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# EFFECT OF HEATWAVE DURING MEDICAL RESPONSE – A STUDY OF DEMOGRAPHIC VARIATIONS IN KOLKATA

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## ABSTRACT
*This paper addresses the impact of demographic attributes such as age, occupation and gender on heat related discomfort among patients reporting to hospitals for treatment. The study is based on empirical data collected through questionnaires and open discussions, the quantitative part of which has been analyzed using the Kruskal Wallis Test. Generic in nature, the research does have significant managerial and research implications.*
**KEYWORDS***: Heatwave, Demographic Impact, Patient Care, Kruskal Wallis Test, Emergency Protocols, Kolkata Hospitals*

## INTRODUCTION
Heatwaves pose a significant health challenge, especially in regions like Kolkata, where rising temperatures are common. This study explores the impact of heatwaves on patients, focusing on how demographic attributes—such as age—influence the severity of heat-related discomfort. Additionally, it examines the extra medical measures implemented by hospitals to mitigate heat-induced distress and identifies key factors hospitals need to consider when admitting patients in heat-related emergencies. The research addresses a critical gap by investigating the relationship between patient demographics and heatwave severity, an area with limited empirical studies in the Indian healthcare context and with significant reason for further studies. **Questions that indicate a research gap are as follows:** *What is the impact of demographic attributes, specifically age, on the severity of heat-related discomfort? What additional medical measures are taken by hospitals to reduce discomfort in heat-related emergency cases? What are the essential factors that hospital emergency departments need to consider when admitting patients for heat-related illnesses?* This paper aims to use empirical study to bridge the said research gaps

## OBJECTIVES
1. To identify demographic factors that cause significant levels of discomfort in heat-related reports to hospital emergencies
2. To identify extra medical measures needed to be taken by hospital administration to mitigate the levels of heat-related discomfort for separate demographic segments

## METHODOLOGY, SCOPE AND LIMITATIONS
This exploratory study employs an initial mixed-method approach, combining some qualitative data from patient records and qualitative interviews with healthcare professionals to get an initial set of variables. It also relates the same to UN's 17 Sustainable Development Goals: Especially Goal No 3 (Ensure healthy lives and promote well-being for all at all ages) and related goals. (Global Sustainable Development Report 2023, 2023), (TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT, 2015)
A total of 148 patients selected by convenience were interviewed across multiple Kolkata hospitals (private unaided and aided) during a heatwave period and their opinions listed on a Likert Scale. The Variable List with Codes is depicted in Table 1.

SPSS Package Ver 27 is used to analyse the said data using Kruskal Wallis Test for independent samples as Normalcy was ruled out in the initial testing. (Reference: Table 2) The variables Age, Gender and Occupation were treated as Ordinal and remaining as Scale to ease computations. It may also be noted that sub-sample responses, treating the different age, gender and occupational brackets as subgroups, are independent of each other and not ordered (thus we do not use the Jonckheere-Terpstra test). It is also assumed with a preliminary inspection that the data within each subgroup has the same variability. (Kruskal-Wallis H Test using SPSS Statistics, 2018) It may be noted that the null hypothesis is that there is no significant difference towards thermal pain perception in each of the said groupings. The null hypothesis, in this case is H0: Variation in Dependent Variable is not significantly affected by Grouping Factor. 7 Dependent Variable would be Mood, Dehydration, Thirst, Discomfort, AvoidOiutdoor, WorkProductivity, SleepProblems and the 3 Grouping factors are: Age, Gender, Occupation. The level of significance is maintained at 95%

The variables have been listed after a single stage interview process and would thus present a limitation in the instrument as a multistage process may have shown deeper insights. Also, the sample is of size 148 and is convenient, lending some bias to the data.

Nevertheless, the study can point to areas that healthcare providers need to focus on as cities in tropical regions battle heatwave concerns.

| **Demographic Variables** | | | **Dependent Variables Judged using Likert Scale** | |
|---|---|---|---|---|
| Name of Variable | Choices | Codes | **Details** | **Name of Variable** |
| Age (years) | 0 to 20 | 1 | Summertime highs have an effect on my mood and general well-being | Mood |
| | 21 to 40 | 2 | I am more prone to dehydration and heat-related illnesses in summer | Dehyration |
| | 41 to 60 | 3 | I feel more uncomfortable while working outside during summer | Discomfort |
| | 61 to 80 | 4 | I feel more thirsty while working outside during summer | ThirstLevel |
| Gender | Male | 1 | I avoid outdoor activities during peak heat hours | AvoidOutdoor |
| | Female | 2 | The summer heat affects my work productivity | WorkProductivity |
| | Others | 3 | I find it difficult to sleep comfortably during hot summer nights | SleepProblems |
| Occupation | Public Sector | 1 | **Details of Likert Scale: Choices** | **Codes** |
| | Private Sector | 2 | Strongly Agree | 1 |
| | Business | 3 | Agree | 2 |
| | Retired | 4 | Neutral | 3 |
| | Student | 5 | Disagree | 4 |
| | | | Strongly Disagree | 5 |

