasms (11%), dizziness (12%), fainting (0.9%), fatigue (7.9%), feeling hot (26%), poor quality of sleep (1.7%), rash (6.4%), vomiting (3.3%).

A significant association was observed between participants' perceiving thermal discomfort and experiencing heat-related symptoms of HRI, such as dizziness (X^2=22.88, p<0.0001), fatigue (X^2=35.58, p<0.0001), feeling hot (X^2=45.50, p<0.0001), feeling sweaty (X^2=7.4, p=0.006), feeling thirsty (X^2=10.2, p=0.001) and headache (X^2=10.5, p=0.001). The odds of sweat and thirst were both 2.0 times higher for respondents who perceived thermal discomfort, followed by headache (OR: 1.6; CI: 1.2-2.2; p=0.001). Significantly, dizziness had a strong positive association with perceived thermal comfort and has around 4.0 times higher odds among participants who perceived thermal discomfort (CI: 2.174-7.333; p<0.0001) than those who did not. However, for other HRI symptoms such as blurred vision, clammy skin, concentration loss, confusion, convulsions, fainting, poor quality of sleep, rash and vomiting, there was no association with perceived thermal comfort. Many of these are symptoms of more severe heat illness, and therefore they would be expected to occur less frequently.

Participants (78%) reported increased difficulties in accessing health service centres that was significantly associated (X^2=10.18, p=0.0014) with perceived thermal discomfort. However, the odds of perceiving thermal discomfort are actually lower for the group that found it harder to access health services. This indicates that thermal discomfort was widespread, but that the specific reasons for accessing health services were unrelated to heat. This is not suprising given the majority of HRI symptoms reported were not severe and in the context of a pandemic where Covid-19 increased the need to access care as well as disrupting the ability of health services to provide non-Covid-19 and non-heat related care.

Pandemic Implications for Time at Home and Thermal Discomfort

An increase in the time spent inside the home was observed during the pandemic (Table 2), was significantly associated with thermal discomfort (X^2=7.07, p=0.008). In addition, a statistically significant correlation was observed for respondents who before the pandemic spend at least half the day at home, with their perceptions of thermal discomfort (X^2=190.99, p=0.0). Both these metrics have odds lower than 1 compared to the group who spend less time at home and before the pandemic spent less than half the day at home, respectively.

Changing Incomes, Food Practices and Thermal Comfort

71% of participants perceived a significant decrease in income levels during the pandemic (X^2=260.507, p<0.0001). Their odds of thermal discomfort were 9.5 times higher compared to those who did not report a decrease in income levels (CI: 7.1-12.8; p<0.0001). There are likely to be multiple mechanisms connecting income loss to increased likelihood of thermal discomfort.

The survey also showed that reductions in income during the lockdown led to almost half the population suffering markedly increased food insecurity, affecting food intake (X^2=8.328, p=0.004). Interestingly, for the 16% of the survey respondents who ate less, this was also statistically significantly correlated with perceived thermal discomfort (11.501; 0.0007; OR: 2.0; CI:1.3-3.1), and the odds of thermal discomfort were ~2.0 times higher than those who ate more or the same during the pandemic (OR: 2.04, CI: 1.3-3.1; p=0.0007).

The relationships between reduced food intake with thermal discomfort are complex. Hunger, starvation, and appetite affect body temperature and thermal perception and lack of electrolytes can affect thermal regulation. However, heat exposure can also impair appetite, so the causal relationship may also be reversed. There is not enough physiological information in the survey to make a clear determination of the causal mechanisms, but these results indicate the need to further investigate this issue.

Further analysis of the survey data could examine the relationship between reduced food intake and HRIs, as there was evidence of increased incidence of HRIs during the pandemic (in the month prior to the survey), as discussed above. While hunger can independently produce some of the same symptoms as HRI, such as dizziness and fainting, our analysis shows a strong relationship between HRIs and thermal discomfort, indicating this is a worthwhile avenue of investigation.

It may also be that food reduction is indirectly associated with thermal discomfort via income loss or inability to access food due to lockdown measures and supply disruptions, whereby increased time at home (in a hot environment) or increased time outside looking for work or waiting for food in queues, contributed to increased heat strain and thus thermal discomfort.

Pandemic Implications for Cooling Behaviours, Utilities, and Thermal Comfort

48% of respondents reported that the pandemic changed what they do when it is hot and experienced thermal discomfort, a correlation which was statistically significant. Those changing their behaviour had 6.5 times higher odds of perceiving thermal discomfort to respondents who didn’t change their behaviour (OR: 6.5; CI: 4.782 – 8.836; p= <0.0001). Given such significant impacts, the precise behaviours that changed during the month of pandemic measures require further investigation.

One key contributor appears to ability to access or use electricity for cooling purposes. 24% of our study participants used less electricity during the pandemic than before, which significantly increased their risk of reporting thermal discomfort (OR: 1.65; CI: 1.1892-2.2903; p=0.003). The reason for this is unclear, given the vast majority of electricity connections were informal. It may be that the type of informal connection (for example, paying a neighbour for access to their power) might be affected by reduced incomes during the pandemic, and thus one reason for reduced use. Given that fan use was by far the most common cooling strategy, this warrants further investigation.

Changes in ability to go outside are likely to have played a significant role. Of those who noted pandemic changes to their daily lives, 83 respondents (13%) explicitly noted changes in the amount of time they could spend outdoors, presumably as a result of the lockdown and curfew although 8 people mentioned fear of being infected with/spreading the virus as the reason. Such findings are significant as going outside was the second most common cooling strategy.

Domestic Violence

Constant heat strain undermines mental wellbeing, including by increasing irritability. Associated with this, heat exposure is known to increase the likelihood of violence (including in domestic abuse in India).[13] The survey found that 16% of participants reported increased physical conflict such as domestic violence compared to before the pandemic. However there was no significant association with perceived thermal discomfort.

The lack of connection to thermal comfort here is somewhat to be expected, as the thermal comfort question is about the respondents' own experience, while those reporting violence are most likely to be the victims rather than the perpetrators of said violence.[14] However, in other cities covered by the survey, there was an statistically significant association between increased discomfort and increased rates of physical violence. This indicates that incrases in physical violence in Hyderabad specifically were more likely produced by other drivers, such as stress resulting from income loss, uncertainty and confinement to a shared space.

6.4 Conclusion

In response to a general question regarding whether heat had affected them more, which followed qestions related to physical as well as mental health outcomes and physical violence, more than half of participant (54%) reported that heat affected them more compared to this time last year. There was statistical significance with perceived thermal discomfort (OR: 2.2; CI:1.7-2.9; $p<0.0001$). While this is a broad statement, affected by both memory of the previous year and variations in weather, the survey data bears out such claims through strong relationships between: pandemic-associated effects on income, food intake and power use, and thermal discomfort; and between thermal discomfort and symptoms of heat related illness.

The impact of the pandemic in combination with hot weather is perhaps best summarised by the results that 48% of respondents changed how they managed heat as a result of the pandemic, and had 6.5 times higher odds of perceiving thermal discomfort. The precise mechanisms warrant more detailed analysis from the survey data. These include increased vulnerability and exposure to heat and the role of food intake, and the precise configurations of cooling strategy use in relation to power availability, and ability to go outside as a result of pandemic measures and gender. Further research on and the particular type of informal electricity connection and its relationship to income vulnerability has also emerged as being of importance, as has the variety of water sources used by households, water scarcity and the almost complete absence of low-energy water-based strategies for cooling as a result.

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13 See, for example: Blakeslee, D., R. Chaurey, R. Fishman, D. Malghan and S. Malik (2018). "In the heat of the moment: economic and non-economic drivers of the weather-crime relationship." *Working Paper*; and Chersich, M. F., C. P. Swift, I. Edelstein, G. Breetzke, F. Scorgie, F. Schutte and C. Y. Wright (2019). "Violence in hot weather: Will climate change exacerbate rates of violence in South Africa?" *SAMJ: South African Medical Journal* 109(7): 447-449; anz-Barbero, B., C. Linares, C. Vives-Cases, J. L. González, J. J. López-Ossorio and J. Díaz (2018). "Heat wave and the risk of intimate partner violence." *Science of The Total Environment* 644: 413-419.

14 This can be further examined in the dataset through comparison of the *Gender* and *Physical Violence* responses, with correlations checked for thermal comfort as classed in the above analysis.

7 Case Study: Jakarta, Indonesia

Summary

- 1108 low-income respondents completed the survey.
- Only 30% of respondents had electricity for more than 12 hours a day, and most relied on informal connections.
- Spending time outdoors was a key strategy for managing heat before and during the pandemic period considered in the survey.
- Water use was positively associated with reduced thermal discomfort. However, 10% of the survey population had to reduce water use as a result of the pandemic. More nuanced analysis of the survey data and further research is needed to identify the reasons for this.
- 82% of respondents reported a significant decrease in income levels during the pandemic, however, this does not appear to have affected their thermal comfort.
- 5% of respondents reported an increase in levels of physical conflict in the home, but this is not related to the impacts of increased heat stress.
- *The survey population as a whole exhibited low levels of thermal discomfort and symptoms of Heat-Related Illness (HRIs) as a result of changes to behaviour during the pandemic period.
- However, key groups did have higher levels odds of thermal discomfort pre-pandemic: Employes of private companies or the government had 1.4 times higher odds of thermal discomfort; paid labour, street sales and self-employed having 1.5 times higher odds.
- A key group that emerged with similar odds (1.4) were homemakers, housewives, students and the unemployed, suggesting that domestic exposure to heat stress is also significant.
- 29% of participants who reported that they ate less during the pandemic (X^2=6.058, p=0.014), and this had a statistically significant relationship with thermal discomfort. The causal relationship here is unclear, suggesting a need for further research.

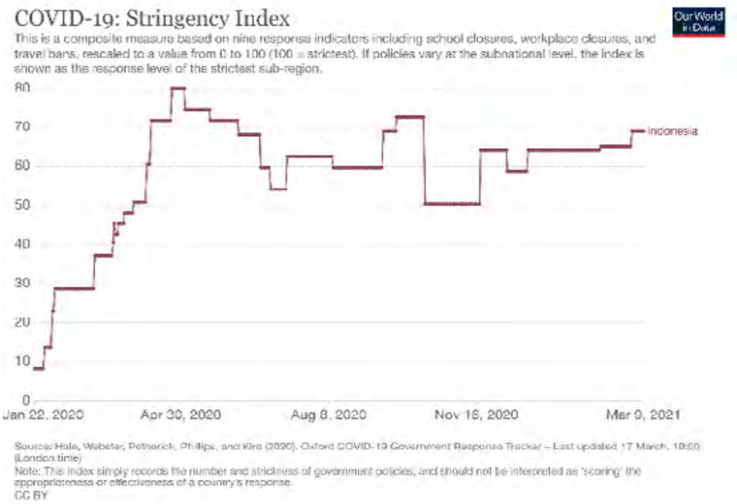
7.1 Timeline and Context

Timeline

2 March – First COVID-19 cases in Indonesia officially announced[1]
14 March – Schools closed and suspend examinations for at least 2 weeks[2]
16 March – Usage of public transport limited[3]
20 March – Governor of Jakarta declares state of emergency, urging residents not to leave their homes except for urgent and essential matters such as food and health care, with other regions of the country following suit[4]
7 April – Large scale social restrictions (PSBB) imposed in Greater Jakarta, relief packages containing basic supplies promised for poorer households[5]
1 June – Jakarta still in state of emergency with heavy restrictions on travel, economic activities and access to offices, shops and places of worship, plans announced to gradually ease them over the course of June
13 June – Restrictions eased on parks and recreation areas[6]
15 June – Restrictions eased on shopping malls[7]
1 July – Jakarta authorities extend restriction through to July 15th, with schools remaining closed, but places of worship, shopping malls and some offices allowed to reopen. Checkpoints have been set up across the city to check health and permits for travellers, residents need permits before leaving the city and visitors need official approval[8]
16 July – Governor of Jakarta announces extension of large scale social restrictions until the end of July[9]

Key Survey data

Data collection 1	June 30 – July 7
Data collection 2	July 14-18
Total number:	1108
Percentage of men	49.5%
Percentage of women	50.5%



Weather conditions: maximum temperatures ranged between 30°C and 34°C degrees with high humidity (Heat Index 35°C – 41°C); minimum temperatures were between 25-27 degrees, (HI 26°C – 31°C).

Heatwave definition: not met.

Sources: :
1. https://www.thejakartapost.com/news/2020/03/02/breaking-jokowi-announces-indonesias-first-two-confirmed-covid-19-cases.html
2. https://www.thejakartapost.com/news/2020/03/14/covid-19-jakarta-suspends-schools-exams-for-two-weeks.html
3. https://jakarta.bisnis.com/read/20200316/77/1213775/virus-corona-di-jakarta-pembatasan-transportasi-umum-bikin-kacau
4. https://jdih.jakarta.go.id/himpunan/produkhukum_detail/10155
5. https://www.thejakartapost.com/news/2020/04/07/covid-19-health-ministrygrants-jakartas-request-to-impose-large-scale-social-restrictions.html
6. https://www.republika.co.id/berita/qbnyrd383/tempat-wisata-di-jakarta-dibuka-bertahap-mulai-13-juni-2020
7. https://tirto.id/mal-buka-15-juni-langkah-instan-pemerintah-alih-alih-hadapi-covid-fHJx
8. https://www.thejakartapost.com/news/2020/07/01/jakarta-extends-transition-phase-postponing-further-relaxation-by-14-days.html
9. https://www.kompas.id/baca/metro/2020/07/16/psbb-transisi-fase-1-dki-jakarta-diperpanjang-hingga-akhir-juli/

The first cases of COVID-19 infection in Indonesia were announced on 2 March 2020, and rose rapidly. The Indonesian government was criticised for the lack of transparency and sluggish action. But in mid-April, the central government imposed large-scale social restrictions (known as PSBB) on several cities, including Jakarta. These restrictions involved the closure of offices, shops, restaurants, factories and retailers, as well as limits on the use of public transport. The Governor of Jakarta, Anies Baswedan, extended many of these measures until the end of June and released a schedule for gradual easing of these measures.

In May, due to economic constraints, the central government pushed the whole country to enter a "new normal", which prompted the Jakarta government to gradually ease the social restrictions. As a result, many public activities began to resume during the so-called 'PSBB transition'. This included the reopening of places of worship to half-capacity, along with offices, shops, small and medium businesses, factories, and retailers. Yet, Governor Baswedan reminded Jakarta residents that an 'emergency brake policy' would be taken if the implementation of health protocols failed and cases resurged (WHO Indonesia, 2020).

During this period, Jakarta ramped up its testing capacity, resulting in a sharp increase of reported daily cases. Three months of relaxation caused the number of active cases to soar, causing the healthcare system to become overloaded. In September, Governor Baswedan took a decision to bring Jakarta back on PSBB for four weeks before it returns to the transition period. The pandemic heightened political tensions between the national government and the provincial government of Jakarta. The national government pushed local governments to reopen businesses and public transport to minimise economic impacts, whereas local governments were more cautious. The central government was accused of wishing to avoid the financial burden of supporting poor communities requiring social assistance. The economic impacts of social restrictions have been significant and, for many, are a bigger concern than the virus itself. This has particularly impacted precarious and informal workers living in the city's poorer neighbourhoods.

Information about the pandemic was circulated by the government through daily radio and TV transmissions and through a regularly updated website. However, risk perceptions of the pandemic have remained low. A survey of public perceptions of COVID-19 risk in Jakarta, conducted in 2020 by the Social Resilience Lab at Nanyang Technological University in collaboration with LaporCOVID19.org, showed that the city's residents had relatively low levels of risk perception.[15] This had knock-on implications for people's adherence to measures such as social distancing and mask wearing. The low risk perception of COVID-19 in Jakarta meant that, with or without formal measures, people were quick to return to regular, daily lives. While measures to prevent transmission of COVID-19 were followed initially, and enforced by the police, compliance decreased over time.

15 See: Lapor COVID-19. (2020, July 5). Persepsi Resiko DKI Jakarta. Lapor COVID-19. https://laporcovid19.org/persepsi-risiko-dki/

Pandemic mitigation strategies – such as regular handwashing, social distancing, and self-isolation – presented significant challenges for Jakarta's residents, especially for the urban poor. Social distancing was also difficult in densely populated urban areas, where residents share public space for cooking and washing. Many of the city's poorer neighbourhoods already had limited access to clean water and sanitation facilities, and the pandemic put this under even greater strain. In Jakarta, water supplies are mostly privatised. Up to 40% of households, for example, rely on informal sources for drinking and clean water supply. Typically, urban households buy bottled and packaged water on a daily basis from vendors for consumption. The precarity around income streams as a result of COVID-19 social restrictions may have negatively impacted households' ability to access water.

There was, however, heightened awareness of COVID-19 in some localities, including the high density, informal neighbourhoods who may be respondents of the survey. However, these same communities were also at higher risks of losing sources of income and were not necessarily able to afford the costs of isolation or social distancing measures.

According to the Statistical Bureau of Jakarta City Government, between February and August 2020, 193,698 people lost their jobs and became jobless.[16] The challenges of increased unemployment were compounded by the lack of adequate government support and high levels of dependency on informal economies which have been strongly affected by PSBB measures. Cash and staple food assistance packages have been distributed by the the national and city governments. Yet, the distribution of these assistance has been uneven and mismanaged. Furthermore, because many of the poorest are not registered as Jakarta residents or not eligible for social assistance, there are concerns that these will not reach the people who need them (Wilson, 2020). These circumstances also put the medical system under severe strain. Hospitals were overloaded with many of them working at full capacit, despite the development of support facilities. Patients were turned away or asked to queue for hours in the emergency rooms due to the lack of available hospital beds.

In early June 2020, Jakarta began easing social restrictions – including the reopening of malls, public transport, places of worship and offices – however, the city was yet to return to its normal functioning.

Given the complex interaction of changing vulnerability and exposure to heat stress as a result of the pandemic measures, particularly in low income households, the survey was undertaken to ascertain the relationships between heat, pandemic measures and health and wellbeing outcomes. The survey took place against the backdrop of somewhat restrictions – ranging between about 70% and 55% of potential stringency – during Jakarta's cooler season, with maximum temperatures ranging between 30°C and 34°C degrees with high humidity (Heat Index 35°C – 41°C); minimum temperatures were between 25-27 degrees, (HI 26°C – 31°C).[17]

16 The formal sector lost 453,295 workers, of which only 259,597 workers were able to be absorbed by the informal sector, leaving the remainder out of work (BPS DKI Jakarta, 2020).

