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VULNERABILITY ASSESSMENT OF HOUSEHOLDS IN DELHI TO HEAT STRESS

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Rohit Magotra

Principal Investigator & Deputy Director, IRADe

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Executive Summary

Extreme heat and heat stress are worsening worldwide due to the effects of climate change. Its impacts can be felt more in cities, where a city's physiology has concrete, brick buildings and decreased green spaces. Heat stress is especially very difficult for vulnerable population. Heat wave management and minimizing populations' exposure to heat stress will be necessary to keep cities safe, resilient, sustainable (SDG 11) and support its residents' income and productivity targets (SDG 8).

In India, there is a well-recognized association between heat waves and morbidities and mortalities. There is evidence of a threshold at 40 °C above which mortality increases[1]. The city of Delhi has often witnessed heat-based extreme weather events in the past. It is one of the most populated cities with a population of more than 16.8 million (Census 2011). Rise of mortality and morbidity due to heat waves can be attributed to the effects of variations in temperature and relative humidity, and an increase in the population. Heat waves often leads to heat-health issues. Such situations make it critical to be sensitive to the devastating impacts of climate change, especially on the vulnerable sections of society. Delhi accommodates more than 10 per cent of the city population in the slums. With increasing number of people getting affected by extreme temperature, heat wave should be treated as a calamity and need a systematic approach rather than treating it as an aberration. This report not only captures the challenges faced by the people due to heat wave but also makes a vulnerability assessment of communities prone to heat stress and its associated risks.

The purpose of this report is to underline the importance of Heat Stress Action Plan (HSAP) and to generate robust evidence-based policy recommendations to integrate them into the current and future climate actions at local, state and national levels. A comprehensive index was developed comprising of total nine sectors and twenty-six respective sub sectors to understand the impacts of extreme heat events on health, work productivity, and livelihoods of vulnerable population. It includes the sectors namely, Housing, Cooking, Sanitation, Water, Electricity, Health,

[1] V. K. Desai, S. Wagle, S. K. Rathi, U. Patel, and H. S. Desai, "Effect of ambient heat on all-cause mortality in the coastal city of Surat, India," *Current Science*, vol. 109, no. 9, pp. 1680–1686, 2015.

Awareness, Transport, and their respective sub-sectors. The following indexes are selected as they are compounding risks/ impacts. They interact with the existing risk and tend to exacerbate climatic impact.

The study identified heat and vulnerability hotspots to help city governments deploy targeted measures to mitigate impacts of heat stress. The city-level vulnerability assessment of Delhi proves that urban poor are most vulnerable to heat stress and its associated impacts. Notably, households are most susceptible to heat stress due to housing viz., the material used and its structure, lack of access to basic services such as water, and electricity. These not only aggravate heat, but also results in deterioration of health, loss of lives and livelihoods.

A critical factor that emerged from the study is that households do not have sufficient awareness and knowledge about heat waves and the adaptive and mitigation strategies undertaken by local institutions. In a scenario of low affordability for health insurance, it imperative that public health systems should be improved while focusing on knowledge dissemination as part of the preparedness.

Heat stress impacts are visible through the sectors mentioned above, so, cities can combine sectoral initiatives with a well-defined and coherent framework that ties both mitigation and adaptation together. Specific sectors like public health, housing, infrastructure, and services provide entry points. The recommendations outline an overarching framework to ensure maximum impact through sector-based initiatives.

To ensure this, stakeholders need to be involved in the planning and execution of heat stress minimization interventions. Measures have to be both short-term and long term in promoting heat stress management, and its planning.

Vulnerability Assessment of Households in Delhi to Heat Stress

Climate change has already started to show its impacts with an increase in the extreme weather events across the globe. The United Nation's Intergovernmental Panel on Climate Change (IPCC) in its study maintains that there will be "Global Warming of 1.5C"[2]. As per the latest IPCC AR6 (2020), it is certain that heat extremes (including heat waves) have become more frequent and intense across most land regions. Impacts of heat stress are severe in urban areas due to Urban Heat Island (UHI) effect (CCA, 2016). Heat stress-induced deaths in 2100 is being estimated to be about 85 per 100,000 (Climate Impact Lab 2019). It is therefore, inevitable that there will be frequent hotter days/ temperature extremes than the normal over land areas as global mean surface temperatures increase. Heat waves are going to increase in frequency, duration, and intensity, and it will create health impacts that include morbidity and mortality. In countries with adequate reporting systems, it is being registered that heat waves are causing a large number of deaths. The World Meteorological Organization statements on the status of global climate during (March 2016) showed that global temperatures continue to increase, and the year 2016 recorded historically high global temperatures (approximately 1.1° C /1.98 °F above pre-industrial levels), surpassing the record set in 2015. The health impacts of the heat waves range from cardiovascular, respiratory, neurological, and psychiatric diseases. In severe cases, it results in mortality. It logically gives rise to critical questions--what does this increasing temperature mean for human health? How would communities cope with extreme temperatures? Proper responses can help in minimizing heat-health consequences. Public health programmes will, therefore, become critical to prevent the occurrence of heat-related diseases caused by heat waves (Jang et al., 2013)[3]. Heat stress-related illnesses are manageable and even preventable if proper responses and actions are taken, such as avoiding exposure to high-temperatures.

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[2] Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R.Dasgupta, P.(2014). Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change:IPCC.

The combination of rising temperatures and large vulnerable population will exacerbate the impacts of heat waves in India and other developing countries. As per the IPCC AR6, it is likely that surface temperatures over South Asia will increase greater than the global average, and with projected increases of 4.6 °C (3.4–6.0 °C) during 2081–2100.

Studies show that Low and Middle-Income Countries (LMICs) which includes India are most likely to bear a very high burden of deaths (World Health Organization, 2014)[4]. Further, it will impact the availability of public services of water supply, electricity, sanitation, and food availability for consumption.

Located close to the Equator, India experiences a hot tropical climate. Long dry, hot summers are interspersed by monsoon showers, and then hot wet summers replace monsoons. The heat wave occurrences in India will rise with climate change.

Heat waves in India are declared by the Indian Meteorology Department (IMD) when a particular station reaches at least 40 °C or more in Plains, 37 °C or more in coastal stations, and at least 30 °C or more in Hilly regions. Mentioned below are the criteria to declaring a heat wave:

(a) Based on Departure from Normal

i) **Heat Wave**: Departure from normal is 4.5 °C to 6.4 °C

ii) **Severe Heat Wave**: Departure from normal is >6.4 °C

Based on Actual Maximum Temperature (for plains)

i) **Heat Wave**: When actual maximum temperature ≥ 45 °C

ii) **Severe Heat Wave**: When actual maximum temperature ≥47 °C

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any opinion on the part of IRADe concerning the legal status of any country, state, or city or the delineation of their frontiers or boundaries.

[4] World Health Organization. (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s: World Health Organization.

To declare a heat wave, the above criteria should be met at least in 2 stations in a Meteorological sub-division for at least two consecutive days, and it will be declared on the second day (IMD, 2018).

Indian Institute of Tropical Meteorology has the following criteria for Heat Waves:

a) If maximum temperature is ≥ 39 °C and minimum temperature ≥ 90th percentile of the observed minimum temperature for that day.

b) If maximum temperature ≥ 95th percentile of the observed maximum temperature for that day, and actual maximum temperature is ≥ 39 °C, and maximum temperature departure from normal is ≥ 3.5 °C or maximum temperature is ≥ 44 °C.

c) If maximum temperature ≥ 99th percentile of the observed maximum temperature for that day, and actual maximum temperature is ≥ 39 °C, and maximum temperature departure from normal is ≥ 5.5 °C or maximum temperature is ≥ 46 °C.

Hot days (HOT): if satisfying A

Heat Wave (HW): if satisfying B

Severe Heat Waves (SHW): if satisfying C

1 Heat waves

A heat wave is a prolonged period of excessive heat along with excessive humidity. In urban areas, Urban Heat Island effect comes into play. It is primarily due to the absorption of solar energy by the buildings, roads, and other infrastructures, resulting in higher temperatures. The heat waves can cause blackouts and power outages, especially in areas that experience the urban heat island effect. In India, the months between March to June are typically the hottest, with temperatures reaching up to 45 °C in certain areas. Loss of lives during a heat wave is caused both by direct and indirect effects due to worsening of pre-existing conditions, the latter being far more common than the former. Utmost priority must be given to prevent heat-related illnesses in vulnerable population, especially women, children, and the elderly, as well as the poor and marginalized (slum population, homeless). The need of the moment is to prepare comprehensive strategies to deal with and adapt to extreme temperatures. Various criteria for determining the heat waves include percentile thresholds of maximum temperature, excess heat indices (Panda et al., 2017)[5]; positive Extreme Heat Factor (EHF); Multi-measurement index (Meehal et al. 2009)[6]; and Exceedance index[7] (Fischer et al. 2010). Heat Stress is primarily classified in the following five[8] types (table-1).

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[5] http://amir.eng.uci.edu/publications/17_JGR_HW_India.pdf

[6] Meehal, G.A., Tebaldi, C., Walton, G., Easterling, D., McDaniel, L., 2009. Relative increase of record high maximum temperatures compared to record low minimum temperatures in the US. Geophys. Res. Lett. 36 (23)

[7] Fischer, E.M., Schär, C., 2010. Consistent geographical patterns of changes in high-impact European heatwaves. Nat. Geosci. 3 (6), 398–403

[8] Heat Stress - Heat Related Illness by CDC.

1. Heat Rash
2. Heat Cramps
3. Heat Exhaustion
4. Heat Syncope
5. Heat Stroke

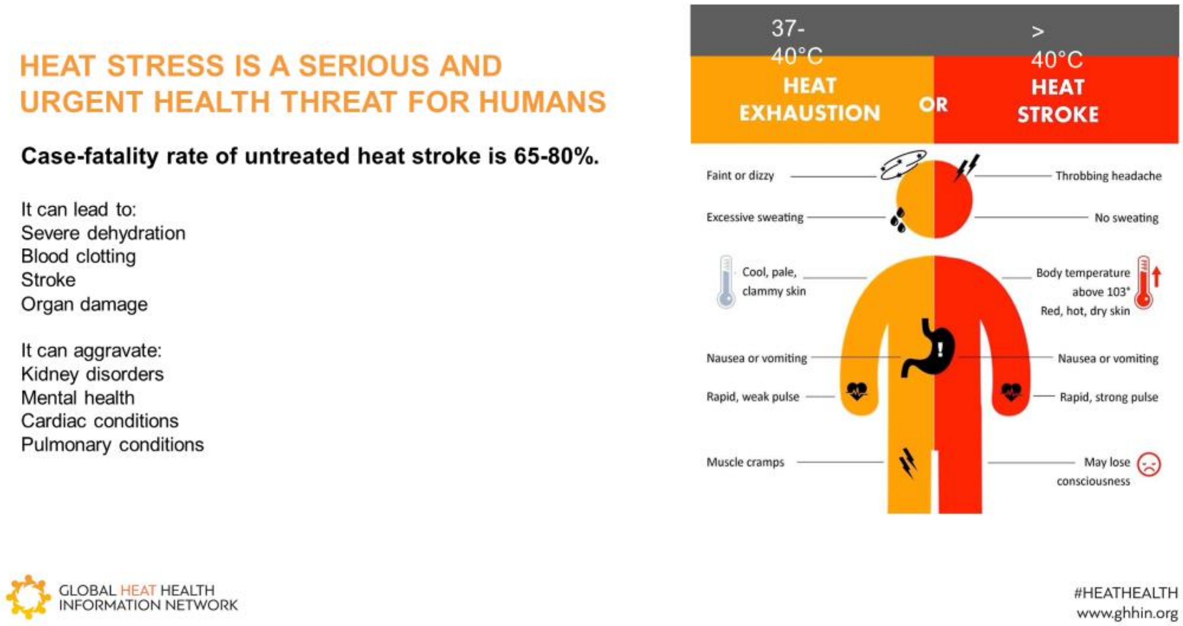

Table 1: classification of heat stress

Heat Rash: Itchy rash with small red bumps at pores in a setting of heat exposure; bumps can sometimes be filled with clear or white fluid.

Heat Cramps: Painful contractions of frequently-used muscle groups in the heat exposure setting, often with exertion.

Heat Exhaustion: Sweaty/diaphoretic; flushed skin; hot skin; average core temperature; +/- dazed, +/- generalized weakness, slight disorientation.

Heat Syncope: Brief generalized loss of consciousness in a hot setting, the short period of disorientation, if any.

Heat Stroke: Flushed, dry skin (not always), core temperature ≥ 40 °C, (103 °F or higher), altered mental status with disorientation, possibly delirium, coma, seizures, tachycardia, +/- hypotension.

2 Heat waves in India

Heat wave is one of the extreme weather events (EWE) (Kamaljit Ray). In 50 years (1971-2019) EWE killed 141,308 people. Of this, 17,362 people were killed due to heat wave — a little over 12 per cent of the total deaths recorded[9]. According to the State of Environment Report (2018), from 1998 to 2018, intensive occurrence of heat stress caused material damage and affected the quality of life like none in the last 100 years [10]. Temperatures peaked around 49 to 50 °C and lasted for almost a week, resulting in a massive spike in heat strokes, other heat-related illnesses, and death. The year 2019 was the seventh-warmest year on record since nationwide meteorological records keeping commenced in 1901. Since about 50% of India's GDP is already dependent on heat -exposed work like agriculture, mining and construction — there would be an immediate, palpable impact, one worth $250 billion[11]. 23 states have been affected by heat stress in 2020 compared to just 9 in 2015[12]. This needs to tackled by the Heat Action Plans through

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9 Kamaljit Ray, R.K. Giri, S.S. Ray, A.P. Dimri, M. Rajeevan, An assessment of long-term changes in mortalities due to extreme weather events in India: A study of 50 years' data, 1970–2019, Weather and Climate Extremes,Volume 32,2021,100315,ISSN 2212-0947, https://doi.org/10.1016/j.wace.2021.100315.

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11 By Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Brodie Boland, and Carter Powis.McKinsey Global Institute. Climate risk and response: Physical hazards and socioeconomic impacts
January 16, 2020

12
https://ndma.gov.in/sites/default/files/IEC/Booklets/HeatWave%20A5%20BOOK%20Final.pdf

improved sensitization, capacity building, inter-agency coordination, and enhanced data collection.

June-July of 2019 have been the hottest months recorded globally, with National Oceanic and Atmospheric Administration (NOAA) confirming June being the hottest on record, + 0.95 ^{o}C above normal average temperature. On 26 May 2020, Churu in Rajasthan bagged the record of being the hottest place not just in India, but in the entire world [13].On the same date, 10 of the 15 world's hottest sites were in India, including Delhi NCT, which recorded its hottest day of May in 18 years at 47.6 ^{o}C. Parts of North Western, Northern, and Central plains of the country experienced severe heat waves during the month of May[14].

The annual average temperature of our earth has risen by 2 °C in 200 years (until 2006), and this may further increase by another 1.5-2 °C by 2030[15]. Within 50 years, 1.2 billion people would live in areas as hot as the Sahara if greenhouse gas emissions keep rising ToI, 2020[16].

Heat waves cause the highest number of deaths compared to deaths caused by any other natural hazard in Indian cities[17]. However, it needs to be highlighted that the extreme temperatures can create adverse impacts on human health and ecosystems. Despite being one of the top three killers in the country, heat waves are not classified as a natural calamity by the Government of India.

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13 https://www.hindustantimes.com/india-news/18-year-old-record-broken-in-delhi-churu-sizzles-as-world-s-hottest-place-all-you-need-to-know-about-heatwave/story-wbax5MsJunWXrUVMeMN1WI.html

14 ibid

15 IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5 °C. An IPCC Special Report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp

16 https://timesofindia.indiatimes.com/city/nagpur/1-2-bn-indians-will-live-in-places-as-hot-as-sahara-if-emissions-norurbed/articleshow/75576951.cms#:~:text=Nagpur%3A%20More%20than%201.2%20billion,as%20hot%20as%20the%20desert.

17 Kamaljit Ray, R.K. Giri, S.S. Ray, A.P. Dimri, M. Rajeevan, An assessment of long-term changes in mortalities due to extreme weather events in India: A study of 50 years' data, 1970–2019, Weather and Climate Extremes,Volume 32,2021,100315, ISSN 2212-0947, https://doi.org/10.1016/j.wace.2021.100315

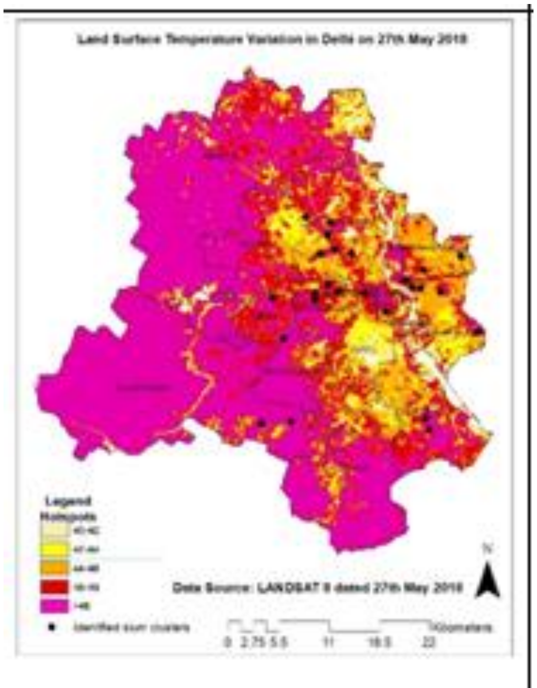
3 Understanding Heat Stress Vulnerabilities

3.1.1 Study Area Selection

The process of selecting wards began by the identification of vulnerable areas through Land Surface Temperature (LST) maps and locating slum settlements. The LST maps are intended to select heat hotspots. The areas identified in Delhi were with LST > 40 °C. Besides, data for mapping ambient air temperature measured by Automatic Weather Stations (AWS) was procured from IMD (India Meteorological Department) and municipal corporations. A total of 10 hotspots were identified in Delhi (table -3.1.1& Map- 3.1.1).