**Table 1: A Description of Variables; Source: Research Output**

**Tests of Normality: Age**

| Age | | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Mood | 1 | 0.252 | 21 | 0.001 | 0.815 | 21 | 0.001 |
| | 2 | 0.309 | 67 | 0.000 | 0.761 | 67 | 0.000 |
| | 3 | 0.204 | 33 | 0.001 | 0.857 | 33 | 0.000 |
| | 4 | 0.460 | 27 | 0.000 | 0.549 | 27 | 0.000 |
| Dehydration | 1 | 0.262 | 21 | 0.001 | 0.812 | 21 | 0.001 |
| | 2 | 0.220 | 67 | 0.000 | 0.864 | 67 | 0.000 |
| | 3 | 0.229 | 33 | 0.000 | 0.811 | 33 | 0.000 |
| | 4 | 0.404 | 27 | 0.000 | 0.614 | 27 | 0.000 |
| Discomfort | 1 | 0.346 | 21 | 0.000 | 0.663 | 21 | 0.000 |
| | 2 | 0.318 | 67 | 0.000 | 0.687 | 67 | 0.000 |
| | 3 | 0.275 | 33 | 0.000 | 0.821 | 33 | 0.000 |
| | 4 | 0.452 | 27 | 0.000 | 0.551 | 27 | 0.000 |
| ThirstLevel | 1 | 0.359 | 21 | 0.000 | 0.682 | 21 | 0.000 |
| | 2 | 0.375 | 67 | 0.000 | 0.690 | 67 | 0.000 |
| | 3 | 0.265 | 33 | 0.000 | 0.788 | 33 | 0.000 |
| | 4 | 0.385 | 27 | 0.000 | 0.626 | 27 | 0.000 |
| AvoidOutdoor | 1 | 0.331 | 21 | 0.000 | 0.711 | 21 | 0.000 |
| | 2 | 0.331 | 67 | 0.000 | 0.719 | 67 | 0.000 |
| | 3 | 0.220 | 33 | 0.000 | 0.847 | 33 | 0.000 |
| | 4 | 0.478 | 27 | 0.000 | 0.516 | 27 | 0.000 |
| WorkProductivity | 1 | 0.227 | 21 | 0.006 | 0.839 | 21 | 0.003 |
| | 2 | 0.238 | 67 | 0.000 | 0.809 | 67 | 0.000 |
| | 3 | 0.326 | 33 | 0.000 | 0.725 | 33 | 0.000 |
| | 4 | 0.511 | 27 | 0.000 | 0.427 | 27 | 0.000 |
| SleepProblems | 1 | 0.277 | 21 | 0.000 | 0.780 | 21 | 0.000 |
| | 2 | 0.345 | 67 | 0.000 | 0.724 | 67 | 0.000 |
| | 3 | 0.444 | 33 | 0.000 | 0.441 | 33 | 0.000 |
| | 4 | 0.535 | 27 | 0.000 | 0.294 | 27 | 0.000 |

a. Lilliefors Significance Correction

**Tests of Normality: Gender**

| Gender | | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Mood | 1 | 0.207 | 75 | 0.000 | 0.832 | 75 | 0.000 |
| | 2 | 0.393 | 73 | 0.000 | 0.620 | 73 | 0.000 |
| Dehydration | 1 | 0.270 | 75 | 0.000 | 0.852 | 75 | 0.000 |
| | 2 | 0.281 | 73 | 0.000 | 0.796 | 73 | 0.000 |
| Discomfort | 1 | 0.278 | 75 | 0.000 | 0.764 | 75 | 0.000 |
| | 2 | 0.350 | 73 | 0.000 | 0.666 | 73 | 0.000 |
| ThirstLevel | 1 | 0.298 | 75 | 0.000 | 0.758 | 75 | 0.000 |
| | 2 | 0.388 | 73 | 0.000 | 0.607 | 73 | 0.000 |
| AvoidOutdoor | 1 | 0.273 | 75 | 0.000 | 0.771 | 75 | 0.000 |
| | 2 | 0.390 | 73 | 0.000 | 0.661 | 73 | 0.000 |
| WorkProductivity | 1 | 0.251 | 75 | 0.000 | 0.823 | 75 | 0.000 |
| | 2 | 0.314 | 73 | 0.000 | 0.762 | 73 | 0.000 |
| SleepProblems | 1 | 0.343 | 75 | 0.000 | 0.707 | 75 | 0.000 |
| | 2 | 0.284 | 73 | 0.000 | 0.749 | 73 | 0.000 |

a. Lilliefors Significance Correction

**Tests of Normality: Occupation**

| Occupation | | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Mood | 1 | 0.371 | 13 | 0.000 | 0.706 | 13 | 0.001 |
| | 2 | 0.222 | 46 | 0.000 | 0.862 | 46 | 0.000 |
| | 3 | 0.401 | 11 | 0.000 | 0.625 | 11 | 0.000 |
| | 4 | 0.430 | 22 | 0.000 | 0.590 | 22 | 0.000 |
| | 5 | 0.326 | 56 | 0.000 | 0.757 | 56 | 0.000 |
| Dehydration | 1 | 0.345 | 13 | 0.000 | 0.821 | 13 | 0.012 |
| | 2 | 0.238 | 46 | 0.000 | 0.854 | 46 | 0.000 |
| | 3 | 0.353 | 11 | 0.000 | 0.649 | 11 | 0.000 |
| | 4 | 0.496 | 22 | 0.000 | 0.474 | 22 | 0.000 |
| | 5 | 0.232 | 56 | 0.000 | 0.848 | 56 | 0.000 |
| Discomfort | 1 | 0.392 | 13 | 0.000 | 0.628 | 13 | 0.000 |
| | 2 | 0.280 | 46 | 0.000 | 0.751 | 46 | 0.000 |
| | 3 | 0.332 | 11 | 0.001 | 0.756 | 11 | 0.002 |
| | 4 | 0.539 | 22 | 0.000 | 0.221 | 22 | 0.000 |
| | 5 | 0.351 | 56 | 0.000 | 0.654 | 56 | 0.000 |
| ThirstLevel | 1 | 0.456 | 13 | 0.000 | 0.567 | 13 | 0.000 |
| | 2 | 0.294 | 46 | 0.000 | 0.685 | 46 | 0.000 |
| | 3 | 0.401 | 11 | 0.000 | 0.625 | 11 | 0.000 |
| | 4 | 0.419 | 22 | 0.000 | 0.556 | 22 | 0.000 |
| | 5 | 0.366 | 56 | 0.000 | 0.691 | 56 | 0.000 |
| AvoidOutdoor | 1 | 0.470 | 13 | 0.000 | 0.533 | 13 | 0.000 |
| | 2 | 0.245 | 46 | 0.000 | 0.807 | 46 | 0.000 |
| | 3 | 0.343 | 11 | 0.001 | 0.697 | 11 | 0.000 |
| | 4 | 0.452 | 22 | 0.000 | 0.561 | 22 | 0.000 |
| | 5 | 0.335 | 56 | 0.000 | 0.742 | 56 | 0.000 |
| WorkProductivity | 1 | 0.354 | 13 | 0.000 | 0.705 | 13 | 0.001 |
| | 2 | 0.259 | 46 | 0.000 | 0.829 | 46 | 0.000 |
| | 3 | 0.343 | 11 | 0.001 | 0.697 | 11 | 0.000 |
| | 4 | 0.475 | 22 | 0.000 | 0.522 | 22 | 0.000 |
| | 5 | 0.273 | 56 | 0.000 | 0.780 | 56 | 0.000 |
| SleepProblems | 1 | 0.470 | 13 | 0.000 | 0.533 | 13 | 0.000 |
| | 2 | 0.320 | 46 | 0.000 | 0.735 | 46 | 0.000 |
| | 3 | | 11 | | | 11 | |
| | 4 | 0.515 | 22 | 0.000 | 0.412 | 22 | 0.000 |
| | 5 | 0.340 | 56 | 0.000 | 0.724 | 56 | 0.000 |

a. Lilliefors Significance Correction

**Table 2: Tests for Normality; Source: Research Output vide SPSS Ver 27**

## REVIEW OF LITERATURE

Given the increasing severity of heat waves brought on by climate change, research on the effects of demographic characteristics on the intensity of heat-related suffering is crucial.

