



Temperature Related Disasters (Heat & Cold Wave)

Implications for Health Adaptation & Resilience



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National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)



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National Institute of Disaster Management (NIDM)

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FOREWORD

Disasters related to extreme temperature are the direct consequences of climate change and the severity, intensity and frequency of such events are most likely to increase in coming years. Devastating impact of heat/cold wave on environment, human health, agriculture produce, livestock, forests, etc have now been a global challenge. In past few years the duration of extreme temperatures have increased that has posed a severe health impact particularly to the vulnerable populations and marginalized community. The individuals working outdoors during peak hours and prolonged exposure to heat/cold wave cause severe health impacts.



The best approach in the entire disaster management cycle to tackle the impact of extreme temperatures is by undertaking prevention, mitigation and preparedness measures. Several initiatives and measures have been undertaken for the mitigation and adaptation of heat waves related consequences while for the cold wave related consequences no such measures have undertaken. Equal emphasizes must be given to the documentation and research on health impact of cold and heat waves to devise new adaptation stratagems.

It is in utmost need to enhance the preparedness and mitigation strategies for disasters related to extreme temperature. The Heat wave Action Plan prepared by NDMA has helped states in preparing their own Heat Action Plans. Similarly, in years to come Cold wave Action Plan must be formulated in order to strategize mitigation and preparedness measures in states with recurrent incidences of cold wave.



(Manoj Kumar Bindal)



PREFACE

In the present days, a lot of emphasis is given on the climate change and the allied consequences. The impacts of the changing climate are becoming severe with each passing years, and extreme temperature events like heat wave and cold wave are increasing, which is resulting in increased mortalities and morbidities. Therefore, the need of the improvement in the Climate Change Adaptation measures and mainstreaming Disaster Risk Reduction (DRR) in the healthcare systems are to be prioritized.



Under the project “Health Adaptation and Resilience: Advancing Strategic Knowledge and Capacities” (HER-CAP) implemented by the ECDRM division of NIDM with the support of The World Health Organization (WHO) India, special focus is on the integration of Climate Change Adaptive - Disaster Risk Reduction adaptation measures by addressing the knowledge, planning, and mitigation gaps.

There are number of scientific research papers, reports, journals and other documentations available on the extreme temperature events and this very thematic paper primarily focuses on the health perspective of the heat/cold wave and attempts at highlighting the possible mitigation measures from policy and planning, climate actions, community actions, businesses & industries, Panchayats, Urban Local Bodies, local bodies and from research point of view. It also focuses on the capacity building and training for a resilient health system.



(Prof. Anil K Gupta)



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ABSTRACT

Heat and cold waves are one of the major adverse effects of climate change resulting short-term increase in morbidity and mortality all over the world. Studies have shown that the frequency and duration of both these temperature related disasters have increased, especially in urban areas, consequent to increased anthropogenic activities. The health implications due to heat wave are exhaustion, dehydration, heat rashes, fatigue, heat cramps, heat syncope and passive heat stroke leading to death while those of cold wave include chilblains, urticaria, frostbites, asthma, coronary events and premature mortality. Infants, elderly, individuals with chronic medical conditions and persons performing physical activities while exposed to extreme weather conditions are more vulnerable to the effects of heat and cold waves

Keywords: Extreme Temperature, Heat wave, Cold wave, Risk management, Health implication

I. Introduction

Climate change is the biggest challenge faced by the world in 21st Century, and its impact is a matter of global concern. On this planet Earth, the mean temperature has increased by 0.85°C above the pre-industrial time, due to the increase in anthropogenic activities (Rohini et al. 2016). This is resulting in sea level rise, increased frequency of extreme weather events and natural disasters (floods, droughts, and forest fires), loss of agricultural productivity, extinction of important flora and fauna species and a multitude of health effects. According to the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment report, the frequency and intensity of extreme climatic events are likely to increase in coming years with rainfall deficit. Heat waves and cold waves are among the extreme weather events that have extensive impact of health problems, malnutrition and reduction in agricultural yield, loss of life and economy (Mandal et al. 2019).

This paper describes the occurrence of temperature extremes - heat and cold waves, with special focus on India, along with its health impacts and suggestive measures for mitigating the health effects.

II. Heat wave

Heat waves are abnormal meteorological events with high surface air temperature that usually lasts for 3-7 days (Rohini et al. 2016). It is an anomalous phenomenon with very high temperature for several days and is associated with severe health impacts (Sandeep, 2018). Although the definition of heat wave varies depending on the local climatic conditions of different countries and states (NDMA, 2017). Attempts has been made by many researchers to define and understand the mechanism of heat waves (Mandal et al, 2019; Sandeep & Prasad, 2018; Ratnam, 2016; Ghatak et al. 2017; Robinson, 2000). The heat wave is a period with abnormally hot weather that persists for at least five or more consecutive days during which the daily maximum temperature exceeds the average maximum temperature by five degrees Celsius. In India, it is considered as heat wave when maximum temperature of an area is $\geq 40^{\circ}\text{C}$ for plains, $\geq 37^{\circ}\text{C}$ for coastal and $\geq 30^{\circ}\text{C}$ for hills (NDMA, 2018). According to the Indian Metrological Department (IMD), criteria to declare a heat wave depends on the maximum temperature and its departure from normal (Table 1).