Delhi **Surveyed Hotspots**	**New Ward Name/ No.**
Indira kalyan Vihar	Harkesh Nagar 092S
Sanjay colony Okhla phase 2	Harkesh Nagar 092S
Slum in Khayala	Khyala 008S
Prem bari Bridge	Wazir Pur 072N
Slum near Samalkha	Bijwasan 048S
New Sanjay Amar colony, Vishwas nagar	Vishwas Nagar 017E
Mayapuri slum along Rewari railway line	Harinagar A 010S
Jahangirpuri	Jahangir Puri 021N
Shakoor ki Dandi	Delhi Gate 088N
Buland masjid slums	Shastri Park 025E
Delhi – 10 Hotspots	

Table 3.1.1: classification of heat stress



Map- 3.1.1

4 Methodology

4.1 Purpose of the Study

This study aims to understand and analyse the implications of extreme heat on health, productivity, and livelihoods of vulnerable groups, especially working population (like construction workers, vendors, rickshaw pullers, factory workers, casual laborers, maids/helpers and office workers.), women, children, and senior citizens and to select appropriate, innovative and affordable climate adaptation measures for improving health and livelihood resilience for urban population. It would help in strengthening the capacity of key stakeholders to facilitate the implementation of the Heat Stress Action Plans and their long-term sustainability in selected areas through trainings. The study further facilitates active use of information and evidence for policy-makers to drive the implementation of Heat Stress Action Plans into municipal disaster strategies for better preparedness. The research framed a detailed quantitative and qualitative framework for heat wave mitigation and building adaptive capacity of the people.

4.2 Selection of Participants

The identification of vulnerable population included economically weaker sections, women, children and elderly and working individuals such as construction workers, factory workers, transportation, sweepers, laborers and vendors/street hawkers. The vulnerability mapping was done by overlapping layers of identified vulnerable areas with vulnerable sections. Further, comprehensive household surveys were conducted to measure susceptibility to heat stress. A total of 392 households participated in the study.

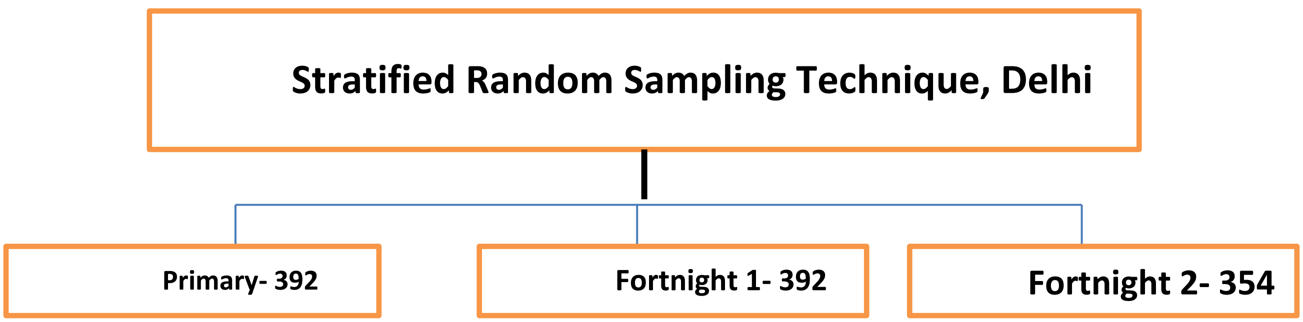


Table: 4.2

4.3 Declaration

The participants were aware before the survey that the information shared will be used only for research purposes, and hence, there is no risk foreseen with the study.

4.4 Confidentiality and Participation in the survey

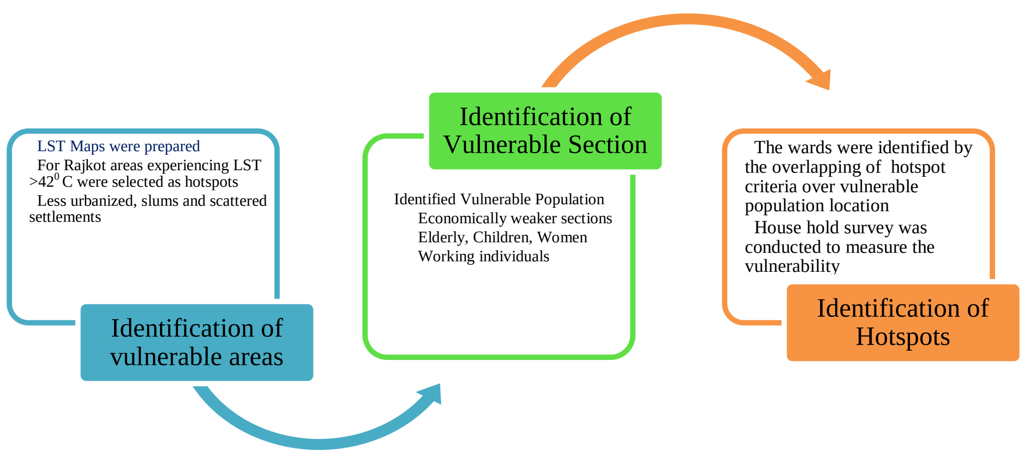
Participation in the survey was voluntary, and they could withdraw at any stage of the survey. The information gathered would be kept confidential.

4.5 Ethical consideration

Consent from participants was taken, and all the questions in the survey were verbally explained to the enrolled participants before the survey.

4.6 Survey Design, Study Area Selection and Data Collection

The survey assessed the impact of heat stress on health, work productivity, and livelihoods. The sample size was 300 households (HHs), and two sets of questionnaires/ research tools were used to capture the base information about household members and a fortnight longitudinal survey to capture the impact of heat stress in the previous 15 days on individual health, productivity, and livelihood. The surveys were initiated in the first week of May 2018 after the pilot surveys. Multi-level-stratified sampling was used for selecting 300 households within the hotspots identified in each city (table-4.6). For better analysis, vulnerable group were categorized and identified such as the drivers, casual workers, shopkeepers, construction workers, slum dwellers, street vendors, children and women, and elderly directly exposed to heat. Hotspots were identified based on the surface temperature recording, over a period during April to May 2016 & 2017, geographic location (ward level), and the socio-economic conditions identified as hot spots, having small means to adapt to the heat stress.



Trable-4.6 Identification of heat spots

Detailed questionnaires for household level survey were structured in epi-info software and a stratified random sampling technique was used to conduct field surveys were conducted in the selected slums of the city. In addition, structured interviews were carried out at the household level. The investigators collected data by going door-to-door and helping the identified groups in responding where required.

Under the survey, the impacts of extreme heat events on health, work productivity, and livelihoods of the vulnerable population were determined using a comprehensive index of compounding factors that tend to exacerbate climatic impact, comprising of total nine sectors and twenty-six respective sub sectors as listed in the table below.

S. No.	SECTORS	SUB - SECTORS
1	**Sanitation**	Type of Toilet
		Individual Toilets
2	**Water**	Water Source
		Water Source Location
		Water Collection Time
		Frequency of Water Supply
3	**Electricity**	Electricity Cut-off
4	**Health**	Access to Health Infrastructure- Public/Private/Both
		Distance to the nearest PHC
		Health Insurance
5	**Transportation**	Mode of Transport
6	**Housing**	Years of Occupancy
		Number of Rooms

		Type of House
		Floor Type
		Roof Type
		Wall Type
		Number of Windows
		Wall Colour
7	**Cooking**	Cooking Place
		Cooking Fuel
8	**Awareness**	Heat Stress Awareness
		Awareness about use of Medical facilities for heat
		Awareness about availability Medical measures from ULB
9	**Heat Stress Symptoms**	Heat Exhaustion
		Heat Stroke

4.7 Data Analysis

Primary survey data was collected and cleaned on Epi-Info platform. The primary survey provided the basic household information and general knowledge about heat stress and its implications, the other set was a longitudinal tool to monitor the impact of heat stress on the selected household members over a period of 14 days. Most of the families were Below Poverty Line (BPL) and they included labour, daily wage earners and mobile workers. The primary and fortnightly surveys conducted were compiled on the Epi-info platform. Further, the data was analysed using EXCEL, SPSS and STATA.

5 Results

5.1.1 General Characteristics of Studied Participants

During summer, with rising temperatures, heat stress continues to affect citizens. It has some discernible impacts, such as a rise in mortality, an increased strain on infrastructure (power, water, and transport), and ecosystem services. However, we all know by now that it is the vulnerable sections of the society, especially the poor, that experience its impact the most. This section is economically disadvantaged and has limited access to resources. The synergistic effects may, eventually, prove to be fatal for some. They often live-in poor neighbourhoods and usually a minimal number of services are available to them. It must also be mentioned that type of house, its building material, the number of hours spent indoor, and cooking may also add to the heat stress. The survey highlights how critical infrastructure and services (lack thereof) aggravate the impact of heat stress.

5.1.2 Gender Distribution in the Survey

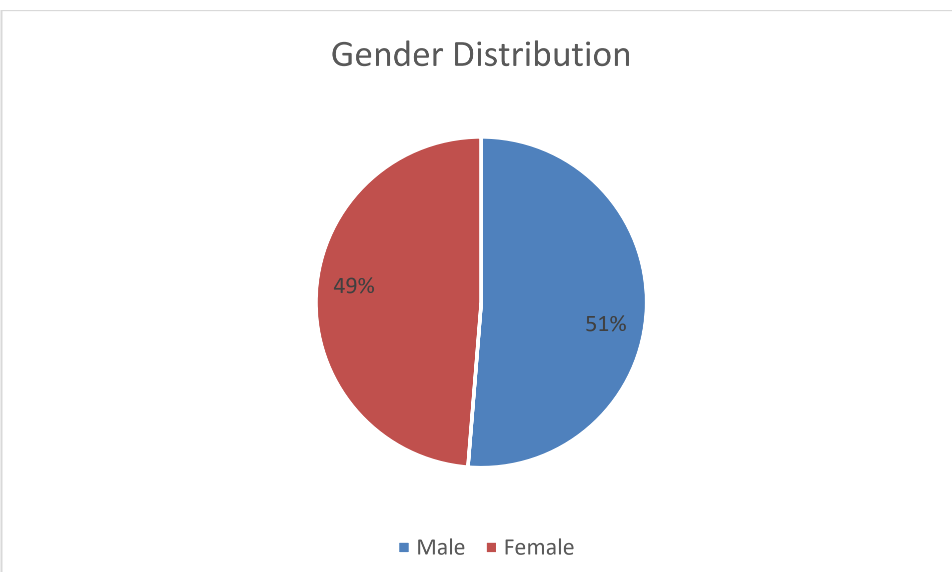


Table: 5.1.2 Gender distribution in survey

Equal gender distribution is ensured in order to capture the differential impact heat stress has on women and men. This will enable understanding of the underlying causes and help design HSAPs that take the differential impact into consideration.

5.1.3 Gender Disaggregation by Age

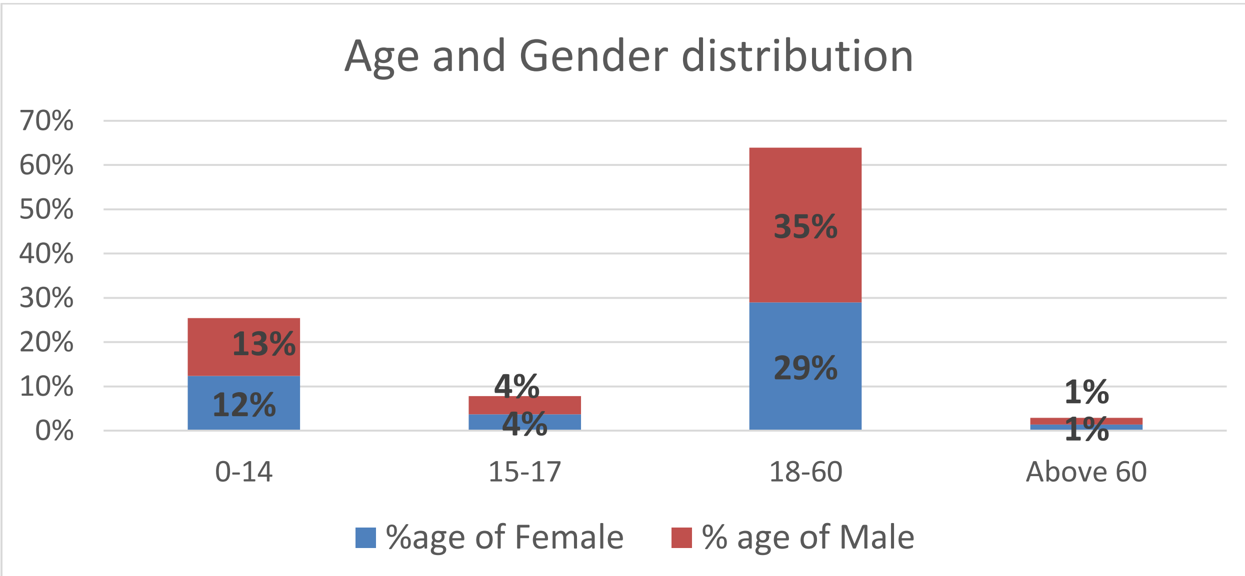


Table: 5.1.3 Gender disaggregation by age

It is observed that the ratio of male to female is almost equally divided across all age groups.

5.1.4 Occupation of the survey participants

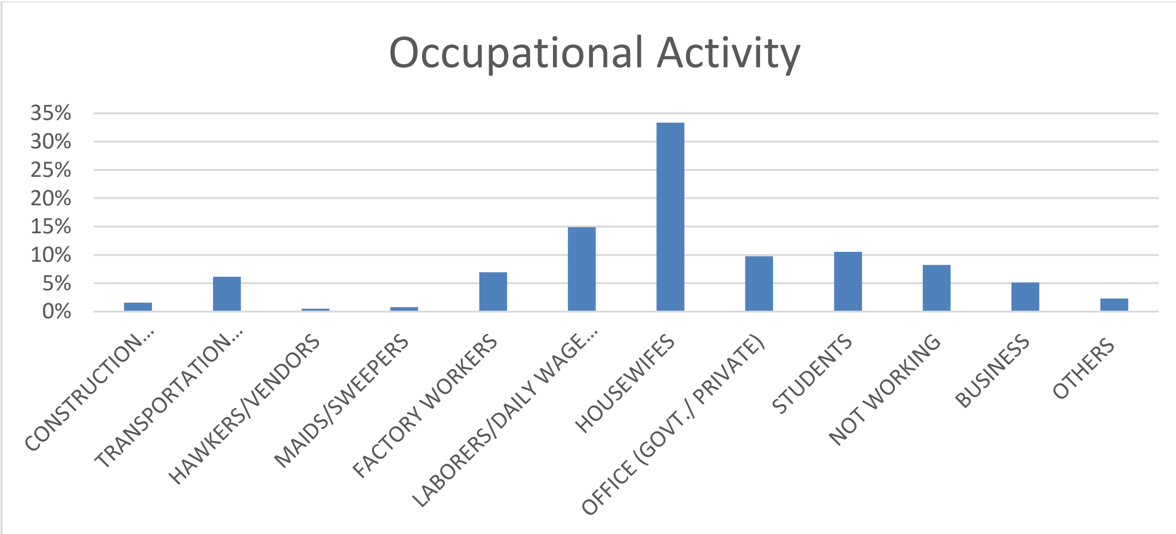


Table: 5.1.4 Occupation of the survey participant

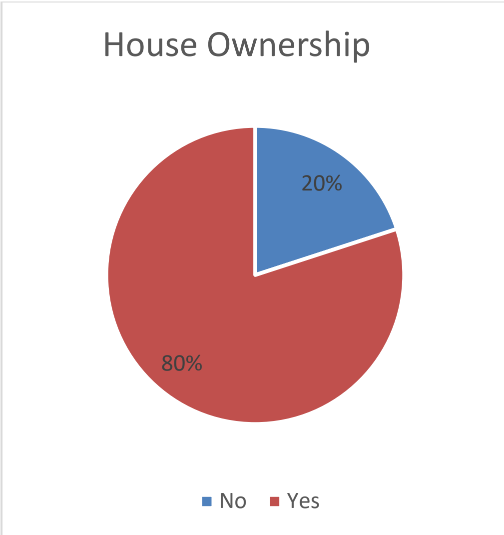
Heat affects livelihoods and productivity. To understand, it is essential to capture the type of occupation. It is observed that majority of the working population is employed in sectors such as daily wage workers/causal laborers, office workers and factory workers.

5.2 Housing

5.2.1 Ownership

House Ownership			
Delhi city	No	Yes	Total
Absolute Numbers	78	312	390
Percentage distribution (within options)	20	80	100

Table: 5.2.1 (a)



Graph:-5.2.1 (a)

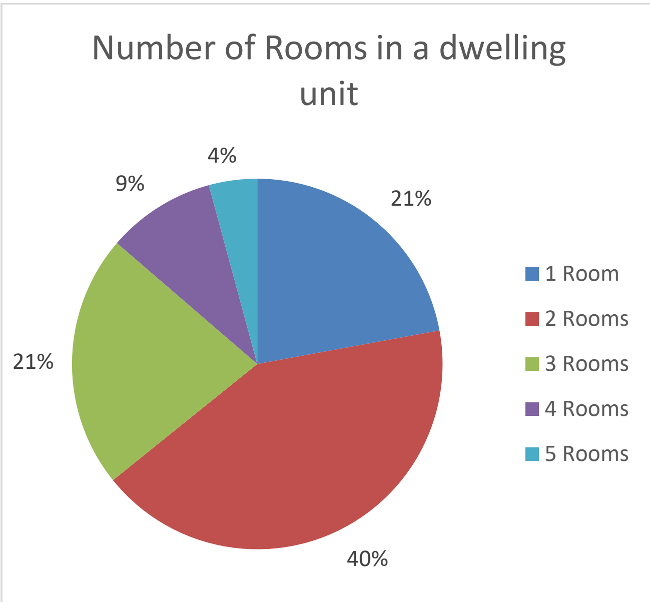
It was reported that around 80% of participants own their dwelling units. It is easier for a house owner to introduce required structural amendments to combat heat.