**Ageing Effects on thermal pain perception**:

- Edwards & Fillingim, 2001, examined how ageing affects thermal pain perception, focusing on pain intensity and unpleasantness in response to repeated stimuli. It compared 34 younger (mean age 22.4) and 34 older adults (mean age 62.2) using thermal stimuli at 47°C, 50°C, and 53°C applied to the forearm. Results showed that older adults experienced higher pain intensity and unpleasantness, particularly at lower temperatures (47°C and 50°C), and displayed greater temporal summation of pain, suggesting age-related differences in pain modulation. (Edwards & Fillingim, 2001)
- Macintyre, et al., 2018, found that during heatwaves, urban heat island (UHI) intensity can reach up to +9.6°C, with older age groups and more deprived populations being disproportionately areas. Additionally,

hospitals and other centres experience higher-than-average temperatures both day and night during such events. (Macintyre, et al., 2018)

- Chambers, 2020 focussed on the increasing global temperature rise caused by climate change and heatwaves as a concern, especially towards populations above 65 years. This study's methodology uses global climate, population, demographic, and health data from 1980 to 2018 to assess trends in heatwave exposure for vulnerable groups worldwide. The findings reveal an alarming trend where heatwave days posed to vulnerable populations is highly extreme, exceeding times the global average. (Chambers, 2020)
- Weitz, Mukhopadhyay, & Das, 2022, examined heat-related stress in elderly populations in Kolkata slums and rural areas, focusing on 310 participants across both locations. Researchers used monitoring devices to track temperature, humidity, and heat index over 24-hour periods during the summer. Results showed that slum residents faced significantly hotter indoor conditions due to urban heat effects, leading to a 4.3 times higher likelihood of experiencing dangerous heat index levels (≥ 45°C) compared to their rural counterparts. (Weitz, Mukhopadhyay, & Das, 2022)

**Effects of occupation on thermal pain perception**

- Balasubramanian, 2023, noted that many of the Indian farmers who work outside are likely to face worsening health impacts due to extreme global warming owing to increased incidences of heat stroke, asthma, skin conditions and chronic kidney diseases, among others. The constant threat of high temperatures can also lead to psychological influences such as depression, anxiety and other sociological disturbances. It notes that the effective combination of both psychological and pharmaceutical measures aiming at psycho-stress management in climate-induced disorders may have a better outcome. (BALASUBRAMANIAN, 2023)
- Venugopal, Latha, Shanmugam, Krishnamoorthy, & Johnson, 2020, investigate the worrying health hazards of excessive exposure to heat among catered workers, more specifically in tropical industrial settings. Using cross-sectional methodology, information was collected from around 1,900 employees in eight industries. Results showed that 67% of workers experienced heat levels above recommended limits, with many reporting heat-related symptoms. Notably, workers in employment with high exposure to heat suffered 2.3 times higher adverse health outcomes like kidney stones. (Venugopal, Latha, Shanmugam, Krishnamoorthy, & Johnson, 2020)
- Lala & Hagishima, 2023, researched on heat vulnerability among school children in India and noted that such studies still limited. In February 2020, a survey was conducted with 335 primary school teachers across 35 schools in seven hot-climate Indian cities (Delhi, Jaipur, Ajmer, Vadodara, Udaipur, Ahmedabad, and Pune). The study revealed significant challenges faced by teachers and students during heatwaves, including noticeable physical symptoms of heat distress among children, such as exhaustion and dizziness and increased instances of absences on extreme heat days. Findings show that nearly all teachers (96%) have felt physically unwell due to excessive heat, affecting their teaching effectiveness. Importantly, all teachers noted a direct correlation between rising temperatures and an increase in student complaints of heat-related sickness. (Lala & Hagishima, 2023)

**Effects of Heatwave on Public Health**

- Rathi, Sodani, & Joshi, 2021, focused on the link between extreme heat and all-cause mortality in Jaipur's urban population, analysing summer data (March to June) from 2006 to 2015. By assessing daily maximum, minimum, and mean temperatures, relative humidity, and the heat index (HI), researchers found that mortality rose significantly with increased temperatures. Specifically, there was a 39% increase in deaths on days where maximum temperatures reached or exceeded 45°C. (Rathi, Sodani, & Joshi, 2021)
- Khan, et al., 2023, explored how educational training on heat emergencies could improve emergency department (ED) practices in diagnosing and managing heat-related cases in Karachi, Pakistan. Conducted as a quasi-experiment in four hospitals, researchers assessed pre- and post-intervention data around an educational program, designed to help healthcare providers recognize and treat heat emergencies. Out of over 8,200 patients enrolled with heat-related symptoms, more than 4,100 cases were documented in the pre-intervention period (May to July 2017) and around 4,022 in the post-intervention period (May to July 2018). These results highlight the effectiveness of targeted educational interventions in enhancing critical diagnostic and management practices for heat emergencies in emergency settings. (Khan, et al., 2023)
- Awasthi, Vishwakarma, & Pattnayak, 2021, A study examined the increase in the frequency and severity of heat waves (HW) globally, analysing their impact on public health. They discussed the importance of heat index (HI) metrics and documents how definitions of HW and HI vary across regions using data the research assesses daily temperature and humidity records across 40 years (1979–2018), examining annual trends and temperature variations across global regions. The analysis highlights a need for updated formulas and region-

specific adaptations to assist researchers and policymakers in creating tailored responses to heat stress. (Awasthi, Vishwakarma, & Pattnayak, 2021)