Table 1 : IMD Criteria for defining heat wave

Normal Maximum Temperature		Heat Wave	Severe Heat Wave
1.	$\leq 40^{\circ}\text{C}$	5°C to 6°C^*	7°C or more*
2.	$> 40^{\circ}\text{C}$	4°C to 5°C^*	6°C or more*

*Departure from normal

Extreme weather events like heat waves are increasing worldwide. Areas including South Asia, Southeast Asia and West Africa are facing challenges due to erratic climate events, poor climate adaptive capacity. Urbanization is making it more susceptible to heat wave due to phenomenon like Urban Heat Island effect (Lee et al. 2019). Heat waves have caused many deaths and agricultural losses in the past and some of the most severe examples are Chicago heat wave (1995), Europe (2003), Australia (2009), Japan (2010) and Russia (2010) that caused 15000, 70000, 1000, 1800 and 54,000 deaths respectively (Sandeep & Prasad, 2018)



Figure 1 : Major heat waves in the world and deaths
(Source: Author, compiled from various sources)

India is also vulnerable to heat wave. Studies have shown that in India average of 12-18 days heat wave events occur annually. It is predicted that such events will

increase by 2020-2064 due to the increase of global temperature by 1.5-2.5°C (Rohini et al. 2019). Heat waves in India are linked with El-Niño-Southern Oscillation (ENSO), reduction in soil moisture, increase in Sea Surface Temperature (SST) over Indian and Pacific ocean and anti-cyclones in upper troposphere (Sandeep and Prasad, 2018; Bhadram et al. 2005). Anti-cyclone in the upper troposphere causes warming of sea surface due to adiabatic compression (Sandeep and Prasad, 2018; Ratnam et al, 2016) along with low soil moisture due to interruption of wind moisture flow (Guleria & Gupta, 2018) aggravates the heat wave condition.

A study identified two types of heat waves in India: Heat wave in North and Central India and Heat wave in east coast of India. The heat wave in North and Central India is found to be caused due to anti-cyclonic blocking over North Atlantic that generates an anomalous wave at the entrance of African jet causing sinking motion over Indian subcontinent thus creating heat wave over India. The heat wave over east coast of India is due to anti-cyclonic anomalous and change in sea surface temperature over Pacific Ocean creating an abnormally low-pressure along the coast leading to flow of moisture out of India and reduction in precipitation, which reduces the areas humidity significantly (Ratnam et al. 2016; Mandal et al. 2019).

In India, heat wave occurs from the month of March to June and sometimes even extends until July (NDMA, 2019; Rohini et al. 2016; Mandal et al. 2019). Northwest India, Central India and Southeast India are the hotspots for heat waves in the country (Rohini et al. 2016; Mandal et al. 2019) particularly west and east Rajasthan, Punjab, Haryana, Chandigarh, Delhi, West Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Odisha, Andhra Pradesh and Telangana. These states face an average of 6 days heat wave in a season and even up to 8 days heat wave per season in southeast India (Mandal et al. 2019).

An increasing trend in frequency and duration of heat waves is seen particularly in Northwestern and Southeastern part of the country due to climate change (Rohini et al. 2016; Oldenborgh et al. 2018; Sarma et al. 2019) and it is likely to increase by 30 times of the current rate of global increase (Mandal et al. 2019). Studies have shown that in northwestern India, frequency of heat waves has increased by 1 event in 20 days with average duration and maximum duration of 2 days and 1.5 days per decade respectively while the trend in southwestern India are not substantial (Rohini et al. 2016). Heat events during night hours have increased more rapidly than heat events during daytime particularly in western and southern India (Mukherjee and Mishra, 2018) and the areas that are currently

unaffected by heat waves are likely to be affected by such events due to climate variability (Rohini et al. 2019).

III. Health Impacts of Heat Wave

The concurrent day and nighttime heat wave intensifies morbidity and mortality (Guleria and Gupta, 2018). The rise in heat wave mortality attributes to the climate variability in India and it is projected to increase in vulnerable groups like those living in slums, homeless individuals, old age and outdoor laborers (Mukherjee and Mishra, 2018; Akhtar, 2007). WMO (World Metrological Organization) and WHO (World Health Organization) have identified adults above the age of 65 years, infants, pregnant women, outdoor physical workers, athletes, homeless and individuals with existing medical problems like kidney and cardiovascular diseases, or those who are under medications are vulnerable groups during extreme weather events.

Impact on health due to heat wave is more prominent in urban areas as roads, buildings, concrete pavements and pollution absorbs more heat, leading to a phenomenon of Urban Heat Island (UHI). Even a large number of rural populations suffer from heat stress particularly while cooking on firewood stoves, collecting firewood and fetching water (Tasgaonkar et al. 2018). Indoor heat stress is also faced in many rural areas. Tin roofs contribute significantly to indoor heat stress.

Heat wave causes both direct and indirect impact on human health. The direct impact of heat waves on human health typically includes dehydration, heat cramps, heat rash, syncope, exhaustion and heatstroke (Guleria and Gupta, 2018, Rohini et al. 2016). Human body regulates the body heat by sweating and when the body reaches the upper limit of heat tolerance it causes a heatstroke. Indirect impact on health and livelihood can be caused due to direct effect on agriculture production thus causing food insecurity, dietary change, ecosystem and country's economy. It can cause crop failure. Over use of power due to excessive consumption of air-conditioners in urban areas. Power shortage and fluctuations due to heat wave can also affect the healthcare system and service delivery. Heat wave is likely to worsen the air quality as extreme heat increases the concentration of ground level ozone, smog and particulate matter that can be harmful for vulnerable individuals and ecosystem.

Heat wave and its severity is broadly attributed by many variables that can be categorized into physical, social/culture and physiological factors (Malini et al. 2016) as illustrated in .