17 The average temperature may have been related to increasing COVID-19 cases in Jakarta, by affecting the viability of the virus, according to: Tosepu, R., Gunawan, J., Effendy, D. S., Lestari, H., Bahar, H., & Asfian, P. (2020). Correlation between weather and COVID-19 pandemic in Jakarta, Indonesia. *Science of The Total Environment*, 725, 138436. See also: Pusat Database BMKG. (2020). Data Online Pusat Database BMKG. https://dataonline.bmkg.go.id/data_iklim

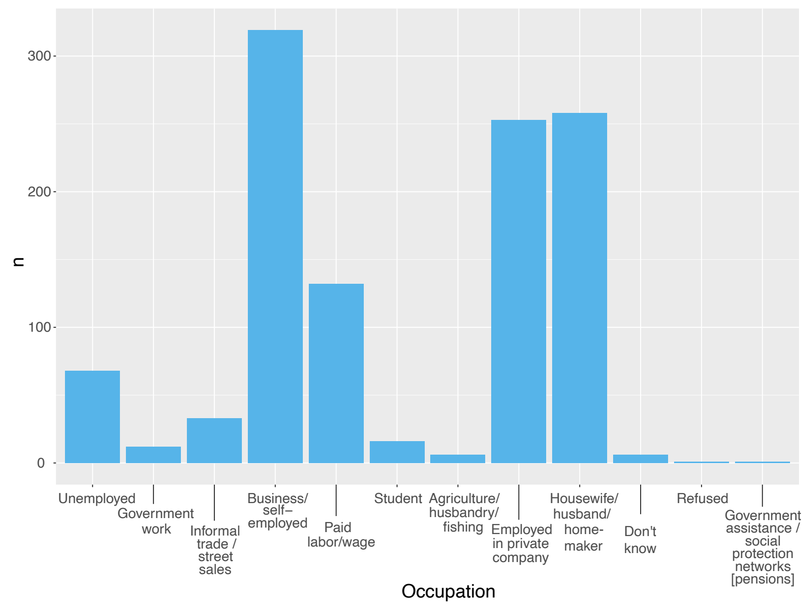


Fig.17.: Jakarta Respondents – Occupation

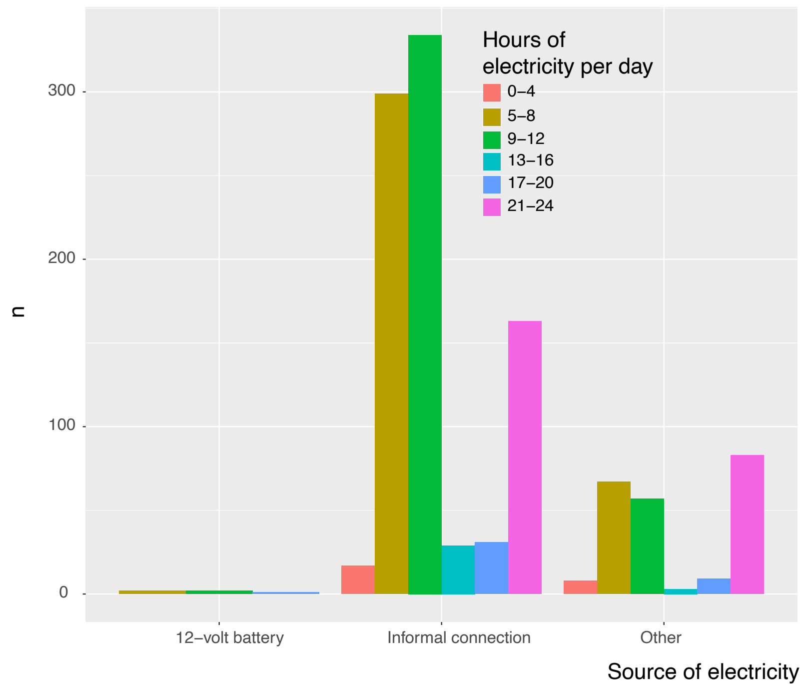


Fig.18.: Jakarta Respondents – Electricity Access

7.2 Overview of Survey Results

Out of 1108 respondents who met the low-income criteria and participated in the survey, 56% of participants were older than 30 years old and a very small percentage (3%) were older than 50 years old. Most respondents (29.1%) work as entrepreneurs or self-employed smallholders. Other respondents described their work as housewives (23.1%), private employees (22.9%), and workers of paid laborers (11.9%). Civil servants or government work (1.08%), retirees (0.09%), and the agrarian sector (0.54%) also participated in the survey. In addition, there were respondents who did not have permanent jobs, such as the unemployed (6.8%), hawkers (2.97%), and students (1.4%).

Electricity

As the nation's capital, Jakarta has the highest rate of electrification. Despite this, only 30% of respondents have electricity for more than 12 hours a day. We also found most respondents rely on informal connections of power, which refers to the practice of a non-registered household sourcing power through a registered household in order to share costs. Figure 5.3-2 shows electricity source and reliability per 24 hrs.

Strategies for Living with Heat

Around 77% of the respondents lived in buildings where at least one part (roof, walls or floor) is made from building materials with poor thermal properties. 72% of respondents had 2 or more rooms in their home and 88% reported having 2 or more windows. A significant percentage of respondents reported that they coped with the heat by opening windows or increasing ventilation (24.2%); going outside (10.8%) or by taking a bath or shower (5.7%). The majority reported making use of electrically powered fans or cooling devices (54%).

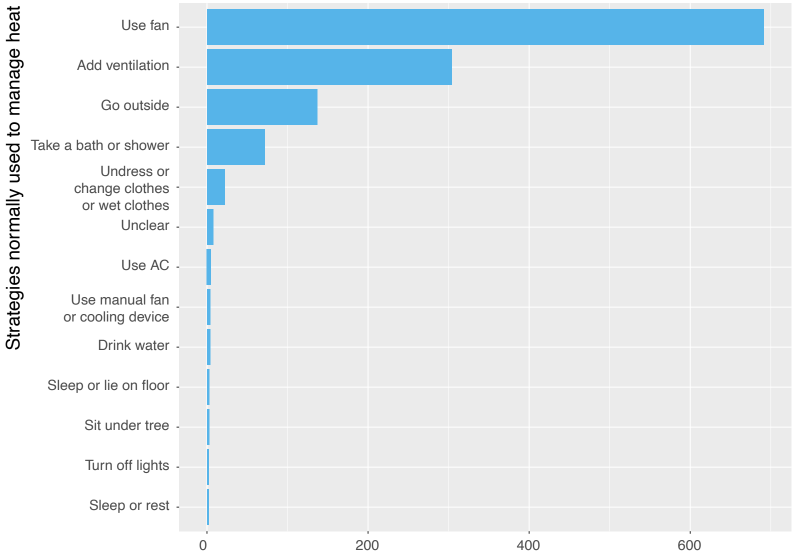


Fig.19.: Strategies to cope with heat before the pandemic

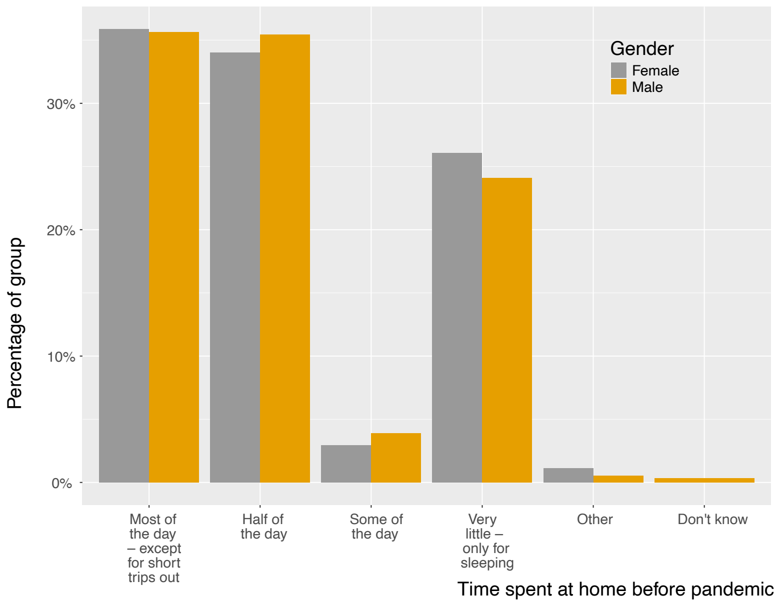


Fig.20.: Time spent at home before pandemic, by gender

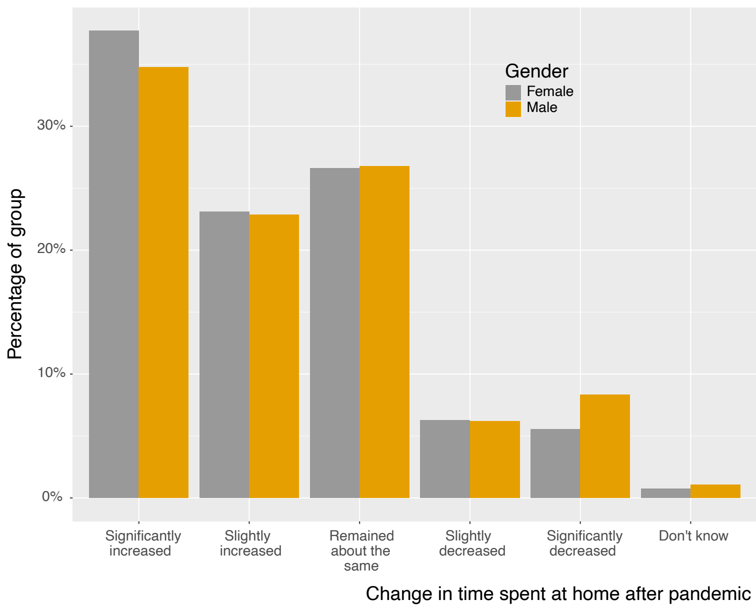


Fig.21.: Time spent at home during pandemic, by gender

A small proportion of respondents reported still utilizing aqua tanks for water supply (11%) and household purposes (3%).

Figure 19 shows the strategies people in Jakarta normally use to cope with heat *before* the pandemic. In pre-pandemic times, Jakarta residents generally used fans to reduce heat stress. This number represents 54.8% of the respondent population. In addition to its practical use, the use of a fan is greatly influenced by its cheap price. Furthermore, Jakarta residents add ventilation in their homes to reduce heat before the pandemic. This number is represented by 24.2% of the population. 11.0% of respondents chose to go outside the house if it was too hot, while others chose to take a shower (5.7%) or undress or change their clothes (1.7%). The remainder includes those hesitant to choose (0.6%), using hand fans (0.3%) air conditioning (0.3%), lying on the floor, turn off the lights, sleep, and do nothing respectively, each representing 0.2% of the population.

Time at Home and Gender

Figure 20 and Figure 21 show the percentage of time spent by men and women before and during the pandemic. After the pandemic, the majority of men and women experienced some increase in time spent at home.

7.3 Heat-health Vulnerability and Impacts

The demographic and personal characteristics of respondents in Jakarta are shown in Table 5.3-1. Using Bivariate Analysis, we investigated the population, welfare facilities and building condition of resident houses. We used crude Odds Ratios (OR) to assesses the risk influence of independent variables to dependent variables, and used a Confidence Interval of 95% and p-value < 0.05 (chi square analysis) to identify significant associations between the variables. See Section 4 for a detailed description of the statistical analysis.

No significant association was observed between perceived thermal discomfort and demographic characteristics, welfare facilities and building condition (in all variables the p-values are higher than 0.05).

Gender had no statistically significant impact on experiences or perceptions of thermal discomfort. Residents aged 50 or older had 1.7 times higher odds to experience thermal discomfort than younger respondents but there was no statistical significance. Housewives, homemakers, students and the unemployed had statistically significant higher odds to perceive thermal discomfort compared to all other occupations (1.4 times higher odds), employes in private companies or by the government (1.4 times higher odds), and paid labour, street sales and self-employed (1.5 times higher odds).

We assessed the influence of the building envelope on the thermal load and perceptions of thermal comfort via questions related to household construction materials. The thermal perceptions of people living in homes (23%) with roofs, walls and floors constructed from materials with a low thermal absorptivity or from materials with natural cooling properties (e.g., palm fronds, dried clay, bamboo, wooden shingles, ceramic tiles) was no different statistically from the perceptions of those people living in homes (77%) made with at least on of roof, walls and floors made of building materials that have poor thermal properties (e.g. galvanized iron, sheet metal, reinforced concrete & t-girder).

Table 5: Demographic and personal characteristics of the study participants and its association with perceived thermal comfort (n=1108)

	Respondents perceiving Thermal Discomfort N (%)	Chi-square, p-value (χ^2)	Crudes Odds Ratio, 95% C.I.
Demographic characteristics			
Age (years) ≥ 25 years/ <25 years	601 (54)	0.298; 0.5852	0.914; 0.661 – 1.264
Age (years) ≥ 30 years/ <30 years	416 (38)	0.314; 0.5749	0.93; 0.722 – 1.198
Age (years) ≥ 40 years/ <40 years	163 (15)	0.153; 0.6956	1.063; 0.782 – 1.445
Age (years) ≥ 50 years/ <50 years	27 (2)	1.637; 0.2008	1.676; 0.754 – 3.727
Gender male vs female	373 (34)	0.816; 0.3665	0.891; 0.693 – 1.145
Occupation Paid labour, street sales, self-employed vs rest	321 (29)	1.284; 0.2572	0.864; 0.671 – 1.112
Occupation Migrant remittances, help from family vs rest	1 (0)í	0.492; 0.4829	Inf; NaN – Inf
Occupation Employed in private company or by government vs rest	169 (15)	1.94; 0.1637	0.814; 0.61 – 1.087
Occupation Homemaker, student, unemployed vs rest	247 (22)	6.052; 0.0139	1.419; 1.073 – 1.877
Occupation Homemaker, student, unemployed vs paid labour, street sales, self-employed	247 (22)	4.523; 0.033	1.385; 1.025-1.871
Occupation Homemaker, student, unemployed vs employed in private company or by government	247 (22)	5.228; 0.0222	1.492; 1.058 – 2.105
Total residence members ≥6 members vs <6 members	94 (8)	0.272; 0.602	0.907; 0.627 – 1.311
Residence per room ≥3 vs <3	311 (28)	0.075; 0.7836	1.036; 0.803 – 1.337
Residence per room ≥4 vs <4	114 (10)	1.426; 0.2324	1.251; 0.866 – 1.808
Welfare facilities			

Electricity connection informal vs solar, generator, other	586 (53)	0.005; 0.9461	1.011; 0.742 – 1.377
Hours of electricity supply <21 hrs vs ≥ 21 hrs	583 (53)	0.557; 0.4555	1.12; 0.831 – 1.509
Cooling interventions Fans vs refrigerator	678 (61)	0.959; 0.3275	0.79; 0.493 – 1.267
Drinking water supply Tanks vs rest	6 (1)	0.225; 0.6351	1.472; 0.296 – 7.329
Drinking water supply Shared tap vs rest	113 (10)	0.584; 0.4449	1.151; 0.802 – 1.652
Drinking water supply Bottles vs rest	510 (46)	2.104; 0.1469	0.814; 0.616 – 1.075
Drinking water supply Other vs rest	115 (10)	1.004; 0.3164	1.204; 0.838 – 1.731
Water for household purpose Tanks vs rest	36 (3)	0.107; 0.7433	1.106; 0.605 – 2.021
Water for household purpose Shared tap vs rest	625 (56)	0.145; 0.7038	0.935; 0.661 – 1.323
Water for household purpose Other vs rest	83 (7)	0.049; 0.8254	1.046; 0.699 – 1.565
Building envelope characteristics (poor vs good thermal properties)			
Building material ≥ 1 hot materials (concrete, metals, etc.) vs <1 hot materials	576 (52)	0.082; 0.774	1.045; 0.776 – 1.407
Roofing material Metals vs natural materials (wood, palm, bamboo)	422 (38)	0.052; 0.8188	0.936; 0.53 – 1.653
Roofing material Metals vs ceramic and clay	422 (38)	0.002; 0.9614	0.993; 0.756 – 1.305
Roofing material Concrete vs natural materials (wood, palm, bamboo)	26 (2)	0.702; 0.4021	1.506; 0.576 – 3.938
Roofing material Concrete vs ceramic and clay	26 (2)	1.272; 0.2593	1.599; 0.703 – 3.636
Roofing material Metals and concrete vs ceramic and clay	448 (40)	0.013; 0.9107	1.016; 0.775 – 1.332
Wall Material Concrete vs bamboo, palm and mud brick	274 (25)	3.496; 0.0615	1.291; 0.987 – 1.688

Floor Material Asphalt, cement vs natural materials, tiles	101 (9)	0.324; 0.5695	0.902; 0.631 – 1.289
No of rooms <2 vs ≥2	214 (19)	0.542; 0.4618	1.111; 0.838 – 1.472
Ventilation <2 vs ≥2 windows	91 (8)	0.028; 0.8666	1.034; 0.699 – 1.53
Electricity usage, windows & people per room Use less electricity, ≤1 window & 4≥ people per room vs rest	411 (37)	2.7; 0.1004	1.234; 0.96 – 1.586
Coping With Heat			
Normal cooling strategies Go outside vs use fan, ventilation, cooler	92 (8)	0.179; 0.6719	1.089; 0.734 – 1.616

7.4 Heat-health Vulnerability and Impacts During the Pandemic

Table 6: Association between participants' perceived thermal comfort and Heat-related Illnesses (HRI), social lives and behaviour in the pandemic context (N=1108)

	Participants perceiving Thermal Discomfort N (%)	Chi-square, p-value (χ^2)	Crudes Odds Ratio, 95% C.I.
Perceived Heat-Related Illness (HRI) symptoms (During Pandemic)*			
Feeling hot	66 (6)	8.37, 0.0038	2.40; 1.303 – 4.407
Poor quality of sleep	58 (5)	6.275; 0.0122	2.114; 1.163 – 3.843
Any one HRI in past month	177 (16)	6.597; 0.0102	1.521; 1.103 – 2.097
Affected more by heat compared to last year			
Affected by heat More vs less or the same	214 (19)	10.811; 0.001	1.661; 1.225 – 2.251
Impact of pandemic on daily life and behaviour			
Physical Conflict More vs less or the same	38 (3)	0.267; 0.6052	1.171; 0.644 – 2.13
Time spent at home before pandemic Half or more of the day vs less than half	532 (48)	0.703; 0.4019	1.124; 0.855 – 1.478
Time spent at home during pandemic Increased vs same or decreased	449 (41)	1.427; 0.2323	1.167; 0.905 – 1.505

Change in Income levels during pandemic Decreased vs same or increased	609 (55)	0.121; 0.7281	1.059; 0.766 – 1.464
Access to Health Services during pandemic Harder vs same or easier	295 (27)	2.928; 0.0871	1.256; 0.967 – 1.631
Impact of pandemic on Behaviour			
Change in eating Habits during pandemic Eat less vs same or more	233 (21)	6.058; 0.0138	1.43; 1.075 – 1.903
Change in Water Intake during pandemic Use more vs same or less	316 (29)	4.27; 0.0388	1.313; 1.014 – 1.701
Changed what you do when hot Yes vs rest	347 (31)	0.448; 0.5031	1.09; 0.847 – 1.402

Note: *The following HRI during pandemic that did not have a significant association with the thermal discomfort: blurred vision, clammy skin, concentration loss, confusion, convulsions, fainting, fatigue, rash, vomiting, feeling sweaty, feeling thirsty, headache, irrational behaviour, loss of consciousness, muscle cramps, muscle weakness, nausea.

Thermal Comfort

Among the 1108 study participants, ~48% who perceived thermal discomfort also reported that they spent at least half the day before the pandemic at home. Even so, there was no statistical correlation between the time spent at home and the perception of thermal discomfort. Similarly, about 41% of respondents who perceived thermal discomfort spent more time at home during the pandemic but again no statistical significance was observed. This indicates that there is risk of thermal discomfort regardless of whether people are at home or outside of it, and that sudden changes in daily practices do not seem to have produced further vulnerability. The lack of statistical significance for more time at home and thermal discomfort might also indicate that Jakarta's limited diurnal temperature range, and the fact that it was the drier part of the year, moderated the potential effects of staying at home for more hours during the day.

The difference between pandemic exposure and pre-pandemic exposure would also vary depending on type of employment. In the previous section we identified that prior to the pandemic, housewives, homemakers, students and the unemployed had statistically significant higher odds to perceive thermal discomfort compared to all other occupations (1.4 times higher odds). For this group, their daily practices were largely unchanged as a result of pandemic measures, so increased thermal discomfort from staying at home would not be anticipated.

Employes of private companies or the government had 1.4 times higher odds of thermal discomfort pre-pandemic, with paid labour, street sales and self-employed having 1.5 times higher odds. This group may have experienced a decline or similar levels of thermal discomfort in the home and therefore no significant relationship between increased time at home and thermal discomfort was found by the survey. Further analysis of the suvey data, including normal employment type, changes in time at home during the pandemic and changes in income is needed to reveal more detailed patterns, and identify whether respondents from any particular sector were more affected than others.

Gender and Pandemic Measures

The survey showed respondents spending greater amounts of time at home, which is primarily due to the reduction in employment or work activity caused by the COVID-19 pandemic. These figures are significantly gendered: nearly 60% of women spent more time at home during the pandemic. By comparison, around 30% of male respondents spent little time at home during the pandemic, except for sleeping. Given that housewives, and homemakers were among the group with statistically significant higher odds of perceiving thermal discomfort compared to all other occupations (1.4 times higher odds), the gendered increase in time at home is significant.