- Dutta, et al., 2020, in Bhubaneswar, India, investigated the link between ambient heat and all-cause mortality over a decade (2007–2017). Findings showed that mortality risk rose significantly when temperatures exceeded two thresholds: a lower threshold of 36.2°C and a higher threshold of 40.5°C, with a 2% increase in mortality risk for each degree above 36.2°C. High minimum temperatures (over 25.6°C) intensified this risk, suggesting that sustained night-time heat exacerbates health impacts. (Dutta, et al., 2020)
- Ganguli, 2023, investigated compound warm-dry spells in India's urban and peri-urban areas, focusing on the combined impacts of heatwaves, low rainfall, and synoptic wind patterns over 1970–2018. It identifies four regions with clustered timing of heatwaves and reveals that severe heat stress driven by temperature alone is evolving into more frequent, complex events when accounting for interdependencies like precipitation and wind. Specifically, these extreme compound warm-dry spells, previously expected to occur once every 50 years, are now anticipated every 5 to 17 years due to climate interactions, highlighting a six-fold increase in frequency. This report indicates that as global temperatures rise, urban areas will increasingly face higher risks from extreme heat, with heatwaves potentially resulting in heightened human mortality, stress on power grids, and increased demand on hospitals and emergency services. (Ganguli, 2023)
- Kumar, et al., 2020: In response to the growing health impacts of climate change, India expanded its climate response framework in 2015 by including health as a core focus area. This effort led to the establishment of the National Action Plan for Climate Change and Human Health (NAPCCHH) in 2018, aiming to fortify healthcare services against climate-related health risks. In 2019, the Ministry of Health and Family Welfare (MoHFW) further solidified these objectives by approving the National Programme on Climate Change and Human Health (NPCCHH) under the National Health Mission (NHM**)**. The NPCCHH addresses climate-sensitive diseases (CSDs), such as those linked to air pollution, heat stress, waterborne and vector-borne diseases, as well as nutrition-related and mental health issues. Their focus lies on Air pollution, heat and human health, climate resilient healthcare facilities. (Kumar, et al., 2020)
- Ninan, et al., 2020, highlighted that heat-related illness (HRI) can lead to severe health consequences, with central nervous system and respiratory system dysfunctions as common manifestations of multiple organ dysfunction syndrome (MODS). Patients admitted with HRI, mostly elderly (mean age 61), were found to experience MODS in 66% of cases, with a mortality rate of 11.1%. The mean heat index in the affected localities was 39.6°C, underscoring the challenging thermal conditions. Cooling techniques like evaporative cooling and cold saline infusions were critical interventions in patient management, applied to all patients and 60% of patients, respectively. (Ninan, et al., 2020)
- Patel, et al., 2022, highlighted in a study that the escalating threat of heatwaves due to climate change and identifies specific health vulnerabilities exacerbated by extreme heat events (EHEs). Key findings include the direct link between EHEs and increased morbidity and mortality, especially for older adults and those with pre-existing health conditions. The study emphasizes disparities in heat exposure globally, with vulnerable populations experiencing up to five times more heatwave days compared to the global average, particularly in regions like the Middle East, Southeast Asia, and parts of China and India. (Patel, et al., 2022)
- Raju, et al., 2021 conducted a study in India during the peak summer months examined heat-related illnesses among patients presenting to the emergency department (ED). Key findings revealed that a majority (63.8%) suffered from heat stroke, while 36.2% experienced heat exhaustion. The affected demographic predominantly included homemakers and manual labourers, with a mean patient age of 59.7 years and a slight male predominance (56.9%). Common symptoms observed were tachycardia and tachypnoea, affecting 80.5% of patients. Computed tomography (CT) scans of the brain in a subset of patients showed acute infarcts (19.6%) and, less commonly, intra-cranial bleeds (3.8%). The study reported a mortality rate of 19.5%, highlighting the serious impact of heat-related conditions on health in tropical climates. (Raju, et al., 2021)
- Sapari, Selamat, Isa, Ismail, & Mahiyuddin, 2023, in an article outlined a systematic review to analyse the impact of heat waves on healthcare systems in low- and middle-income countries (LMICs), where such studies are limited compared to high-income countries. The study anticipates that increasing heat wave events will substantially strain healthcare systems in low- and middle-income countries (LMICs), leading to higher rates of ambulance call-outs, emergency department visits, hospital admissions, and in-hospital mortality, as well as elevated operational costs. (Sapari, Selamat, Isa, Ismail, & Mahiyuddin, 2023)
- Singh, Mall, & Singh, 2020, conducted study on heat waves (HW) and severe heat waves (SHW) in India from 1951 to 2016 reveals an increasing trend in the frequency, duration, and intensity of these events, especially in northwest, central, and south-central regions, with West Madhya Pradesh experiencing the highest rise (0.80 events/year). Conversely, Gangetic West Bengal showed a decline in HW occurrences. SHW events expanded southward in recent decades, particularly in 2001-2010 and 2010-2016. Mortality rates

correlated strongly with HW/SHW events in eastern coastal states like Odisha and Andhra Pradesh, emphasizing the health risk for vulnerable populations. (Singh, Mall, & Singh, 2020)

- Malik, Bhardwaj, & Singh, 2021conducted a study analyses heatwave-related fatalities across India from 1978 to 2014, revealing a total of 660 events causing 12,273 deaths, with Andhra Pradesh, Rajasthan, Odisha, Uttar Pradesh, and Bihar contributing over 80% of fatalities. Heatwave occurrences showed a significant rising trend, with most events in May and June, impacting men more severely than women and children. (Malik, Bhardwaj, & Singh, 2021)
- As the world observes the accomplishment of 17 Sustainable Development Goals (SDSGs), particular attention is drawn to Goal No 3: Good Health for All. Global Sustainable Development Report 2023, 2023 says that leaders need to focus on the extended impact of climate change and the cross impact on the 17 It has also listed that countries need to create capacity to achieve the SDGs. (Global Sustainable Development Report 2023, 2023), (TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT, 2015)

