Vulnerability to Heat Stress: A Case Study in Yavatmal, Maharashtra, India

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Key Messages

- Over the past half century heat wave frequencies in India have increased by a third and the risk of morbidity and mortality related to heat stress is increasing.

- Housing material particularly of roofs and cooling devices, play an important role in regulating indoor temperature.

- Post noon in the peak of summer, people in the rural agrarian Vidarbha region are exposed to high temperatures both outdoors, as well as indoors.

- For reducing heat stress, preventive action is essential. Coordination between government institutions such as Departments of Rural Development, Health, Agriculture and the National Disaster Management Authority (NDMA) need to be brought into the discussion.

Context and Focus

In India, heat wave conditions are generally experienced in the summer months of April and May and from time to time deaths due to heat waves have been reported from several parts of the country. Between 2001 and 2012, heat stroke accounted for 4% of all deaths from natural calamities (Chart 1), with a marked rise seen in recent years. According to the India Meteorological Department (IMD), over the past half century (from 1961 to 2010) heat wave frequencies have increased by a third. With the rise in average global temperature, a further increase in the number of hot days and greater frequency and severity of heat-waves is expected. The risk of morbidity and mortality related to heat stress will continue to increase. Hence, effects of heat stress on human health are becoming an issue of growing concern in India.

Environmental factors that define exposure to heat, human thermal comfort and heat stress are air temperature, airflow (wind speed), humidity and radiation. In an indoor environment, these factors are influenced by building style, characterized by type and construction of the roof and walls and the application of cooling devices such as fans and water coolers. Besides these, the nature of work, physical activities and behaviour of individuals play a role. Sensitivity to heat is related to personal factors such as age and general health conditions, combined with the body’s ability to respond to heat, which defines the vulnerability.

Most epidemiological studies on heat and health rely on meteorological data from standardized weather stations.
study area:

The study is located in Sonurli and Eklara villages (Map 1) in Yavatmal district, Maharashtra.

Yavatmal district in the Vidarbha region in eastern Maharashtra, experiences high summer temperatures up to a 45°C in the peak of summer. Of its population, 78.4 percent live in rural areas and 79.2 percent are engaged in agricultural and other outdoor manual labour. Houses in villages are earthen, or made of tin sheets or of brick with cement. Roof materials used for houses in the district are of tin, re-enforced cement concrete (RCC) and tiles (handmade or industrial). Census data (2011) shows that in Yavatmal district as a whole, 64% of all houses have roofs made of tin sheets. Fans and more recently coolers are used to make houses more habitable during hot weather conditions.

Map 1: Study location: Sonurli and Ekalara villages, Ralegaon block, Yavatmal district, Maharashtra, India.

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v. All figure are taken from census 2011 from http://www.censusindia.gov.in/2011census/Hlo-series/HH2A.html
Methodology:

Outdoor temperature was measured by an Automated Weather Station (AWS) installed in Sonurli village (Photo 1). Indoor temperature was measured using 20 data loggers\(^\text{vi}\) that recorded air temperature at fixed intervals of 10 minutes. Household selection for installing data loggers was based on roof type. The roof structures found in the study location are tin sheets (67%, Photo 3), RCC (23%), and tiles (10%). The temperature loggers (Photo 2) were installed in rooms where most of the household members spent most of their time when indoors.

Through interviews and focus group discussions, people's perceptions on heat stress and human health, livelihood patterns and coping mechanisms were collected. A total of 70 sample households (comprising of 326 individuals - 54% male and 46% female) were interviewed through a structured questionnaire.

\(^{vi}\) 18 HOBO UX100-001 for temperature and 2 HOBO UX100-011 for temperature and relative humidity (Onset, USA).
Key Findings:

The indoor temperature in houses with tin roofs is higher throughout the day as compared with RCC roof houses; it even exceeds the outdoor temperature (Chart 2).