In the midst of pandemic related employment uncertainties, women experienced a double burden by working for additional income for the family while being responsible for most of the household work and childcare.[18] Unfair conditions for women prompted Minister of Finance Sri Mulyani to publically highlight the impact of the COVID-19 pandemic on women, who increasingly have to play a double role both inside and outside of home.[19] Further analysis of survey results in terms of thermal discomfort and HRI by gender after the pandemic would help ascertain whether the double burden (livelihood labour and household chores), led to higher odds of women being negatively impacted by heat.

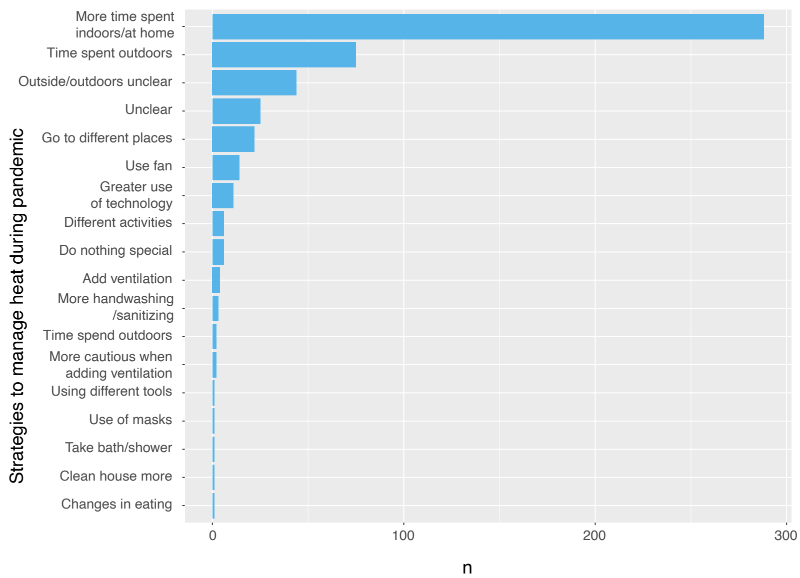


Fig.22.: Strategies to cope with heat during the pandemic

Coping with Heat

Almost half of respondents (46%) stated that the pandemic changed what they do to cope with the heat. Of these, 31% also experienced thermal discomfort but the relationship was not statistically significant (see Table 7.2). Figure 22 shows the strategies people in Jakarta do to cope with heat *during* the pandemic. As many as 56.6% answered that they prefer spending time at home to avoid the heat. However, there are still residents who spend their time outside (15.1%). Respondents also answered that there were several changes in behaviour, activities, and feelings (3.5%) and also increased discipline towards health (1.0%). The remaining respondents answered that there were changes in the

18 In the Jakarta, households are typically patriarchal, affecting labour division; men are expected to play a breadwinner role and spend more time outside of the house, while women usually spend more time at home as the homemaker. See: Asriani, D. D., & Ramdlaningrum, H. (2019). *Examining Women's Roles in the Future of Work in Indonesia*. Jakarta: Friedrich Ebert Stiftung Indonesia; see also https://theconversation.com/in-indonesia-the-covid-19-pandemic-hurts-poor-women-the-most-145694

19 https://www.thejakartapost.com/news/2020/11/19/covid-19-has-deepened-indonesias-gender-inequality-says-sri-mulyani.html

use of fans (2.9%), doing nothing (1.2%), bathing (0.2%), using other tools to reduce heat (0.2%), and still hesitate to answer (4.9%).

Access to Electricity

Amidst the risks of unemployment and introduction of pandemic response measures, many households in Jakarta reported changes in their access to and consumption level of electricity and water. Rising unemployment and a loss of income in low-income households prompted some residents to cut their consumption of electricity and water during the pandemic. Furthermore, at the time of the survey, only 22% of respondents reporting having access to electricity for more than 20 hours, including as a result of power-outages or lack of supply.

One of the hypotheses for the survey was that reduced income levels might add another driver to thermal discomfort if those staying at home might also be unable to pay for sufficient water or electricity. However, while 82% of respondents reported a significant decrease in income levels during the pandemic, there was no significant statistical relationship to people's perceived levels of thermal comfort in the month prior to the survey period. There are many reasons why this might be the case. The lack of reliable supply under normal conditions may have been that dependence on electricity was low and the pandemic did not significantly change this.

Causal factors beyond electricity may also have been at play. As mentioned, the average weather conditions at the time of the survey, during the drier season where conditions are slightly less hot, may have reduced discomfort overall. It should also be noted that pandemic measures were at moderate stringency during this period, and, as discussed above, many residents were still able to go outside too cool down.

Access to Water

Opportunities to effectively manage heat with water were significantly shaped by the measures to address the COVID-19 pandemic. There was a statistically significant relationship between respondents (40%) using *more* water and reporting increased thermal discomfort ($X^2=4.3$, $p=0.04$), indicating that water use was an available coping strategy. Of more concern however are the 10% who had to use less water (50% reported no change).[20] In Jakarta, low-income households obtain water and electricity through various kinds of sources, ranging from mobile water sellers and informal water pipe connections, but most reported using end-of-street taps to access water. Given this, the decline in water usage was likely to be amongst those people closely observing mobility restrictions and avoiding water taps, and possibly to do with income changes for those who purchased water (the results were ambivalent as the question on reductions didn't distinguish between water use for drinking or household purposes). More nuanced analysis (such as structural equation modelling) would help elicit clearer patterns in the data, although the sample size is limited.

20 This is consistent with studies from high income countries, where residential water demand increased as a result of the pandemic. See: Lüdtke, *et al.*, (2021). D. U., Luetkemeier, R., Schneemann, M., & Liehr, S. (2021). *Increase in Daily Household Water Demand during the First Wave of the COVID-19 Pandemic in Germany.* Water, 13(3), 260.

Thermal Discomfort and HRI

More than a quarter of respondents replied that heat affected them more during the pandemic than at the same time last year. This is supported by statistical analysis which shows a significance correlation between this answer and perceived thermal discomfort (OR: 1.6; CI: 1.2-2.3; p=0.001). Despite this, the correlation between thermal discomfort and various symptoms of Heat-Related Illness was less often statistically significant than in the other case studies, only demonstrating signficant correlations between feeling hot (as would be expected) and lack of sleep (Table 5.x-2).

People reported poor quality sleep and feeling hot regardless of whether they lived in homes made from heat-absorbing materials (53%) or whether they lived in houses with less heat-absorbing material (47%). The reasons for this are unclear, and merit further analysis of the survey data and further research.

Domestic Violence

Given that spikes in domestic violence have been widely reported during the pandemic, and the fact that exposure to heat stress can also lead to irritability and episodes of violence, we asked respondents whether they had observed or experienced any change in physical conflict in the home. ~5% of people reported increased physical conflict such as domestic violence compared to before the pandemic but there was no statistical significance with perceived thermal discomfort. This indicates that spikes in violence in Jakarta were more likely to do with non-heat related causal pathways, such as increased proximity/opportunity due to lockdown measures and the stress of the pandemic situation.

Access to Health Services

38% of people reported increased difficulties in accessing health service centres but there was no statistical significance with perceived thermal discomfort (X^2=2.93, p=0.087). No connection was found, or anticipated, as thermal discomfort is not itself a direct driver of seeking health care, although HRI's can be if severe enough. Given few and milder HRI symptoms were associated with thermal discomfort in Jakarta, the pandemic response does not seem likely to have been significant for heat-health outcomes at the time of the survey.

Changes in Eating Habits

While there was no statistical significance between those who had to change how they coped with heat and thermal discomfort, there was statistical significance between thermal discomfort and the 29% of participants who reported that they ate less during the pandemic (X^2=6.058, p=0.014). The relationships between reduced food intake with thermal discomfort are complex. Hunger, starvation, and appetite affect body temperature and thermal perception and lack of electrolytes can affect thermal regulation. However, heat exposure can also impair appetite, so the causal relationship may also be reversed. There is not enough physiological information in the survey to make a clear determination of the causal mechanisms, but these results indicate the need to further investigate this issue.

7.5 Conclusion

The survey shows that exposure to heat in the domestic environment and beyond creates thermal discomfort and triggers symptoms associated with heat-related illness for low income residents in Jakarta. The statistical analysis shows that, while residents had to deal with both the pandemic and heat at the same time, the pandemic restrictions per se do not, at a braod level, magnify thermal discomfort or increase the incidence of heat-related illness in the month prior to the survey. In fact, Jakarta was the only city of the four where there was no statistical significance between changing strategies for managing heat and thermal discomfort, or between increased violence and thermal discomfort. It also had much fewer HRI symptoms with statistically significant relationships to thermal discomfort.

Inversely, this may in fact indicate an association with pandemic measures, as Jakarta had the least stringent COVID-19 measures in place at the time of the survey. The lack of thermal discomfort and HRI's may also be somewhat explained by the relatively moderate weather conditions, in an area where weather varies little and behaviour is broadly well-adapted. It should be noted here that, Jakarta was experiencing average conditions for the time of year, but was hotter than both Douala and Hyderabad (India). It was nowhere near as hot as Karachi and Hyderabad (Pakistan).

However more detailed analysis of the data is needed to ascertain whether particular groups (such as women, and those paying for private access to water) had increased odds of thermal discomfort and HRIs as a result of the pandemic than others. The relationship between food intake and thermal comfort also needs further research.

Given that there was a statistically significant correlation between eating less and thermal discomfort, this relationship also needs further research. The relationship between eating less and incidence of HRIs would also be useful to assess from the survey data, particularly as hunger can trigger some of the symptoms associated with heat-related illnesses, such as dizziness and fatigue.

Broadly, the survey respondents appear to be well adjusted to their environment, both physiologically and behaviourally, within the limits of the resources available to them. The majority of those who live in slum areas have to invent ways to cope with heat with limited amounts of resources, such as water, electricity, and sanitation. Where available, public utilities (believed to be primarily water from public taps) played a key role in giving residents the means to cool themselves. Further research is needed to understand why 10% of respondents didn't have access to this during the pandemic month reported in the survey. If this is a result of social distancing or hygiene measures as a result of the pandemic, or due to costs of paying for water, these add yet more weight to the already substantial arguments for urgent increases in the provision of piped, safe water for drinking and household purposes in Jakarta.

The role of informal electricity connections is an example of how resilience to heat in low income areas, is often attained through creative means, not formally supported. The survey results showing high levels of informal electricity connections, some of which are primarily via neighbours' connections, supports claims that social relations at the community level play a crucial role in improving resilience to environmental hazards, in this case to heat stress.

One final key finding of the survey was that spending time outdoors to deal with heat, prior to and during the pandemic was a key strategy for low income households. This raises the prospect the provision of public shade is of immense value in low income settlements, and may be quicker and less complicated to address than issues of utilities supply if public land is available to use for this purpose, or if shade infrastructures can be mainstreamed into other infrastructure and building development.

8 Case Study: Douala, Cameroon

Summary

- Heat-management strategies among low-income households are low-energy intensity, with most relying on increasing ventilation (natural air flow), and significant numbers spending time outside.

- *There is relatively limited reliance on electric fans and limited power supply.

- About quarter of respondents (23%) changed their heat management strategies as a result of the pandemic, primarily reducing time spent outside.

- Half of respondents (48%) spent more time at home as a result of pandemic measures.

- 4 out of every 5 people (79%) reported reduced income.

- We found no evidence that the odds of thermal discomfort or heat related illness were increased by the pandemic measures, however, these results were likely shaped by the fact the survey took place at the coolest time of year.

- Populations most vulnerable to poor heat-health outcomes under more extreme weather or pandemic-response conditions are those that rely on “communal or street end tap” water, or who rely on “going outside” to cool down.

- Those who reported thermal discomfort were 1.7 times more likely to report physical violence in the home, even during Douala’s coolest conditions.

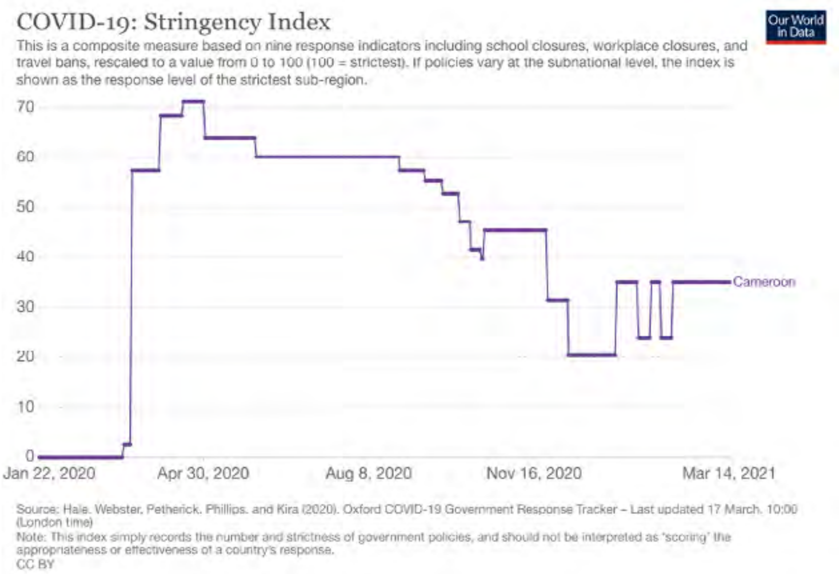
8.1 Timeline and Context

Timeline

February 15th	**Free phone number for advice set up by government; advice about handwashing, coughing and sneezing**
February 25th	**First case in Cameroon (Yaoundé)**
March 18th	**Social distancing encouraged; ban on large gatherings, universities closed; international borders closed; self-isolation of COVID-19 cases**
April 2nd	**launch of systematised tests in Douala**
April 30th	**Curfew and some other measures lifted, but social distancing and mask wearing still encouraged**
June 1st	**Schools reopen, rising number of cases recorded.**

Key Survey data

Data collection Part 1	26th June 2020 – 2nd of July 2020
Data collection Part 2	14th July 2020 – 20th July 2020
Total number surveyed:	1,104
Gender breakdown:	Men 65% Women 35%



Weather conditions: maximum temperatures ranged between 30°C and 34°C degrees with high humidity (Heat Index 35°C – 41°C); minimum temperatures were between 25-27 degrees, (HI 26°C – 31°C).

Heatwave definition: not met.

Sources: OCHA, WHO Cameroon
Relatively cool and typical for the time of year. Maximum temperatures of 27°C – 32°C with high humidity (Heat Index 32.2°C -39.8°C). Night-time minimum temperatures 23°C -24°C, with 100% relative humidity (HI of 24-25 degrees).

Heatwave conditions: no.

Cameroon reported its first COVID-19 case in late February 2020 and cases were soon concentrated in the largest cities, Douala, and Yaoundé. From the 18th March, social distancing was encouraged, universities were closed, large gatherings were banned, and land, air and sea borders were shut. A testing campaign was initiated in Douala, with door-to-door testing undertaken by a dedicated team. Subsequent measures were implemented to slow the spread of COVID-19, including mandatory mask wearing, the closure of schools and a night-time curfew enforced across the country. Both the Government and NGO community expressed concerns that healthcare infrastructure would not be able to deal with a large-scale outbreak.[21] The initial stricter measures, including the night curfew, were eased in early May, prior to the survey which took place in June and July. The curfew reportedly had a significant impact on jobs and economic activities, particularly for informal workers. The curfew was also perceived as being ineffective in preventing COVID-19 transmission.[22]

Over the period of the survey, advice to wear masks in public and to continue social distancing remained in place and were enforced in city centres and public spaces where there was a police presence.[23] However, outside Central Business District areas, by and large, life continued as normal, particularly as people perceived a higher level of safety from the virus within their local neighbourhoods. There were few distancing measures on public transport although people endeavoured to keep distance in taxis.

Decision making about how to manage the virus at an individual and household level was also shaped by a series of public discourses, stigma, and economic considerations. Over the period of the survey, there was little government support or assistance for those facing reduced incomes or lacking in food or water. Personal supplies of food and cash are limited for urban poor. Many of those in low income and informal work had little choice but to continue working, regardless of formal measures or personal preference.

In many public debates, COVID-19 was often characterised as a predominantly 'European' disease, where an older age profile was blamed for the high death rates. In Cameroon, there was widespread belief that with a population that was widely exposed to disease with poor healthcare, and as a younger population, there would be better resistance to the virus than that observed in Europe. As such, the lockdown and social distancing measures introduced in Europe and east Asia were perceived as largely unnecessary for Cameroon. There was also a significant social stigma around getting tested, which, combined with the fact that testing was a public spectacle, with the hazmat-suited health workers blocking off homes, undermined people's willingness to be tested.

While testing for COVID-19 was free, treatment was not, which acted as a deterrent to seeking testing because they could not afford the subsequent cost of care. INGOs working in Cameroon, and Douala specifically, also cited concerns that many in urban areas live in cramped housing, without rooms to isolate those infected.[24]

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21 See: OCHA. (2020). *Cameroon: COVID 19 Emergency Situation Report No.1 – As Of 18 May 2020*. [online] Organisation for the Coordination of Humanitarian Affairs. Available at: https://reliefweb.int/report/cameroon/cameroon-covid-19-emergency-situation-report-no-01-18-may-2020 [accessed 20 oct. 2020]

22 See: D'pola Kamdem, U. and Kakdeu, L.-M. (2020). *Cameroon's Informal Sector Put To The Test By Coronavirus (COVID-19).* [online] Nkafu Policy Institute. Available at: https://nkafu.org/cameroons-informal-sector-put-to-the-test-by-coronavirus/ [accessed 20 oct. 2020].

23 See: Mussa, C. and Unah, I. (2020). *Masks, Bans And Questions: Inside Cameroon's COVID-19 Response. [online] al jazeera news.* Available at: https://www.aljazeera.com/news/2020/4/23/masks-bans-and-questions-inside-cameroons-covid-19-response [accessed 20 oct. 2020].

24 OCHA, 2020

Weather Conditions

Douala has a tropical monsoon climate. Average temperatures are fairly stable; however, rainfall and humidity fluctuate according to season. The rainy season is typically June to October, and higher temperatures occur between November and April.[25] The survey ran in June and July, amongst the coolest months in Douala. In practice, it experienced maximum daytime temperatures ranging from 27°C to 32°C. This was accompanied by high humidity, meaning that the heat index ranged between 32.2°C and 39.8°C. Such values present some risk of heat strain particularly if engaging in physical activity. However, the low level of variation throughout the year means the population is likely to be well acclimatized physiologically and behaviourally to such conditions.

Given the complex interaction of changing vulnerability and exposure to heat stress as a result of the pandemic measures, particularly in low income households, the survey was undertaken to ascertain the relationships between heat, pandemic measures and health and wellbeing outcomes.