**Effects of occupation on thermal pain perception**

- Toloo, Guo, Xin, Aitken, & Tong, 2014: The study examined the connection between heat-related hospital visits in Brisbane during heatwaves from 2000 to 2008 and socioeconomic disadvantage. The majority of age groups showed elevated risks; however, this impact did not hold over time. Those 65–74 years old living in more underprivileged regions had the highest risk Compared to women males from more underprivileged regions had a somewhat higher relative risk to heat stress. (Toloo, Guo, Xin, Aitken, & Tong, 2014)The study pointed out that overlapping confidence intervals indicate these socioeconomic inequalities should be regarded with caution in spite of these findings.
- Bhan, Kumar, & Paul, 2022: A study examined the association between gender-specific all-cause mortality and maximum temperature in Chandigarh, India, during the summer months of May and June between 2011 and 2015. The results showed that a maximum temperature of 40°C markedly raised death rates, establishing this as a threshold for elevated health risk. According to the study, the mortality rate for both sexes increased significantly at temperatures over 40°C, with a male-to-female ratio of 1.67. (Bhan, Kumar, & Paul, 2022)
- Azhar, Saha, Ganguly, Mavalankar, & Madrigano, 2017: By creating a Heat exposure Index (HVI) at the district level, a study offers a thorough evaluation of heat exposure throughout India. The study finds districts at different risk levels for heat vulnerability by using principal component analysis (PCA) to 17 normalised variables about demographic, socioeconomic, and environmental aspects. Ten of the 640 districts were classified as extremely high-risk, and 97 as high-risk. Most of the riskiest districts were located in central India, where factors such as low literacy, restricted urbanisation, poor access to water and sanitation, and fewer home amenities increase risk. (Azhar, Saha, Ganguly, Mavalankar, & Madrigano, 2017)
- Zavala, Cejas, Rubinstein, & Lopez, 2024: Examining the relationship between gender, health, and climate change, this scoping review highlights how women are disproportionately affected by the health effects of climate change, which exacerbates already-existing gender disparities. Key findings show that mental health, reproductive health, gender-based violence, occupational health, and illnesses connected to heat and air pollution are the areas where gender differences in climate-related health concerns are most noticeable. Furthermore, gender and socioeconomic disparities interact to increase the likelihood of negative health effects. Gender-sensitive and socioeconomic determinants of health-focused climate policy are to be promoted as per the findings. (Zavala, Cejas, Rubinstein, & Lopez, 2024)
- Trahan, Walshe, & Mehta, 2022: A study looks at Ahmedabad, India's Heat Action Plan (HAP), which was put into effect in 2013 and is the first heatwave preparation plan in South Asia. It includes an early warning system (EWS) to reduce heat-related risks. The study evaluates the social vulnerability of female outdoor workers to heat and their access to EWS. Results show that gender influences social vulnerability along with employment, income, and education. Low literacy rates and a lack of access to phone are obstacles to EWS access. Community involvement and verbal warnings might assist in lessening some of these issues. (Trahan, Walshe, & Mehta, 2022)

## FINDINGS FROM THE LITERATURE REVIEW

### Effect of Age on Heat Related Pain Perception

Studies on the impact of heat on older adults reveal that they are highly vulnerable to thermal stress. During heatwaves, urban environments can reach temperatures up to 9.6°C higher than rural areas, disproportionately affecting older and economically disadvantaged groups and keeping hospitals warmer even at night. Global temperature rises and frequent heatwaves pose severe risks to those over 65. Furthermore, elderly people living in urban slums, such as those in Kolkata, are at a much higher risk of experiencing hazardous indoor heat levels due to urban heat effects, making them 4.3 times more likely to endure dangerous heat conditions compared to rural residents. These findings emphasize the critical health risks faced by older adults in densely populated, low-income urban settings during extreme heat events. School children in India also endure significant health issues during heatwaves, commonly experiencing symptoms like exhaustion and dizziness.

**Effect of Occupation on Heat Related Pain Perception**

Studies show that people working outdoors or in high-heat environments face heightened health risks due to extreme temperatures. Indian farmers and other outdoor laborers frequently encounter severe physical illnesses such as heat stroke and kidney disease and also experience rising mental health challenges. Similarly, industrial workers in tropical settings often face dangerous heat levels, with many exposed to conditions beyond safe limits, leading to increased occurrences of heat-related illnesses, including kidney stones. Teachers reported frequent heat-related discomfort, impacting their well-being and teaching capacity. These findings underscore the need for protective measures for those in heat-vulnerable occupations and environments.

**Effects of Heatwave vs Public Health**

Studies show that the rising frequency and intensity of heatwaves are having serious impacts on public health worldwide, especially in India and other regions prone to extreme temperatures. In Jaipur and Bhubaneswar, days when temperatures exceed critical thresholds see sharp increases in mortality rates. In healthcare settings, training has improved responses to heat emergencies, yet the overall strain on hospitals—especially in low- and middle-income countries—is expected to grow with more heat-related emergency visits, admissions, and operational costs. Heatwaves disproportionately impact vulnerable groups, like older adults and individuals with pre-existing conditions, who are exposed to up to five times more extreme heat days compared to global averages. India's central and coastal regions, where heat events are becoming longer and more severe, have also observed high mortality rates, underscoring the urgent need for targeted public health interventions and updated heat index measures to reduce heat-related health risks.

**Effect of Gender on Heat Related Pain Perception**

Men are often at higher direct mortality risk, largely due to outdoor work in heat-vulnerable occupations. However, women also encounter significant heat-related challenges, particularly due to socioeconomic and structural factors. In central Indian districts, low literacy, inadequate urban infrastructure, and limited water access heightened vulnerability to heat waves. Women in particular suffer increased mental and reproductive health challenges during heatwaves. Female outdoor workers, especially those with limited access to early warning systems, are disproportionately impacted. These findings underscore the need for climate policies that address both direct risks faced by men in labour-intensive jobs and indirect, structural vulnerabilities that heighten heat-related health risks for women.

**Survey of Primary Data**

A questionnaire was given to 148 respondents to realize their opinions using a Likert Scale on variables decided through a qualitative interview and discussion. Refer Table 1 & 2, wherein Normalcy of Data was checked. The data was observed to be non-normal. Thus, since it was also unordered, Kruskal Wallis Test was conducted, and the results are shown in Table 3 and Figure 1(a-c).