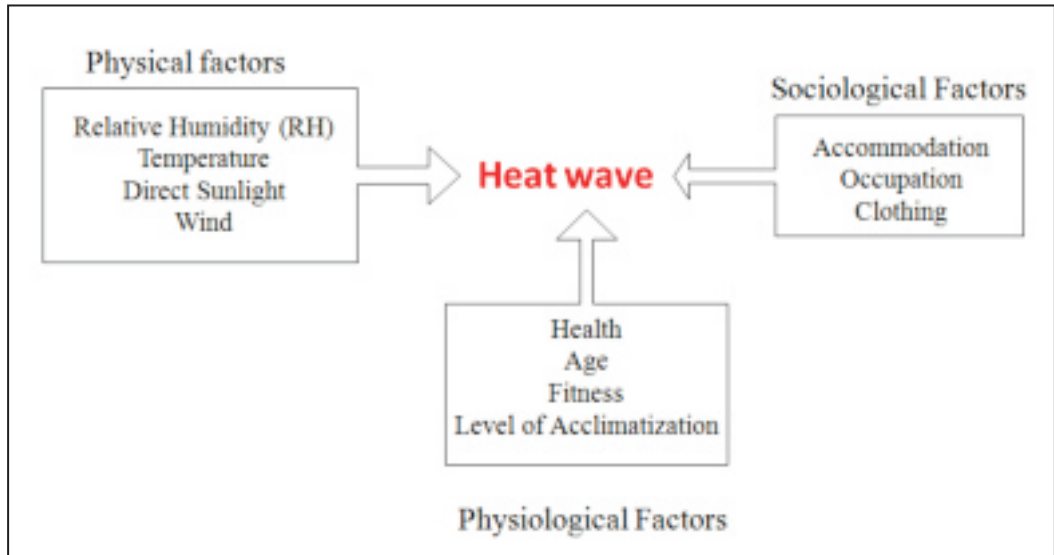


*Figure 2 : Factors determining the impacts of Heat wave
(Source: Author)*

Heat wave is due to a combined phenomenon of physical factors including temperature, wind and relative humidity. These factors affect various physiological functioning like the thermoregulatory property of the human body, which varies with age and biological condition (fitness, health and level of acclimatization) of the individual. If the atmospheric temperature is high enough to hinder the body's heat regulation, it gives rise to health problems or even death depending upon the vulnerability of the person. Sociological factors like socio-economic condition, occupation, clothing and accommodation aggravated the impact. Poor and marginalized communities face the brunt of heat waves more severely than who can afford air-conditioners and coolers. Predisposing factors and symptoms due to prolong exposure are shown in Table 2 .

Table 2 : Predisposing factors, signs and symptoms due to heat wave

Factor Contributing to Heat Vulnerability	Risk Factor	Impact on Prolong Exposure and/or Physical Activity
Physiological condition		
Age	Less aware and adaptable to extreme heat	Thermoregulation in elderly/ infants/ pregnant women is less efficient causing heat cramps, heat syncope, exhaustion, fatigue and passive heatstroke
Individual with disability	May not be able to access help quickly	
Medical condition		
Depression/ diabetes/ cardiovascular disease	Those taking medications can worsen the impact of extreme heat are especially vulnerable	Dehydration can exacerbate the health impact in individuals presently under medication thus worsening the health condition.
Socio-economic condition		
Poor/ Homeless/ outdoor workers	May not receive warning messages, may be unaware of cooling centers and may have limited access to other cooling measures	Higher risk from dehydration/ heat stress/heat stroke-affecting livelihood. They are highly vulnerable to extreme heatstroke, heat rash, heat cramps, swelling, fatigue due to strenuous labor and physical work.

In India till now death toll due to heat wave has reached up to 24,380 during 1991 to 2018 period. According to local authorities in Andhra Pradesh (May 2016) and Telangana (May 2015) due to severe heat wave nearly 2,422 people died, excluding the deaths due to pre-existing medical problems (Roxy et al, 2015). Most deaths and casualties due to heat wave mainly occur in the states of Odisha, Andhra Pradesh and Telangana. Intense efforts are made by stakeholders

including preparation of heat wave guidelines by NDMA that provides a framework for heat wave prone states in preparation of state heat action plans, implementation, coordination and evaluation of response activities. The HAPs has the standard operating procedures mentioned for different ministries and departments that help in understanding the roles and responsibilities of the concerned authorities. Improvement in timely information system through early warning and dissemination of information through social media, IEC (Information, Education and Communication), pamphlets, posters, Television Commercials (TVCs) on do's and don'ts and treatment measures for heat related illnesses has resulted in significant reduction in the impact. The number of deaths have reduced from 2,040 in 2015 to 1111 deaths in 2016 to 384 and 25 in the year 2017 and 2018 respectively where as in the year 2019, the deaths recorded was 215 . Figure 3.