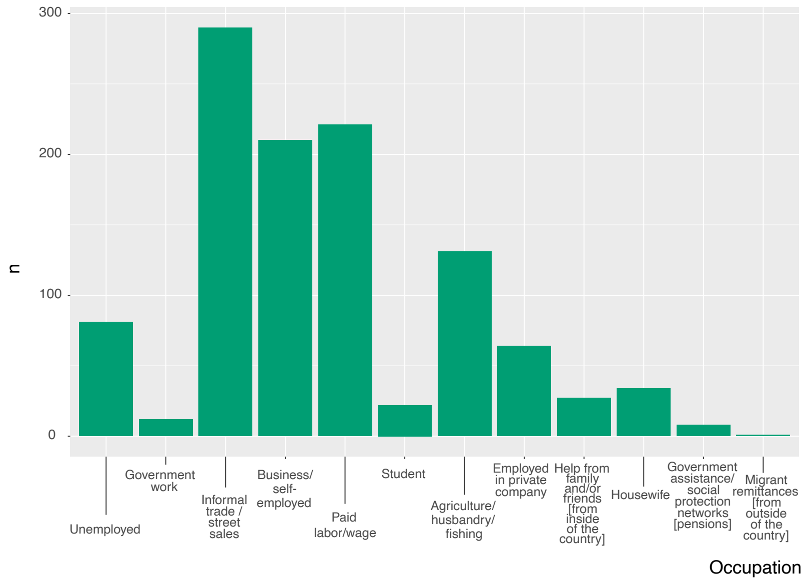

Fig.23.: Douala – Occupation

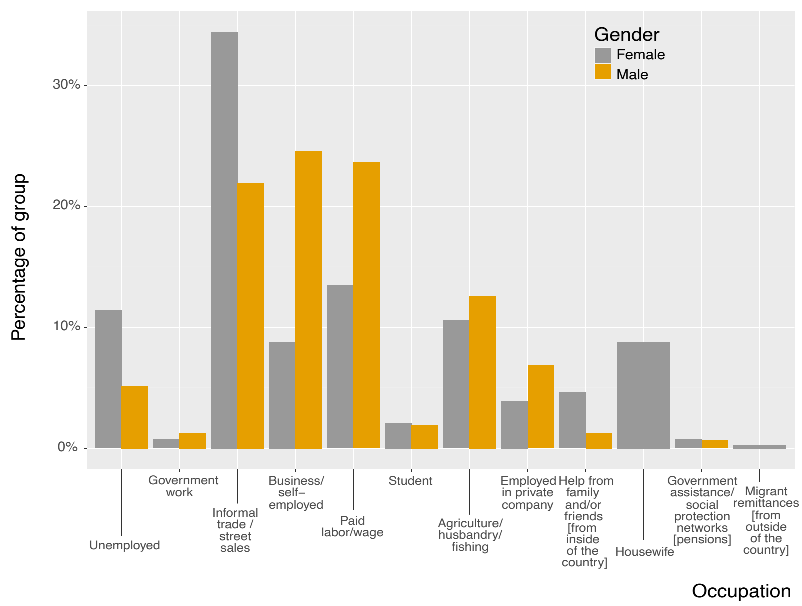

Fig.24.: Douala – Occupation by gender

8.2 Overview of Survey Results

Socio-Economic Demographics

The respondents to the survey were disproportionately men, who made up almost two thirds (65%) of respondents; with the largest proportion aged between 20-39.[26] The largest proportion of respondents were self-employed men aged between 30-39 years, working in what they reported as business or informal trade.

A high proportion of people aged between 18-24 described themselves as students and significant number of respondents, primarily those between 18-40 were employed in some form of waged labour; those respondents aged over 60 were most likely to report their occupation as related to agriculture, animal husbandry or fishing. Whilst there are commercial farms and fisheries near Douala, this category is also likely to have captured informal urban farming and artisanal subsistence fishing in the estuaries and creeks around the

25 Nematchoua, M. K., G. Roshan, and R. Tchinda (2014). "Impact Of Climate Change On Outdoor Thermal Comfort And Health In Tropical Wet And Hot Zone (Douala), Cameroon." *Iranian journal of health sciences* 2: 25-36.

26 This was the lowest figure across all our case studies. The low number could have been due to women refusing to answer calls from unknown numbers as much as access to mobile phones.

city. Almost all participants reported living in homes made of materials with poor thermal properties (galvanized iron, sheet metal, reinforced concrete & t-girders).

Heat and Thermal Comfort

The survey took place at the coolest time of year for Douala, which is reflected in the respondent's perceptions of temperature inside and outside the home. The survey recorded a diverse range of perceptions of thermal comfort in the month prior to the survey. Almost half of respondents reported feeling 'comfortable to cold' (47%) in the month prior to the survey, although about 44% felt it had been 'slightly warm to very hot'. While thermal preferences do vary across populations, including by gender and age, variation in perceived conditions is also likely to capture the different levels of heat exposure experienced by respondents, as a result of socio-economic variations in living conditions, housing materials and access to cooling infrastructures or services.

There was a wide range of responses to the question, 'When it feels too hot in your home what do you normally do?'.

The most common response (nearly 50%) described practices that aimed to increase ventilation (either by opening windows, shutters, doors); followed by the use of a specific appliance or technologies to circulate air (21% of people listed the use of a fan). The need for electricity is implicit in many of these practices, particularly fan use, and many people indicated that they either used both strategies simultaneously or determined what to do depending on the availability of electricity. Approximately two thirds of respondents had less than 21 hours of electricity a day, and more than 10% had less than 9 hours a day. A few people described the use of makeshift fans (either using "cardboard" or "the calendar") that were not dependent on electrical power[27].

One sixth of respondents (16%) sought outdoor shade when it felt too hot inside their home. People reported going outside or 'under cover' on verandas, courtyards and under trees. This response fits neatly into the profile of space and housing in the city. Douala affords a greater number of heat management options than other cities in this survey, with its low-density housing, open layout of buildings and comparatively high number of urban trees creating opportunities for public shade. Douala is (for the time being) characterised by single-storey buildings which have a veranda or access to collective yards in which daily domestic activities (cooking, laundry, washing up) take place. The current pattern of urbanisation in the city allows people to live between the inside and the outside, encourages air circulation, and allows the heat to escape from the homes in semi-private spaces.

Just under one sixth of respondents (15%) said 'they did nothing' when it was too

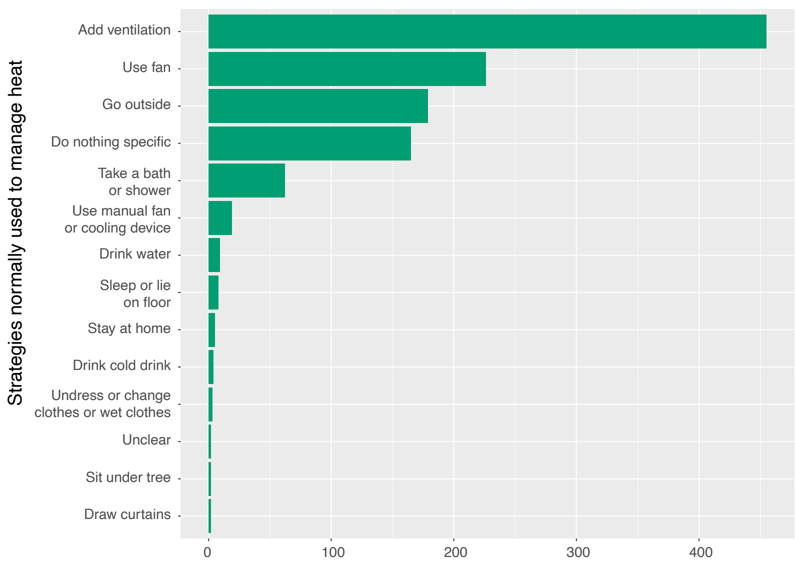

Fig.25.: Normal practice in the Heat

27 It was not clear whether the use of makeshift air-cooling technologies was connected to the reliability of power (these respondents typically had between 20/24 hrs of power connection and no less than others who didn't specify this behaviour).

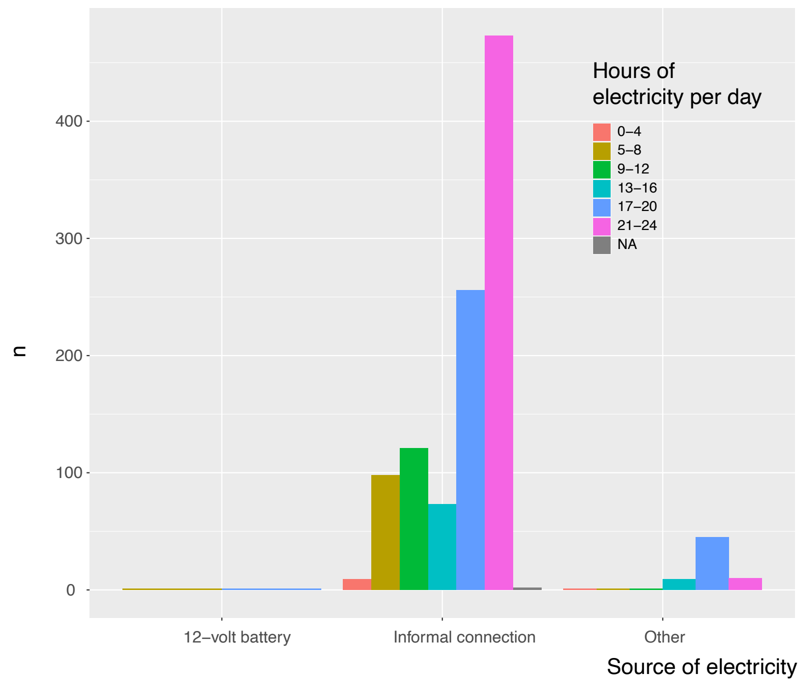

Fig.26.: Electricity – Pandemic Change

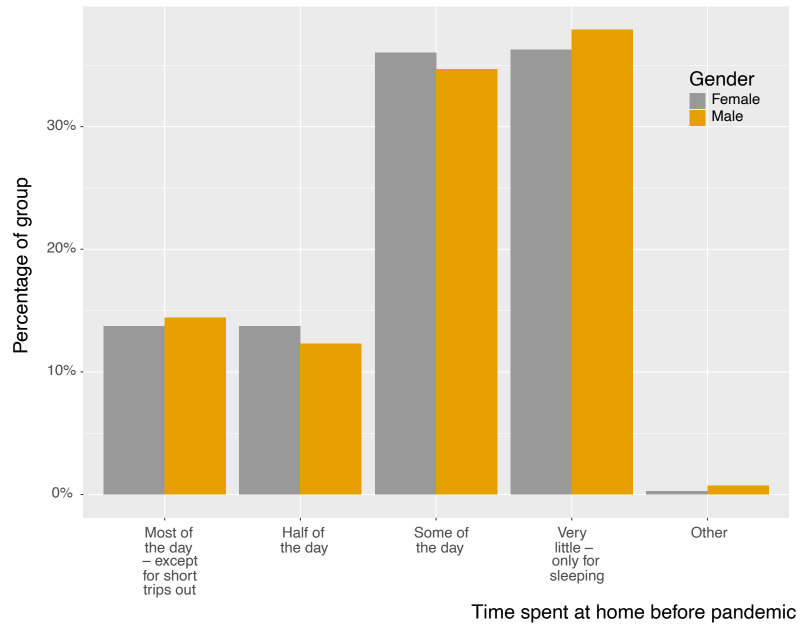

Fig.27.: Douala – Time at home before the pandemic

hot at home; sometimes adding a clarifying statement – such as "We are used to it" or "We manage" – that might have implied a habituated tolerance of discomfort, a feeling that the heat was bearable, or that there were few other options available to them.

Finally, 6% of Douala's residents described the use of water to cool the body by bathing ("washing" or "washing myself") when it was too hot. Those bathing to cool down exclusively had water access through communal or street end taps (61 of 62 respondents, or 98%) but this was proportional to the 93% who had access to water this way. Given the importance of water in cooling strategies it is unclear why bathing to cool down is not a more common practice in Douala, although recent research suggests that the reliability of water flow and distance to a working tap are likely to make a difference[28].

Only 250 people (23%) responded that the pandemic changed their heat-management behaviour, and not all of these responses were relevant to heat management directly. Of these, responses 182 noted they now went outside less, while 39 noted they now went outside. One reason for the apparent contradiction is that both may have stemmed from the desire to avoid airborne virus transmission, depending on whether the source was seen as indoors or outdoors. Some indication of this is apparent in the changing of ventilation and fan use, with a few noting they no longer ventilated or used fans to avoid increasing the likelihood of virus transmission.

Of people who described a reduction in how much they went outside, there was a

28 See: Sanou, S. M., E. Temgoua, W. R. Guetiya, A. Arienzo, F. Losito, J. Fokam, J. F. Onohiol, B. Djeunang, N. F. Zambou, G. Russo, G. Antonini, A. Panà and V. Colizzi (2015). "Water Supply, Sanitation And Health Risks In Douala 5 Municipality, Cameroon." *ig sanita pubbl* **71**(1): 21-37.

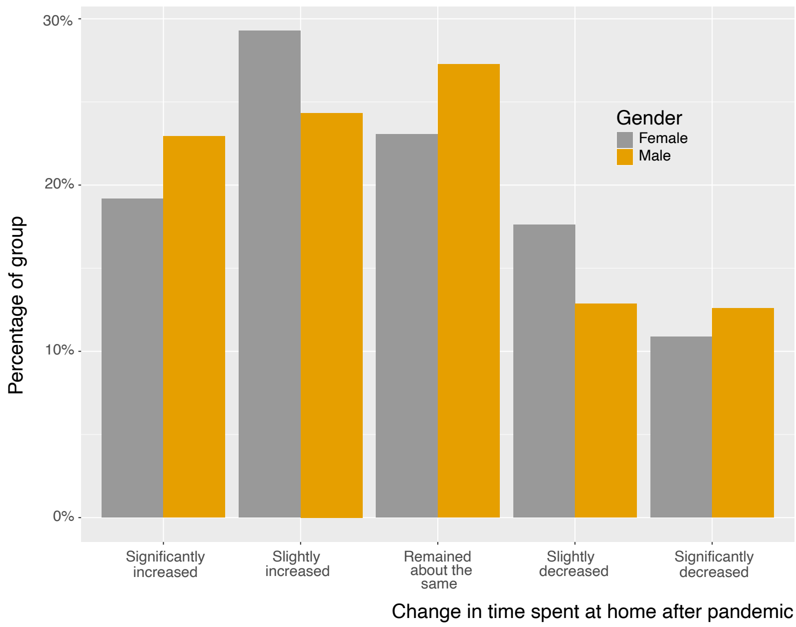

Fig.28.: Douala – Time at home pandemic change

positive/less imperative tone than in countries where there was a clearer indication of fear of exposure to the virus and legal requirements to stay indoors as opposed to choosing to.[29] It is also worth noting that Douala was not particularly hot at the time the survey was conducted, so in some cases people noted that they happened to not need their usual cooling strategies, but this had nothing to do with the pandemic per se: "It's no longer very hot" "The fan is not required. Open the windows."

Douala shows one of the most equal distributions between genders of different amounts of time spent at home prior to the pandemic. Almost half of respondents (48%) in Douala saw a slight or significant increase in the amount of time they spent at home because of the pandemic. Normalised for gender, these changes are shown in the second graph below.

There is no readily apparent relationship here, although there may be relationships visible in the online data relation to occupation and/or age.

8.3 Thermal Comfort and Heat-Related Illness Symptoms

In the study respondents reported experiencing various symptoms associated with thermal stress during the survey period, such as, blurred vision (1.6%), concentration loss (2.1%), confusion (1.6%), dizziness (1.0%), fatigue (62%), feeling hot (40%), poor quality of sleep (17%), rash (2.3%), vomiting (1.5%), feeling sweaty (33%), feeling thirsty (26%), headache (38%), irrational behaviour (1.2%), muscle cramps (3.6%) and weakness (3.6%), and nausea (1.5%).

While some of these symptoms could be associated with the pandemic itself or other sources of stress (such as poor quality of sleep) or illness, there was a statistically significant association between participants' perceiving thermal discomfort and experiencing heat-related symptoms. This was observed for HRI-s that are clearly associated with heat exposure, such as feeling thirsty (X^2=47.23, p<0.0), feeling hot (X^2=172.65, p<0.0) and feeling sweaty (X^2=148.37, p<0.0). Other symptoms might be interpreted as associated with the pandemic and corona virus itself, but given their statistically significant relationship with thermal discomfort, indicate that it was heat, rather than other aspects of the Covid-19 situation, that was the cause. These included poor quality of sleep (X^2=75.44, p<0.0), concentration loss (X^2=4.36, p=0.037).[30] Confusion (X^2=3.87, p=0.049), was just below statistical significance. By contrast, those reporting irrational behaviour (X^2=4.33, p=0.037) and fatigue (X^2=14.2, p=0.0002), while

29 The data from Douala fits with wider analysis of the response to the pandemic in Cameroon, which suggests that people's responses were shaped by widespread distrust at state and public health authorities.

30 Fatigue and irrational behaviour are significantly correlated with thermal discomfort but interestingly the odds of feeling thermal discomfort reduce if you are experiencing fatigue or irrational behaviour.

having statistically significant associations with thermal discomfort, actually presented lower odds than for people *not* experiencing discomfort, indicating these symptoms may be primarily associated with the Covid-19 situation.

For other HRI symptoms there was no statistically significant associations with perceived thermal discomfort (blurred vision, clammy skin, convulsions, dizziness, fainting, rash, vomiting, headache, loss of consciousness, muscle cramps and weakness and nausea). However, given that people experiencing heat illness are not likely to have all symptoms, we analysed the results for having *at least one* of: feeling sweaty, feeling thirsty, headache, irrational behaviour, muscle cramps, muscle weakness or nausea. With this grouping there was a strong positive association with perceived thermal discomfort. The odds for experiencing a heat illness symptom was reported ~2.9 times higher among participants who perceived thermal discomfort (CI: 2.2-3.8; $X^2=61$, $p<0.0001$) than those who did not perceive thermal discomfort.

Table 7: Demographic and personal characteristics of the study participants and its association with perceived thermal discomfort (n=1104)

	Respondents perceiving Thermal Discomfort N (%)	Chi-square, p-value (χ^2)	Crudes Odds Ratio, 95% C.I.
Demographic characteristics			
Age (years) ≥ 25 years/ <25 years	457 (41)	0.875; 0.3496	0.771; 0.446 – 1.333
Age (years) ≥ 30 years/ <30 years	402 (36)	1.775; 0.1827	0.8; 0.576 – 1.111
Age (years) ≥ 40 years/ <40 years	197 (18)	0.902; 0.3423	0.89; 0.699 – 1.133
Age (years) ≥ 50 years/ <50 years	59 (5)	0.804; 0.37	0.85; 0.596 – 1.211
Gender male vs female	324 (29)	1.791; 0.1808	1.186; 0.924 – 1.523
Occupation Paid labour, street sales, self-employed vs rest	386 (35)	0.386; 0.5346	1.1; 0.813 – 1.488
Occupation Migrant remittances, help from family vs rest	20 (2)	1.785; 0.1815	1.572; 0.805 – 3.068
Occupation Employed in private company or by government vs rest	25 (2)	4.592; 0.0321	0.585; 0.357 – 0.959
Occupation Homemaker, student, unemployed vs rest	47 (4)	0.042; 0.837	1.044; 0.694 – 1.57
Occupation Homemaker, student, unemployed vs employed in private company or by government	47 (4)	2.95; 0.0859	1.712; 0.925 – 3.169
Total residence members ≥6 members vs <6 members	302 (27)	0.0; 0.9965	0.999; 0.779 – 1.281
Residence per room ≥3 vs <3	398 (36)	3.432; 0.0639	0.734; 0.529 – 1.019
Residence per room ≥4 vs <4	254 (23)	1.373; 0.2413	1.153; 0.909 – 1.463
Welfare facilities			
Electricity connection informal vs solar, generator, other	438 (40)	15.778; 0.0001	0.359; 0.212 – 0.607

Hours of electricity supply <21 hrs vs ≥ 21 hrs	301 (27)	12.702; 0.0004	1.552; 1.218 – 1.977
Cooling interventions Fans vs refrigerator	345 (31)	23.275; 0.0	0.494; 0.37 – 0.66
Drinking water supply Tanks vs rest	12 (1)	0.663; 0.4157	1.408; 0.616 – 3.219
Drinking water supply Shared tap vs rest	443 (40)	3.831; 0.0503	0.627; 0.391 – 1.004
Drinking water supply Bottles vs rest	29 (3)	3.154; 0.0757	1.654; 0.944 – 2.898
Drinking water supply Other vs rest	0 (0)	NaN; NaN	NaN; NaN – NaN
Water for household purpose Tanks vs rest	39 (4)	7.325; 0.0068	2.002; 1.201 – 3.338
Water for household purpose Shared tap vs rest	444 (40)	7.288; 0.0069	0.505; 0.305 – 0.835
Water for household purpose Other vs rest	1 (0)	0.031; 0.8605	1.282; 0.08 – 20.549
Building envelope characteristics (poor vs good thermal properties)			
Building material ≥ 1 hot materials (concrete, metals, etc.) vs <1 hot materials	483 (44)	1.282; 0.2575	0.0; 0.0 – NaN
Roofing material Metals vs natural materials (wood, palm, bamboo)	317 (29)	0.449; 0.5026	0.546; 0.091 – 3.288
Roofing material Metals vs ceramic and clay	317 (29)	NaN; NaN	NaN; NaN – NaN
Roofing material Concrete vs natural materials (wood, palm, bamboo)	164 (15)	0.693; 0.405	0.473; 0.078 – 2.863
Roofing material Concrete vs ceramic and clay	164 (15)	NaN; NaN	NaN; NaN – NaN
Roofing material Metals and concrete vs ceramic and clay	481 (44)	NaN; NaN	NaN; NaN – NaN
Wall Material Concrete vs bamboo, palm and mud brick	282 (26)	7.492; 0.0062	0.71; 0.555 – 0.908
Floor Material Asphalt, cement vs natural materials, tiles	400 (36)	8.816; 0.003	0.595; 0.421 – 0.841
No of rooms <2 vs ≥2	88 (8)	0.947; 0.3305	1.169; 0.853 – 1.603