5.2.2 Total Number of Rooms

Number of rooms in a dwelling unit					
	1 Room	**2 Rooms**	**3 Rooms**	**4 Rooms**	**5 Rooms**
Absolute Numbers	80	157	82	36	15
Percentage distribution (within options)	20.51	40.26	21.03	9.23	3.85

Table: 5.2.2 (a)

The average number of rooms in a dwelling unit for a majority of the participants is two, which accounts for about 40 % of the households. Whereas, only 33 % approximately have dwelling unit with three or more rooms.

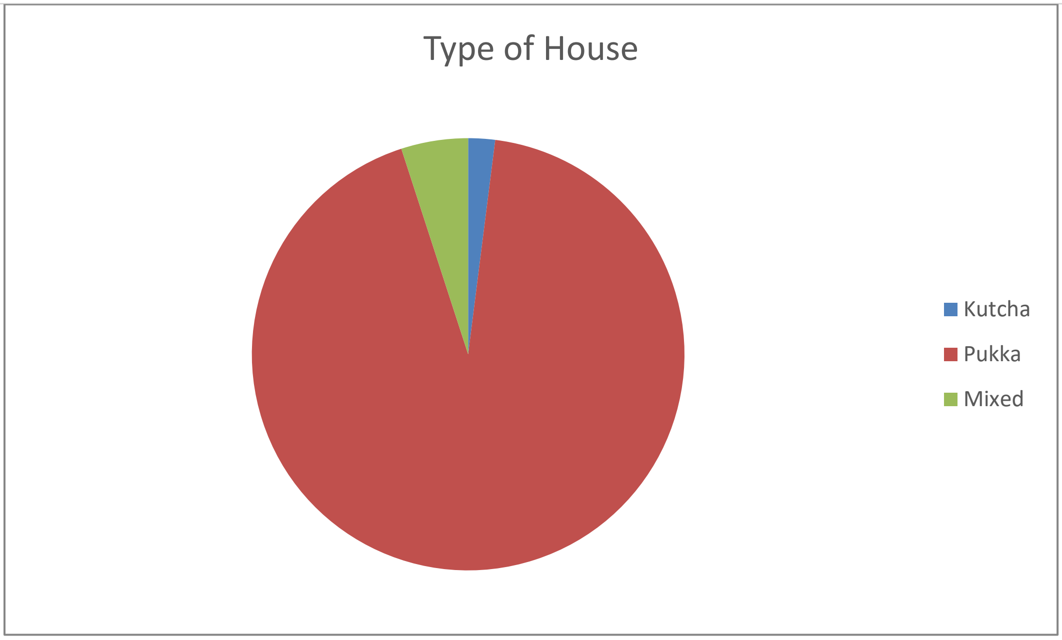


Graph: 5.2.2 (a)

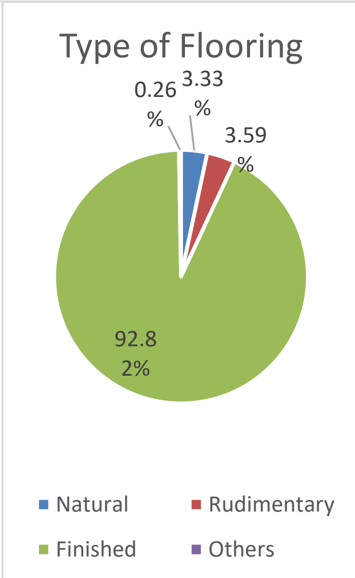
5.2.3 Type of Housing Structure, Floor Material, Wall Material, and Roof Material

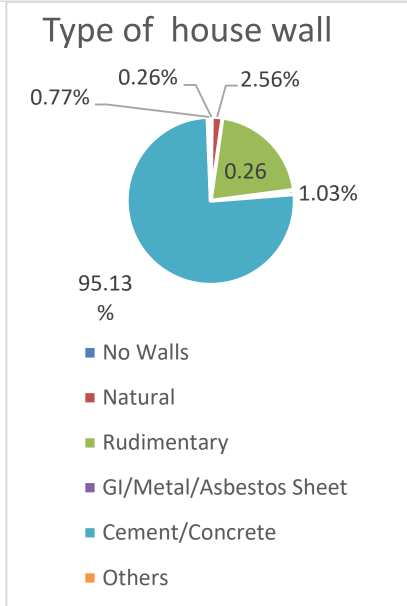
Types of House				
	kutcha	**pucca**	**mixed**	**Total**
Absolute Numbers	7	363	20	390
Percentage distribution (within options)	1.79	93.08	5.13	100

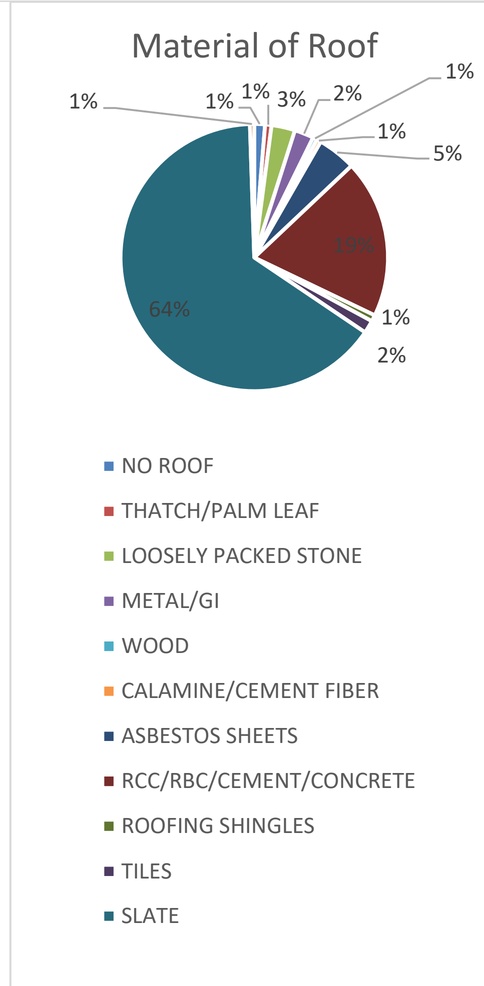
Table: 5.2.3 (a)



Graph: 5.2.3 (a)







Graph: 5.2.3 (a)

Type of Flooring					
	Natural	**Rudimentary**	**Finished**	**Others**	**Total**
Absolute Number	13	14	362	1	390
Percentage distribution (within options)	3.33	3.59	92.82	0.26	100

Table: 5.2.3 (b)

Type of House Wall							
	No Walls	**Natural**	**Rudimentary**	**GI/Metal/ Asbestos Sheet**	**Cement/ Concrete**	**Others**	**Total**
Absolute Number	1	10	1	4	371	3	390
Percentage distribution (within options)	0.26	2.56	0.26	1.03	95.13	0.77	100

Table**:** 5.2.3 (c)

Material of Roof													
	No Roof	**Thatch/ Palm Leaf**	**Loosely Packed Stone**	**GI/Metal**	**Wood**	**Calamine/Cement Fibre**	**Asbestos Sheets**	**RCC/ RBC/ Cement/ Concrete**	**Roofing Shingles**	**Tiles**	**Slate**	**Burnt Brick**	**Total**
Absolute Number	5	3	11	9	2	2	18	74	3	6	251	2	390
Percentage distribution (within options)		1%	3%	2%	1%	1%	5%	19%	1%	2%	64%	1%	100

Table**:** 5.2.3 (d)

According to table 5.2.3 (a), most of the of the respondent's houses (93%) in the sample are pucca that helps to adequately protect from high temperatures. The most common material used for building is cement for the flooring (90%), walls (96%), and slate for roof (64%). However, Heat trapping and unsustainable material such, asbestos sheets for roofs are still used by the 5% (Table 5.2.3 (b), (d)).

Implications: People suffer from high retention of heat due to the usage of materials like cement and asbestos.

5.2.4 Number of Windows, Exterior Wall Paints

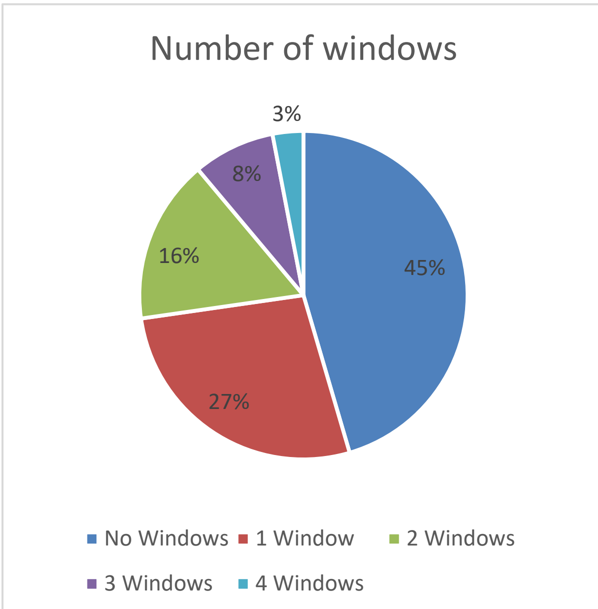
Number of Windows in House						
	Number of Windows	**1**	**2**	**3**	**4**	**5**
Absolute Numbers	174	106	62	30	12	0
Percentage distribution (within options)	44.62	27.18	15.9	7.69	3.08	0

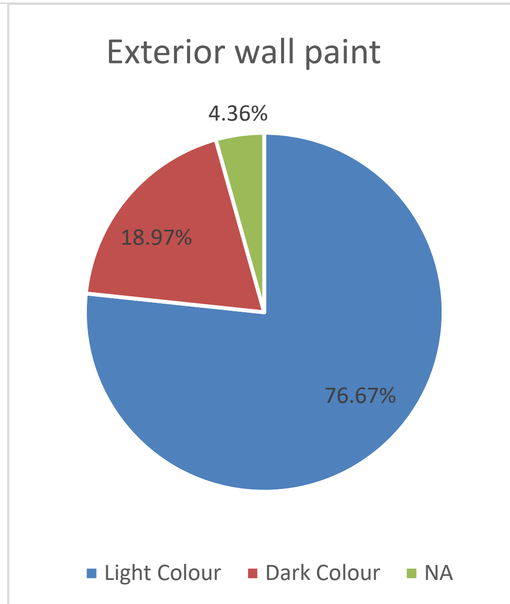
Table: 5.2.4

Exterior Wall Paint				
	Light Colour	**Dark Colour**	**NA**	**Total**
Absolute Number	299	74	17	390

Percentage distribution (within options)	76.67	18.97	4.36	100

Table: 5.2.4 (b)





Graph: 5.2.4 (b)

In the sample settlements, about 45% have no windows at all, followed by 27% with one window. In all, 72% of the sample has poor ventilation and only 28% has 2 or more windows (Table 5.2.4(a)). A poorly ventilated and confined dwelling unit might cause a lack of airflow, resulting in one of the causes of heat-related vulnerabilities. The exterior wall paint however, is helping the citizens to deal with heat much better. Around 77% of the sample households have light colours on the exterior walls (Table 5.2.4 (b)). This practice will help in combating heat and is not an impending factor for exacerbating heat stress among the residents. However, more focus on passive cooling techniques to allow ventilation and natural light inside the house are important.

Implications: Poor quality of housing in terms of design and materials used in such settlements exacerbates discomfort and health risks during extreme heat, particularly heat waves. It increases the indoor temperature as houses heat up quickly and cool down very slowly. Staying home during heat waves may lead to other health risks in heat vulnerable housing, and overcrowding too might aggravate these risks.

5.3 Cooking

5.3.1 Type of Fuel

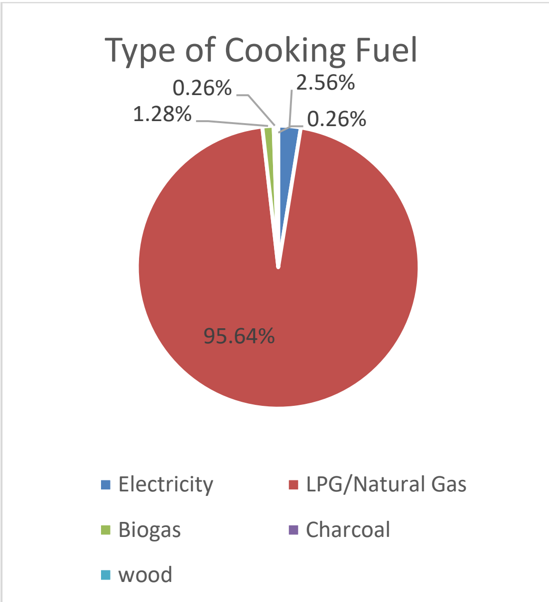
	Electricity	**LPG/ Natural Gas**	**Biogas**	**Kerosene**	**Coal/ Lignite**	**Charcoal**	**Wood**	**Animal Dung**	**Total**
Absolute Number	10	373	5	0	0	1	1	0	390
Percentage distribution (within options)	2.56	95.64	1.28	0	0	0.26	0.26	0	100

Table**:** 5.3.1 (a)

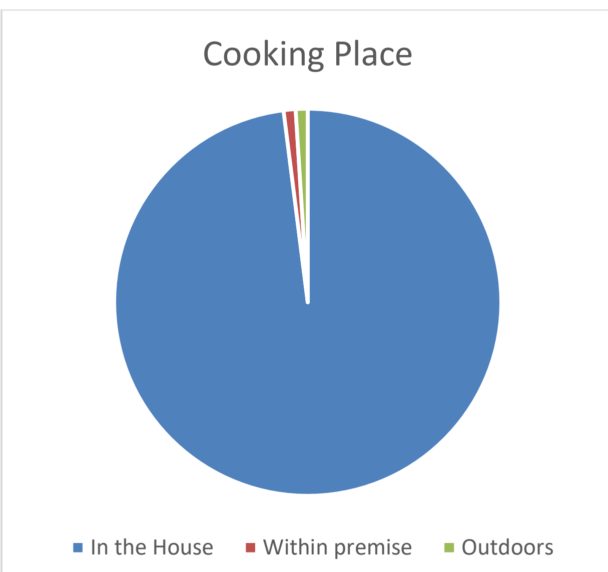
Cooking Place				
	In the house	**Within premises**	**Outdoors**	**Total**
Absolute Number	381	5	4	390
Percentage distribution (within options)	97.69	1.28	1.03	100

Table: 5.3.1 (b)

Graph: 5.3.1 (a)



Graph: 5.3.1 (b)



Graph: 5.3.1 (c)

Table 5.3.1 (a) indicates that majority of the households surveyed (96%) have access to LPG/ Natural Gas for cooking purposes. The rest 1.8% either use electricity or Biogas—both do not emit pollutants at the point of use and are clean. However, 2.56 % still depend on wood for cooking. 98% of the households have a facility to cook food in the house. It is found that above 90% of adult females cook food and the ones using wood are most vulnerable. Clean energy promotes better preparedness towards heat and decreases cooking time with almost no health impacts on the households. Cooking time has a bearing on heat exposure. Hence, while cooking fuels may not be a critical factor impacting heat stress, heat exposure could exacerbate heat stress.

Implications: The females in the households are exposed to extreme heat while cooking. During hot period, cooking increases heat exposure and makes women vulnerability to heat stress. The location of the kitchen, housing design, ventilation, windows and the type of fuels used in cooking also have a bearing on indoor temperatures and pollution.

5.4 Sanitation

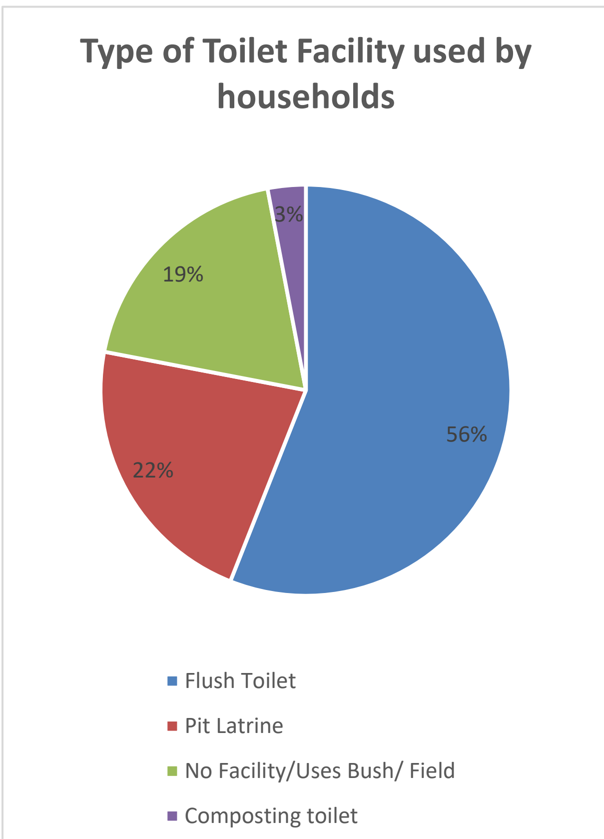
5.4.1 Access to Toilet

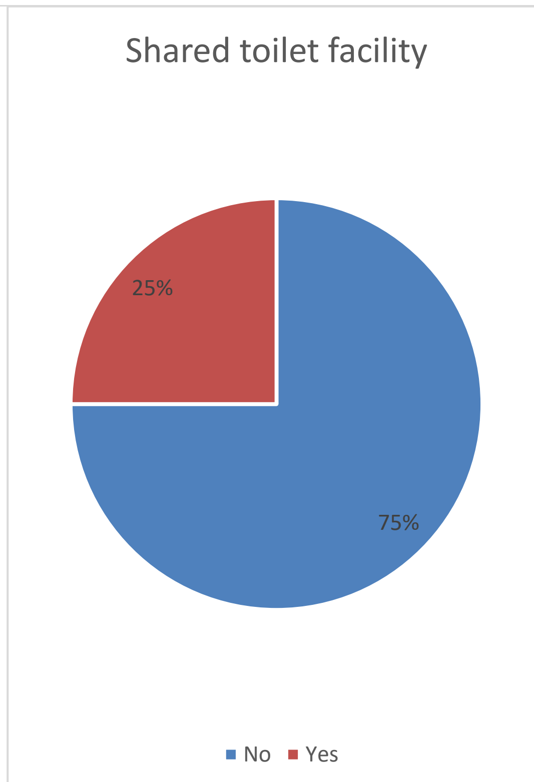
Type of Toilet Facility						
	Flush Toilet	**Pit Latrine**	**No Facility/ Uses Bush/ Field**	**Composting toilet**	**Other**	**Total**
Absolute Number	220	84	76	10	0	390
Percentage distribution (within options)	56.41	21.54	19.49	2.56	0	100

Table: 5.4.1 (a)

Public toilet used by households			
	No	**Yes**	**Total**
Absolute Number	234	80	314
Percentage distribution (within options)	74.52	25.48	100

Table: 5.4.1 (b)





Graph: 5.4.1 (b)

The sample survey shows that 78% of the households have access to either pit latrines or flush toilets. 75%, making up the majority, do not use a shared facility (Table 5.4.1 (a)). Since there is already an awareness of hygiene among households, no actions are needed in majority. However, the 21% with either no toilet or composting toilet facilities should be empowered to continue to transition as they are under high risk. Sustained efforts should be taken to maintain consistency of hygiene. Sanitation is not a critical factor leading to heat stress in the city of Delhi.