## RESULTS AND FINDINGS

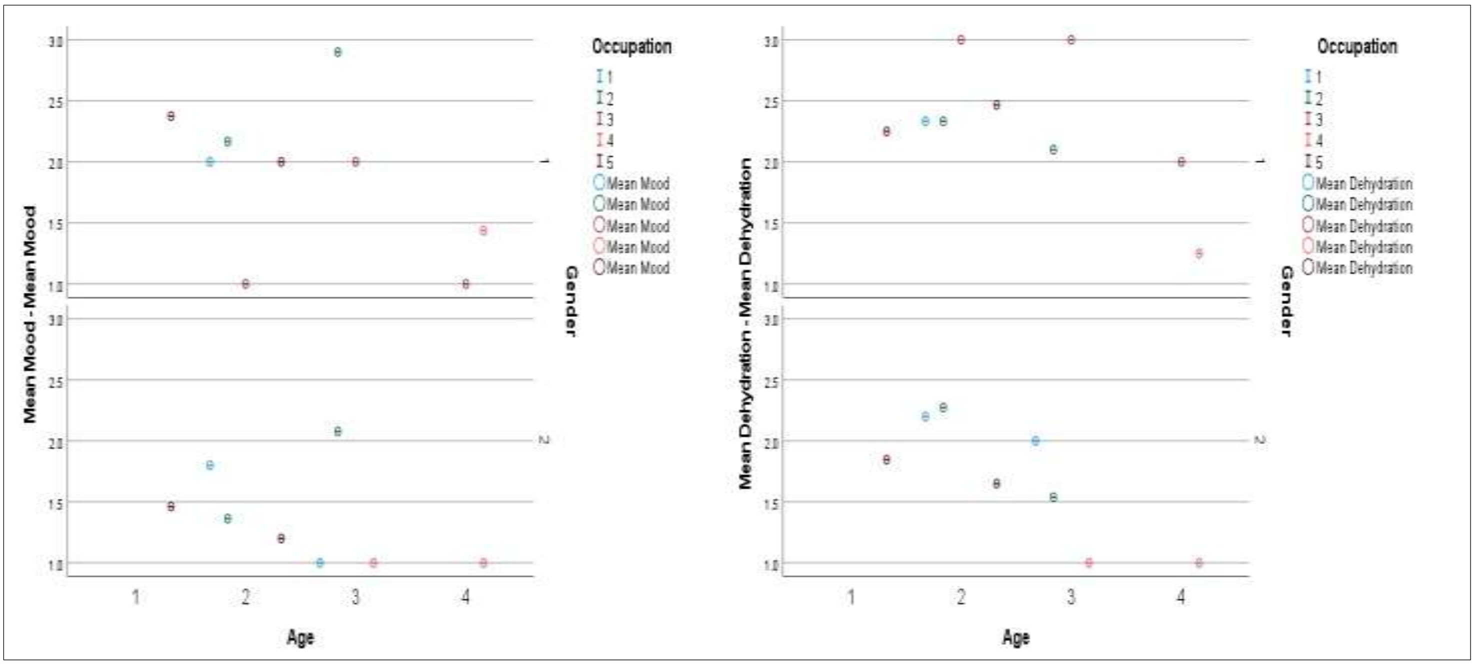


**Figure 1a: High-Low Plot of Mood & Dehydration on Groupings (Source: Research Output, SPSS Ver 27**

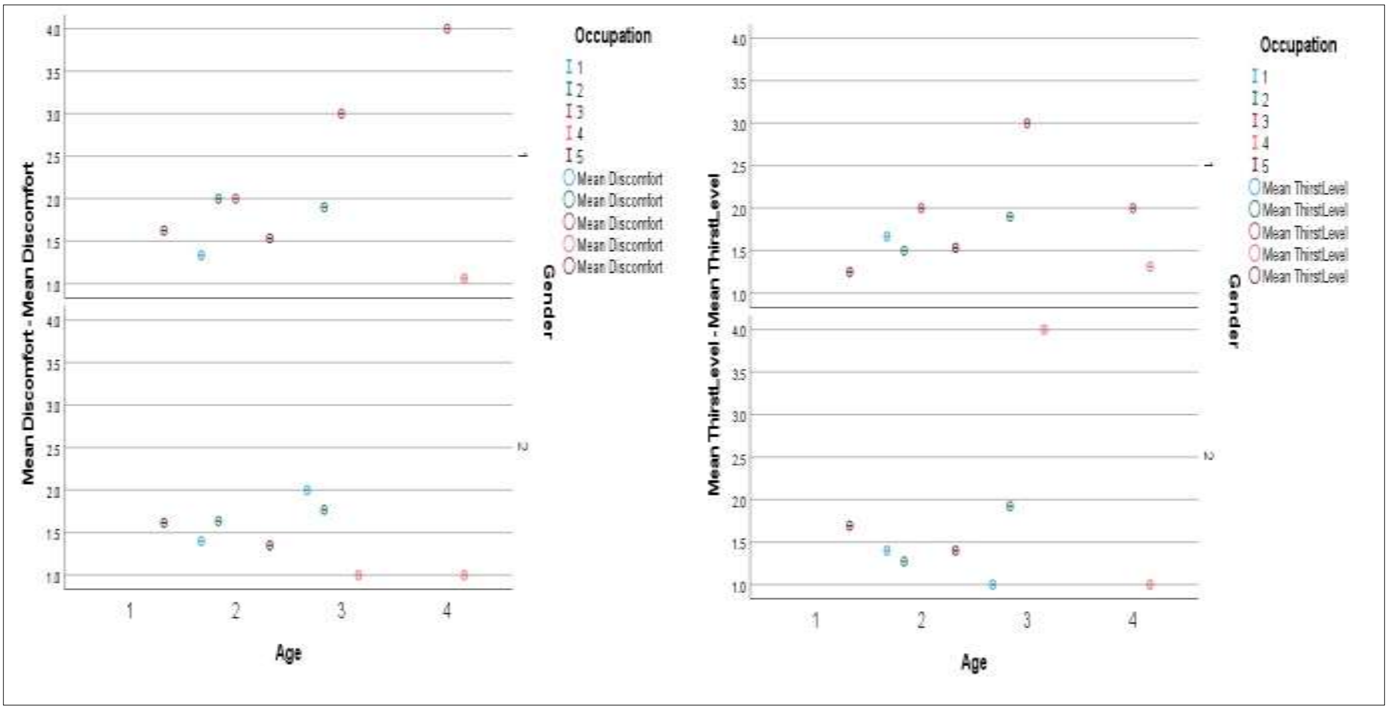


**Figure 1b: High-Low Plot of Discomfort & Thirst on Groupings (Source: Research Output, SPSS Ver 27)**

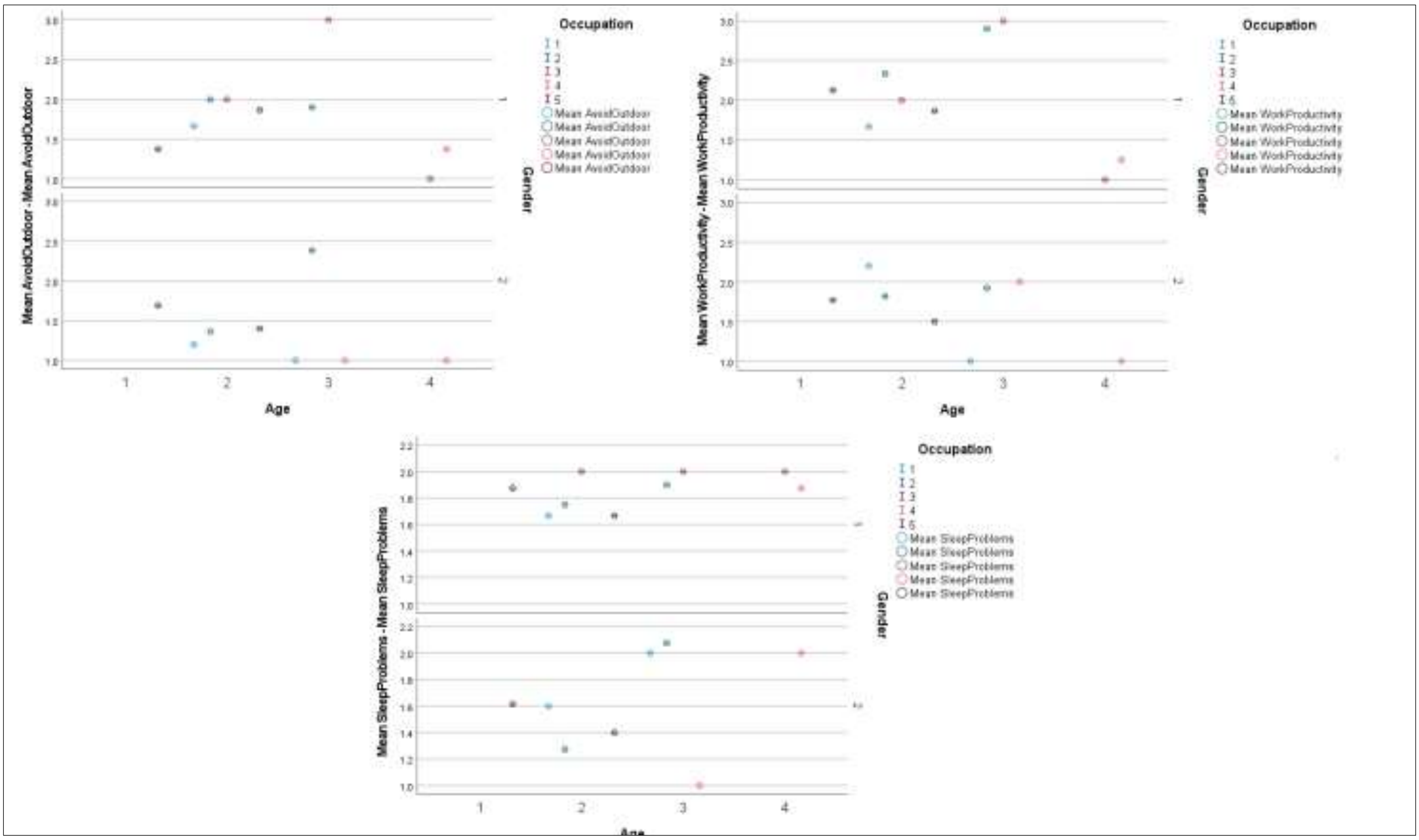


**Figure 1c: High-Low Plot of AvoidOutdoor, WorkProductivity & SleepProblems on Groupings (Source: Research Output, SPSS Ver 27)**

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**Test Statistics[a,b]**

| | Mood | Dehydration | Discomfort | ThirstLevel | AvoidOutdoor | WorkProductivity | SleepProblems |
|---|---|---|---|---|---|---|---|
| Kruskal-Wallis H | 14.957 | 16.472 | 7.416 | 5.441 | 14.012 | 24.680 | 20.693 |
| df | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Asymp. Sig. | 0.002 | 0.001 | 0.060 | 0.142 | 0.003 | 0.000 | 0.000 |

a. Kruskal Wallis Test
b. Grouping Variable: Age

**Test Statistics[a]**

| | Mood | Dehydration | Discomfort | ThirstLevel | AvoidOutdoor | WorkProductivity | SleepProblems |
|---|---|---|---|---|---|---|---|
| N | 148 | 148 | 148 | 148 | 148 | 148 | 148 |
| Median | 2.00 | 2.00 | 1.00 | 1.00 | 1.00 | 2.00 | 2.00 |
| Chi-Square | 14.160[b] | 12.324[c] | 10.618[d] | 2.250[e] | 10.390[f] | 23.224[g] | 5.087[h] |
| df | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Asymp. Sig. | 0.003 | 0.006 | 0.014 | 0.522 | 0.016 | 0.000 | 0.166 |

Grouping Variable: Age

**Test Statistics[a,b]**

| | Mood | Dehydration | Discomfort | ThirstLevel | AvoidOutdoor | WorkProductivity | SleepProblems |
|---|---|---|---|---|---|---|---|
| Kruskal-Wallis H | 19.555 | 6.013 | 2.936 | 4.409 | 3.425 | 4.159 | 4.295 |
| df | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Asymp. Sig. | 0.000 | 0.014 | 0.087 | 0.036 | 0.064 | 0.041 | 0.038 |

a. Kruskal Wallis Test
b. Grouping Variable: Gender