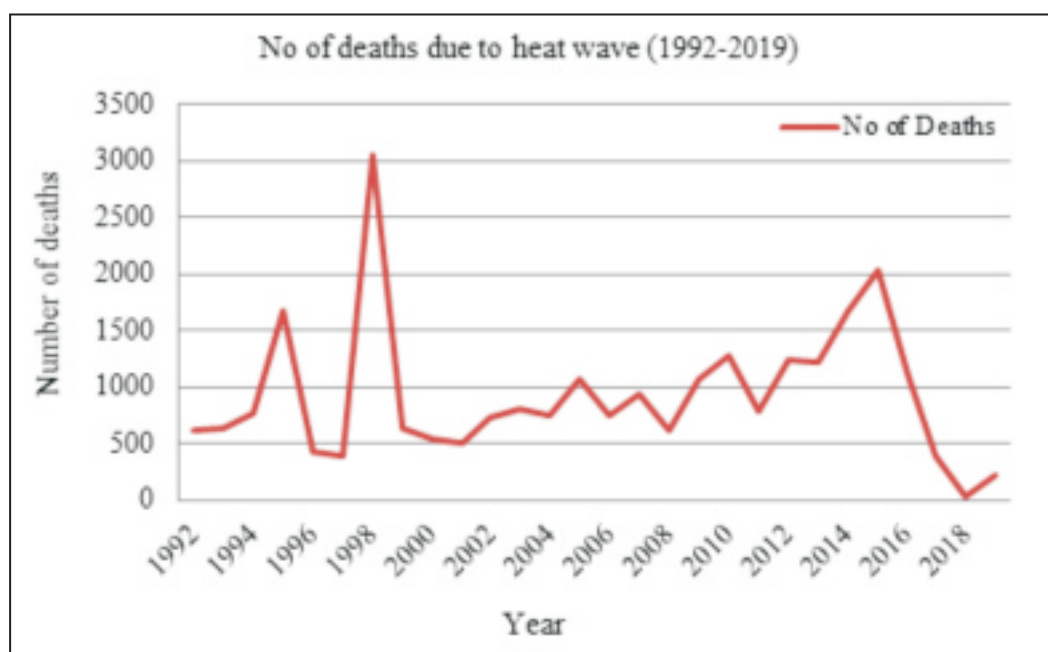


Figure 3 : Deaths per year due to Heat wave in India from 1992-2019
(Data Source: National Disaster Management Authority, NDMA)

IV. Cold Waves

Different authors, climatologists and meteorological organizations in accordance with the local climatic conditions, have variedly defined cold wave but the term widely refers to an extreme persistent temperature, below which there is an increase in morbidity and/or mortality, especially in the vulnerable parts of the population (De Prez et al.2018).Definition of the terms “extreme” and “persistent”, cold waves are considered to be episodes during which the maximum daily temperature ($T_{\max}$) is less than the 5thpercentile of all maximum daily temperatures and the minimum daily temperature ($T_{\min}$) is less than the 5thpercentile of all minimum daily temperatures for two consecutive days (De Prez et al.2018).

In the Indian context, the IMD considers as cold wave when the normal minimum temperature of a station is more than or equal to 10 °C, a departure of -5 °C to -6 °C from normal is considered a cold wave and departure of -7°C or less is considered as severe cold wave. Whereas when the normal minimum temperature of a station is <10 °C, a departure of -4 °C to -5 °C from normal is considered a cold wave and departure of -6 °C is declared as severe cold wave(Table 3).

Table 3 : IMD Criteria for defining cold wave

Normal Minimum Temperature		Cold wave	Severe Cold Wave
1.	$\geq 10^{\circ}\text{C}$	-5 °C to -6 °C*	-7 °C or less*
2.	$< 10^{\circ}\text{C}$	-4 °C to -5 °C*	-6 °C or less*

**Departure from normal*

Climate change has resulted in an increase in the frequency and severity of extreme weather events globally, including cold waves. The tropical zones report fewer extreme weather events than other parts of the globe, but countries within the temperate zone and closer to the poles have been experiencing an increasing number of both heat and cold waves (De Prez et al.2018).Countries in Eastern Europe have reported a death rate of 28 per million consequents to cold events over a 25-year period from 1991 to 2015. Estimates from the Department of Health of the United Kingdom have revealed that the annual cost of treating

diseases related to cold events by the National Health Services amount close to £859 million (WHO, 2018).

A study conducted by De Prez in 2018, have used modeling techniques to collate data on the occurrence of cold waves and human exposure over a period of 31-years, and devised maps depicting areas of the world where the hazard and risk of cold waves is maximal. In Figure 4, the light shade shows no cases of heat/cold wave is a span of 31-years where as darker shades indicate the occurrence of temperature related extreme events. The darkest shades in the map are seen over parts of Europe and Africa (De Prez et al.2018).