Implications: Availability of sanitation is not a critical factor in combatting heat stress for majority however focus should be on the ones with no toilet facility. As its absence might create numerous health issues, especially for women and children. Access to sanitation services are important for the health of heat vulnerable households.

5.5 Water

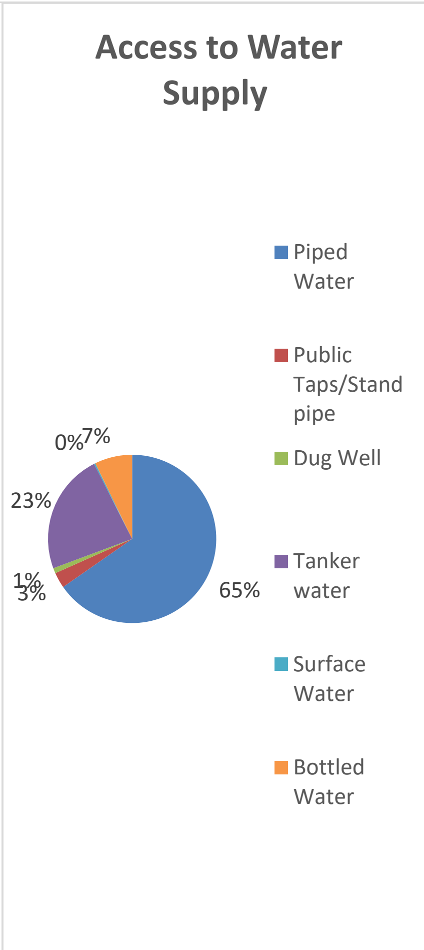
5.5.1 Access to Water Supply

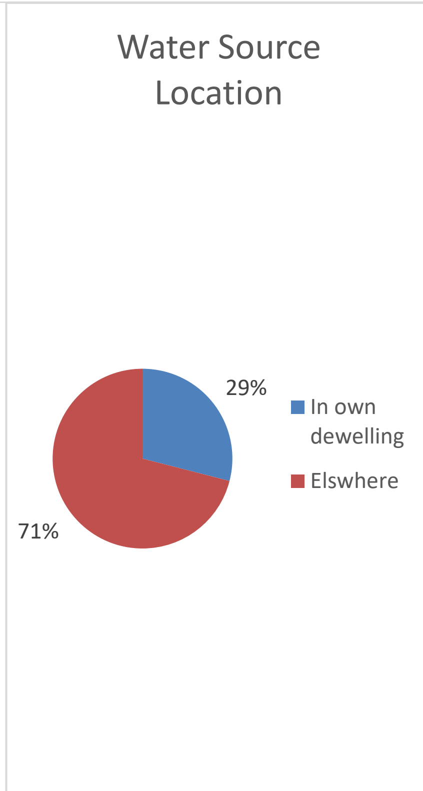
Access to Water Supply									
	Piped Water	**Public Taps/ Stand pipe**	**Tube well Bore well**	**Dug Well**	**Tanker water**	**Surface Water**	**Bottled Water**	**Other**	**Total**
Absolute Number	255	12	0	4	90	1	28	0	
Percentage distribution (within options)	65.38	3.08	0	1.03	23.08	0.26	7.18	0	

Table: 5.5.1 (a)

Water Source Location			
l	**In own dwelling unit**	**Elsewhere**	**Total**
Absolute Number	113	277	390
Percentage distribution (within options)	28.97	71.03	100

Table: 5.5.1 (b)





Graph: 5.5.1 (a)

About 56% (majority) of the households' water is available in the vicinity and is fetched in a time-frame of 1-10 minutes. For others, it ranges between 11- 20 minutes (18%), 21-30 minutes (2%), and more than 30 minutes (3%). There is a need for direct water supply networks to households to cut down exposure while fetching water, in addition to the numerous other benefits.

Table 5.5.1 (a) shows that 65% of the sample households have access to piped water supply. Rest of them fetch water from sources like public taps, tanker, bottle water, nearby streams, dug wells groundwater and so on. For 29%, the water source is within the house. For the rest,71%, water source is elsewhere (Table 5.5.1 (b)). It may lead to vulnerability towards heat and other health implications such as diarrhoea, cholera, diarrhoea, dysentery, hepatitis A, typhoid. During hot season, there may be limited water supply due to low pressure, poor access water from different sources, pointing to increased water demand or scarcity. Mitigation actions to be included for affordable user tariffs, adding more households in the distribution network, water dispensing trucks, and water storage facilities at the community level.

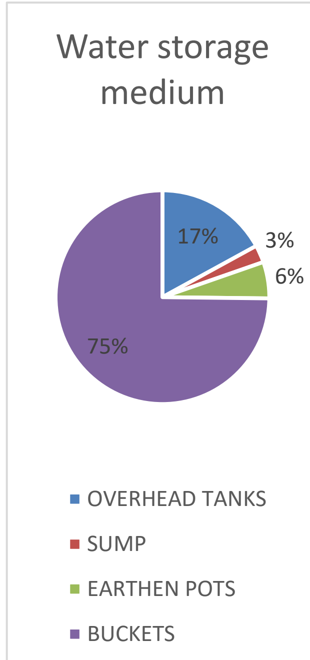
5.5.2 Water Supply (litres)

Frequency of Water Supply					
	24 *7	**Twice a Day**	**Once a Day**	**Once in 3-4 Days**	**Total**
Absolute Number	13	141	191	45	390
Percentage distribution (within options)	3.33	36.15	48.97	11.54	100

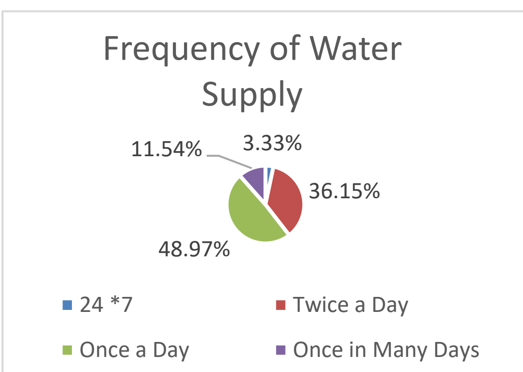
Table: 5.5.2 (a)

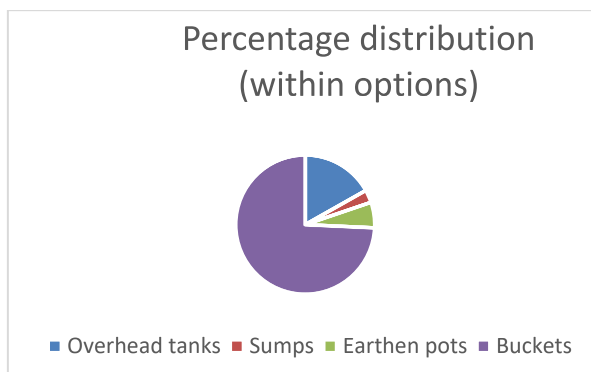
Water Storage Facility (in litres)					
	Overhead tanks	**Sumps**	**Earthen pots**	**Buckets**	**Total**
Absolute Number	71	11	23	312	417
Percentage distribution (within options)	17	3	6	75	100

Table: 5.5.2 (b)

	Water storage a	***Amount of water storage***
		

Graph: 5.5.2 (a)





Graph: 5.5.2 (b)

According to table 5.5.2 (a), 49% of the sample households are supplied water once a day. The frequency of water supply needs to increase to avoid risk on high heat days. To mitigate water shortage, measures such as spreading awareness on water conservation techniques among the households could be adopted.

Implication: Access to safe and affordable water available to all is critical during heat stress. Its paucity, might result in securing water from unreliable sources. It not only increases public health risk but raises issue of water security.

5.6 Electricity

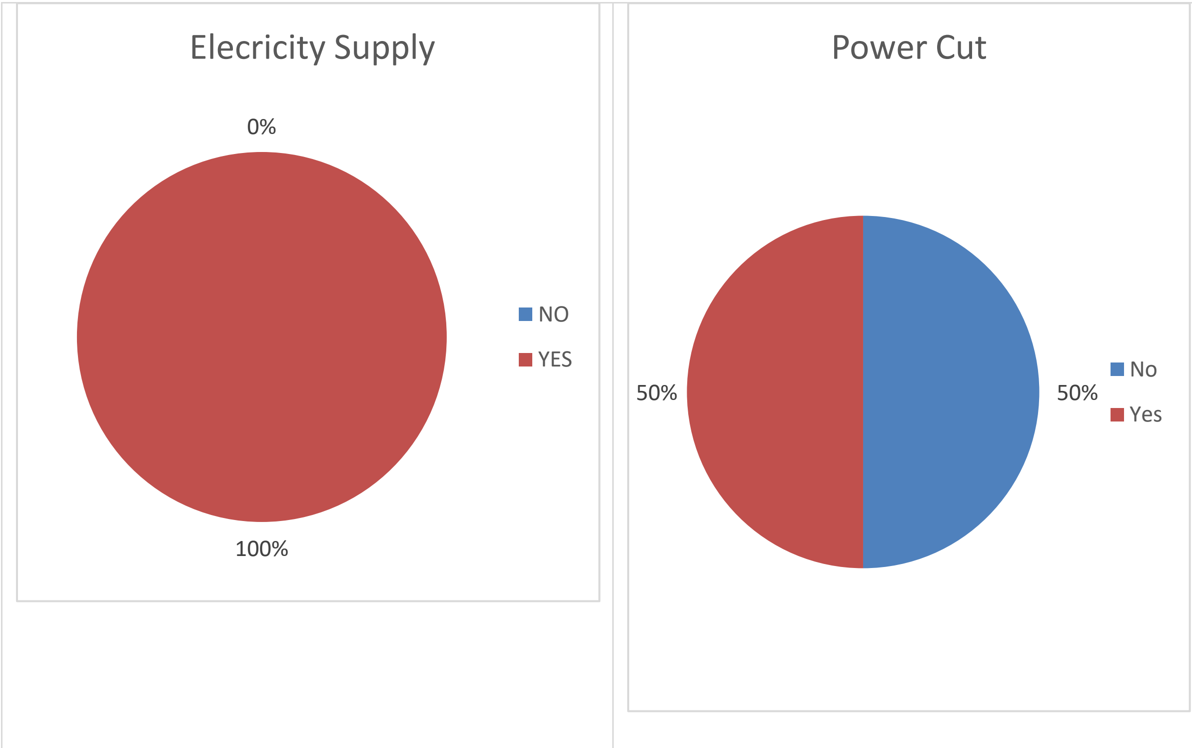
5.6.1 Electricity Supply and Frequency of Power Cuts in Summer Months

Electricity Supply			
Delhi	**No**	**Yes**	**Total**
Absolute Number	0	390	390
Percentage distribution (within options)	0	100	100

Table: 5.6.1 (a)

Power cut (blackout in hours or days)			
	No	**Yes**	**Total**
Absolute Number	194	196	390
Percentage distribution (within options)	49.74	50.26	100

Table: 5.6.1 (b)



Graph 5.7.1 (a)

All 100% households are connected to the grid (have legal electricity connection). Therefore, it is not a disrupting factor. However, the survey shows, 50% of the sample households claim that they face power cuts (Table 5.7.1 (a)). Government should ensure power supply during hot periods in summer season.

5.6.2 Types of Electric Appliances Used and Electricity Bill

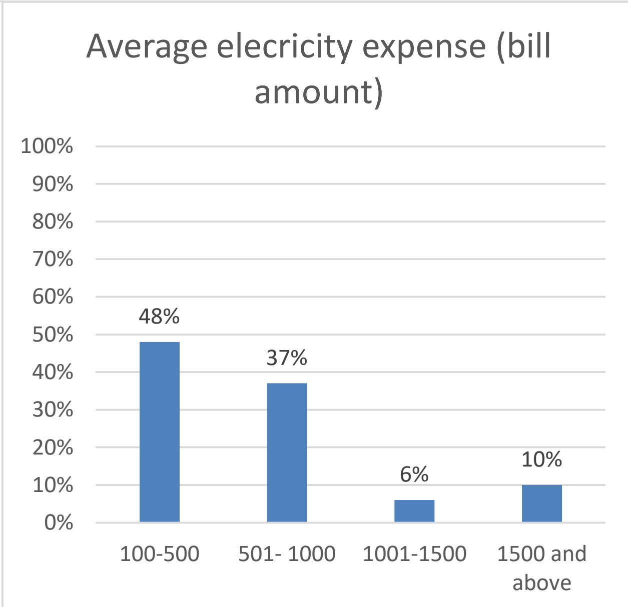
Average Electricity Expense					
	100-500	501- 1000	1001-1500	1500 and above	**Total**
Absolute Number	185	142	24	38	389

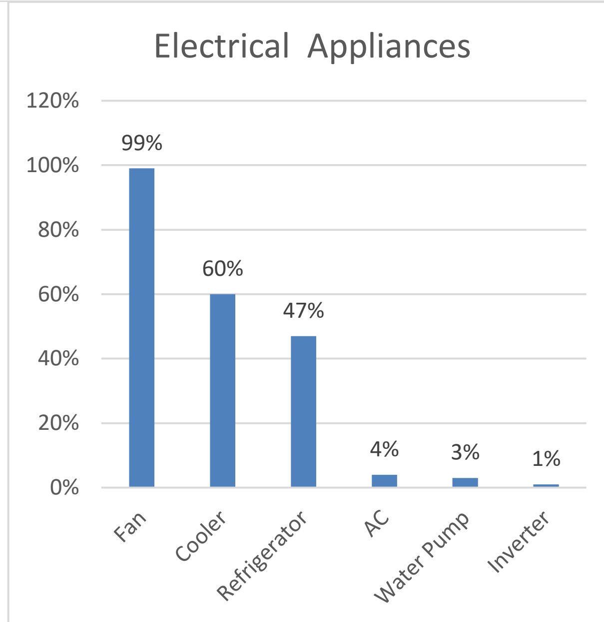
Percentage distribution (within options)	47.56	36.5	6.17	9.77	100

Table: 5.6.2 (a)

Electrical Appliances							
	AC	**Fan**	**Cooler**	**Refrigerator**	**Water Pump**	**Inverter**	**Generator**
Absolute Number.	14	387	235	184	10	4	0
Percentage distribution (within options)	3.59	99.23	60.26	47.18	2.56	1.03	0

Table: 5.6.2 (b)





Graph 5.6.2 (a)

Majority of the households have fans, followed by coolers and refrigerators (Table 5.6.2 (a)). 48% incurred expenses in the range of INR 100-500 (Table 5.6.2 (b)). Majority of the respondents incurred higher than INR 500 as the expense. Households should be trained about harnessing natural resources for mitigating heat stress. This will also help the households in minimising their electricity costs.

Implication: Accessibility to electricity helps to minimize the acute impacts of heat stress, especially during a heat wave. High temperatures exacerbate energy insecurity for those living in poor neighbourhoods.