**Test Statistics[a]**

| | Mood | Dehydration | Discomfort | ThirstLevel | AvoidOutdoor | WorkProductivity | SleepProblems |
|---|---|---|---|---|---|---|---|
| N | 148 | 148 | 148 | 148 | 148 | 148 | 148 |
| Median | 2.00 | 2.00 | 1.00 | 1.00 | 1.00 | 2.00 | 2.00 |
| Chi-Square | 11.428[b] | 1.116[c] | 1.787[d] | 6.307[e] | 5.472[f] | 5.873[g] | .002[h] |
| df | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Asymp. Sig. | 0.001 | 0.291 | 0.181 | 0.012 | 0.019 | 0.015 | 0.965 |

Grouping Variable: Gender

**Test Statistics[a,b]**

| | Mood | Dehydration | Discomfort | ThirstLevel | AvoidOutdoor | WorkProductivity | SleepProblems |
|---|---|---|---|---|---|---|---|
| Kruskal-Wallis H | 17.731 | 27.335 | 43.879 | 20.859 | 10.800 | 22.659 | 12.081 |
| df | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Asymp. Sig. | 0.001 | 0.000 | 0.000 | 0.000 | 0.029 | 0.000 | 0.017 |

a. Kruskal Wallis Test
b. Grouping Variable: Occupation

**Test Statistics[a]**

| | Mood | Dehydration | Discomfort | ThirstLevel | AvoidOutdoor | WorkProductivity | SleepProblems |
|---|---|---|---|---|---|---|---|
| N | 148 | 148 | 148 | 148 | 148 | 148 | 148 |
| Median | 2.00 | 2.00 | 1.00 | 1.00 | 1.00 | 2.00 | 2.00 |
| Chi-Square | 14.348[b] | 10.322[c] | 31.753[d] | 19.629[e] | 7.757[f] | 20.089[g] | 6.269[h] |
| df | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Asymp. Sig. | 0.006 | 0.035 | 0.000 | 0.001 | 0.101 | 0.000 | 0.180 |

Grouping Variable: Occupation

Table 3: Kruskal Wallis Test and Median Test Results on Groupings (Source: Research Output, SPSS Ver 27)

**Further Findings from Primary Data Researcher (Author 2)**
The test results underscore that occupation is a particularly influential factor in determining heat-related symptoms, as it significantly affects all measured variables. Age and gender also show meaningful associations with multiple factors, though their influence is somewhat more specific to particular symptoms.