Ventilation <2 vs ≥2 windows	53 (5)	2.644; 0.1039	1.405; 0.931 – 2.12
Electricity usage, windows & people per room Use less electricity, ≤1 window & 4≥ people per room vs rest	292 (26)	14.205; 0.0002	0.617; 0.48 – 0.794
Coping With Heat			
Normal cooling strategies Go outside vs use fan, ventilation, cooler	22 (2)	100.431; 0.0	0.117; 0.073 – 0.188

Table 8: Association between participants' perceived thermal discomfort and Heat-related Illnesses (HRI), social lives and behaviour in the pandemic context (N=1104)

	Participants perceiving Thermal Discomfort N (%)	Chi-square, p-value (χ^2)	Crudes Odds Ratio, 95% C.I.
Perceived Heat-Related Illness (HRI) symptoms (During Pandemic)*			
Concentration loss	15 (1)	4.36; 0.0368	2.447; 1.029 – 5.82
Confusion	12 (1)	3.872; 0.0491	2.602; 0.969 – 6.984
Fatigue	272 (25)	14.172; 0.0002	0.625; 0.489 – 0.799
Feeling hot	298 (27)	172.646; 0.0	5.493; 4.224 – 7.143
Poor quality of sleep	139 (13)	75.439; 0.0	4.223; 3.001 – 5.943
Feeling sweaty	260 (23)	155.43, <0.0001	5.33, 4.05 – 7.01
Feeling thirsty	177 (16)	47.227; 0.0	2.587; 1.964 – 3.407
Irrational behaviour	2 (0)	4.326; 0.0375	0.23; 0.051 – 1.043
Any one HRI in past month	384 (35)	61.475; 0.0	2.904; 2.214 – 3.81
Affected more by heat compared to last year			
Affected by heat More vs less or the same	206 (19)	66.818; 0.0	2.988; 2.287 – 3.904
Impact of pandemic on daily life and behaviour			
Physical Conflict More in last month vs before	43 (4)	5.379; 0.0204	1.734; 1.084 – 2.775
Time spent at home before pandemic Half or more of the day vs less than half	139 (13)	1.303; 0.2536	1.168; 0.894 – 1.525
Time spent at home during pandemic Increased vs same or decreased	203 (18)	11.958; 0.0005	0.656; 0.516 – 0.834

Change in Income levels during pandemic Decreased vs same or increased	419 (38)	32.769; 0.0	2.479; 1.806 – 3.403
Access to Health Services during pandemic Harder vs same or easier	286 (26)	0.82; 0.3653	0.894; 0.701 – 1.14
Impact of pandemic on Behaviour			
Change in eating Habits during pandemic Eat less vs same or more	201 (18)	91.247; 0.0	0.302; 0.235 – 0.388
Change in Water Intake during pandemic Use more vs same or less	216 (20)	34.697; 0.0	2.116; 1.646 – 2.72
Changed what you do when hot Yes vs rest	76 (7)	23.713; <0.0001	0.477; 0.353 – 0.645

Note: *The following HRI during pandemic that did not have a significant association with the thermal discomfort: blurred vision, clammy skin, convulsions, dizziness, fainting, rash, vomiting, headache, loss of consciousness, muscle cramps, muscle weakness, nausea.

8.4 Discussion: Pandemic Effects on Heat-health Risk

Changes in Exposure and Thermal Discomfort

The survey revealed significant changes in the amount of time spent at home, with about 48% of respondents reported spending more time at home during the previous month, as a result of the pandemic. There was high statistical significance between spending time at home and perceived thermal discomfort (X^2=11.96, p=0.0.0005). However, the odds of thermal discomfort were lower for those who spent more time at home, compared to those who spent less time at home. There was no statistical significance observed between the usual amount of time spent at home and thermal discomfort. Among the 1104 study participants, only ~13% who describe feeling thermal discomfort reported that they spent at least half the day at home. These results indicate that spending more time at home, while not protecting residents entirely from thermal discomfort, generally meant they were less likely to experience it.

The reduced risk of discomfort for those spending more time at home is not surprising considering the survey ran in the coolest part of the year, where thermal discomfort would be more likely to occur when exposed to full sun (i.e. not indoors at home) or when engaging in more strenuous activities associated with labour-intensive work outside of the home.

Access to Health Facilities

Participants (61%) reported increased difficulties in accessing health service centres but there was no statistical significance with perceived thermal discomfort, indicating they were seeking health services for reasons not related to heat. This finding is not surprising, given this question pertained to use of health services during the coolest time of year.

Changes in Daily Behaviours, Electricity and Water Use

Douala respondents demonstrated a negative correlation between those who changed their heat-management behaviour as a result of the pandemic and thermal discomfort (7%) – that is, they experienced less thermal discomfort if they changed their behaviour (OR 0.5; CI 0.4-0.7; P = <0.0001). This seems to demonstrate that some were afforded additional adaptative capacity as a result of the pandemic, at least in the month prior to the survey, in mid-2020.

Access to electricity and water infrastructures among the survey respondents was broadly aligned with information available about access and availability in Douala. The survey identified substantial changes in patterns of use of electricity and water in the month prior to the survey, associated with pandemic measures. During this period, over one-third of respondents said they used less water, while a similar number said they used more. For the ~35% of participants who used more water during the pandemic, there was significant association with thermal discomfort (X^2=34.69, p<0.0001, OR=2.1) – indicating they were able to respond to heat stress, and increased time at home, by increasing water use.

However, the ability to do this seems to be partly determined by the type of water supply; respondents who had water supplied in tanks were more likely to use more, whereas those accessing a “communal or street end tap” used less. The reasons for this are not immediately apparent from the available survey data.

As tank deliveries of water require payment, it may be that loss of income had less impact among the group who sourced water from tanks, or that income was more resilient for this group. Further analysis of the characteristics of these different groups from the data is needed to identify likely causal mechanisms behind increased and decreased water use in response to thermal discomfit in the context of the pandemic.

The single survey category "communal or street end tap" combines public taps, which are in declining use in Douala [Sanou *et al.*, 2015] and the taps that people may share in compounds but must pay building owners to access. It is possible that reduced income reduced water use to those taps requiring payment for access. It is also possible that time spent outdoors, in public or proximity to others was a deterrent to collecting water from all of these taps, or that the curfew reduced the amount of time in which water could be collected. However, there is no evidence of this in the open questions, so further research is required as to why this group is more vulnerable to reduced water use in pandemic conditions.

About 29% of participants perceived that they had to use less electricity than before the pandemic, which also showed statistical significance with thermal discomfort (X^2=99.92, $p<0.0001$, OR=0.2). Interestingly, they had lower odds of perceiving thermal discomfort than those who were able to use more. The causal mechanisms here also require further investigation.

Changes in Eating Practices and Income

About 58% of participants reported that they ate less during the pandemic, and there was significant association with thermal discomfort (X^2=91.25, $p<0.0001$). The relationships between reduced food intake with thermal discomfort are complex. Hunger, starvation, and appetite affect body temperature and thermal perception and lack of electrolytes can affect thermal regulation. However, heat exposure can also impair appetite, so the causal relationship may also be reversed, although in Douala this seems unlikely – or limited to particularly hot homes – given it was experiencing a relatively cool time of year. There is not enough physiological information in the survey to make a clear determination of the causal mechanisms, but these results indicate the need to further investigate this issue.

The causes of reduction in food intake could be related to disruption of supplies, ability to travel and to income loss as a result of pandemic measures. 79% of respondents reported a significant decrease in income levels during the pandemic month and around half of these perceived thermal discomfort (38% of respondents), with a statistically significant relation between reduced income and perceived thermal discomfort (X^2=32.77, $p<0.0001$).

Further analysis is needed to identify the precise mechanisms linking income loss, reduced food intake and increased thermal discomfort. For example, loss of income may be a common driver for both eating less and thermal discomfort, for example by prompting looking for work or to make sales while exposed to full sun or walking long distances.

Changes in Levels of Physical Violence in the Home

Around 7% of participants reported increased physical conflict such as domestic violence compared to before the pandemic. The risk of increased physical conflict was 1.7 times higher among participants who perceived thermal discomfort (CI: 1.1-2.8, X^2=5.4, p=0.02), although the question does not specify if they were victims or perpetrators, and therefore whether their own thermal discomfort is a driver. Men and women were proportionally as likely to report physical violence in the home as each other (33% of reports of violence were from women, and they made up 35% of total survey respondents).[31]

Around 30% of participants reported that heat affected them more compared to this time last year. This generic question followed questions on physical health, mental health and experiences of violence in the home. The 30% of respondents may have observed an increase in one or more of these aspects. There was statistical significance with perceived thermal discomfort (OR: 2.99; CI:2.3-3.9; p<0.0001), indicating that there is a clear relationship to the physical experience of heat exposure.

Changes in the Impact of the Weather

The low fluctuation in annual weather conditions means Douala's population is likely to be well acclimatized physiologically, and well adapted behaviourally, at least within the limits of their available finances, services, and materials.

However, there is some indication that, even in the coolest period of the year for this well-adapted population, the pandemic context modulated vulnerability and exposure with some implications for both thermal discomfort and HRI.

This bodes poorly for Douala at hotter times of year; if Covid-19 measures are intensified, or as any financial reserves, such as they are, decline as the pandemic drags on, the outcomes may be more severe.

Further investigation is needed, particularly as the vaccine rollout is slow, new variants of the virus may complicate the trajectory to recovery, and lockdown measures may be required to the end of 2021 and beyond.

31 Further analysis of the dataset responses to the *Gender, Physical_Conflict* and thermal discomfort responses would yield a more nuanced picture here.

8.5 Conclusion

In the June-July period in which the survey took place, Douala was experiencing pandemic response measures at about 60% of potential severity. This had a major impact on behaviours and resources for people with low-incomes. About half of respondents (48%) were spending more time at home as a result, and almost 80% had reduced income. This clearly translated into impacts on health and wellbeing, such as reduced food intake, and in some sub-groups, reduced ability to pay for water and electricity. The statistically significant relationships between these variables and thermal discomfort and risk of symptoms of heat related illness indicates that these factors may also have significance for heat-health either through changing heat exposure or increasing vulnerability. However, in the period in which the survey took place, at the coolest time of year for Douala, there was no clear evidence that the odds of HRI were increased by the pandemic measures.

Nonetheless, if Covid-19 measures are intensified or occur in hotter conditions, the outcomes may be more severe. Particular areas of concern in this regard are: why use of “communal or street end tap” water decreased, and whether there are particular types of water supply arrangement that are particularly vulnerable. As “going outside” was the most affected heat-management behaviour, consideration of how to enable this safely during the pandemic or identify alternatives need to be found for hotter weather. Failing to do so may have impacts beyond immediate heat-health; the risk of increased physical conflict was 1.7 times higher among participants who perceived thermal discomfort (CI: 1.1-2.8, X^2=5.4, p=0.02) during Douala’s coolest conditions, such odds seem likely to increase if weather conditions warm up while residents are at the same time asked to forgo a key strategy of escaping indoor heat, or if they have reduced access to water.

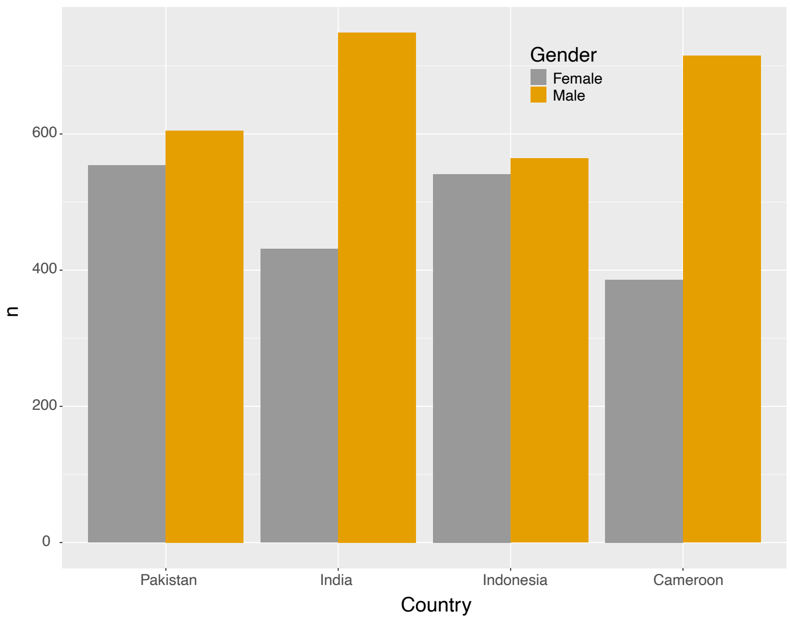

Fig.29.: Total number of Survey Respondents Grouped by Gender and Country

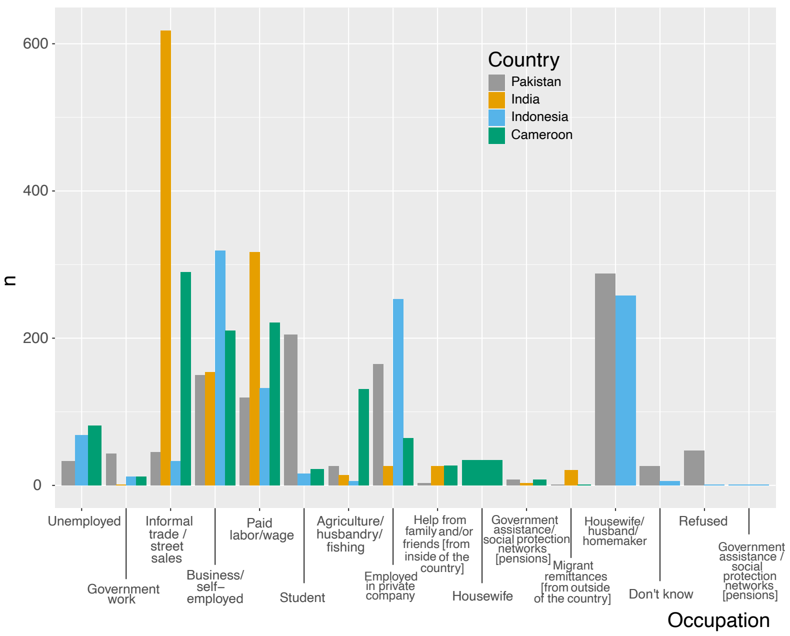

Fig.30.:Occupation groups of Survey Respondents per Country

9 Comparative Results & Analysis

9.1 Introduction

The previous chapters provided an initial analysis of our results for each city and performed a statistical analysis of the results in relation to thermal discomfort. This chapter compares the city-based results to highlight key findings and outcomes across all four countries. The data also highlights differences and regional/city-level specificities that point to the importance of situating study results in their context.

We review and summarise the demographic characteristics of survey respondents across each city (section 9.2); the characteristics of their physical environment – namely, their home, and living conditions (9.3); before discussing the data thematically, drawing on survey results and statistical analysis from Tables 1 and 2 in each previous chapter (9.4). Within these themes, we then examine similarities and differences in whether and to what extent the pandemic changed vulnerability and exposure to extreme heat and its impacts.

Overall, the data shows that COVID-19 amplified the existing vulnerabilities of low-income urban communities in Pakistan, India, Indonesia and Cameroon to heat. Specific vulnerabilities to domestic heat exposure – including those related to building materials, access to electricity and water, and gender – were accentuated by measures to prevent the transmission of COVID-19, including confinement, lockdown, and social distancing. The pandemic response created different magnitudes of disruption to everyday practices and sources of vulnerability and exposure to heat in each of the different cities.

Our comparative analysis demonstrates the need for data-linkage and interdisciplinary methodological approaches to further examine thermal risk. Our data reveals changes in vulnerability and exposure to heat for low-income urban residents of global cities during the pandemic but also reveals the importance of thinking socially *and* spatially about heat and cooling.

Given the breadth of information collected, much further analysis is possible from the data set produced by survey. Where we have identified specific issues that warrant further analysis while preparing this report, they are identified below.

9.2 Socio-Economic Profiles

The tables and figures below summarise demographic and socio-economic data from 4564 respondents across India, Pakistan, Indonesia and Cameroon. Most respondents identified as working-age men and women from low income, urban communities. The majority (93.5%) were aged between 18 and 49 years. Just over one third (34%) were aged between 30-39). In total, 42% of all our respondents were women.[32]

Virtually all respondents were involved in forms of work and urban labour that regional literature and expert knowledge in each city associates with the informal urban economy. One in five (20%) of survey respondents described themselves as either street vendors of goods and services. Just under a fifth of all respondents described themselves as either self- employed (18%) or waged labourers (17%). A fractional 4% of all respondents described themselves as un-employed.

There was diversity in the types of employment between each country and city. This may, in part, reflect both gender and age distributions within each survey location as well as social, cultural and religious norms governing women and work. In Pakistan and Indonesia, for example, over half of all our women respondents described themselves as working primarily within the home; by comparison with only 3% of Cameroon and virtually none in India.

Whilst we did not ask respondents to report the actual monetary value of household income, we used data on occupations, alongside building properties and materials (see Section 2), and access to electricity and water (see Section 3) as a proxy for income. In the context of each city, this placed all respondents within the lowest income tiers of the urban population. This profile was reflected in the impact of the pandemic. Just over half of our respondents (52%) reported a decrease in income since the onset of the COVID-19 pandemic, with important implications for their use of electricity. Those worst affected were those respondents whose major source of income was derived from street vending and informal waged labour. Amongst these two economic groups, between one half and two thirds (63% of waged labourers and 57% of street vendors) respectively reported a decrease in income since the start of the pandemic. As we explore below, these changes in income had important implications for people's thermal comfort and potential vulnerabilities to heat.

32 ndonesia had the highest percentage of female respondents (at 54%), followed by Pakistan (at 48%) and Cameroon the worst (at 35%), closely followed by India (36.5%). The age profile of respondents varied by country, with the largest number of young adult respondents (18-24) in South Asia (India and Pakistan). The gender ratio of survey informants and the small percentage of respondents from older age groups (50-59 and above 60) likely reflects the differences in access and use of mobile phones. There are known regional gender disparities in mobile phone ownership. To account for a known gender gap in mobile phone ownership between men and women in south Asia and sub-Saharan Africa, our survey method had sought to ensure a minimum of 33% respondents in each city were women.

9.3 Environmental Characteristics (Building Properties and Building Materials)

Across all four countries in this study, one effect of the COVID-19 pandemic response was that people were confined to their homes for long periods of time following local lockdowns that were implemented in an effort to prevent transmission. Given the quality and condition of housing in many low-income urban communities across the Global South, a more detailed understanding of the impact of lockdowns on heat exposure was essential. Our study collected data on the number of rooms and inhabitants in each home, the number of windows, and construction materials to analyse the effect of the building's thermal properties on thermal comfort and domestic exposure to extreme heat during the pandemic. We cross referenced this data with responses to survey questions relating to thermal comfort and symptoms of heat-related illness, as well as open-ended qualitative questions.

In general, our study respondents live in domestic spaces constructed with materials that create a poor thermal envelope. Three quarters (78%) live in homes with a roof made from metal or concrete and two fifths (40%) live between walls that are made from concrete. The internal dimensions are generally very small, and materials are assumed to be uninsulated. Attempts to model thermo-dynamic flows for domestic buildings in South Asia, Southeast Asia and Sub-Saharan Africa often rely on national building standards that do not represent the forms of informal and auto-constructed housing that most of our respondents live in. There is often very little data on the construction materials they use. Our data catalogues such materials, providing a basis for the analysis of the thermodynamic environment, and shows how such materials, as well as density, shape thermal comfort and cooling practices.