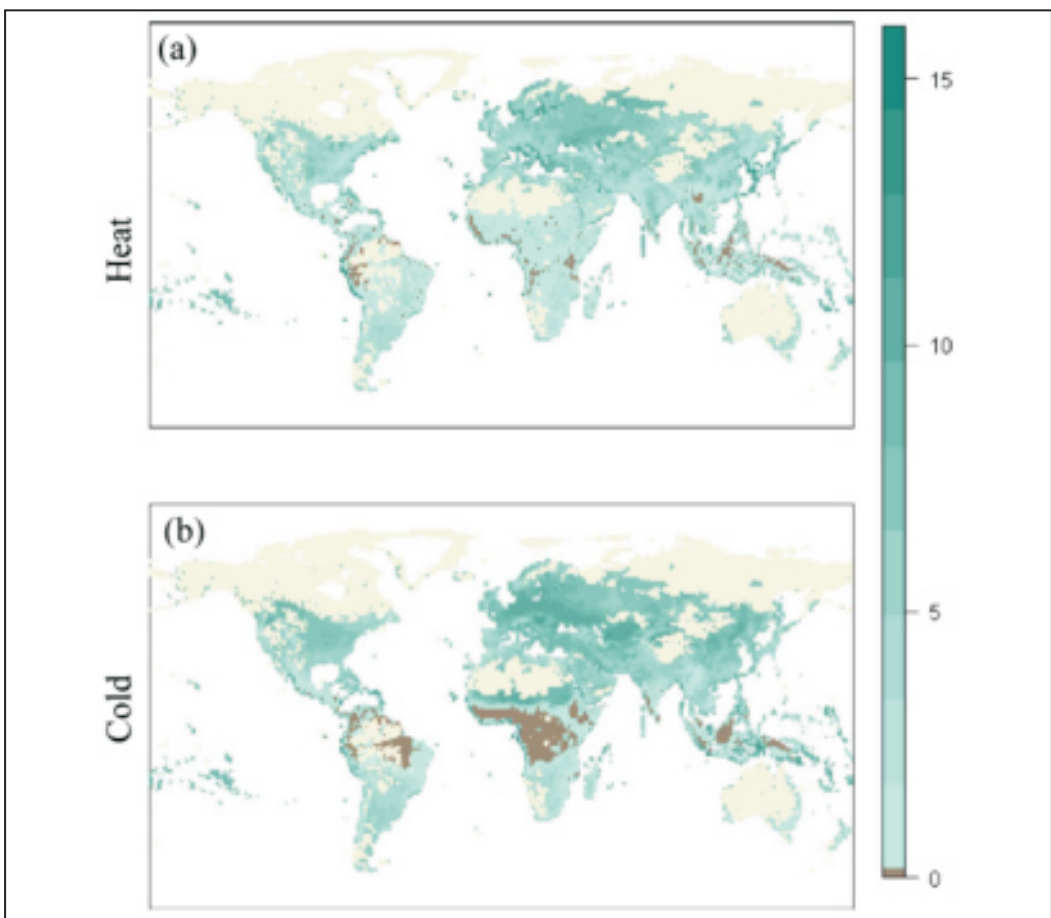


Figure 4 : Occurrence and human exposure of Heat and Cold Waves using NOAA model
(Source: De Prez et al. 2018)

The WMO report on the state of global climate in 2018 described unusual snow falls, storms and cold waves from several parts of the world, including Ireland, France, Italy and the UK from North eastern Europe; Lesotho from southern Africa; Chile, Peru and Uruguay from South America and the Indian sub-continent as well (WMO, 2019). Northern, northwestern and eastern part of the country witnessed severe cold wave/cold wave in January 2018 (Kashyapi et al. 2019).

In India, cold waves in northern parts of the country occur due to the passage of western disturbances, during which there is an intrusion of cold air in the north and northwestern parts of India from the northern latitudes. Few incidences also occur as a result of low-pressure area over the North Arabian Sea. This results in the easterlies transporting cold air from higher latitudes. Cold waves in India generally occur between November and February, with peaks in the month of January. During the cold waves, the minimum temperature drops by 4 °C or more, for a period of 3-5 days, and is associated with increased discomfort for the people of North India (Ratnam et al, 2016). The northern states of Punjab, Haryana, Delhi, Uttar Pradesh, Bihar and areas of Jammu & Kashmir have reported the maximal number of cold waves over a period of 2001-14 (Mahapatra et al, 2018).

V. Health Impacts of Cold Wave

Cold waves produce a wide range of health effects varying from an ailment as minor as the common cold to an incident as severe as death. While heat waves result in dehydration and an increase in the blood viscosity, cold stress affects the body's physiology by causing vasoconstriction, thereby elevating the blood pressure, and activity of the sympathetic nervous system. It also promotes platelet aggregation and an increase in the red blood cell count (Cheng & Su, 2010). Injuries such as frostbite, trench foot, hypothermia and falls are common during cold waves. The spectrum of systems affected and symptoms produced due to cold waves as described by the World Health Organization are summarized in (WHO, 2018).

Table 4 : Diseases, signs and symptoms associated with Cold wave

System affected	Signs, symptoms and complaints	Cold-related diseases
Respiratory	Increased mucus secretion, shortness of breath, wheezing, cough	Asthma, Chronic Obstructive Pulmonary Disease, Infections
Cardiovascular	Chest pain, Arrhythmia, shortness of breath	Coronary and other Heart Disease, Myocardial Infarction, Cerebrovascular Accidents
Peripheral circulation Musculoskeletal	Color change of fingers and toes, pain, numbness, tickling sensation	Raynaud's Phenomenon, Hand-Arm Vibration Syndrome
Dermatologica	Itching, skin eruption, pale skin, Erythema, Oedema	Cold Urticaria (Hives), Pernio (Chilblains), Psoriasis, Atopic Dermatitis

A multi-country study revealed that more deaths are associated with moderate cold than with moderate heat (Gasparrini et al. 2015), and the WHO states that total mortality in most populations is higher in the winter season than in the summers. Coronary heart disease, cerebro-vascular accidents and respiratory diseases are the most common causes of death associated with cold waves (WHO, 2018).

In north India, 3,264 deaths were reported due to cold waves during the period 1978-1999, and this number had increased to 900 in the year 2003 (De et al. 2000, De et al. 2005). A study over the period 2001-2014 reported that deaths due to cold waves account for 11.4% to 18.5% of all deaths related to extreme weather events. Among the reported deaths, more than 80% of the deaths occurred among individuals aged more than 44 years. Half of the cold wave-related deaths are reported from northern India, and a little more than one-quarter of such deaths are reported from Eastern India (Mahapatra et al, 2018). According to a report by The World Meteorological Organization, the state of Uttar Pradesh reported 135 deaths attributable to cold over a ten-day period in January (WMO, 2019).

The impact of any extreme weather event varies with the vulnerability of the population and of the individual, which in turn depends on their age, degree of exposure to the extreme weather, and existing co-morbid conditions that compromise the cardiovascular, respiratory or renal system. It also depends on social and cultural norms like clothing, housing and access to temperature-controlled shelters (Hajat et al. 2010).