5.7 Health

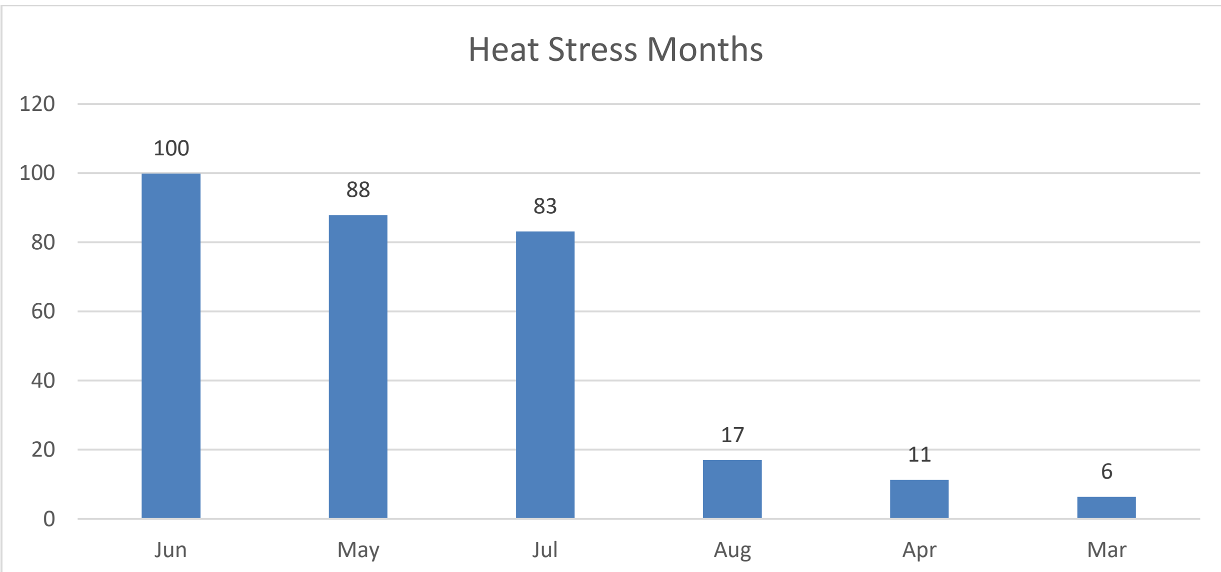
5.7.1 Mapping High Heat period

Heat stress months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Absolute Number	0	0	133	236	1844	2095	1745	356
Percentage distribution (within options)	0	0	6.34	11.24	87.85	99.81	83.13	16.96

Table: 5.7.1 (a)

Delhi experiences summer from March to July as it falls under the core heat wave zone of northern India. The hot season is at its peak in May, June, and July. During this period, the temperatures not only peak but also results in severe heat wave conditions, deterioration in public health and causing heat stress. It is during these months that extreme caution has to be adopted, and the government should share heat stress advisory among the households.



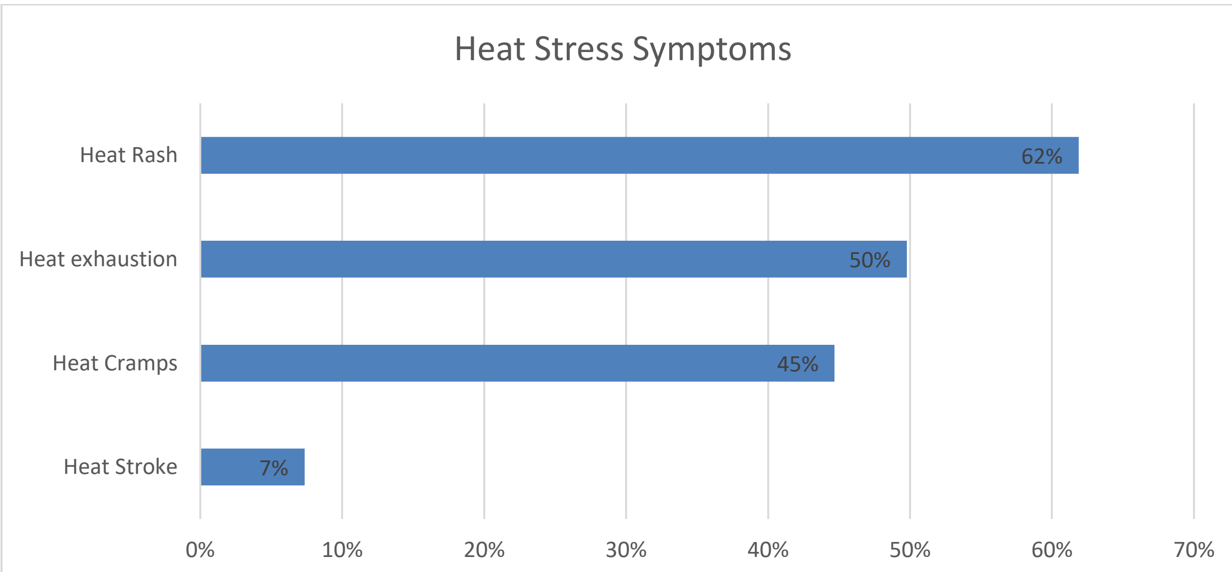
Graph: 5.7.1 (a)

The Graph 5.7.1 (a) above shows the month of June reported as 100 % hottest month, followed by May (87%) and July (81%).

5.7.2 Time of Heat Discomfort: (Dot graph to be retrieved from Probal Sir, Image of the graph)

Dot graphs to be added and results to be retrieved from the same

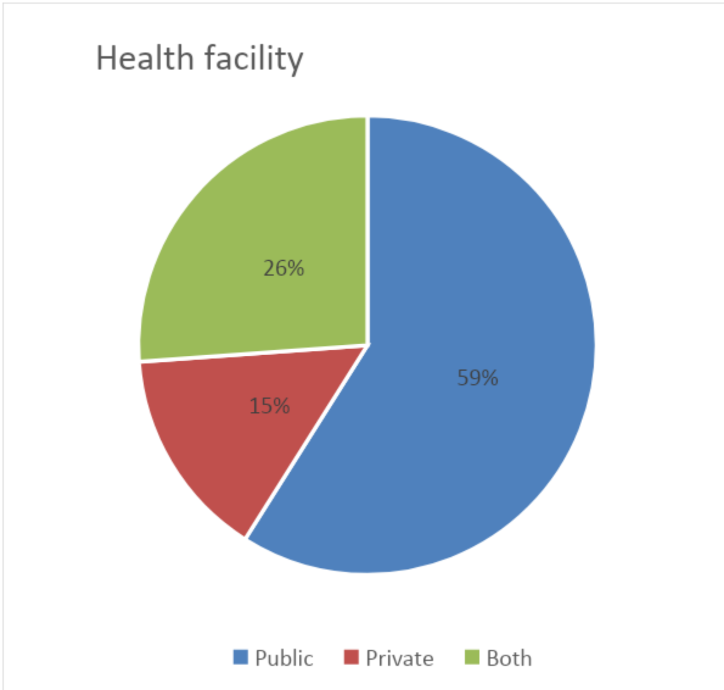
5.7.3 Heat Stress Symptoms



Graph: 5.7.3

Households reported heat stress symptoms— 62 % reported heat rashes, 50 % said they suffered heat exhaustion, 45 % bore heat cramps. The figures indicate that heat stress is a growing public health issue (Graph: 5.7.3) .

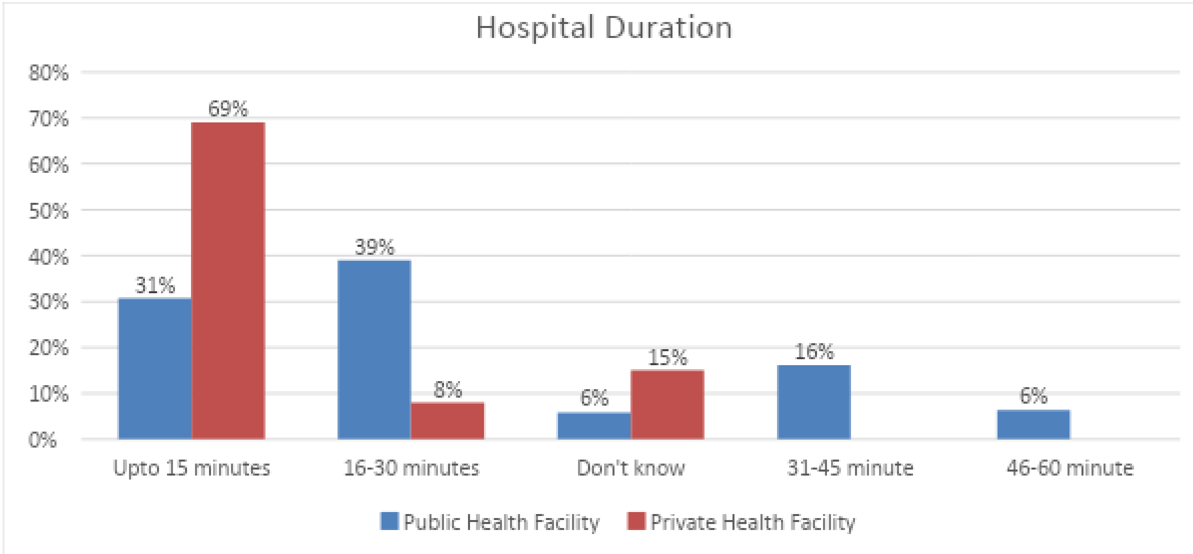
5.7.4 Access to Health Infrastructure



Graph: 5.7.4

About 59 % of the households accessed public health care, 26 % accessed both public and private health care facilities. Only 15 % accessed only private health care (Graph: 5.7.4).

5.7.5 Distance from the to the Nearest Health Centre

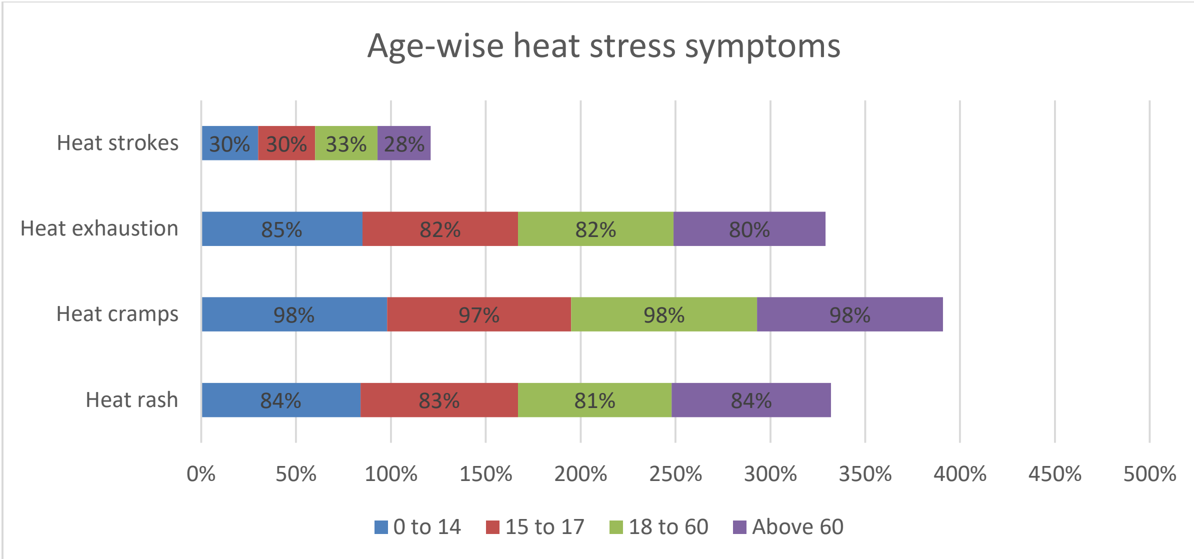


About 69 % had private health facility within 15 minutes distance from their home, and 31 % public health facility users took upto 15 minutes. Similarly, about 8 % of private health facility users and 39 % of public health facility users took 16-30 minutes. It indicates that there is limited access to public health facilities. If it is corroborated with per cent of households accessing public health facilities, it suggests that people travel a long distance to visit available facilities due to their low affordability.

5.7.6 Age-wise Symptoms

	Heat rash				**Heat Cramps**				**Heat Exhaustion**				**Heat Stroke**			
	0 to 14	**15 to 17**	**18 to 60**	**Above 60**	**0 to 14**	**15 to 17**	**18 to 60**	**Above 60**	**0 to 14**	**15 to 17**	**18 to 60**	**Above 60**	**0 to 14**	**15 to 17**	**18 to 60**	**Above 60**
Absolute Numbers	**452**	**137**	**1,086**	**51**	**527**	**160**	**1,308**	**60**	**458**	**136**	**1,099**	**49**	**159**	**50**	**441**	**17**
Percentage distribution (within options)	**83.86**	**83.03**	**81.4**	**83.61**	**97.77**	**96.97**	**98.05**	**98.36**	**85**	**82.4**	**82.38**	**80.3**	**29.5**	**30.3**	**33.1**	**27.9**

Table: 5.7.6 (a)



Graph: 5.7.6 (a)

Across all ages, heat cramps followed by heat rashes and heat exhaustion were the most common symptoms. Children (0 to 14) and adolescents (15 to 17) reported symptoms of heat cramps. The majority of adults, working-class, reported suffering from heat cramps, followed by heat exhaustion and heat rashes. Similarly, senior citizens struggled with heat cramps and heat exhaustion, the most.

Age group	**1st Heat symptoms**	**2nd Heat symptoms**
0 to 14	Heat cramps	Heat rash
15 to 17	Heat cramps	Heat exhaustion
18 to 60	Heat cramps	Heat exhaustion
Above 60	Heat cramps	Heat exhaustion

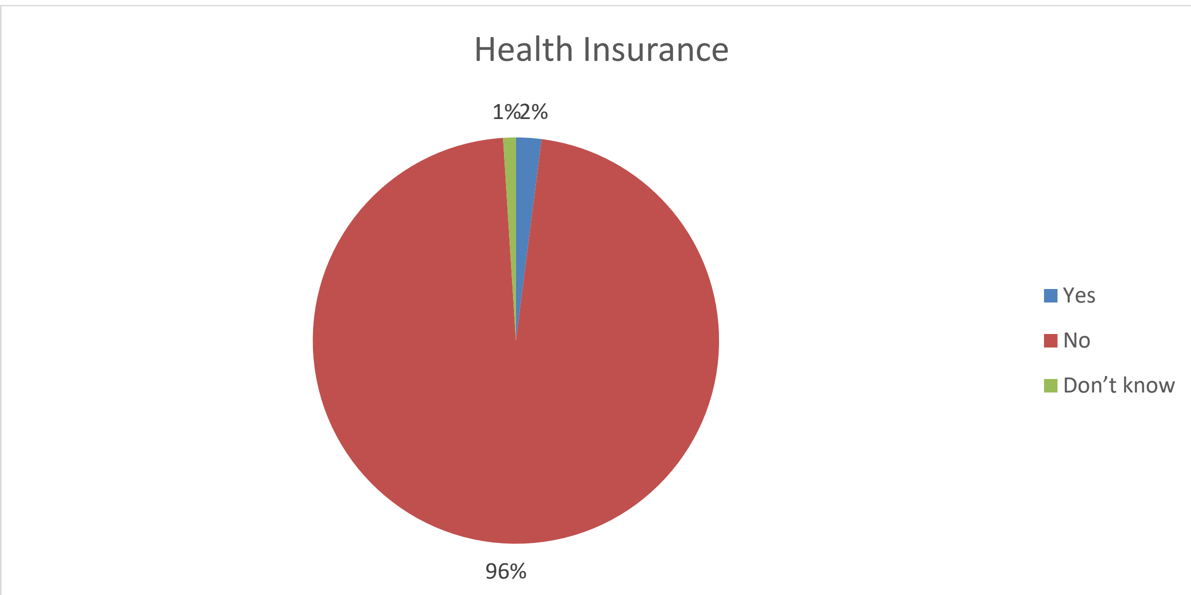
Table: 5.7.6 (b)

Two households each reported death of a family member due to heat stress in the sample survey.

5.7.7 Health Insurance

Health insurance				
	Yes	**No**	**Do not know**	**Total**
Absolute Number	9	376	5	390
Percentage distribution (within options)	2.31	96.41	1.28	100

Table ~~7. 7.4 (a)~~ 5.7.7 (a)



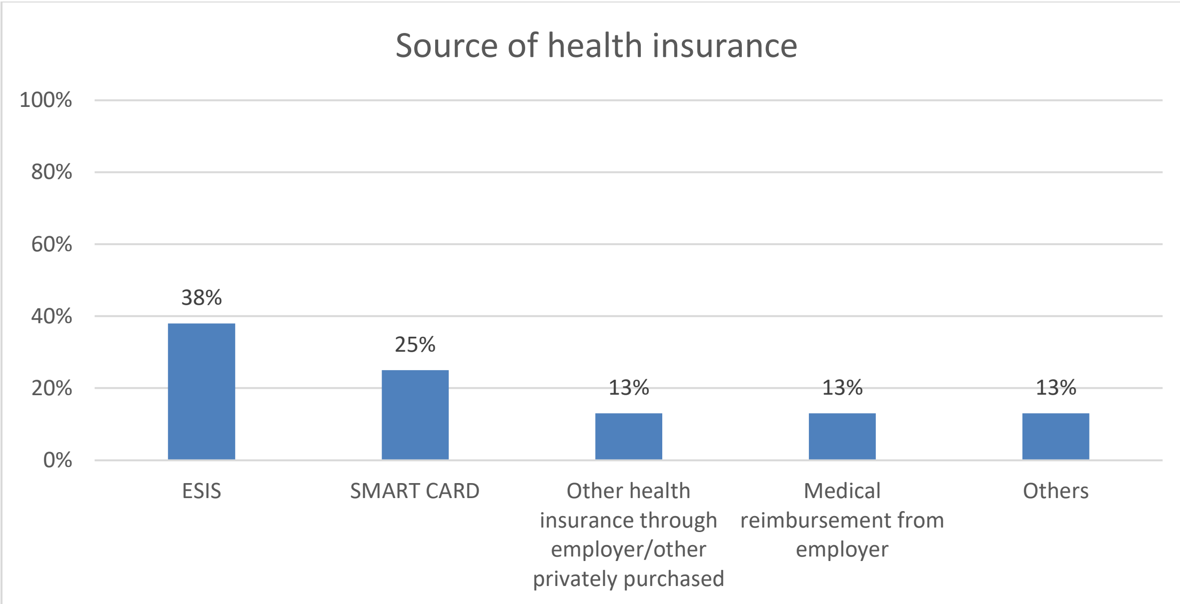
Graph 5.7.7 (a)

As per Graph 5.7.7 (a), 96% of the people from do not have access to health insurance. Due to affordability, most of the households are out of the insurance network and have very poor awareness about the govt sponsored medical schemes such as Ayushman Bharat Pradhan Mantri Jan Arogya Yojana. To improve access to health insurance, government should come out with insurance schemes for people below poverty line, and local government hospitals should treat heat stress illnesses free of cost.