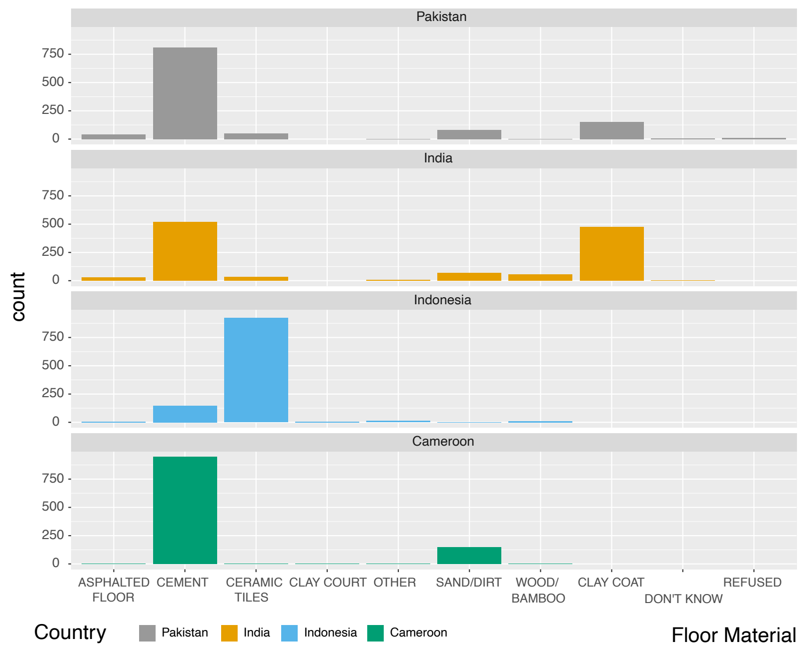

Fig.31.: Floor materials by country

Building Materials

The study data suggests that, during the COVID-19 pandemic, there was a strong correlation between certain building materials and an increased experience of thermal discomfort. Across India, Pakistan and Indonesia, respondents living in homes with concrete walls were twice as likely to feel 'hot' or 'very hot' (OR 2.095) in their home than those living in homes made of palm fronds, dried clay, or other natural materials. The same, for those respondents living beneath roofs made of sheet metal (OR 2.45)

The survey results of building material for roofs, floor, and walls, are shown below, to demonstrate the kinds of housing that respondents lived in, and to gesture to their potential exposure to heat indoors as a result.

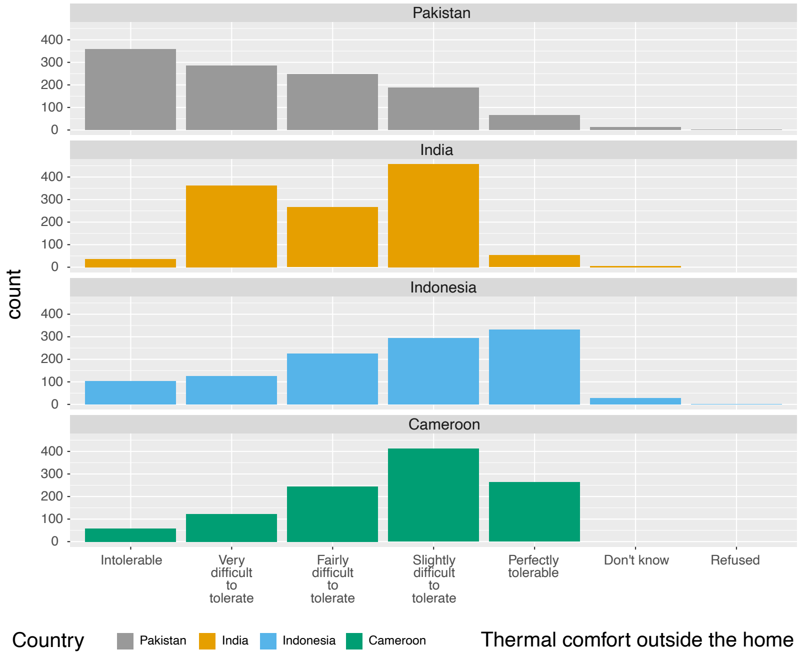

Fig.32.: Thermal comfort outside home

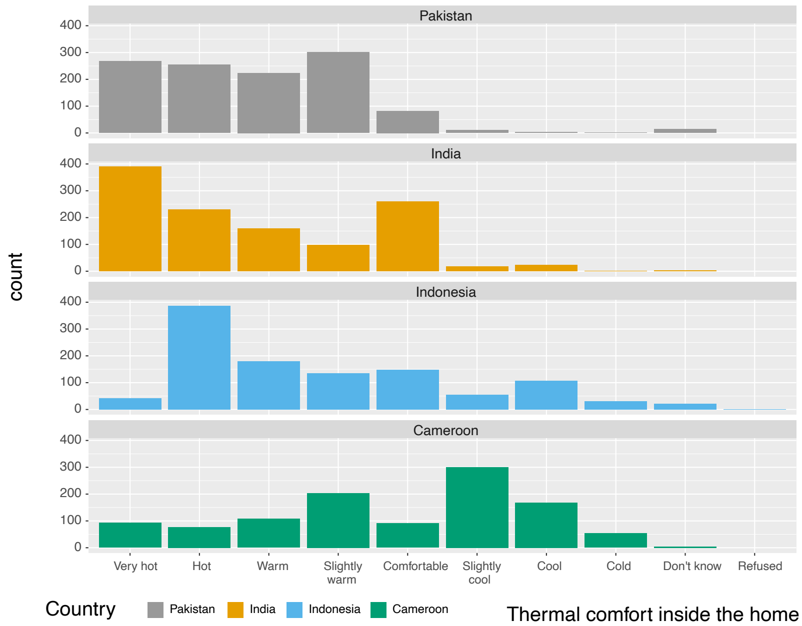

Fig.33.: Thermal comfort intside home

Living Area, Ventilation and Overcrowding

Over one third (37%) of our respondents lived in what UN Habitat identifies as overcrowded conditions. That is, homes with more than 3 people per room.[33] Over half (57%) of respondents live in a home with only 2 rooms and just under half (46%) live in a home with only 2 windows. One quarter (25%) of respondents live in homes with only one room and one window (22%).[34]

The lack of cross ventilation as a result of limited windows and doors, in combination with living in single rooms and crowded conditions increases exposure to heat, and reduces the ability of individuals to manage thermal comfort. As we explore below, our study suggests that overcrowding in low income urban areas give rise to different kinds of heat management practices or behaviours: people choose between the use of mechanical and passive cooling systems, increased electricity use or increased water use.

Cooling Practices

Our data suggests relationships between building materials and number of rooms per house, perceptions of thermal comfort and the cooling practices (or behaviours) that people adopt to mitigate or manage heat. These cooling practices entailed use of different resources such as relying predominantly on either electricity or water, and shaping patterns of energy demand. In Karachi, for example, people living in homes built from reinforced concrete with more than 6 people per room were more likely to cool themselves by taking a bath than turning on an electric fan.

33 The UN Habitat's definition of overcrowding is a maximum of 3 people per habitable room (minimum for 4 meters square). See: United Nations Human Settlements Programme (UN-Habitat) 2020. Available at: https://unstats.un.org/sdgs/metadata/files/Metadata-11-01-01.pdf

34 These figures were derived by calculating the number of residents per room by dividing the number of residents by the reported number of rooms. We also included the total number of people in each home as a stand-alone category.

Such findings indicate the need for further research into the social, cultural, and economic rationales for such behaviours. It may be that the cost or availability of electricity simply makes fans an unworkable option, particularly if multiple fans are needed to cool a larger number of people. Perhaps residents have learned that circulating air in concrete homes, which can retain heat for long periods of time, does not substantially improve thermal comfort. Or perhaps people simply prefer the feeling of water on the body if the option is available, or the opportunity to escape to a private space, when living in crowded conditions. Such patterning of behaviour highlights the need to further investigate what shapes cooling practices in high-density homes using qualitative or ethnographic methodologies.

The data revealed home design and urban environment had other important effects. The presence of semi-private courtyards or vegetation, particularly trees, created outdoor spaces for cooling. In Douala, Cameroon, for example, communal courtyards were a major feature of domestic life that allowed people respite from the heat, while in India access to a tree on the street was an incidental, but highly valued, environmental asset that enabled cooling.

9.4 Weather, Climate and Heatwaves

In each location, our survey took place at times when the surface air temperature was lower than the national, regional or city thresholds for identifying a ‘heatwave’ event. Across all four cities, what people perceived to be the temperature outside the home broadly reflected weather conditions in each city at the time of the survey, relative to average climate and the season.[35]

Regardless of season or weather conditions, however, the study suggests that low-income urban residents across India, Pakistan, Indonesia and Cameroon, rarely if ever experience their homes as cooler than the outside. Across all four countries people’s perception of the temperature inside their home was predominantly either *equivalent to or hotter* than the temperature outside. This data suggests that heat exposure *based on environmental conditions alon*e may underestimate the frequency and magnitude of heat exposure of low-income urban populations, and challenges assumptions that homes provide a refuge from extreme heat.

Each city report analyses these findings further in relation to a basic classification of ‘hot’ and ‘cool’ materials and specific local contexts. Our findings varied accordingly. In Indonesia, for example, outdoor conditions were more likely to be perceived as tolerable but indoor conditions were most often declared as ‘hot.’ Responses reflected the thermal comfort of buildings, perceived differences in acceptable indoor and outdoor conditions, as well as regional variations in diurnal temperature (and night-time humidity) that affect whether homes can cool down.

35 Respondents in Karachi and Hyderabad were most likely to comment that the conditions were intolerable compared with other countries; Karachi had recently experienced two heatwaves and Hyderabad was entering its summer season. Respondents in Jakarta and Douala found conditions more tolerable. Jakarta residents were the most likely to say conditions were ‘perfectly tolerable’ which may be indicative of the lack of seasonal variation rather than of particularly comfortable weather. In Douala, the survey took place during the coolest part of the year.

9.5 COVID-19 Changes in Heat Exposure

Across all four countries, we asked respondents to report on changes in their general exposure to heat during the COVID-19 pandemic. Overall, 43% of our respondents (44% of men and 42% of women) reported an increased heat effect in July/August 2020 compared with the same time during the previous year. We use their description of thermal comfort (expressed in terms of thermal discomfort) and reported symptoms of heat related illness (HRIs) as well as incidences of physical conflict as key metrics of how heat affected them. The results allow us to map changing impacts of heat exposure in relation to changes to exposure reported above (time at home) and in relation to changes in specific vulnerabilities (including access to electricity, water, income, and food intake).

Heat Related Illness

Across all four countries, low-income urban residents were *more likely* to report they had experienced symptoms of heat related illness May and June 2020, compared to what they described as their experience at the same time in 2019, pre-pandemic.[36]

Residents of the cities we surveyed in Pakistan and Indonesia were *slightly more likely* to have experienced symptoms of HRI between May and June 2020, compared to what they described as their experience at the same time in 2019, pre-pandemic (OR between 1.2 and 1.4). By contrast, in Douala (Cameroon) residents who reported experiences of thermal discomfort in their homes before the pandemic were more than 2 times (OR 2.6) more likely to experience it during the pandemic. In Douala, this was also clearly correlated with a decline in income. Here, people who experienced a difference in income levels before and after the pandemic were 2.4 times more likely to experience HRI.

In Jakarta, residents reported fewer HRI symptoms with statistically significant relationships to thermal discomfort than the other cities. However, this may in fact indicate an association with pandemic measures. Jakarta had the least stringent COVID-19 measures in place at the time of the survey, meaning that, although people found their homes to be hotter than outdoors, they were less likely to be confined to them at the time the survey took place than those in Hyderabad (India), for example. The lack of thermal discomfort and HRIs may also be explained by the relatively moderate weather conditions, in an area where weather varies little, with the result that people are physiologically acclimatized and behaviour is well-adapted. Jakarta was experiencing average conditions for the time of year but was hotter than both Douala – where conditions are also relatively stable – and Hyderabad (India). In absolute terms, it was nowhere near as hot as Karachi and Hyderabad (Pakistan), where conditions also vary throughout the year.

36 Some symptoms associated with heat stress may also be a result of psychological stress arising from the pandemic or other causes. For example, irritability and difficulty concentrating could also be the outcome of being anxious about loss of income and associated impacts, fear of becoming ill, or concern for loved ones.

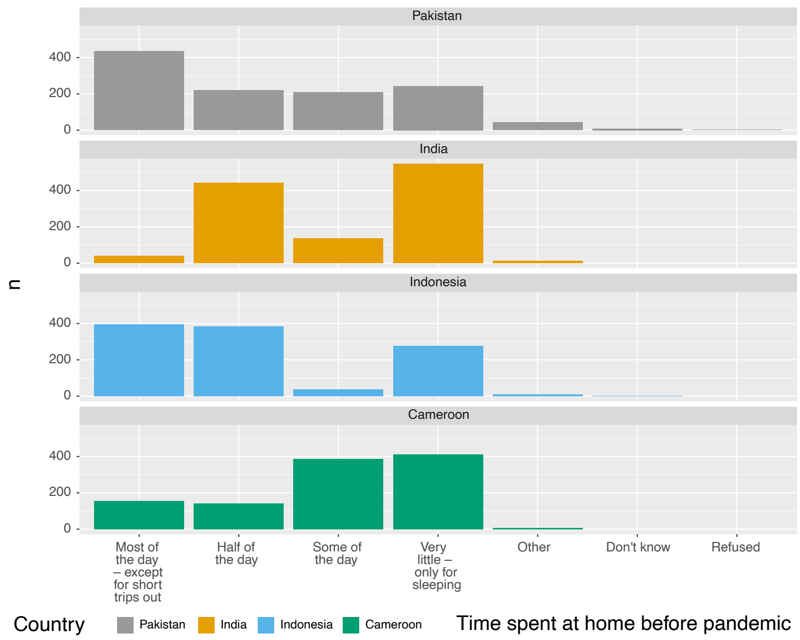

Fig.34.: Time at home pre-pandemic

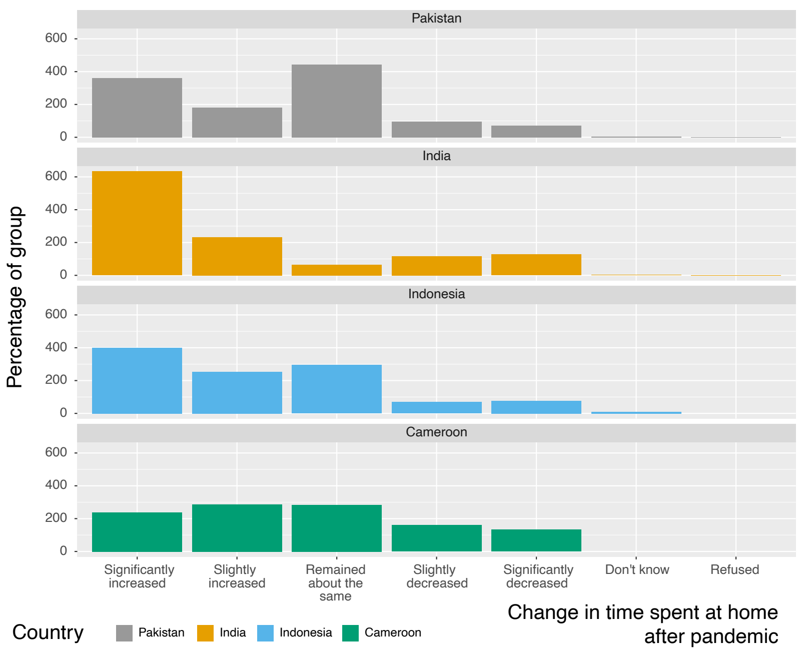

Fig.35.: Time at home post-pandemic

Time Spent at Home

Across all four countries, our study found that increased amount of time spent inside the home also *increased* the likelihood that respondents would experience thermal discomfort and *may have* increased the risk of heat-related illness, even during periods of cooler weather.

The amount of time spent inside the home is rarely quantified but is an important measure for assessing heat exposure in domestic environments. Across all four countries, COVID-19 changed how much time people spent at home. Most respondents (57%) reported a slight to significant increase in the amount of time they spent inside their home compared to the same time in the previous year, closely reflecting national, regional and city level measures to prevent transmission of COVID-19 through lockdowns and restrictions on movement.[37] There were major differences between men and women (although these differences were markedly greater in South and South-East Asia). For most people, time spent at home increased during daylight hours when temperatures were highest, thereby increasing exposure to heat in the domestic environment.

37 Time at home before the pandemic was needed to assess the baseline exposure, and time at home during the pandemic was needed to understand whether exposure to heat at home changed.

9.6 COVID-19 and Changing Vulnerabilities to Heat

Our study revealed regional variations in everyday heat management practices amongst the low income, urban populations surveyed, both before and during the COVID-19 pandemic. In part, this variation reflects differences in social practices and material cultures across four diverse city environments, defined by distinct histories of urbanisation, migration, and planning. In particular, our study highlighted the cultural and gendered dimensions of the heat/COVID-19 nexus and the 'thermal agency' of women. Our study also reveals differences in the 'adaptive response' of low-income urban respondents to changing patterns of access to basic services (water and electricity) as well as livelihoods and food. The ability to respond to heat through active measures depended in large part in all countries on access to electricity and water, as discussed in the sections below. These findings have important implications for future interventions aimed at alleviating heat-stress and reducing vulnerabilities to heat.

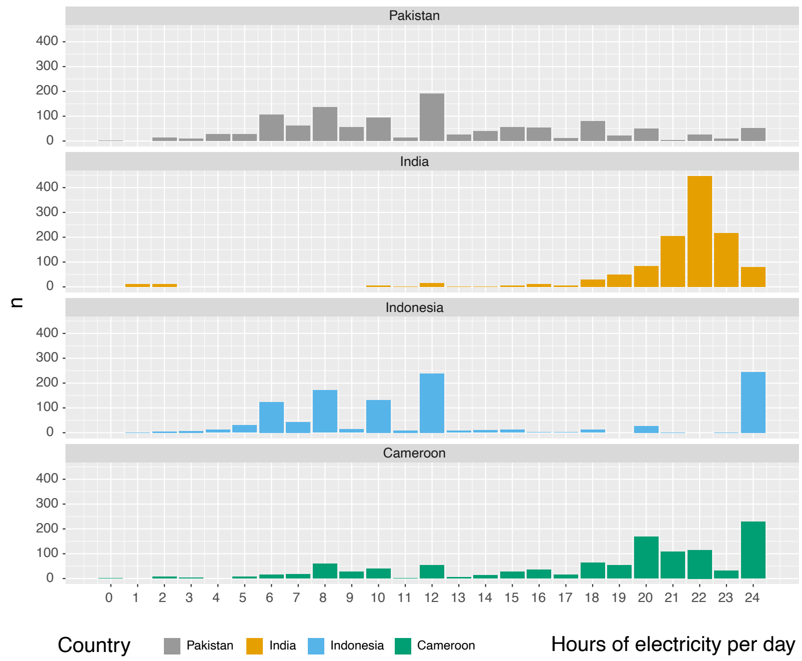

Fig.36.: Electricity access by country

Electricity Access, Supply and Use

COVID-19 had a direct impact on the access of low-income urban residents to electricity, with between 25% and 28% of all respondents to our survey reporting that they have had to make do with reduced electricity access during the pandemic. COVID-19 related declines in household income appeared to have prompted many respondents to cut their electricity consumption, suggesting that the willingness or ability to pay for electricity is highly sensitive to income security. Across all the cities we surveyed, there was a statistically significant relationship between changes in income and reductions in electricity use. Among all our respondents, people who reported either a "significantly" or even "slight decrease" in income since the start of the pandemic were over two times (OR 2.78) more likely to report using less electricity at home.

Across all cities, this decrease in the supply of electricity was correlated with a *significant increase* in the likelihood that people reported experiences of thermal discomfort in the home. Most survey respondents reported accessing electrical power through an informal connection to a mains electricity grid (that is, through a connection to a neighbouring home, or directly to mains electricity). However, low-income urban residents living entirely off the grid – people who reported living with neither a formal or informal/illegal connection and relying on either solar panels, generators, or batteries for electricity – were more than one and half times as likely to report having been more affected by heat during the pandemic (OR 1.6).