VI. Mitigation measures

Given the increase in the number and frequency of heat and cold waves across the globe, holistic mitigation measures must be undertaken at all levels including policy and planning, science and technology, environment actions, community actions, healthcare system, businesses and industries, Urban Local Bodies and panchayats, research and capacity building. Many heat wave vulnerable states in India including Gujarat, Odisha, Karnataka, Maharashtra, and Bihar have taken good initiatives in reducing the human health as well as livestock health impact due to heat but no such initiative has been taken for cold waves in cold wave vulnerable states. The reason may be due to the non-availability of a particular medical diagnostic mechanism for cold waves. Furthermore, India needs significant efforts and initiatives in minimizing the health impact due to extreme temperatures in various aspects discussed below in brief.

a. Policy and planning

Countries need to have preparedness and adaptation policies and planning in place to mitigate the adverse consequences of temperature extremes. India has a comprehensive heat wave adaptation plan prepared by National Disaster Management Authority (NDMA) which is improvised yearly, but due emphasis in preparedness and adaptation plan for the cold waves is needed. However, a guideline for extreme events does include a small section on cold wave but it doesn't suffice the impact it poses. Therefore, a separate national action plan dedicated specifically to cold wave is required. The National Health Adaption Plan (NHAP) and the Action Plan for Heat/Cold must be in synergy and must support in preparation of State/District or even block level action plans. The Action Plan must be integrated with State Disaster Management Plans and District Disaster

Management Plans. A long-term mitigation measure is needed for the achievement of the global targets of disaster management.

Planning is the backbone of good governance and especially urban planning is necessary for the prevention of the formation of Urban Heat Island (UHI). Planning for the dissemination of information, alerts and knowledge from higher to local level of governance is necessary in a country like India for the successful implementation of the existing strategies and formulation of new ones. Proper planning for resource mobilization and inter-sectoral, inter-departmental and inter-agency coordination is needed for successful implementation of State Action Plans (NDMA, 2019). Forecasting mechanism by climate services, weather services and early warning system must be strengthened and close coordination of inter-agencies is needed for the appropriate and timely dissemination of extreme temperature alerts. Health and social services must also plan and coordinate among different care providers, to specially take care of vulnerable populations and ensure timely dissemination of information to the public so that they can enforce protective measures for themselves and their families (WHO, 2018). Such plan should include capacity building mechanism, resource mobilization, monitoring and evaluation.

b. Climate and environment actions

Mainstreaming of DRR (Disaster Risk Reduction) and CCA (Climate Change Adaptation) with heat/cold adaptation planning is necessary since disaster is a multidisciplinary subject that brings environment, health, development and technology under one umbrella (Gupta et al. 2016). Mainstreaming DRR with urban planning and development for building cities by provisioning resilient critical services, ecosystem management of urban and peri-urban areas (Gupta et al, 2019) that may incorporate long-term measures of nature-based solutions. Ecosystem based approach including greening urban spaces to counter the urban heat island, cool roofing system, sustainable buildings, energy efficient appliances, proper land-use, conservation of water bodies etc must be emphasized.

c. Awareness and community actions

Community level awareness programmes can be organized for the sensitization of vulnerable population. Appropriate, sensible and easily understandable advisories (possibly in local language) using radio, cinemas, electronic, social media and IEC materials like pamphlets, posters, advertisements, hoardings etc

can be disseminated for well-timed action at community level. Dos and don'ts must be made available locally especially for communities at risk. At the community level, measures must be taken to reduce the health impact of extreme weather events like in heat wave by providing space to rest and providing drinking water facilities for outdoor laborers at specific locations, during the peak time of the hot summer days. Design of houses must be made in such a manner so to reduce heat stress, as well as withstand cold waves.

d. Role of Industry and businesses

Industries and businesses must prepare their extreme temperature action plans for the continuity of businesses during the adverse heat and cold wave while creating safe working environment for work force. Working hours during extreme temperature days must be rescheduled. Workers working in high temperature rooms/areas (brick kilns/road construction workers using Asphalt, bitumen and coal tar) must be stopped when there is heat wave alerts. Working space in offices must have good ventilation and cooling agents (fans/coolers/air conditioners) must be functional.

e. Role of Local bodies, ULBs and Panchayats

The ULBs and Panchayats must encourage community actions and work in coordination with the state for timely weather information and broadcasting of the alerts to the vulnerable population. Affordable and cost-effective solutions need to be made available at the grass root level in the form of temperature-controlled shelters, public cooling/heating place, ensuring drinking water supply, change of cooking fuel from chulhas to clean fuels, distribution of blankets and protective clothing to the homeless and vulnerable population on the street. Shift in timings of schools/ offices and working hours to reduce the cases of morbidity and mortality due to extreme temperature (NDMA, 2017). Healthcare systems need to be prepared in terms of availability of beds and logistics to address an increased inflow of patients during times of heat and cold waves, while ensuring continuity of regular health care services. Due preparedness needs to be ensured for addressing the needs of the vulnerable population like the elderly and those with pre-existing diseases (Villanueva et al., 2019).

f. Research

Extensive research is needed on identification of local thresholds of heat wave, vulnerability assessment locally and data collection for the formulation of

evidence-based policies (NDMA, 2019). Risk management by vulnerability assessment, identification of heat and cold wave hotspots, mapping of communities at risk, vulnerability mapping is needed. Auditing and gap analysis of the existing action plans must be undertaken for future improvement in formulation of mitigation measures. Short term and long-term effects of extreme temperature conditions on human health are important areas of research.

g. Capacity Building

Capacity building of officials, legislators, professionals, teachers, NGOs, trade unions, ULBs, and industry's workers and owners must be carried out to properly implement and execute the Action Plans and initiate mitigation measures. Emphasizes must be laid on capacity building of healthcare professionals, paramedics and volunteers to carry out surveillance for the health impact of heat and cold waves and provide an accurate estimation of disease burden must be emphasized. The health systems will also need to enhance their preparedness for the same in the form of capacity building of medical professionals and health workers. Medical personnel and health workers need to be trained to address the diseases caused due to climatic change and sensitized towards their role in spreading awareness in the community about climate related illnesses.