5.7.8 Source of Health Insurance

Source of health insurance								
	ESIS	Aam Aadmi Bima Yojana Mother Absolute Affection / Delhi Government Employees Health Scheme	CHIP	SMART CARD	Other health insurance through employer/ other privately purchased	Medical reimbursement from the employer	Others	Total
Absolute Number	3	0	0	2	1	1	1	8
Percentage distribution (within options)	37.5	0	0	25	#	#	#	#

Table: 5.7.8 (a)



Graph 5.7.8 (a)

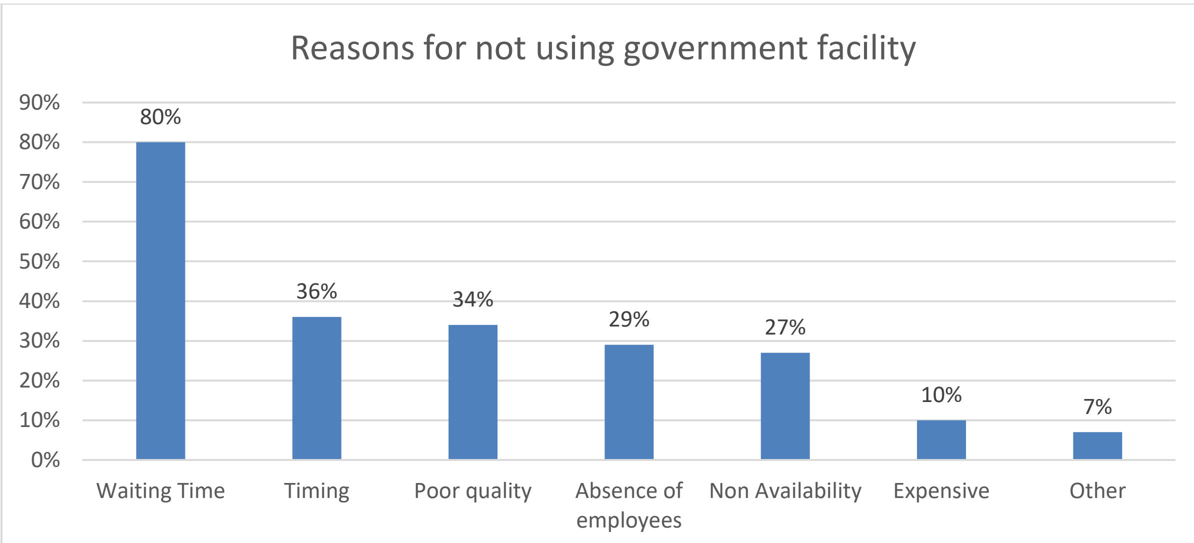
The Graph 5.7.8 (a) shows that about 38% have State Health Insurance and another 25 %with smart health cards for clinical information. These are the govt sponsored schemes to help economically weaker sections of society to access medical care. While some households have health insurance, bringing more people under health insurance net by improving access, making schemes affordable and increasing awareness about benefits.

5.7.9 Reasons for Not Using Government Health Facilities

Reasons of not using government facilities							
	Non Availability	**Timing**	**Absence of employees**	**Waiting Time**	**Poor quality**	**Expensive**	**Other**
Absolute Numbers	16	21	17	47	20	6	4
Percentage distribution (within	26.67	35.59	28.81	79.66	33.9	10.17	6.78

options)								

Table: 5.7.9 (a)



Graph: 5.7.9(a)

Graph 5.7.9 (a) indicates that long waiting time is the most (80%) prominent reason for not accessing public facilities. The other reasons are inconvenient timing (36%), low quality care (34%), absence of health personnel (29%), distance (27%), and affordability (10%).

Implications: Heat stress often results in frequent hospitalizations during hot months, and it results in financial strain on households, especially on patients with chronic health conditions. Public health systems need acute measures responding to heat waves.

5.7.10 Women-Specific Impacts of Heat Stress

The impact of heat stress on women is manifold, and many factors, both physiological and environmental aspects, play a critical role in causing more heat stress among women and thereby putting them more at risk for heat-related mortality. Through the studies conducted on Gender inequality, it is inferred that women are more likely than men to be affected by climate change. Female mortality due to heat-stroke shows an increasing trend since 2011 in the age group of below 14 years, whereas male mortality has been reducing continuously. With growing heat stress, women become vulnerable as their ability to thermoregulate is compromised. There is an increasing number of heat-related illnesses and stillbirths, which further gets intensified due to social norms and gender discrimination. Moreover, pregnant and post-partum women and their infants are uniquely vulnerable to health impacts of climate change due to the many physiologic and social changes that occur as a result of pregnancy.

Among working women from economically weaker sections, the heat stress vulnerabilities are high, and it further increases due to resource crunch and their insufficient adaptive capacities. Low-income women are disproportionately vulnerable to the ill-effects of climate variability and change, in part because of gender inequalities (e.g., unequal political, social, economic, and cultural rights; lower levels of access to resources, information, and education; and lower levels of participation and influence in shaping policies and decision-making processes at all levels, including the household). For working women, the factors affecting their thermal comforts, such as air temperatures, radiant temperature, humidity, and air movement, expose them to various health risks. Besides, there are personal factors that affect thermal comfort are viz., clothing insulation, and metabolic heat. Furthermore, outdoor workers are also vulnerable to urban heat island effects. It has been observed that high temperatures can give rise to air pollutants causing chronic health effects, such as respiratory diseases and allergic reactions.

Furthermore, the lack of timely access to information on heat alerts increases their risk of heat stress. Exclusion in decision-making adds to vulnerability, because of low awareness on adaptation strategies and mitigation measures resulting in poor adaptation behaviours.

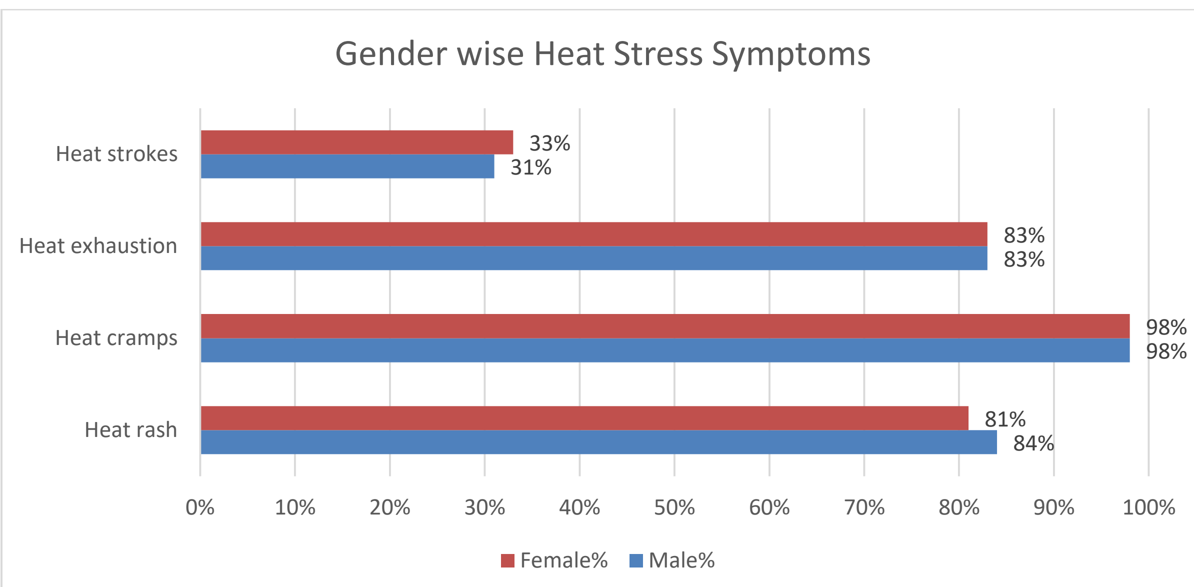
5.7.11 Differential Impact of Heat on Gender

Delhi	**Heat Rashes**	**Heat Cramps**	**Heat Exhaustion**	**Heat Stroke**

	Male	Female	Male	Female	Male	Female	Male	Female
Absolute Numbers	817	908	955	1,099	811	930	303	364
Percentage distribution (within options)	83.54	81.07	97.65	98.13	82.92	83.04	30.98	32.5

Table: 5.7.11

Heat waves have a differentiated impact on gender. Table 5.7.11 shows that females suffer many severe implications of heat stress than men. About 98.13 % of women bear heat cramps, 83 % suffer from heat exhaustion, and about 32 % are affected by heat-stroke. Women, being caregivers, proactively work both outdoors and the indoors putting them at higher risk.



Graph: 5.7.11

The survey highlights that woman are equally vulnerable to symptoms like heat cramps followed by heat exhaustion, and heat rash was most common among the sample. The table shows that males and females experience similar heat stress symptoms. It is observed that heat rash is more common in males, while heat stroke is more common in females. Heat strokes are common in women as they stay indoors, and the factors like social norms, housing design, and its material aggravate heat-stroke conditions.

5.8 Livelihood – Wage and Productivity Loss

Due to the rise of heat stress, its impact reflected on the wage and productivity loss amongst the working population, especially in vulnerable sections.

5.8.1 Average Wage Loss

Average Wage Loss						
	No wage loss	**1-999**	**1000-1999**	**2000-2999**	**3000 and above**	**Total**
Delhi						
Absolute Numbers	420	134	0	0	1	555
Percentage distribution (within options)	75.68	24.14	0	0	0.18	100

Note: No wage loss was not considered while calculating the Average Wage Loss Table ~~9.9.1~~

Table: 5.8.1

Graph 5.8.1 Average wage loss

The average wage loss in the city falls under the category INR 1 to 999. The survey shows that the majority of casual workers fall in class 1 to 999.

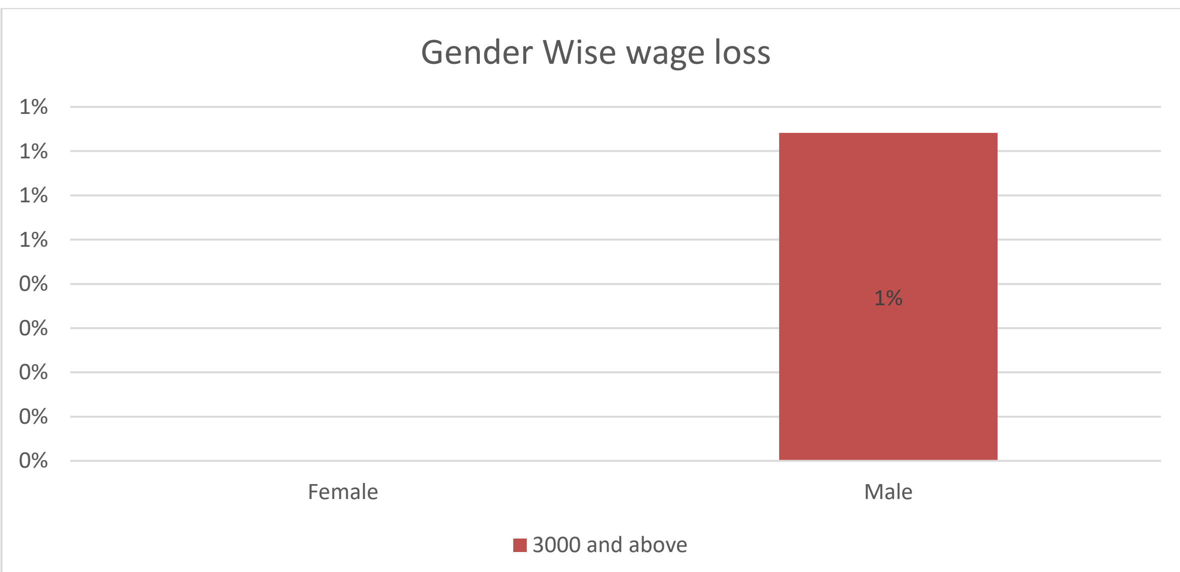
5.8.2 Gender Wise Wage Loss

	Gender Wise wage loss			
Gender	**No wage loss**	**1-999**	**3000 and above**	**Total**
Female	45	10	0	55
	81.82	18.18	0	100
	10.71	7.46	0	9.91
Male	375	124	1	500

	75	24.8	0.2	100
	89.29	92.54	100	90.09
Total	420	134	1	555
	75.68	24.14	0.18	100
	100	100	100	100

Note: No Wage Loss was not considered while calculating the Gender Wise Wage Loss.

Table: 5.8.2



Graph: 5.8.2

The survey shows that the majority of males (90% out of the total) experienced wage loss due to heat as compared to the women involved in work. Both males and females experience wage loss in the category INR 1 to 999. The average monthly wage loss in females in INR 20 while in males is INR 120.

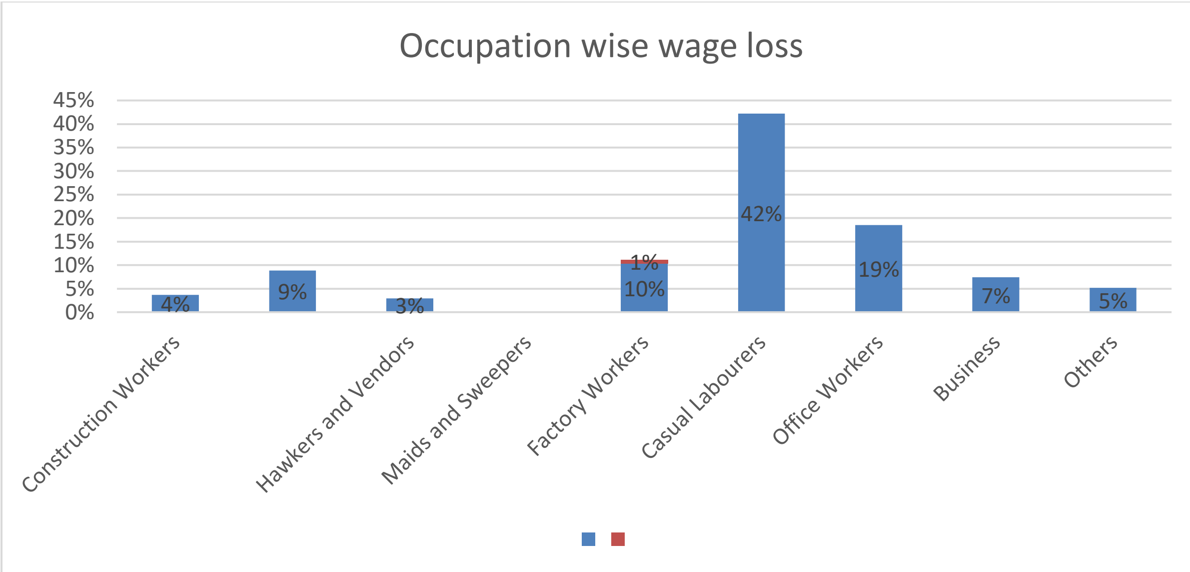
5.8.3 Occupation Wise Wage Loss

Occupation wise wage loss			
Occupation code	**No wage loss**	**1-999**	**3000 and above**
Construction Workers	20	5	0
Transportation Workers (Rickshaw/Auto likewise)	54	12	0
Hawkers and Vendors	11	4	0
Maids and Sweepers	5	0	0
Factory Workers	65	14	1
Casual Labourers	119	57	0
Office Workers	90	25	0
Business	43	10	0
Others	13	7	0

Note: No Wage Loss was not considered while calculating the Occupation of Wise Wage Loss.

Table: 5.8.3

Numerous occupations were incorporated in the survey while calculating the occupation wise wage loss in the city. The outdoor workers and the causal workers are most at risk of losing wages.



Graph: 5.8.3 Occupation wise wage loss

The casual labourers are most affected by the high heat days, as the maximum wage loss is reported in the daily causal labourers (42%). It is due to the high share of involvement and a low percentage of income, which is followed by the office workers experiencing heat exhaustion during high temperatures. Hawkers and maids are least affected amongst the identified occupations.

5.9 Productivity Loss

5.9.1 Average Productivity Loss

Average Productivity Loss						
	No absence	**1-5 days**	**6-10 days**	**10-15 days**	**more than 15**	**Total**

Absolute Numbers	508	43	1	3	0	555
Percentage distribution (within options)	91.53	7.75	0.18	0.54	0	100

Note: No Absence was not considered while calculating Average Productivity.

Table: 5.9.1

Graph: 5.9.1

With loss in productivity, the wages of individuals are directly affected. Majority (91%) of the working population reported a fall in the working days by 1 to 5 during heat stress periods, followed by 10 to 15 days (21%) in a month.

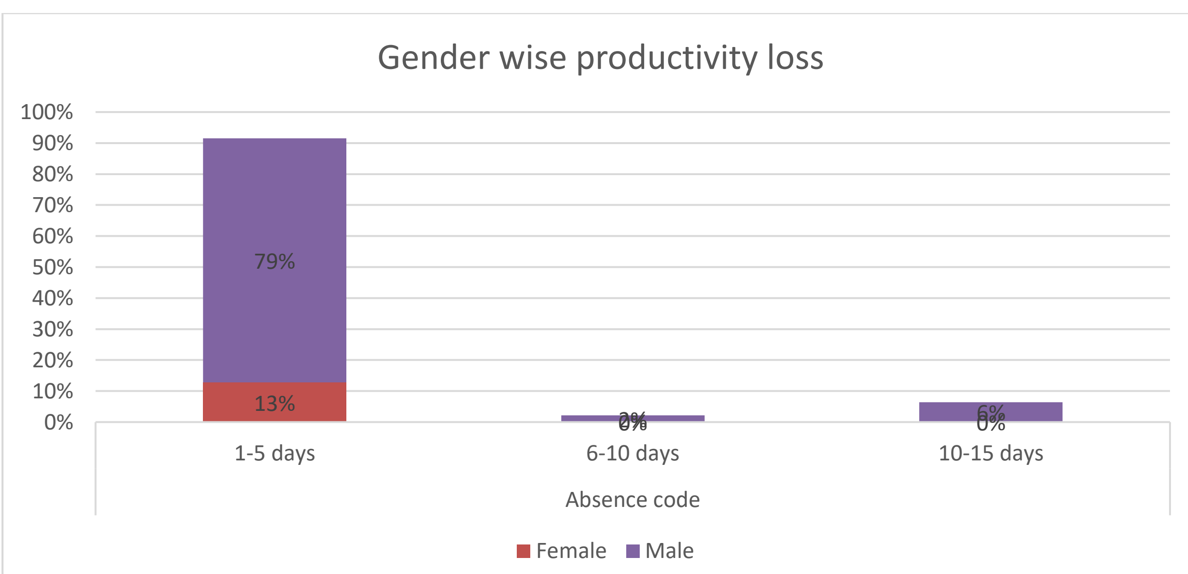
5.9.2 Gender Wise Productivity Loss

	Productivity Loss				
Gender	**No absence**	**1-5 days**	**6-10 days**	**10-15 days**	**Total**

Female	49	6	0	0	55
	89.09	10.91	0	0	100
	9.65	13.95	0	0	9.91
Male	459	37	1	3	500
	91.8	7.4	0.2	0.6	100
	90.35	86.05	100	100	90.09
Total	508	43	1	3	555
	91.53	7.75	0.18	0.54	100
	100	100	100	100	100

Note: No Absence was not considered while calculating Gender Wise Productivity.