One reason for this may be that most currently available, low cost, electric fans – the most widely used cooling technology amongst all our respondents – are configured for alternating current (AC); which is the type of electricity provided by the mains electricity grid. Many off grid electricity systems (including solar panels) are only able to generate direct current (DC). Virtually no respondents who lived off the grid reported owning an electric fan (1%), whilst 37% of all those connected to mains electricity did.

In addition to questions of availability and reliability there is also the issue of 'how much' power is available, and what kinds of devices families can afford to run off the available power – both of which shape how much cooling electricity provides in practice. There was considerable variation across the cities we surveyed in the number of hours of available electricity per day. In total, however, over one third (40%) of all respondents reported that they had less than 12 hours electricity per day. Similarly, there was considerable variation in the stability or continuity of supply. In Jakarta (Indonesia) and Karachi (Pakistan), for example, people reported a much less reliable supply of power compared to Hyderabad in India. Counter-intuitively, informal electricity connections appeared to provide the greatest continuity or stability in the level of supply. Compared to those respondents with a formal grid connection, respondents with an informal connection reported less variation or reduction in power supply during the COVID-19 pandemic.

In developing our study, we had hypothesised that respondents with constant or near-constant electricity supply (between 22-24 hours/day) would be less likely to experience thermal discomfort than those with gaps in supply (e.g. 12 hours per day or less). However, our data suggests the reverse. Respondents with 22-24 hours of electricity a day were twice as likely (OR 2.75) to report feeling being more affected by heat during the COVID-19 pandemic than those with only 0-3 hours of electricity each day. Such a finding suggests both that locally acceptable or minimal perceptions of thermal comfort change with increased access to electrical power, and that people with less access to electricity power are not dependent on electrical power to meet their cooling needs. However, further analysis of this data responses and the deployment of further methodologies is needed to substantiate such an analysis.

Only 7 respondents out of 4564 described having or using an air conditioning (AC) unit, in a clear indication of the relationships between income, occupation and access to this technology. By contrast, just under two thirds of our respondents (60%) said that they had access to an electric fan but only about one third (34%) indicated that they normally used it when it was hot. One fifth of respondents (21%) reported that, when it got too hot in their home, they left and went outside.

In general, those respondents who had a fan in their home, were less likely to report feeling more affected by heat during the pandemic (OR 0.82) and far less likely to go outside when they felt too hot (OR 0.024). However, fan use was not universally associated with thermal comfort. Fan use appeared more efficacious and more closely associated with thermal comfort in Douala (Cameroon), than in Karachi (Pakistan). In Karachi, people who used a fan were more than one and a half times (OR 1.65) more likely to report being more affected by heat in their home since the start of the pandemic. By comparison with Doula, where respondents where half as likely to report the same (OR 0.50). Douala was much cooler and more humid than Karachi at the time of the survey. Such findings indicate environmental characteristics – both temperature and humidity – may shape the perception of how effective fan use is for cooling.[38]

38 See also: Morris, N. B., English, T., Hospers, L., Capon, A., & Jay, O. (2019). The effects of electric fan use under differing resting heat index conditions: a clinical trial. *Annals of internal medicine*, 171(9), 675-677.

Water Supply, Access and Use

Access to clean water during the COVID-19 pandemic was a major public health issue in all the surveyed cities – not only for hygiene and handwashing but also for hydration and cooling. In early 2020, many public health experts expected that access to clean water supplies during the Covid-19 pandemic might be compromised because of national lockdowns and social distancing measures, or hygiene concerns. Our study data shows that, for most of our respondents, pre-pandemic patterns of water use were either sustained or increased during mid 2020. However, the study data reveals an important relationship between water use and thermal discomfort.

Our survey provides a useful snapshot of water access and supply.[39] Almost half of the respondents in our study reported using communal or street-end taps (47%), which was the most common source of drinking water for household use. Just over a fifth of respondents (23%, and none in Jakarta, Indonesia) used water delivered by tanks.

Water use was one of the key areas in which we observed the greatest divergence of practices for keeping cool between the different cities and countries. In their response to our open questions, for example, people rarely described the use of water for bathing or cooling the body (only 8% percent across all cities), even though other sources of information (including academic literature, city level expertise, and popular culture representations) suggest that bathing is an important practice. This lack of detail may reflect a cultural discomfort with such questions in the context of a remote, mobile phone survey conducted by strangers. Or it may pinpoint a specific shift in cooling practices during the COVID-19 pandemic.

Across all the cities we surveyed, a majority of respondents described an increase in their use of water during the survey period.[40] Whether because they were spending more time at home as a result of COVID-19 lockdowns or restrictions on movement, or because of changes in their employment status, or because of an increased in personal hygiene behaviours as a result of information about COVID-19 transmission, most people appeared to have the ability to collect as much or more water, and appeared to be use it more frequently.

However, in the instances where water use was *reduced*, the impacts were concerning. This data reveals a close relationship between reduced water intake and thermal discomfort during the COVID-19 pandemic. Most markedly, reductions in water intake were closely correlated with more severe symptoms of heat related illness. Respondents whose water intake had reduced since the pandemic were more than 3 times more likely to report experiences of blurred vision than those whose water intake had increased (OR 3.5); 2 times more likely to report experiences of clammy skin (OR 2.02); and 1 and a half times more likely to report a loss of concentration (OR 1.53). People who reported using less water were also 1 and a half times more likely to describe their indoor temperature as very hot (OR 1.6).

39 We did not collect data on the volume of water or period of time it was available, which presented some limitations to our analysis.

40 Our data on changes in 'water intake' does not allow us to distinguish between household or drinking water; so we are unable to clearly indicate whether increased water use describes hydration or bathing practices.

When additional water use was available, the data shows its importance for cooling. People who described an increased heat effect during the pandemic were almost twice as likely to describe an increase in water intake during the same period (OR 1.8). More specifically, the data suggests that when people experience more minor symptoms of heat related illnesses and additional water use is available, they increase their consumption of water. People who described an increase in their water intake during the pandemic were twice as likely to also report a general feeling of being too hot (OR 1.98) or experience of dizziness (OR 2.57) during the pandemic.

As these findings suggest, there is scope for further investigating why the use of water as a cooling strategy is so limited, how localised changes in patterns of water consumption can be used to signal increased vulnerabilities to heat-related illnesses and how the use of water to reduce heat stress, address heat strain and support hydration for improved thermal regulation can be increased.

Access to Health Services

Across all four countries, and regardless of gender, almost all respondents described their ability to access health services as 'harder' during the pandemic compared to prior experiences.

Whilst we would not necessarily anticipate that everyday experiences of thermal discomfort would drive health seeking behaviour, we would anticipate that severe symptoms of a heat related illnesses would be associated with an increase in efforts to access health services. This appears to be the case in Karachi (Pakistan), where temperatures had been higher than the other surveyed cities, and where we found a direct statistical correlation between thermal discomfort and access to health care.[41] By contrast, in Hyderabad (India) we found no correlation between thermal discomfort and access to health care, suggesting that health seeing behaviour here was not linked to heat or experiences of thermal discomfort as a result.

This data suggests either that heat-health impacts in Pakistan during the survey period (rather than COVID-19) were driving people to seek access to health facilities. Or, alternatively, that health-seeking behaviour, perhaps associated with Covid-19, exposed people to more heat and increased thermal discomfort, for example, when people were forced to wait outside in queues for appointments. Either way, this finding identifies a specific need for further research on the relationship between thermal discomfort and health-seeking behaviour, with implications for how major health events are managed.

Food Intake and Thermal Comfort:

Across all four countries, our study showed strong associations between food intake and thermal comfort. There are many hypotheses that could be posited here, as the relationship between food intake and thermal comfort, as well as heat-related illnesses, is complex. For example, there is a relationship between eating enough, and having sufficient electrolytes and associated good hydration to support healthy thermal regulation and the ability to tolerate warm conditions. Eating less as a result of loss of is also a common response to feeling too hot. These associations prompt further

41 In Pakistan, respondents (58%) reported increased difficulties in accessing health services during the pandemic as well as thermal discomfort. This was statistically significant (OR: 4.4; CI: 1.02-2.2; X^2=4.37, p=0.036).

questions of the survey data. When people report that they "eat less" but that it is also "enough" they may be describing a loss of appetite. For those that ate less but considered it was "not enough", further analysis should consider whether lack of food contributed to symptoms associated with heat-related illness, including headaches, weaknesses, and light-headedness. Lack of food here may contribute to poor thermal regulation but may also be an alternative, non-heat related pathway to some of these symptoms .

Domestic Conflict and Violence

Between 14% and 19% of respondents to our survey, 8% of whom were women and 9% men, reported an increase in physical conflict and violence in the home since the onset of the COVID-19 pandemic.[42] Worldwide, domestic violence has been a key issue throughout the pandemic, partly because high rates of domestic violence are often associated with the stress of loss of income and control and experiences of confinement. Our study complemented such analyses by adding the further hypothesis that heat exposure and thermal discomfort in the home may have contributed to domestic violence. In all of the 4 countries we surveyed, there was a statistically significant association between the thermal comfort of respondents and reports of domestic violence (these relationships are discussed in detail in Chapters 5, 6, 7 and 8). Across all locations, the likelihood that respondents reported an increase in physical conflict/violence since the start of the pandemic was more than twice as likely (OR 2.10) amongst those who also reported an increased experience of thermal discomfort. This was most pronounced in Douala (Cameroon), where people who described an increase in thermal discomfort at home were almost three times (OR 2.8) more likely to report an increase in domestic conflict.

The validity of such answers is notoriously difficult to ascertain, but certainly warrants further analysis. These results could be further analysed in relation to other variables from the survey data such as income loss, and in relation to additional research on more detailed timelines of pandemic-associated triggers for domestic violence (such confinement) to identify changes in thermal discomfort in the home vis-a-vis other factors.

42 Our study asked specifically about domestic conflict – a less offensive or taboo term for domestic violence – but also covering instances such as fighting between siblings.

10 Policy Implications: From Emergency Response to Urban Development

Our research has identified how the pandemic response undermined residents' abilities to stay cool or otherwise manage heat stress in low-income areas. However, it has also revealed the high level of exposure to heat as a result of poor-quality housing, and vulnerability as a result of limited affordability, reliability, and access to, electricity and water for low-income communities. The pandemic response has thus exacerbated existing inequalities in vulnerability and exposure to heat.

These findings also indicate the need to substantively reframe how we understand and respond to heat-health risk. The impact of the pandemic response offers an important reminder that heat-health is impacted whenever levels of vulnerability and exposure to heat increase; not only when exceptional heat events take place. Accordingly, heat-health warning and response systems should identify risk not only as a result of changes in the magnitude of the hazard – i.e. weather conditions – but must also monitor and respond to significant changes in vulnerability and exposure.

As the Coronavirus pandemic continues, international organisations and NGOs must reduce the compound risk of heat exposure arising from pandemic response measures. We are not arguing for pandemic measures not to be applied, but rather that they are applied more sensitively, and/or supplemented by support from other policy levers, in order to reduce unintended heat-health impacts.

Seven priority areas for policy action are identified below, based on the survey data and analysis in the preceding chapters. These fall under the categories of: behaviour; gender; water; electricity; shelter and shade; social protection; data and information.

Each priority area is broken down in terms of emergency and humanitarian response functions on the one hand, and development or longer-term planning and services sectors on the other. Both types of response are important, and trade-offs and value-add inter-dependencies between them are highlighted in the discussion below.

Responding to these issues effectively also demands coordinated responses from policy makers and practitioners involved across the domains of public health; energy provision; water, hygiene and sanitation; social protection; urban planners and agencies responsible for temporary and permanent shelter; and, information services, including in relation to weather and emergency warnings.

Seven Priorities for Policy Action

Priority Area	Rationale	Emergency and Humanitarian Actors	Planning / Services Sectors
Behaviour	Policy interventions on Covid-19 and Heat must be attentive to the everyday practices to assess heat-health risk.	Consider how changes to everyday practices as a result of the pandemic have increased exposure and vulnerability to heat. This cuts across all the domains identified below. Increase research and utilize findings in refining policies and programmes to better reflect how everyday practices shape exposure and ability to manage heat, and how these can be affected by changes in social, material and environmental conditions.	Cuts across all domains, affecting all actors identified below. Increase research and utilize findings in refining policies and programmes to better reflect how everyday practices shape exposure and ability to manage heat, and how these can be affected by changes in social, material and environmental conditions.
Gender	*Differential access to cooling, levels of exposure and burdens of dealing with variable income and services.* *Domestic violence is also strongly associated with increased thermal discomfort.*	Attune programmes to gender-based differences in: access to cooling, levels of exposure and the burden of dealing with variable income and services cuts across all the domains below. Increase provision of welfare checks and places in shelters for victims of domestic violence during periods of: increased vulnerability, increased exposure to domestic heat, or increased environmental heat.	Attune policies and programmes to gender-based differences in: access to cooling, levels of exposure and the burden of dealing with variable income and services cuts across all the domains below. Increase public awareness of the role of heat in increasing the likelihood of physical violence, and provide education on methods for reducing heat stress and heat strain. Improve provision of family violence prevention and management programmes.
Water	*Vulnerability to heat changes as a result of shifting access to water, including as a result of pandemic measures.*	Identify the low-income households at risk of reduced water use during Pandemic measures or other periods of vulnerability (e.g. income loss). Support these households with water payment or waivers or alternative sources of supply during these periods. Drinking water is a priority, but water should also be provided for cooling purposes. Provide information to households on low-water usage cooling methods (such as combinations of wet towels and fans) ensuring these are physiologically, culturally, and climate-appropriate.	Develop and maintain mains water access wherever possible, and improve the reliability of supply, at least to street-end/public taps. If water outages are anticipated during vulnerability or heat events, coordinate with emergency and social protection agencies.

Electricity	*Exposure to heat at home is magnified by the unreliability of electricity supply for those with grid access. For those without grid access, power type and limited capacity, can reduce their access to cooling devices.*	Formal and informal (shared) connections may both entail payments. Investigate the efficacy of announcing payment waivers for poorer households during periods of increased income vulnerability and/or heatwave events. Provide DC pedestal fans to off-grid homes in high vulnerability or heat events.	Provide off-grid homes with access to the grid, including through investigating formalising shared grid-access arrangements, or reducing set-up fees. Support the development and roll out of DC fan technologies that can be used off-grid.
Shelter and Shade	*Homes in low-income areas are likely to increase exposure to heat rather than protect occupants from it. Outdoor, public or communal shaded are key sources of respite, but need to be accessible, including to women.*	Where possible, avoid lockdown/confinement through use of other measures (such as social distancing) in areas where housing creates heat-health risk. In informal settlements, consider provision of re-useable/moveable housing elements that improve the thermal envelope, such as light-weight home insulation or window elements. Considering necessary coronavirus precautions, provide shaded open areas within a short distance of at-risk populations during vulnerability or heat events. Where these exist already, ensure these are safe and accessible for both genders.	For low-income residents, develop and support programs supporting improved insulation – particularly of roofing materials. Ensure the provision of shade in public places is protected and increased – including both green and grey infrastructure. Ensure these are safe and accessible to both genders.
Social Protection	*Financial support to assist with daily expenses (rent, utilities bills, food, water, health care)*	Monitor reductions in income for low-income populations and/or households (formal and informal) and provide financial or social assistance. When this is insufficient, alert other agencies responding to heat-health risk.	Strengthen social protection monitoring and provision. Design systems that are able to coordinate with key services and other sectors, including health, utilities, and environmental and meteorological services.
Data and Information	*Changes in vulnerability and exposure need to be monitored when assessing heat-health risk, alongside environmental hazards (extreme heat or heat waves).* *Deeper collaboration across sectors, and potentially between public and private service providers.*	Emergency weather, health, social protection services and utilities providers, should share information to identify any significant shifts in vulnerability, exposure or hazard that will change heat-health risk, particularly for low-income populations which are already highly vulnerable and exposed. These systems should be refined to provide accurate monitoring and operate in an anticipatory fashion.	Support whole-of-government and cross-sectoral development plans, in order to identify and respond to knock-on-effects on heat-health.

10.1 Behaviour: Disruptions to Everyday Practices, Vulnerability and Risk

The survey found that the coronavirus pandemic resulted in significant disruptions to everyday practices, and as a result changed patterns of exposure to heat and vulnerability to its effects.

In particular, the number of hours spent at home increased dramatically, and ability to go to work, buy food and water, or spend time outside for social, economic or thermal comfort purposes, was curtailed. Such changes resulted directly and indirectly from both formal and informal protocols for preventing transmission of the virus, disruptions to employment and loss of income and personal anxieties about social contact.

By changing the amount of time spent at home, time outside or in different – and often cooler – public or communal locations, the pandemic resulted in changes to the amount of heat exposure. In combination with additional vulnerability resulting from income losses and reductions in water and electricity use, this meant that thermal discomfort, HRIs and the incidence of physical violence in the home increased for segments of these populations, even though none of the regions experienced higher than usual heat at the time of the survey.

To address these issues, policy interventions relating to both heat and the Covid-19 Pandemic (and by extension, other epidemics or similar scenarios), must be attentive to the everyday practices of populations in order to accurately assess changes in exposure and vulnerability, and the resulting risk to heat-health. In particular, they should:

- **Understand how everyday practices shape heat exposure profiles:** heat exposure usually arises incidentally, as a result of other practices (such as going to work, waiting for water, tending to the home). Understanding how these practices – and changes to them – shape exposure to heat in domestic, occupational and public environments is critical to understanding the incidental changes to exposure, and potential for heat-health risk, when practices change.

- **Consider how changing vulnerability shapes everyday practices:** for example, where families choose to spend their reduced income on food and water instead of electricity, and thereby stop using fans when they feel hot, even though they own one.

The points above complement the existing focus within heat-health programmes that focuses on changing heat hazards, but otherwise often assume exposure and vulnerability to be static.

10.2 Gender, Bodies and Intersectional Policy

The survey data demonstrated wide differences in the amount of time spent at home before and during the pandemic, as a result of gender.

Women also had markedly reduced options for cooling, primarily as a result of limited ability to go outside or into public spaces to cool down, particularly in South Asia.

Across all four countries, those who also reported an increased experience of thermal discomfort had more than twice as high odds of also reporting an increase in physical conflict in the home. To address these issues, the following policy interventions are recommended:

- **Coronavirus pandemic and heat-health risk assessment should account for gender-based differences in heat exposure.** Given the wide variation in exposure to heat as a result of time use and access to public environments between men and women, it is essential that heat-health risk assessments take this into account. In particular, women should be supported to ensure they have adequate access to cooling – from water, electricity or an appropriately insulated or shaded environment – when at home.

- **Heat-health interventions should consider and support women's 'thermal agency'** including by providing safe and culturally appropriate access to public or communal cool spaces.

- **Increase the provision of welfare checks and places in shelters for victims of domestic violence** during hot weather or when people are confined to hot homes, including when inability to pay for electricity or water may increase heat stress.

- **Increase provisions for reducing physical violence**, including through providing education on methods for reducing heat stress and heat strain that contribute to it, and through improving the provision of family violence prevention and management programmes.

10.3 Water: Hygiene, Hydration and Cooling of Bodies and Homes

The survey results indicate that water was essential to enabling people to address thermal discomfort and minor symptoms of heat-related illness. Water is essential not only for hydration, but also for use in directly cooling the body through bathing, or, in drier environments, through cooling the air and surfaces in the home through evaporation, including via evaporative coolers. Water of course plays a key role in handwashing to prevent viral transmission and overall hygiene, which is of particular concern during the pandemic.

However, when water supply is limited for any reason – through expense, availability or the exertion required to collect it – these multiple uses can be severely constrained, and vulnerability, including to heat, increases. The survey data shows a small percentage of people who had to reduce their water use during the pandemic period. The reasons for this are not known, but require further investigation of the data and research, as this cohort was had much higher odds of more severe heat related illnesses. Furthermore, the near absence of the use of water as a cooling strategy even prior to the pandemic is notable, and likely indicates that water scarcity is pervasive, although there may also be cultural and knowledge factors at play. To address these issues, the following policy interventions are recommended:

- **Identify the reasons why some low-income users had to reduce water use during the pandemic**, considering whether changes may have resulted from: logistical issues with water distribution, inability to pay as a result of loss of income, inability to spend time queuing for water as a result of lockdown and/or social distancing measures, or fear of contagion. Findings should inform future coronavirus response measures.