VII. Conclusion

With the current rate of change in temperature with erratic weather pattern, occurrence of heat and cold related illnesses is most likely to increase. Extreme events like heat and cold wave is a silent disaster that can have a massive impact on humans and animal health causing large number of morbidity and mortality. Emphasizes should be made on adequate capacity building of the medical professionals, health workers, teachers at local levels and preparing the healthcare system for emergency. Although the consequences of extreme temperature appear easier to control in comparison with disasters like earthquake and tsunami, but it is not so easy because of its wider implication on human population. Therefore, timely and right dissemination of information to communities with crisp early warning and appropriate strategization of mitigation measures must be specifically emphasized on. Urban centers and peri-urban areas should be built a heat and cold resilient in which urban local bodies, policy makers and decision makers play a significant role. The existing action plans should be implemented in synergy with National Health Action Plan, Sendai Framework for DRR, Paris Climate Agreement and Sustainable Development Goals for the efficient measures, planning and action. Mainstreaming of CCA-DRR in developmental planning will help in addressing extreme temperatures related consequences by adopting ecosystem-based approaches and nature-based solutions. Significant improvement in the documentation and data collection from different corner of the country needs to be strategized in order to comprehensively understand the recurring health impacts due to extreme temperatures.

VIII. References

- Akhtar, R. (2007). Climate change and health and heat wave mortality in India. *Global Environmental Research-English Edition*, 11(1), 51.
- Cheng, X. & Su, H. (2010). Effects of climatic temperature stress on cardiovascular diseases. *European Journal of Internal Medicine*.21.164-167.
<https://doi.org/10.1016/j.ejim.2010.03.001>
- De Perez, E. C., Van Aalst, M., Bischiniotis, K., Mason, S., Nissan, H., Pappenberger, F., ...& Van Den Hurk, B. (2018). Global predictability of temperature extremes. *Environmental Research Letters*, 13(5), 054017.
- De, U. S. (2000). Weather and climate related impacts on health in megacities. *WMO Bull.*, 49, 340-348.
- De, U. S., Dube, R. K., & Rao, G. P. (2005). Extreme weather events over India in the last 100 years. *J. Ind. Geophys. Union*, 9(3), 173-187.
- Gasparrini, A., Guo, Y., Hashizume, M., Lavigne, E., Zanobetti, A., Schwartz, J., ...& Leone, M. (2015). Mortality risk attributable to high and low ambient temperature: a multicountry observational study. *The Lancet*, 386(9991), 369-375.
- Ghatak, D. Zaitchik, B. Hain, C & Anderson, M. (2017). The role of local heating in the 2015 Indian Heat Wave. *Scientific Reports*. 7: 7707 <https://doi.org/10.1038/s41598-017-07956-5>
- Gupta, A. K. Mani, N. Sarkar, B.B. Singh, S. Katyal, S. (2019). Developing Disaster Risk Resilient Cities. Gorakhpur Environmental Action Group (GEAG), Gorakhpur (UP), National Institute of Disaster Management, New Delhi, India and United Nations Children's Fund (UNICEF), India. September 2019.
- Gupta, A., Chopde, S., Singh, S., Wajih, S. A., & Katyal, S. (2016). Prime minister's agenda 10: India's disaster risk management roadmap to climate resilient and sustainable development.

Guleria, S. and Gupta, A.K. (2018). Heat Wave in India Documentation of State of Telangana and Odisha (2016). National Institute of Disaster Management, New Delhi. Pages 124

Hajat, S. Connor, M. & Kosatsky, T. (2010). Health effects of hot weather: from awareness of risk factors to effective health protection. *The Lancet* . 375: 856-63

Kashyapi, A. Natu, J.C. Shinde, S. & Chopade, P. N. (2019). Weather in India: Winter Season (January -February 2018). *Mausam*. 70. 1. pp: 181-194

Lee, V. Zermoglio, F. Ebi, K. L & Chemonics International Inc. (2019). Heat waves and Human Health: Emerging evidence and experience to inform risk management in a warming world. Prepared for United States Agency for International Development Adaptation Thought Leadership and Assessments (ATLAS)

Mahapatra, B. Walia, M & Saggurti, N. (2018). Extreme weather events induced deaths in India 2001-2014: Trends and differentials by region, sex and age group. *Weather and Climate Extremes* 21 (2018) 110-116. <https://doi.org/10.1016/j.wace.2018.08.001>

Malini, H. B. Lalitha, K. Raju, G. M & Rao, N. K. (2016). Severe heat wave during May 2015 in Andhra Pradesh. *Current Science*. 110 (10). 1893-1894

Mandal, R. Joseph, S. Sahai, A. K. Phani, R. Dey, A. Chattopadhyay, R & Pattanaik, D. R. (2019). Real time extended range prediction of heat waves over India. *Scientific Reports*. 9. 9008. <https://doi.org/10.1038/s41598-019-45430-6>

Mukherjee & Mishra. (2018). A six fold rise in concurrent day and night time heat waves in India under 2 °C warming. *Scientific Reports*. 8:16922. <https://doi.org/10.1038/s41598-018-35348-w>

National Disaster Management Authority, Government of India. (2017). Guidelines for Preparation of Action Plan- Prevention and Management of Heat Wave.

National Disaster Management Authority, Government of India. (2019). Guidelines for Preparation of Action Plan- Prevention and Management of Heat Wave.