The findings support the need for occupation-specific interventions and additional gender- and age-focused measures to address the diverse impacts of heat exposure on different demographic groups.

**Findings from Case Studies, observed in health facilities**
**Study 1**- The boy's symptoms of painful muscle cramps and sweating are typical signs of dehydration and heat-related stress, a key focus in our survey. Our respondents frequently reported dehydration symptoms such as excessive thirst and dry mouth, indicating that dehydration is a common issue during heatwaves, affecting both adults and children.
**Study 2**- It illustrates the severe health impacts of heat waves on vulnerable populations, such as pregnant women. The patient experienced significant dehydration and related complications, reflecting similar findings from our survey.
**Study 3**- The patient's age and existing health conditions (CHF and COPD) significantly increased her risk of severe heat-related illness.
**Study 4-** A 58-year-old male outdoor worker, was admitted to the ICU during peak summer with fever, confusion, and disorientation. His symptoms were indicating severe illness, with both neurological and renal impairment. Blood tests revealed hyponatremia (sodium level: 124 mmol/L), suggesting dehydration and heat exposure. He was treated with fluids, electrolyte management, and cooling therapy, and required ventilatory support for 5 days.
**Study 5-** A 35-year-old female from a low-income rural area, presented with intense vomiting, diarrhoea, and dizziness after working in the fields during a heatwave. The first responders took him to a local PHC where she was provided ORS and cold sponging upon arrival to alleviate her symptoms. Due to her low-income status and lack of immediate access to healthcare, she was more vulnerable to severe symptoms.
**Study 6-** A 45-year-old female, presented to the ICU with severe symptoms of heat-related illness after prolonged outdoor exposure. She arrived with fever, vomiting, confusion, and speech difficulty. Her diagnosis was showing moderate to severe illness with neurological, renal, and liver involvement. Hyponatremia (sodium level: 130 mmol/L) was noted. MRI confirmed signs of heat stroke, and she received fluids, electrolyte replacement, and cooling.
**Study 7**: A government institute has the policy of keeping cool lemon water on roads and pathways for all those who visit, thus mitigating the impact of heat on all demographic groups/.

## SUMMARY OF FINDINGS

1. **Impact of Age on Thermal Pain Perception:** Both the literature review and the main data analysis highlight the importance of age in heat stress, particularly for vulnerable populations such as older persons and children. According to research, older persons are more likely to experience thermal stress during heatwaves, with metropolitan areas exacerbating the risk owing to heat impacts. Elderly inhabitants in densely packed, low-income neighbourhoods, such as Kolkata's urban slums, are 4.3 times more likely than rural residents to encounter excessive interior heat levels, putting them at risk for heat-related ailments. This is supported by primary data, which show substantial age-based variations in heat-related symptoms such as mood problems, dehydration, avoidance of outdoor activities, decreased job productivity, and sleep troubles. These findings demonstrate that elderly people experience both direct and secondary
2. **Impact on Occupation due to age related Discomforts**: Studies indicate that Indian farmers, outdoor labourers, and industrial workers are regularly exposed to extreme temperatures, leading to serious health concerns such as heat stroke, kidney disease, and other physical and mental health issues. Industrial workers in tropical climates often experience heat levels that exceed safe limits, contributing to a high incidence of heat-related illnesses, including kidney stones. The primary data analysis further supports these findings, demonstrating significant occupational differences in responses to heat stress across various symptoms, including mood disturbances, dehydration, discomfort, thirst levels, avoidance of outdoor activities, decreased work productivity, and sleep disruptions. Teachers, who may not work directly outdoors but still operate in high-heat conditions in classrooms, report frequent heat-related discomfort, affecting both their well-being and ability to perform their duties effectively. Collectively, these findings underscore the need for targeted interventions and protective measures in heat-prone occupations, particularly in tropical and developing regions like India, where climate conditions intensify occupational heat exposure risks.
3. **Impact of Gender due to age-related discomforts**:

Both the literature review and primary data analysis highlight distinct gender-based vulnerabilities to heat stress. Men, often working in outdoor and labour-intensive roles, face a higher direct mortality risk from heat exposure due to prolonged time spent in high temperatures, making them more susceptible to severe health outcomes, including heat stroke and dehydration. The primary data analysis aligns with these findings, showing significant gender differences in responses to heat, with men experiencing notable impacts on mood, dehydration levels, thirst, work- productivity, and sleep. However, women also face considerable heat-related health challenges, often stemming from socioeconomic and structural factors. In many central Indian districts, limited literacy, inadequate infrastructure, and restricted access to clean water increase vulnerability to heat waves, especially for women.

**Managerial Implications within Health Care Organizations, Corporates and Governments**:

1. The organization must take cognizance of the harsh reality of heat waves and heat-related discomfort during summer months, ensuring sufficient use of cooling devices.
2. Schools should make sure that their students are sufficiently protected and not exposed to heat. Classrooms should be well aired and adequately cooled.
3. Hospitals should organize the address of all medical issues after making the patient comfortable with respect to summer heat.
4. Hospitals and health care facilities could have a separate department addressing only heat related issues and emergencies.
5. Special precautions should be taken to ensure that vulnerable communities such as children, the elderly, the people who are forced to travel and work outdoors and vulnerable women.
6. Corporates could constitute "heat-relieving" activities under their Social Responsibility, e.g.: Creation of cool drinking water, distribution of affordable cooling devices to those who are marginalized and creation of awareness as to how to battle such heat related issues is a cost-effective manner.
7. Organizations should ensure adequate cooling in factory floors with large-scale cooling.
8. Government policies should address the heat intensity of summer months by have public cold-water dispensers for consumption and cooled public areas.
9. Government policies must ensure the address of climatic warming by ensuring adequate flora and trees.

**Research Implications**

1. The research done so far can be extrapolated to other similar geographical areas.
2. Some of the research may be considered by medical researchers to ascertain how best to address heat related issues and cross issues with other ailments.
3. Projects could be conducted at departmental level to create inclusivity in the address of heat-related health issues.
4. The study could be extrapolated and also extended after the introduction of Post Hoc analysis.

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