- **Improve water availability and reduce wating times for water.** Everyday water scarcity creates high levels of vulnerability to heat, even when no heat wave is declared. Supporting improved access to water, ideally as mains water supply, is essential for basic health and the ability to withstand extreme heat.

- **Improve information sharing about water availability:** As a medium-term measure in places where flows are irregular and limited, there is a need to improve information about water supply to reduce the time families (often women and children) have to wait for water. Care should be taken in designing how such schedules are created, but with transparency of public communication this should help reduce the degree to which political influence and other forms of social capital shape water provision, which is well documented in many countries and in some of the survey cities (for example, Hyderabad)[43].

43 Das, D. and T. Skelton (2020). "Hydrating Hyderabad: Rapid urbanisation, water scarcity and the difficulties and possibilities of human flourishing." Urban Studies 57(7): 1553-1569.

10.4 Electricity: Access, Supply and Equipment

More than a quarter of respondents reported having to reduce electricity use during the pandemic, associated with income loss. Although most respondents had some kind of informal access, it seems these too were affected, most likely those who paid a neighbour for secondary access to a primary, connection (itself formal or informal). As those who reduced electricity use had higher odds of being affected by heat, even in non-heatwave conditions, the cause of the vulnerability of their access to electricity warrants further investigation. Only 1% of those off the grid had a fan, meaning that their source of power or lack of connection to the grid, makes it harder for them to access this cooling technology. However, the efficacy of fans is tied to environmental characteristics (temperature and humidity) which are shaped at the microscale by housing materials. To address these issues, the following policy interventions are recommended:

- **Support wider access to fans**, complemented by information as to their most effective use (for example in combination with wet towels) depending on environmental conditions.
- **Further, examine whether the provision of technologies (such as Direct Current (DC) fans**, may be a solution for those whose energy source type or ability to pay prevents use of ordinary fans.
- **Investigate the efficacy of announcing payment waivers** for poorer areas or households during periods of increased income vulnerability and/or heatwave events. If this is not possible under formal and informal governance arrangements, then coordinate with social protection agencies and organisations to provide emergency funds to at-risk households.
- **Broaden access to the grid**, including by tolerating informal access if necessary.

10.5 Shelter and Shade: Spaces and Places with Cool Grey and Green Infrastructures

The high percentage of respondents who left their homes to cope with hot conditions prior to the pandemic indicates the poor thermal protection, and inadequacy of any cooling technologies, their homes provide. Beyond simply escaping heat in domestic indoor spaces, residents were also moving to places positively viewed as cool, and sometimes also as social. Trees, communal compounds, doorways, and neighbours' homes all featured here. To develop these insights of both push and pull factors of domestic exposure and coping capacity, the following policy interventions on shelter and shade are recommended:

- **Consider alternatives to lockdown or confinement measures for areas with sub-standard housing**, such as enforcing social distancing more rigidly, to enable residents to access cooler public spaces.

- **Identify the homes or structure types that pose the greatest risk to health in hot conditions** in low-income areas, taking into account local environmental conditions and levels of acclimatization. Share this information with emergency response and health authorities when appropriate.

- **Develop design and construction material advice and support for low-income housing.** In formal contexts, this may involve building standards and codes, and the provision of financial support or other incentives for the use of more climate-appropriate materials or housing design. In informal or temporary contexts, examine whether local builders or householders can be supported with new knowledge about passive cooling design (such as cross-ventilation) and whether appropriate material use can supported with removeable and reusable housing materials such as lightweight insulation or window elements.

- **Identify, protect and increase the provision of local respite areas**, whether formal or informal, such as trees or shade shelters. Ensure these are located within a reasonable walking distance of low-income areas. In the context of the pandemic, coordinate with emergency and health agencies in how such spaces are managed, and ensure shaded spaces are safe and accessible to all, including women, providing segregated spaces if appropriate. Mainstream shading of public areas wherever possible, particularly in high traffic/heavily used areas, such as around public water taps and transport hubs.

10.6 Social Protection Measures: Ability to Pay for Cooling and to Avoid External and Domestic Heat Exposure

Pandemic-related reductions in the ability to pay for, or otherwise access electricity and possibly water and possibly food, resulted in very different patterns of thermal comfort and the self-reported incidence of symptoms of heat-related illnesses.

- **The provision of food during the pandemic has dividends for heat-health:** conducted in the early months of the pandemic, our survey data reminds us that residents in low-income communities face far more pressing issues of survival than heat or Covid-19, particularly in relation to having enough income for food and other basic necessities. The need for provision of food in such circumstances has been widely recognised, but may have the added dividend of reducing exposure to heat (searching for employment and/or food) as well as vulnerability to heat (by improving overall health and supporting thermal regulation).

- **Monitor disruptions of income for low-income households as potential triggers of increased vulnerability to heat**, and provide social protection measures to supplement income, or support access to the goods and services it buys, including through coordination with the relevant utilities providers.

10.7 Data and Information: Broadening Collaboration in Heat-health Risk Assessment and Response

All of the aspects considered above demonstrate that the lack of reliable incomes as well as access to water and electricity, remain a source of vulnerability to heat, as does the quality of housing and access to cooling technologies. More fundamentally however, the massive disruption of everyday practices and sources of income during the pandemic has demonstrated that changes in heat-health risk arise not only from changes in the hazard of heat (environmental conditions) itself, but also as a result of changes in vulnerability and exposure – in this case directly and indirectly due COVID-19 pandemic measures.

Low-income residents, particularly those living in informal settlements, or accessing services in informal ways, are 'off the grid' in informational as well as material terms. In some cases this affords them social or political protections, so any interventions should proceed sensitively, However, knowledge of living conditions, health status and thus heat-health risks must be known in order to be responded to. As such, the following policy recommendations are made:

- **Information on vulnerability and exposure factors resulting from housing type, access to utilities, income and public facilities should be gathered and shared**, to enable multi-factorial assessments of vulnerability and exposure considered when developing both pandemic response measures. For low-income communities that are politically or socially disadvantaged or marginalised, and for sensitive health or other personal information, data-sharing practice of course require careful ethical consideration and data de-identification or protection measures.

- **Heat-health warning systems should more effectively integrate information arising from monitoring *changes* in levels of vulnerability and exposure** in order to accurately assess heat-health risk. Economic modelling seems likely to provide opportunity for increased anticipatory capability in relation to assessing the vulnerability of low-income households and populations in relation to economic shocks and structural changes to economic systems.

- **Urgently address inequalities in data on heat hazards at the neighbourhood and city scale.** Not all hot cities have equal data. Some cities attract considerable attention from governments or international organisations seeking to develop or support heat-health policy. Others do not, by virtue of being smaller, without a particular heat event to garner attention, or simply having weak weather observation and climate modelling infrastructure, both historically and in the present. African nations including Cameroon, are particularly poorly served.

- **Prioritise site specific data collection:** Site-specific enumeration exercises, that include geospatial data/maps where appropriate, and combine these with qualitative or ethnographic data, would help to overcome the lacunae in government statistics on housing types, populations and services in low-income areas and informal settlements, and how everyday practices modulate vulnerability and exposure to heat, as well as how these might be affected by pandemic or other measures.

10.8 Further Analysis of the Cool Infrastructures Survey and Beyond

The policy recommendations above indicate several avenues for further research. The potential analysis of the survey data set is not fully covered by this report, particularly if more complex modes of analysis, such as structural equation modelling to assess relationships between multiple variables, are used. While such a data set is of use to health researcher broadly, we particularly encourage government bodies and organisations working in Douala/Cameroon, Karachi and Hyderabad in Pakistan, Jakarta/Indonesia and Hyderabad in India to make use of the publicly available data set and web-based analysis tools, here:

- Data set (Edinburgh repository):
- Webapp (coincidence table, with ORs and Chi squared analysis calculated in

It is more than a year since the survey was completed, and the COVID-19 pandemic has continued to disrupt lives across the globe, including in the four regions covered by this research project. Repeating the survey to assess the degree of change would be a valuable exercise.

Finally, the limitations of survey data should be acknowledged, and the need for more detailed follow-up case studies to verify the associations identified in this report and provide more detailed, situated analysis of heat/COVID-19 would support more effective policy and programme development and implementation. Local information is vital not only to map vulnerability but also to identify the complex thermal relationships between people, their homes, and their environments, as their daily practices navigate both heat and the coronavirus pandemic.

11 Appendices

11.1 Survey Questions in English

The initial survey introduction and protocol has been removed. The core survey questions are below, drawn from the version used in Pakistan. Copies of the full survey are available in different languages at: https://doi.org/10.7488/ds/2961. Organisations or agencies interested in replicating the survey should contact the Cool Infrastructures research team at the University of Edinburgh.

1	Age	**How old are you?** [OPERATOR: RECORD THE AGE IN YEARS – ROUND UP TO NEAREST WHOLE NUMBER. IF THE RESPONDENT GIVES BIRTH YEAR, REPEAT THE QUESTION. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]
2	ADM-1	**Which Province in Pakistan do you live in?** [OPERATOR: SINGLE RESPONSE] 1) Balochistan 2) Khyber Pakhtunkhwa 3) Punjab 4) Sindh 5) DON'T KNOW 6) REFUSED
3	Sindh	**Which city in Sindh Province do you currently live in?** [OPERATOR: SINGLE RESPONSE] 1) Karachi 2) Hyderabad 3) Sukkur 4) Nawabshah 5) OTHER 6) DON'T KNOW 7) REFUSED
4	Gender	**WHAT IS THE SEX OF THE RESPONDENT?** [OPERATOR: LISTEN TO THE VOICE AND CHECK THE BOX WHETHER THE RESPONDENT IS MALE OR FEMALE.] 1) MALE 2) FEMALE 3) DON'T KNOW 4) REFUSED

5	Introduction2	**To understand how heat and covid-19 might affect you, we need to know a little about your living situation. Kindly respond as accurately as possible.** 1) CONTINUE
6	Occupation	**What is your main livelihood or occupation?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) AGRICULTURE/HUSBANDRY/FISHING 2) PAID LABOUR/WAGE 3) GOVERNMENT WORK 4) BUSINESS/SELF-EMPLOYED 5) INFORMAL TRADE / STREET SALES 6) EMPLOYED IN PRIVATE COMPANY 7) GOVERNMENT ASSISTANCE/SOCIAL PROTECTION NETWORKS [PENSIONS] 8) MIGRANT REMITTANCES [FROM OUTSIDE OF THE COUNTRY] 9) HELP FROM FAMILY AND/OR FRIENDS [FROM INSIDE OF THE COUNTRY] 10) Other [specify] 11) DON'T KNOW 12) REFUSED
7	OwnHouse	**Do you own your house and have tenure?** [OPERATOR: SINGLE RESPONSE] 1) YES 2) NO 3) DON'T KNOW 4) REFUSED
8	CoolHome	**Do you use any of the following to keep cool in your home?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) AIR CONDITIONING 2) REFRIGERATOR 3) CEILING FAN 4) TABLE FAN 5) OTHER 6) DON'T KNOW 7) REFUSED

9	Electricity	**Where do you get electricity from?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) OFFICIAL MAINS ELECTRICITY CONNECTION 2) INFORMAL CONNECTION 3) UPS/INVERTER 4) GENERATOR 5) SOLAR 6) 12-VOLT BATTERY 7) OTHER 8) DON'T KNOW 9) REFUSED
10	HoursDay	**Usually, how many hours of electricity do you have each day?** [OPERATOR: RECORD THE NUMERICAL VALUE GIVEN. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]
11	Drinking Water	**Usually, where do you get drinking water from?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) PIPED WATER/INDOOR TAP 2) OWN WELL 3) COMMUNAL TAP/SHARED TAP [ALSO CALLED STAND PIPE/STREET END TAP/ YARD TAP] 4) SUPPLIED IN TANKS 5) BOTTLES 6) OTHER 7) DON'T KNOW 8) REFUSED
12	Household Purposes	**Usually, where do you get water for other household purposes like cleaning, washing clothes and bathing from?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) PIPED WATER/TAP IN HOME 2) OWN WELL 3) COMMUNAL OR STREET-END TAP 4) SUPPLIED IN TANKS 5) OTHER 6) DON'T KNOW 7) REFUSED
13	Rooms	**How many rooms does your home have?** [OPERATOR: RECORD THE NUMERICAL VALUE GIVEN. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]

14	Roofing Material	**What materials is the roof of your home made from?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: MULTIPLE SELECTION] 1) T-GIRDER 2) REINFORCED CONCRETE 3) CERAMIC TILE 4) GALVANISED IRON 5) WOODEN SHINGLES 6) BAMBOO 7) DRIED CLAY 8) PALM FRONDS 9) SHEET METAL [TIN/ZINC/CORRUGATED IRON] 10) DON'T KNOW 11) REFUSED
15	Wall Material	What materials are the walls of your home made from? [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: MULTIPLE SELECTION] 1) MUD BRICK [CRUDE/RAW/COOKED] 2) REINFORCED CONCRETE 3) BAMBOO POLES OR WOOD 4) PALM FRONDS/WOVEN MATS 5) DON'T KNOW 6) REFUSED
16	Floor Material	**What materials is the floor of your home made from?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: MULTIPLE SELECTION] 1) CLAY COURT 2) SAND/DIRT 3) ASPHALTED FLOOR 4) CERAMIC TILES 5) WOOD/BAMBOO 6) CEMENT 7) OTHER 8) DON'T KNOW 9) REFUSED
17	Windows	**How many windows do you have in your home that provide airflow?** [OPERATOR: RECORD THE NUMBER OF WINDOWS GIVEN. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]
18	Adults	**How many adults live in your home?** [OPERATOR: RECORD THE NUMBER OF ADULTS LIVING IN THIS HOUSEHOLD. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]

19	Children	**How many children live in your home?** [OPERATOR: RECORD THE NUMBER OF CHILDREN LIVING IN THIS HOUSEHOLD. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]
20	Normally Do	**When it feels too hot in your home, what do you normally do?** [OPERATOR: RECORD OPEN ENDED RESPONSE. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]
21	Pandemic Change	**Has the COVID-19/Coronavirus pandemic changed what you do when it is hot?** [OPERATOR: DO NOT READ THE OPTIONS: SINGLE SELECTION] 1) YES 2) NO 3) DON'T KNOW 4) REFUSED
22	Yes Pandemic Change	**How did the pandemic change what you do when it is hot? do you engage in different activities, do you use different technology/tools, go to different places, spend more or less time indoors/outdoors?** [OPERATOR: RECORD OPEN ENDED RESPONSE. ENTER 88 FOR DON'T KNOW & 99 FOR REFUSED]
23	Spend At Home	**Prior to the COVID-19/Coronavirus pandemic, how much time each day do you typically spend physically inside your home per day (24 hour period)?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: MULTIPLE SELECTION] 1) VERY LITTLE – ONLY FOR SLEEPING 2) SOME OF THE DAY 3) HALF OF THE DAY 4) MOST OF THE DAY – EXCEPT FOR SHORT TRIPS OUT 5) OTHER 6) DON'T KNOW 7) REFUSED
24	Amount Of Time	**As a result of the COVID-19/Coronavirus pandemic, has the amount of time you spend inside your home…** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) SIGNIFICANTLY DECREASED 2) SLIGHTLY DECREASED 3) REMAINED ABOUT THE SAME 4) SLIGHTLY INCREASED 5) SIGNIFICANTLY INCREASED 6) DON'T KNOW 7) REFUSED

25	Income	**As a result of the COVID-19/Coronavirus pandemic, has your income…** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) SIGNIFICANTLY DECREASED 2) SLIGHTLY DECREASED 3) REMAINED ABOUT THE SAME 4) SLIGHTLY INCREASED 5) SIGNIFICANTLY INCREASED 6) DON'T KNOW 7) REFUSED
26	EatingHabits	**Has the COVID-19/Coronavirus pandemic changed how much you eat?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) NO CHANGE – IT IS ENOUGH 2) I EAT MORE – IT IS ENOUGH 3) NO CHANGE – IT IS NOT ENOUGH 4) I EAT LESS – IT IS ENOUGH 5) I EAT LESS – IT IS NOT ENOUGH 6) DON'T KNOW 7) REFUSED
27	WaterIntake	**Has the COVID-19/Coronavirus pandemic changed how much water you drink or use for bathing or cooling yourself?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) YES – I USE MORE 2) YES – I USE LESS 3) NO – NO CHANGE 4) DON'T KNOW 5) REFUSED
28	Electricity Usage	**Since the COVID-19/Coronavirus pandemic, have you experienced any change to your ability to use electricity – either as a result of ability to pay, physical access, or supply stability?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) I HAVE BEEN ABLE TO USE MORE ENERGY 2) I HAVE HAD TO USE LESS ENERGY 3) NO CHANGE 4) DON'T KNOW 5) REFUSED

29	Health Services	**Since the COVID-19/Coronavirus pandemic, has getting health services or medical supplies been...** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) EASIER 2) HARDER 3) THE SAME 4) DON'T KNOW 5) REFUSED
30	Home Warm	**Yesterday, how warm was it in your home?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) COLD 2) COOL 3) SLIGHTLY COOL 4) NEUTRAL 5) SLIGHTLY WARM 6) WARM 7) HOT 8) VERY HOT 9) DON'T KNOW 10) REFUSED
31	Temperature Inside Home	**On average, over the past month, what has the temperature inside your home been like?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) COLD 2) COOL 3) SLIGHTLY COOL 4) COMFORTABLE 5) SLIGHTLY WARM 6) WARM 7) HOT 8) VERY HOT 9) DON'T KNOW 10) REFUSED

32	Temperature Outside Home	**Over the past month, have you found the temperature outside:** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) PERFECTLY TOLERABLE 2) SLIGHTLY DIFFICULT TO TOLERATE 3) FAIRLY DIFFICULT TO TOLERATE 4) VERY DIFFICULT TO TOLERATE 5)I NTOLERABLE 6) DON'T KNOW 7) REFUSED
33	Experience	**During the past month have you experienced any of the following?** [OPERATOR: MULTIPLE SELECTION] 1) Feeling hot 2) Feeling sweaty 3) Feeling thirsty 4) Fatigue 5) Headache 6) Clammy skin 7) Rash 8) Concentration loss 9) Muscle cramps 10) Muscle weakness 11) Dizziness 12) Nausea 13) Blurred vision 14) Confusion 15)I rrational behaviour 16) Convulsions 17) Fainting [brief loss of consciousness] 18) Loss of consciousness [extensive] 19) Vomiting 20) Feeling listless/lack of engagement with social activities/family 21) poor quality of sleep 22) DON'T KNOW 23) REFUSED

34	Experience Before Heat	**Have you experienced #Experience# before when it is hot?** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) YES 2) MAYBE 3) CAN'T REMEMBER 4) NO 5) DON'T KNOW 6) REFUSED
35	Feeling More	**In the past month, compared to usual, have you felt more:** [OPERATOR: DO NOT READ THE CAPITALIZED OPTIONS: SINGLE SELECTION] 1) IRRITABLE 2) IMPATIENT 3) FRUSTRATED 4) SHORT TEMPERED 5) UNHAPPY 6) DON'T KNOW 7) REFUSED
36	Physical Conflict	In the past month, compared to usual, has there been more physical conflict or violence in your home? [OPERATOR: DO NOT READ THE OPTIONS: SINGLE SELECTION] 1) YES 2) NO 3) ABOUT THE SAME 4) DON'T KNOW 5) REFUSED
37	Heat Affect	Compared to this time last year, has heat affected you more or less? [OPERATOR: DO NOT READ THE OPTIONS: SINGLE SELECTION] 1) MORE 2) LESS 3) ABOUT THE SAME 4) DON'T KNOW 5) REFUSED
38	Language2	Please select the language that the survey was primarily conducted in. [OPERATOR: CHOOSE ONLY ONE OPTION] 1) English 2) Pashto 3) Urdu
NA	Close-Out-Incentive	The interview has come to an end, you will receive your #TOPUP# airtime credit within the next 2 days.