Table: 5.9.2



Graph: 5.9.2

Similar to wage loss, males (64%) are at a more significant loss as compared to females. Majority of males and females experienced productivity loss ranging from 1 to 5 days. The average days lost due to high temperature is ½ a day for males, while for women, it is 4 hours in a month.

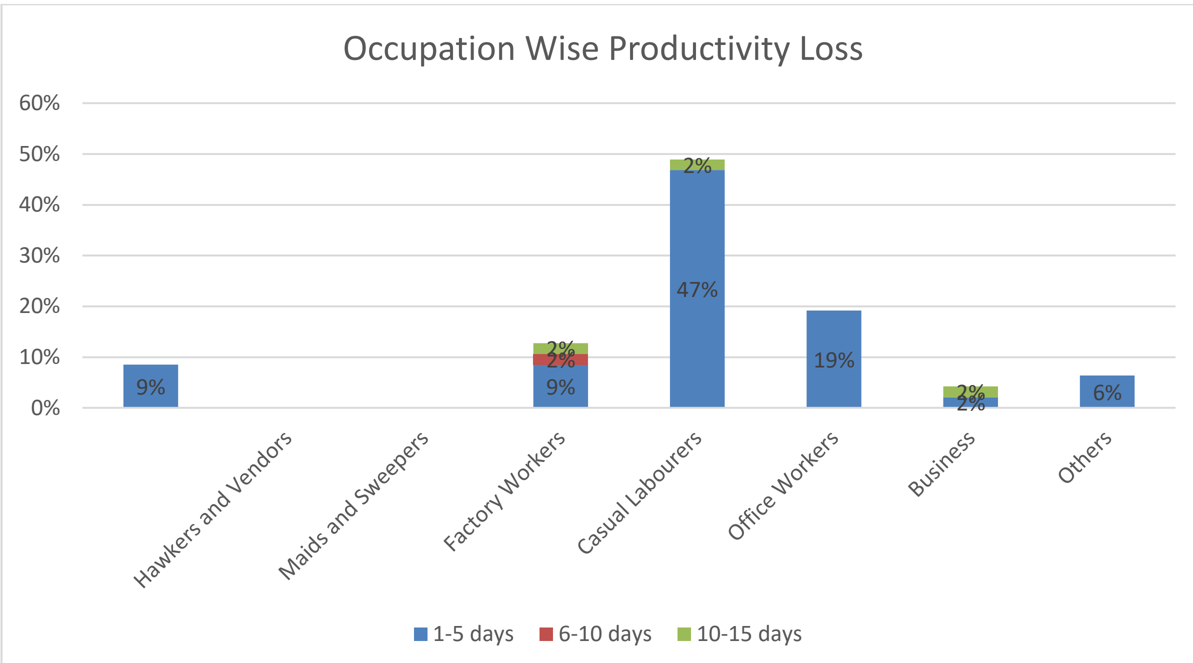
5.9.3 Occupation Wise Productivity Loss

	Productivity Loss				
Occupation Type	**No Wage loss**	**1-5 days**	**6-10 days**	**10-15 days**	**Tota l**
Construction Workers	25	0	0	0	25
Transportation Workers (Rickshaw/Auto, likewise)	62	4	0	0	66
Hawkers and Vendors	15	0	0	0	15
Maids and Sweepers	5	0	0	0	5
Factory Workers	74	4	1	1	80
Casual Labourers	153	22	0	1	176
Office Workers	106	9	0	0	115
Business	51	1	0	1	53
Others	17	3	0	0	20

Note: No Absence was not considered while calculating the Occupation of Wise Productivity.

Table: 5.9.3

The occupation wise productivity loss in the city is the highest among the casual workers, factory workers, and office workers.



Graph:5.9.3

Casual labourers are most affected during high-temperature days, as maximum productivity loss is reported by them (49%), followed by office workers (19%). Prolonged working hours, poor working conditions, and lack of sensitization are some reasons behind the loss. The survey shows that hawkers and maids are least affected amongst the identified occupations.

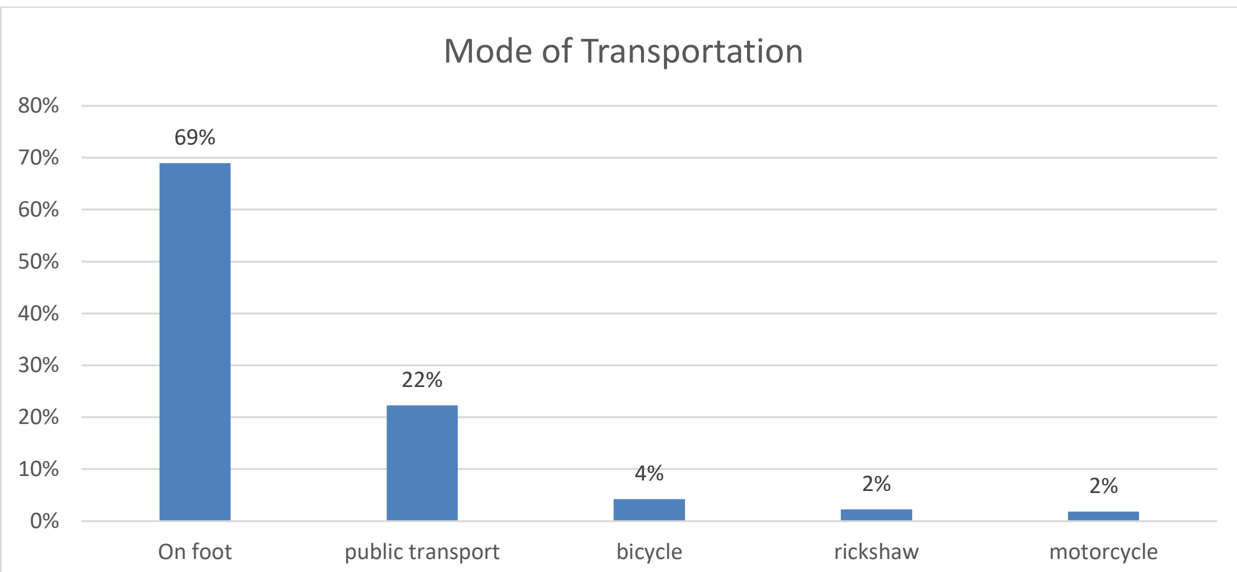
Implications: Occupation and wage loss due to heat stress significantly affect their quality of life and lack of affordability to access medical services in case of emergency.

5.10 Transport

5.10.1 Methods Used for Commuting (workplace/school)

Mode of transport								
Delhi city	**On foot**	**Bicycle**	**Motorcycle**	**Car**	**Public transport**	**Rickshaw**	**Others**	**Total**
Absolute Numbers	962	59	26	4	311	32	1	1395
Percentage distribution (within options)	68.96	4.23	1.86	0.29	22.29	2.29	0.07	100

Table: 5.10.1 (a)



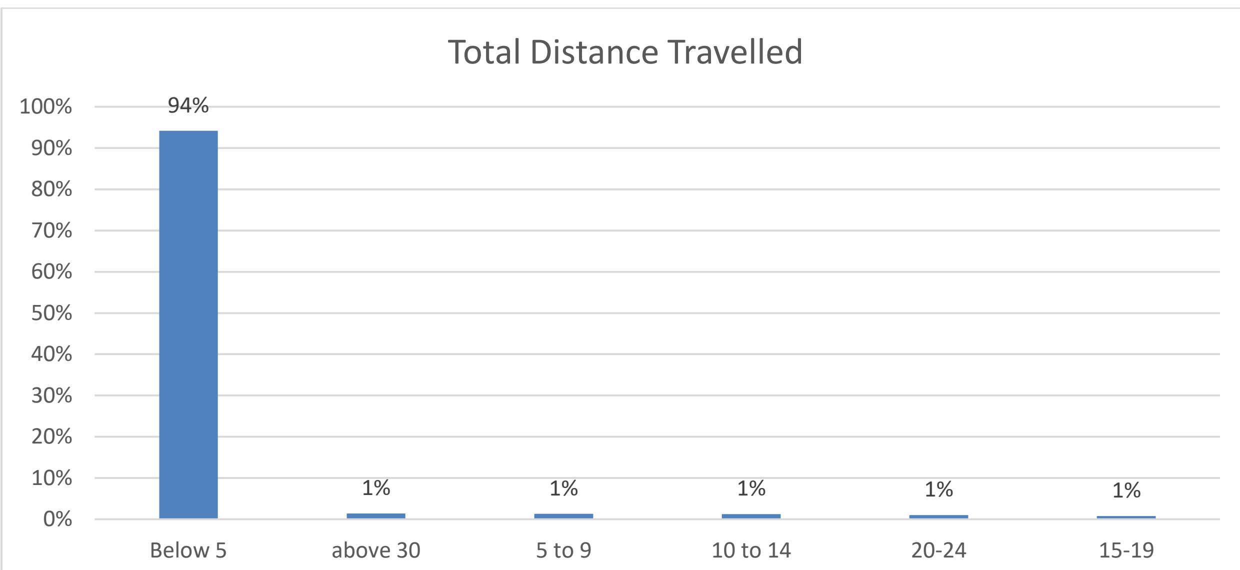
Graph: 5.10.1 (a)

According to table 5.10.1 (a), the most common means of commuting are pedestrians (on foot) (69%), Public Transport (22%), and on bicycle (4%). Travelling on foot can trigger heat-related illnesses if required measures are not taken.

Total Distance Travelled

Distance traveled								
	Below 5 km	**5 to 9 km**	**10 to 14 km**	**15-19 km**	**20-24 km**	**25- 29 km**	**Above 30 km**	**Total**
Absolute Numbers	1977	27	26	16	21	3	29	2099
Percentage distribution (within options)	94.19	1.29	1.24	0.76	1	0.14	1.38	100

Table: 5.10.2 (a)



Graph: 5.10.2 (a)

According to Graph 5.10.2 (a), the maximum (94%) sample households travel within the vicinity of 5 km to reach their respective workplaces/ schools. Only 1% travel a maximum distance of above 30 km.

The survey result highlights that given the underlying poverty; they prefer going on foot. The place of work/school is found within 5 km; walking on foot/ cycling to workplace increases vulnerability during peak summer. Building awareness about mitigation measures like promoting the use of umbrellas, head cover, and carrying water bottles are cost-effective measures for these communities.

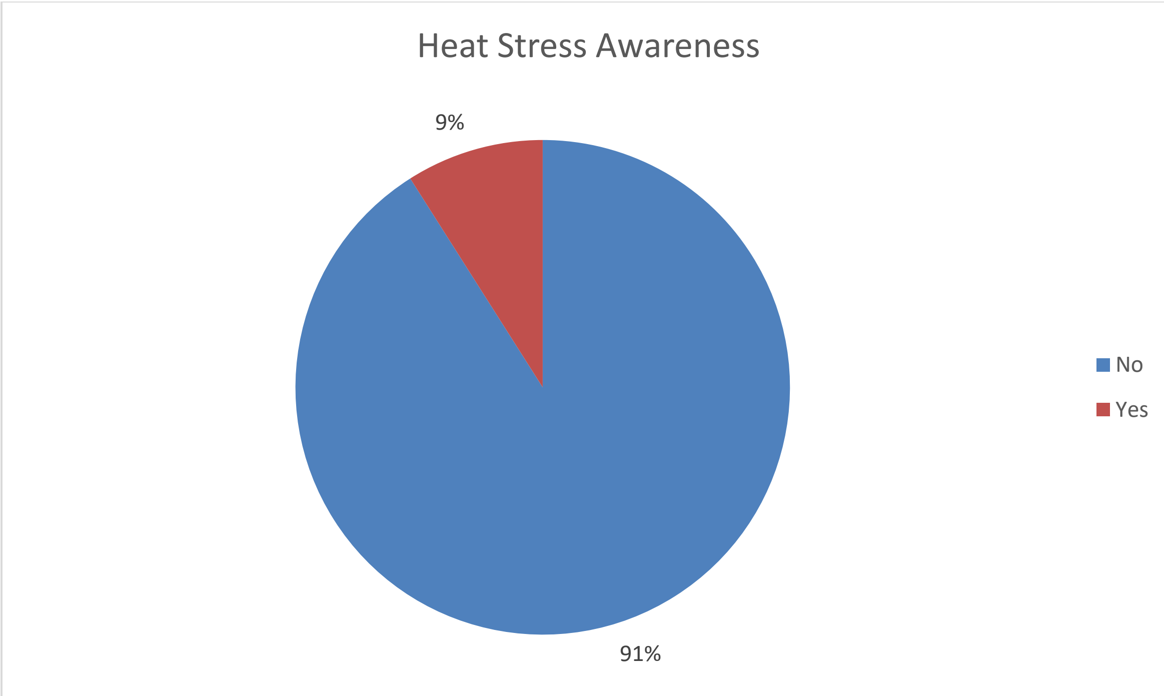
Implications: The opportunities and challenges of increasing transportation access are not well understood by the city. Poor affordability forces people to walk long distances and making it important to have more green public spaces.

5.11 Awareness

5.11.1 Awareness of the term "Heat Stress"

Heat Stress Awareness			
	No	**Yes**	**Total**
Absolute Numbers	353	37	390
Percentage distribution (within options)	90.51	9.49	100

Table: 5.11.1 (a)



Graph: 5.11.1 (a)

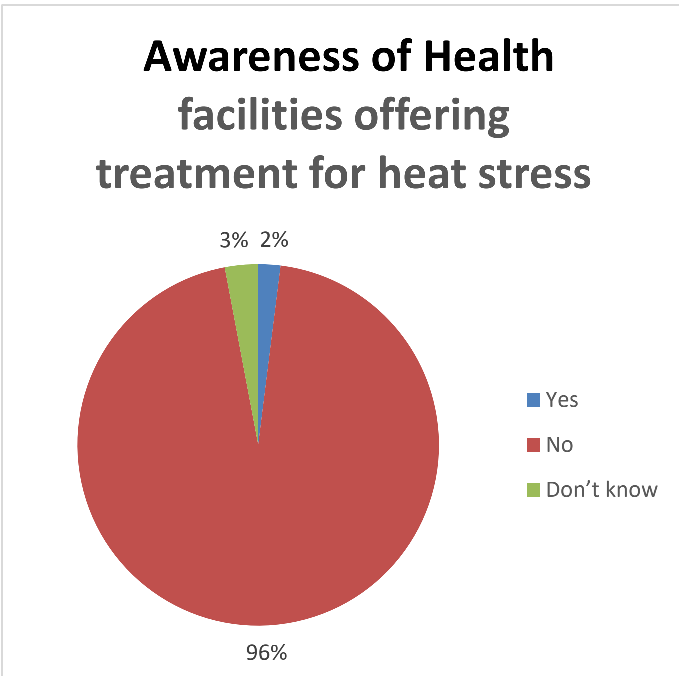
According to Table 5.11.1 (a), only 9% of the sample population are aware of the term heat stress. There is a need to have more awareness in terms of heat stress in Delhi. For this, the stakeholders could come together to ensure that information is disseminated among households about the impacts of heat stress and ways to mitigate it. Along with this, heat alerts could have to be issued on social media/T.V. /mobile phones too.

5.11.2 Awareness of medical facilities offering treatment for heat stress

Awareness regarding medical facilities/ hospitals available for the treatment of heat stress issues				
Delhi city	**Yes**	**No**	**Don't know**	**Total**
Absolute Numbers	7	373	10	390

Percentage distribution (within options)	1.79	95.64	2.56	100

Table: 5.11.2 (a)



Graph: 5.11.2 (a)

About 96% of the sample households are not aware of the medical facilities offering treatment for heat stress (Graph 5.11.2 (a)). The local administration should disseminate useful information through a door-to-door visits and distribution of pamphlets. Medical camps may have to be set up from time to time for health check-ups during the hot season.

5.11.3 Awareness about Adaptive Mitigation Strategies Adopted by ULBs

Awareness about the mitigation strategies adopted by ULB				
	Yes	**No**	**Don't know**	**Total**
Absolute Numbers	7	375	8	390
Percentage distribution (within options)	1.79	96.15	2.05	100
Total	100	100	100	100

Table: 5.11.3 (a)

According to Table 5.11.3 (a), a majority (96%) of the sample population was not aware of the adaptive mitigation strategies adopted by the government. It calls for mitigation actions and sharing of information widely on heat stress and steps that have to be taken to combat it.

Implications: Awareness about heat stress is generally very low, and people have limited knowledge about the precautions that may be taken to protect against heat wave.

1.