National Disaster Management Authority, Government of India. (2019). Report of National Workshop on “Preparedness, Mitigation & management of Heat Wave 2020”. 5th-6th December 2019.

Oldenborgh, V. G. J., Philip, S., Kew, S., van Weele, M., Uhe, P., Otto, F. E. L. & Rao, A. K. (2018). Extreme heat in India and anthropogenic climate change. *Natural Hazards and Earth System Sciences*, 18. <https://doi.org/10.5194/nhess-18-365-2018>

Ratnam, J. V. Behera, S. K. Annamalai, H. Ratna, S. B. Rajeevan, M. & Yamagata, T. (2016). ENSO's far reaching connection to Indian cold waves. *Scientific Reports*. 6:37657. <https://doi.org/10.1038/srep37657>

Ratnam, J. V. Behere, K. S. Ratna, S. B. Rajeevan, M & Yamagata, T. (2016). Anatomy of Indian Heat Waves. *Scientific Reports*. 6. 24395. <https://doi.org/10.1038/srep24395>

Robinson, P. J. (2000). On the Definition of a Heat Wave. *Journal of Applied Meteorology*, 40, 762-775.

Rohini, P. Rajeevan, M. & Mukhopadhyay. (2019). Future projections of heat waves over India from CMIP5 models. *Climate Dynamics*. <https://doi.org/10.1007/s00382-019-04700-9>

Rohini, P., Rajeevan, M., & Srivastava, A. K. (2016). On the variability and increasing trends of heat waves over India. *Scientific reports*, 6, 26153.

Roxy, M. K., Ritika, K., Terray, P., Murtugudde, R., Ashok, K., & Goswami, B. N. (2015). Drying of Indian subcontinent by rapid Indian Ocean warming and a weakening land-sea thermal gradient. *Nature communications*, 6, 7423.

Sandeep, A. & Prasad, V. S. (2018). Intra annual variability of heat wave episodes over the east coast of India. *International Journal of Climatology*. <https://doi.org/10.1002/joc.5395>

Mukherjee, S. & Mishra, V. (2018). A six fold rise in concurrent day and nighttime heat waves in India under 2 °C warming. *Scientific Reports*. 8:16922. <https://doi.org/10.1038/s41598-018-35348-w>

Sarma, N. A. Anderson, G. B. Rajiva, A. Azhar, G. S. Gupta, P. Pednekar, M. S. Son, J. Peng. R. D. & Bell. M. L. (2019). The impact of heat waves on mortality in Northwest India. *Environmental Research*. 176 (2019) 108546

Tasgaonkar, P. D'Souza, M. Bendapundi, R & Jacobs, C. (2018). Vulnerability to heat stress: A case study of Yavatmal, Maharashtra, India. *Adaptation at Scale in Semi-Arid Regions (ASSAR)*. Available at: www.assar.uct.ac.za

Villanueva, B. R., Salvador, M. B., & Huelgas, R. G. (2019). Change climate and health. *Revista Clínica Española (English Edition)*, 219(5), 260-265.

World Meteorological Organization. (2019). WMO Statement on the State of the Global Climate in 2018

World Health Organization. (2018). WHO warns: stay alert and help vulnerable as cold grips Europe. Available at: <https://www.euro.who.int/en/health-topics/environment-and-health/Climate-change/news/news/2018/2/who-warns-stay-alert-and-help-vulnerable-as-cold-grips-europe2>. Accessed on 25 August 2020

About CECR and HER-CAP Project

Centre of Excellence on Climate Resilience (CECR)

National Institute of Disaster Management (NIDM) has a dedicated division for Environment, Climate and Disaster Risk Management (ECDRM) which has been designated as a Centre of Excellence on Climate Resilience (CECR) under the National Action Plan for Climate Change and Human Health (NAPCCHH). CECR is implementing six research projects namely Climate Adaptive Planning for Resilience and Sustainable Development in Multi-hazard Environment (CAP-RES) with support of DST-Govt of India, National Agriculture Disaster Management Plan (NADMP) funded by the Ministry of Agriculture & Farmers Welfare, Health Resilience and Capacity Building (HER-CAP) with World Health Organization India, Crisis Management Plan for Dealing with Contamination of Water Bodies (CMP-WB) funded by CPCB, Disaster Management Plan for Ministry of Environment, Forest and Climate Change (NEFC-DMP) with the support from MoEFCC and the Disaster Management Plan for Dept. of Chemicals and Petrochemicals (NCP-DMP) supported by DCPC-MoC&F. It also collaborates with a number of international and national organizations working in the areas of climate change adaptation, resilience and disaster risk reduction.

HER-CAP Project

NIDM in collaboration with WHO India has implemented the project “Health Adaptation and Resilience: Advancing Strategic Knowledge and Capacities” (HER-CAP). Under this project, the following documents have been drafted.

- National Health Adaptation Plan for disasters related illnesses' for Ministry of Health and Family Welfare.
- Training Manual on 'Health Adaptation and Resilience to Climate Risks'.
- A compendium of case studies on 'Climate Change related Disasters and Health Resilience'.
- Four Policy briefs on Regional Issues and Opportunities for Health System Resilience to Climatic Disasters. (For North, East & North-East, West and South Region of India).

- Along with this, four thematic papers on key areas are as follows:
 - Temperature related disasters: Heat and Cold Wave - Implications for Health Adaptation and Resilience.
 - Water related disasters: Floods and Drought - Implications for Health Adaptation and Resilience.
 - Air Pollution and Health: Special Focus on Air Quality Emergencies.
 - Disaster Waste Management and Health Risk Reduction.



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