Chart 2: Average diurnal temperature of the outdoor temperature and houses with different roof material

With the outdoor average temperature reading of 42.5°C, the temperature under tin roofs was the hottest (average 45.8°C) between 12md and 6pm. A layer of crop residues over the tin roofs reduced the temperature by 4°C. Under RCC roofs the indoor temperature is substantially decreased (by 9 °C) by using coolers (Chart 3). Under both roof types, the night indoors was found to be warmer as compared to outdoors.

Maximum temperature under tin roofs generally occurs in the early afternoon, before the maximum in the outdoor air temperature. This may be indicative of a strong correlation with solar radiation, which may be expected because of the low heat capacity of the tin roofs in comparison to RCC roofs. The maximum of incoming solar radiation usually occurs well before the maximum in air temperature.

During the hottest period of the day in summer, i.e., between 11am and 5pm, when people are generally indoors, it was found that for a duration of 10 consecutive days, the outdoor readings ranged from 42°C to 45°C, while within the tin roof houses people were exposed to temperatures ranging from 45°C to 48°C, which was even higher than the outdoor temperature.

Chart 3: Average air temperature measured outdoors and indoors under different roofs (20 data loggers)
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Of the 326 individuals interviewed, 152 (47%) individuals reported at least one heat related symptom (HRS); 67% of these were people who resided in tin roof houses. A higher percentage of men (57%) reported HRS as compared to women (42%). Among age groups, the 19-45 years group (Chart 5) reported more HRS as they spend long hours in outdoor livelihood activities exposing them to high temperatures and direct sun-light.

Chart 4 shows the average diurnal variation of indoor temperature in the 20 houses. The indoor temperature between 12 hrs to 16 hrs inside tin roof houses recorded up to 49°C. The temperature peaked in the afternoon in all house types. In general, indoor room temperature was highest between 12 hrs to 16 hrs in all types of roofs.

Chart 5: Percent of individuals reporting Heat Related Symptom (HRS)
The main HRS reported during the summer of 2016 in the study sample are: heavy sweating, leg cramps, intense thirst, fatigue and disorientation (Chart 6).

Conclusions and Recommendations:

The findings of this pilot study show that a large rural population is exposed to heat stress both outdoors and indoors. Besides working men, the other people affected by heat stress are: the ill, the elderly and women particularly when cooking (using firewood based cooking stoves), fetching drinking water, and collecting firewood. Tin roofs contribute most to indoor heat stress during peak summer months. Heat related symptoms need to be identified early and precautionary measures taken in order to avoid extreme heat stress.

Urgent measures are required to reduce exposure to heat stress: e.g. promotion of crop residue layers on tin roofs; constructing community halls to provide space to rest during the hottest hours of summer months. The use of coolers greatly reduces indoor temperature, but the availability of water and electricity, as well as funds to purchase them are required. Heat stress may be reduced by improving housing design, adjusting work hours in summer e.g. in Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and providing drinking water for labourers during work hours.

Heat stress in rural areas is an overlooked problem. This pilot study highlights the urgency for wider and more in-depth studies to better understand heat stress and thermal comfort, ventilation and radiation, and how rural areas are affected by these. This in turn will help identify appropriate responses. While addressing heat stress related symptoms is essential and rests with the health department, its prevention will reduce morbidity and mortality. However prevention falls in the domain of other government departments' e.g. rural development. Findings from such studies will call for various government departments to work together towards this end.
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About Watershed Organisation Trust (WOTR) & the WOTR Centre for Resilience Studies (W-CReS)

WOTR is a not-for-profit organization founded in 1993 operating currently in 7 Indian states; namely Maharashtra, Telangana, Seemaandhra, Madhya Pradesh, Rajasthan, Jharkhand and Odisha. WOTR is recognized widely as a premier institution in the field of participatory Watershed Development and Climate Change Adaptation. Its unique strength lies in its on-field experience and in a systemic, participatory approach. The W-CReS is the applied research unit of WOTR.

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