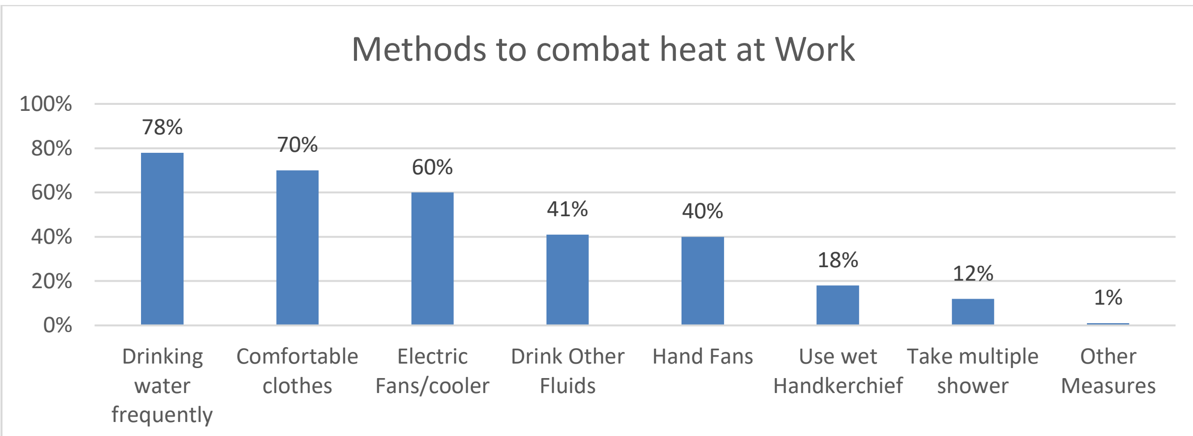
5.12 Adaptation

5.12.1 Coping with Heat-Related Discomfort at Work

Coping with Heat at work								
	Comfortable clothes	**Hand Fans**	**Electric Fans/ cooler**	**Drinking water frequently**	**Use wet Handkerchief**	**Drink Other Fluids**	**Take multiple showers**	**Other Measures**
Absolute Numbers	273	157	235	306	72	161	45	2

Percentage distribution (within options)	70	40.3	60.26	78.5	18	41.28	11.54	0.51
Total	100	100	100	100	100	100	100	100

Table: 5.12.1 (a)



Graph: 5.12.1 (a)

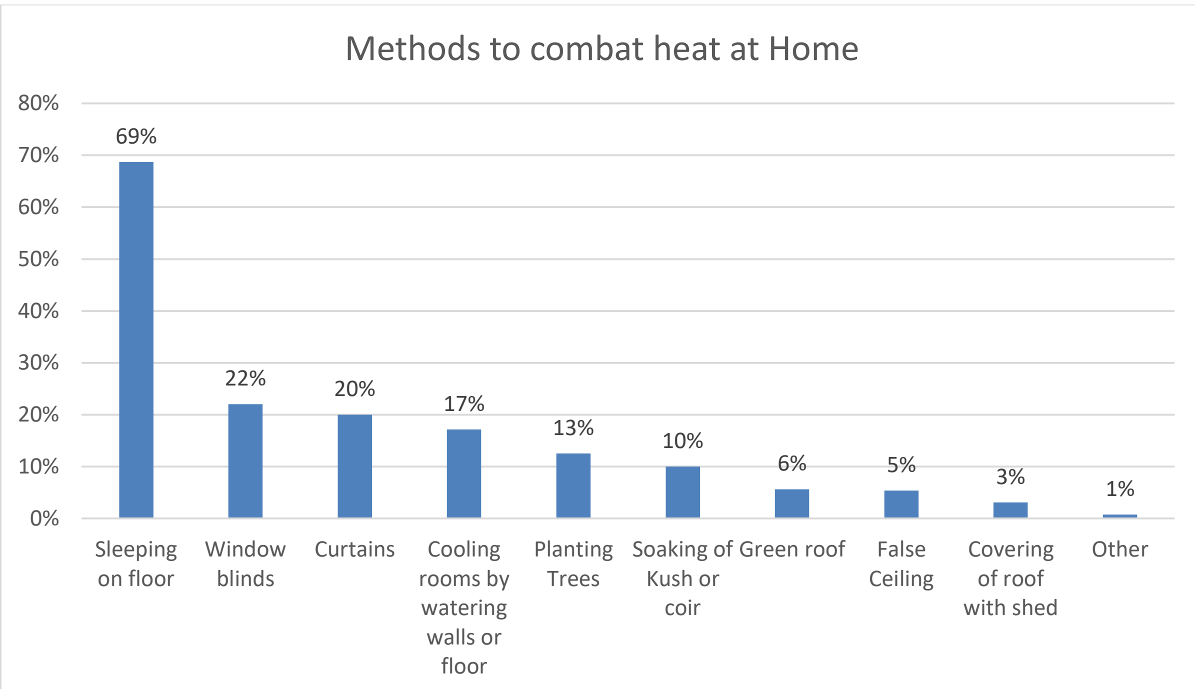
The table 5.12.1 (a) shows that mitigation actions include coping heat-related discomfort are drinking water frequently (78%), wearing comfortable clothing (70%), using electric fans/coolers/ACs (60%).

5.12.2 Initiatives at HH Level to Combat Heat

Methods to combat heat at home										
Delhi city	**Window blinds**	**Curtains**	**Soaking of Kush or coir**	**Sleeping on floor**	**False Ceiling**	**Green roof**	**Covering of roof with**	**Planting Trees**	**Cooling rooms by watering walls or**	**Other**

							shed		**floor**	
Absolute Numbers	86	78	39	268	21	22	12	49	67	3
Percentage distribution (within options)	22.05	20	10	69	5.4	5.64	3.08	13	17	1

Table: 5.12.2 (a)



Graph: 5.12.2 (a)

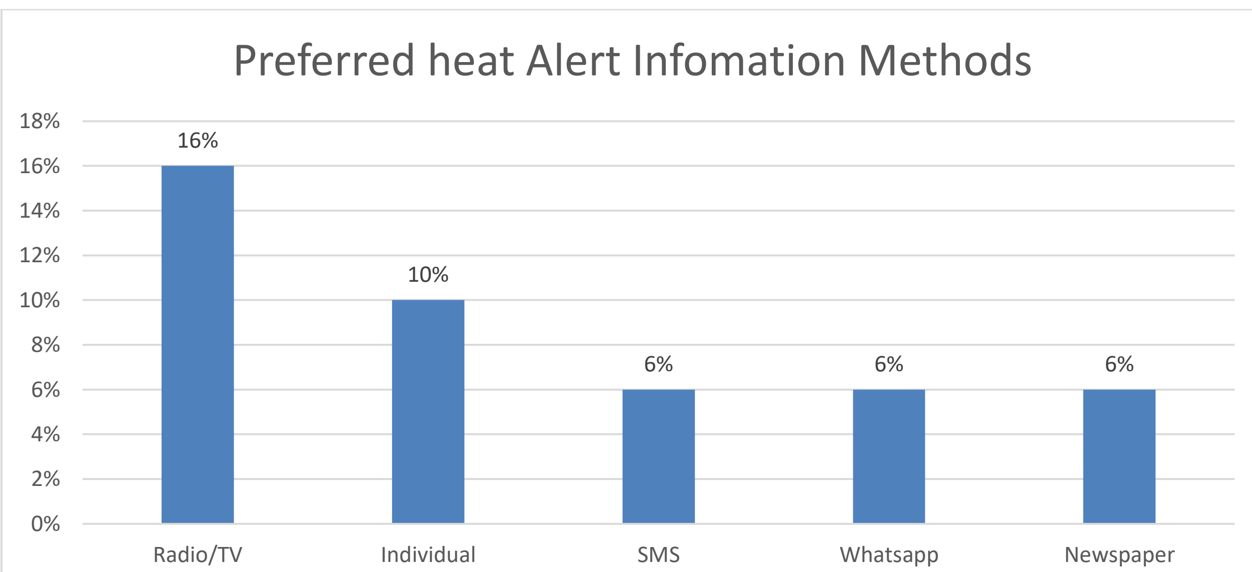
Table 5.12.2 (a) shows that the most preferred mitigation methods to combat heat at the household level are – sleeping on the floor (69%), window blinds (22%), and using curtains (20%).

5.13 Preferred Communication Strategies

5.13.1 The Medium of Communication for Receiving Alerts

Preferred Communication Medium for Alerts								
Delhi city	**SMS**	**Whats App**	**Leaflet s**	**Newsp apers**	**Radio/ TV**	**Individ ual**	**Others**	**Don't Know**
Absolute Numbers	23	22	0	22	64	38	0	1
Percentage distribution (within options)	5.9	5.64	0	5.64	16.4	9.74	0	0.26

Table: 5.13.1 (a)



Graph: 5.13.1 (a)

For a majority (16%), radio is the most preferred medium for alerts, which is followed by information from individuals (10%). The information dissemination methods could use this knowledge for dissemination on heat stress. It will also improve information sharing at the community level.

Implications: The preferred medium as the survey shows for information sharing is radio/TV, which should be used by city authorities to spread awareness about heat wave and give advisories to deal with associated health impacts.

6 Conclusions and Key Recommendations

The analysis of the city level Vulnerability Assessment of Delhi indicates that urban poor are most vulnerable to heat stress and its associated impacts. Notably, due to heat stress, households are most susceptible due to housing viz., the material used and its structure, access to services such as water, and availability of services such as electricity. These not only aggravate heat related issues, but also result in deterioration of health, loss of lives and livelihoods. A critical factor that emerged from the study is that households have very little knowledge and awareness about the adaptive and mitigation strategies adopted by local institutions. In a scenario of low coverage of health insurance, the imperative is that public health systems should be improved and focus should be on knowledge dissemination.

While the impacts of heat stress are visible through the sectors, cities can combine sectoral initiatives with a well-defined and coherent framework that ties both mitigation and adaptation together. These provide entry points to combat heat stress in specific sectors of public health, housing, infrastructure, and services. The recommendations outline an overarching framework to ensure the maximum impacts of these sector-based initiatives.

6.1 Public Health

6.1.1 Key Challenges

1. Households do not have access to public health facilities in immediate areas. Thereby making it difficult to access public health facilities in case of an emergency.

2. Most households prefer to visit public hospitals due to their affordability or trust in the public health care system.

3. Among the members in a household, senior citizens struggle the most from heat cramps and heat exhaustion, indicating that the indoor heat stress is a huge challenge.

4. The effects of heat stress are causing public health issues among households, and access to public health in the vicinity is essential.

6.1.2 Way Forward

1. Public health centres may be built closer to the neighbourhood with sufficient capacity to cater to all the people. These centres should be provided, especially in the identified heat vulnerability zones of the city.

2. Awareness of the potential effects of heat stress and ways to mitigate it should be disseminated to the households.

3. Line workers such as Anganwadis and Asha workers should routinely visit senior citizens to monitor their health. Necessary sensitization and trainings should be provided to these workers.

6.2 Transport

6.2.1 Key Challenges

1. Since most of the residents live close to their work place, most of them walk. However, walking is problematic in that the footpaths are not well constructed or broken and lack greenery to provide thermal comfort.

2. During the peak summer, public health risk might increase for people walking to work. It may cause thermal discomfort and lead to a loss of workdays. Heat-vulnerable people, e.g., older people or pregnant women, might not be in a situation to travel.

3. Roads in extreme heat can cause roads to melt and concrete surfaces to rip apart. These make cycling very difficult.

6.2.2 Way Forward

1. Construction of footpaths to ensure people walk with ease and greening provides shaded spaces to walk. It needs to be highlighted greening lowers surface and air temperatures due to evapotranspiration.

2. Greening may be carried around the pavements and designated places for pedestrians to rest.

3. Awareness should be increased about protection measures like promoting the use umbrellas, covering the head, and carrying water which are also cost-effective measures.

4. Road quality improvement to deal with the changing temperatures and allowing easy movement of vehicles is very important.

6.3 Housing

6.3.1 Key Challenges

1. Affordability is a big factor that forces people to stay in small sized houses. Often, resulting in many people living in small spaces. Among the informal settlements, investment is still lower due to high rental tenure and inadequate housing finance.

2. Housing design, materials, and construction methods are often inappropriate, increasing heat stress vulnerabilities. These structures trap heat inside the house also due to little ventilation.

3. The microclimate needs to be improved to make it thermally comfortable. Existing housing options may not meet the needs of vulnerable sections of society, especially the elderly.

6.3.2 Way Forward

1. Provide support to mitigate extreme impacts of heat stress by painting the roof white, increase intake of fluids, and wearing cotton clothes.

2. Incremental upgrading of housing may be undertaken to reduce heat stress vulnerabilities by way of improving the building design and material.

3. Encourage pro-poor housing finance by making traditional markets and credit mechanisms accessible to the urban poor.

6.4 Water

6.4.1 Key Challenges

1. Due to rising temperatures, there is often water shortage, and there may be limited water availability due to low pressure.

2. There are challenges regarding the availability of water from different sources.

3. Local watersheds are severely stressed with rising temperatures.

6.4.2 Way Forward

1. Widen the network of municipal water supply to households to ensure adequate water availability.

2. Improve water availability, and its quality to minimize the dependence of households on other sources of water supply.

3. Educate people for using water wisely to deal with water shortages.

4. Implement affordable water tariffs for households to improve water access.

6.5 Electricity

6.5.1 Key Challenges

1. Electricity demand tends to increase during heat stress, which puts a strain on existing systems and leads to shortages. It often results in frequent power cuts and blackouts.

2. The power tariffs may be too high making it less affordable among poor households.

3. Electricity cuts can leave people vulnerable, mostly elderly, children, and women, to the risks of heat and have cascading impacts on other urban services.

6.5.2 Way Forward

1. Focus should not only be on electricity generation but also on connecting all households to the grid.
2. Technological alternatives for electricity should be explored to ensure energy efficiency.
3. Electricity conservation measures may be shared with households.
4. Heat stress awareness and adaptive measures are essential.

6.6 Heat Stress Awareness and Adaptive measures

6.6.1 Key Challenges

1. Low-income residents often have sparse information on vulnerability due to heat stress.
2. Households have insufficient knowledge of the adaptive and mitigation measures to be undertaken to deal with heat stress, such as information about medical facilities offering treatment for heat stress. They have little information on such measures being undertaken by their ULBs.
3. Due to unaffordability, most of the households are out of insurance cover. It not only decreases the ability of households to take care of medical expenses, but also limits their ability to access private medical facilities in case of emergency.

6.6.2 Way Forward

1. Use social media platforms to increase access to information on heat alerts, heat stress advisories.

2. Government hospitals have to organize health check-up/ sensitization workshops for households in the community.

3. Develop affordable health insurance schemes, especially for the vulnerable sections of society, such as the elderly, poor, and women.

6.7 Livelihood and Productivity

6.7.1 Key Challenges

1. Due to heat stress a majority of workers not only lose their wages but also lose their man-days of work as well.

2. Growing heat stress and extreme outdoor temperatures make it difficult for outdoor workers, and causal workers are most at risk of losing wages.

3. Travelling to workplace may also lead to workers experiencing heat exhaustion during high temperatures.

4. Along with loss in wages, the productivity of individuals is also positively affected.

6.7.2 Way Forward

1. The focus should be on improved urban design, and sustainable planning can help in increasing the green spaces, and cooling the environment is critical to minimizing heat-health issues.

2. Develop an early warning system for heat stress that helps in preparedness.

3. There should be flexibility in working hours, especially for outdoor workers during the peak period. It will improve workers' productivity.

4. The heat stress evidence base needs to be reviewed regularly to design advisories for targeted prevention strategies.

5. For peak summers special intervention plans should be developed.

7 The Overarching Framework for Sustainable Heat Stress Response

Coherent measures taken in each of the identified sectors will help in minimizing extreme impacts of heat stress vulnerabilities among households. A macro framework is needed to help in further strengthening heat mitigation measures and inform policymaking. The measures include viz., governance and institutional framework, local institutional capacity; resilient infrastructure; improving socio-economic conditions, encouraging public-private partnership. Their components are detailed in the table.

Macro- framework component	**Short-term Actions**	**Long-term Actions**
Governance and institutions	-Heat Action Plans -Health-system preparedness -Monitoring and health surveillance -Clarity of role and coordination among agencies -Cool roofs -Public awareness and community outreach -Uninterrupted access to the basic services	-Climate risk reduction in alignment with heat reduction -Policy development -Post heat wave review on the existing plan and updating the plan -Minimizing vulnerability due to heat stress

Local institutional capacity	-Building capacity for better systemic response and preparedness -Early warning system - Temperature forecast	-Strengthening existing system structures to make it more responsive -Community engagement for the inclusion of vulnerable households -Emergency preparedness
Resilient infrastructure	-Pooling resources -Improving coverage and service delivery -Social infrastructure: Capacity building communities, community-based organization, and mobilizers such as Mahila Arogya Samiti, ASHA workers, anganwadis workers and Self-Employed Women's Association (SEWA).	-Setting heat standards and implementation for urban planning, infrastructure, industries, services like transport, building design, road, water resource management, etc. -Revising the existing building Regulation -Encouraging the passive building designs -Affordable tariffs
Improving socio-economic conditions	-Implementation of central/ state-sponsored schemes on services and housing	-Redevelopment of housing for below poverty line households to combat heat—with measures like cool roofs - Improving access to basic services
Encouraging public-private partnership	-Collaboration with non-government and civil society -Private hospitals to provide treatment for heat stress -Resource mobilization	-Health insurance for the vulnerable, especially the poor, elderly, and women -Joint venture for infrastructure development / service delivery

Table Macro-Framework for reducing Heat stress vulnerability

Heat stress has to be managed at the local level which necessitates comprehensive planning and coordination. A macro framework will consider sector-specific initiatives and tie them well to ensure sustainability and effective management.

However, stakeholders need to be involved in planning and execution of heat stress minimization interventions. These measures have to be both short-term and long term in promoting heat stress management. The outcomes of such steps are:

1. Transparent allocation of roles and responsibilities of stakeholders for better preparedness and prompt response.
2. Identify vulnerable hotspots in the city and provide targeted measures.
3. Knowledge dissemination and capacity building of the communities, including the institutions and stakeholders.
4. Heat stress management plans to mitigate impacts of heat stress effectively.