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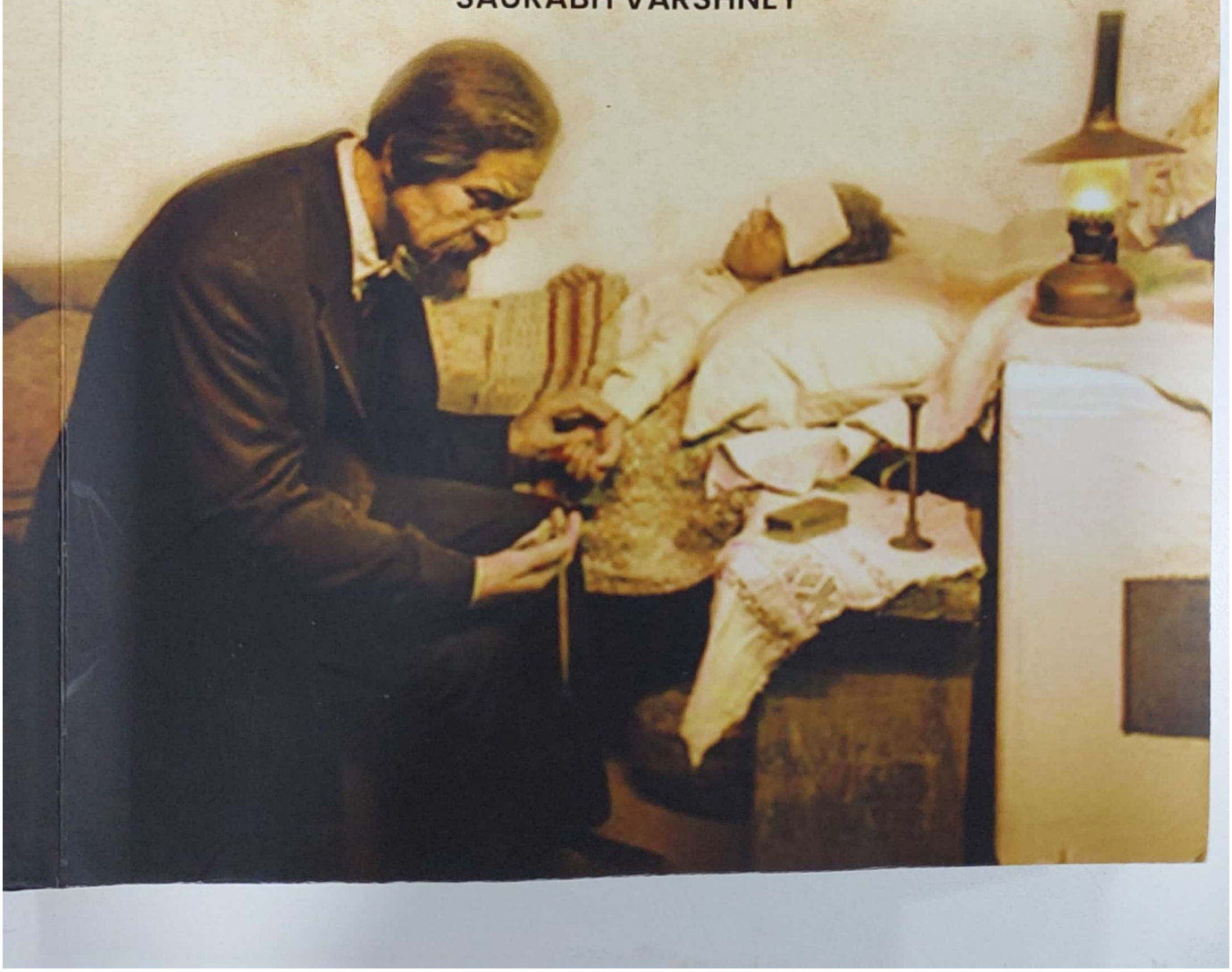

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EXTREME HEAT AND ITS IMPACT ON URBAN ALL-CAUSE MORTALITY: A CASE REPORT OF SMART CITY SURAT

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ABSTRACT

Coastal cities of India behave differently from climate change perspective and Surat is one of them. According to World Bank Sustainable Development Network, Surat is also one of the world's most climate change affected cities. Research shows that the days having temperature ≥40°C are increasing in both frequency and number of consecutive days. Nevertheless, there is very limited data on the spatial variations of extreme heat and effects of heat waves for Surat. There is no vaccine for extreme heat but there are various methods for coping extreme heat. With rapid urbanization and climate change, resilience planning is very crucial. This case report is of its kind and focusses on temperature and Heat Index (HI) with all-cause mortality which provides insight in better understanding the effect of ambient temperature on urbanites of Surat. Every city is different and success of city specific coping capacity depends on a city specific planning considering the local factors complexity. Surat city specific intervention package may include Heat and Health Action Plan.

BACKGROUND

The aim of this case report for Surat city is to explore the likely influence of extreme heat on urban all-cause mortality.

Surat is a coastal, industrialized and one of the most rapidly developing cities with the population of 5 million plus including

55 per cent migrants [1]. It has seen an exponential rate of urbanization since last 30 years. Surat has been divided into seven administrative zones. The climate of Surat city is hot and humid because of closeness of Sea. Surat's summer temperature ranges between 37°C to 44°C and experiences high relative humidity (around 60% average humidity) throughout the year [2].

The analysis of Integrated Diseases Surveillance Programme (IDSP) and death reports data of last 5 years have less likely reported any heat morbidity events. This suggests that in current scenario all-cause mortality is the option to relate effect of heat on health. Hence, a combination of high temperature, HI (comparatively under-valued climate change factor for urban areas) and all-cause mortality was observed for different time periods.

1. Surat city is influenced by a global rise in temperature. Data from 1985 to 2014 shows that Surat is burning in summer months as there were more frequent maximum temperature spikes identified in the decade of 2005 to 2014 as compared to previous two decades (1995-2004 and 1985-1994). Average, maximum and minimum temperature are increased by 0.8°C, 0.4°C, and 3.7°C, respectively and average humidity increased from 54.9% to 60.4% [1]. There was more summer (March to May) days {724 (79%) out of 920} with feel like temperature (HI more than 41°C) in the decade of 2005-2014 as compared to 646 (70%) out of 920 summer days and 488 (53%) out of 920 summer days in previous two decades (1995-2004) and (1985-1994) respectively. This shows that there is a rising trend of temperature, humidity and summer days.
2. The analysis of all-cause mortality data (36,167 Surat city deaths) with temperature and humidity for the summer months (March–May) for the period of 2001 to 2012 revealed that mean daily mortality was 37.6 ± 9.4 [2]. An excess of over 11 per cent and 18 per cent deaths per day recorded when maximum temperature ≥40°C and heat index crossed 54°C during the summer season [2]. Year 2010 was considered as hottest year in terms of high temperature with the maximum temperature of ≥40°C for 22 of 92 summer days and HI of ≥41°C for 80 of 92 summer days. There were 157 excess deaths

in the month of May 2010 as compared to average deaths of May 2009 and 2011.

3. A total of 53,042 deaths (all-cause mortality) for summer months from 2006 to 2015 were considered with regards to temperature and humidity. Of 1,180 summer days, there were 75 (6.35%) days when temperature is 40°C and above and 195 (16.50%) days with HI more than 54°C. Surat also has the highest share of days (71.3 per cent) for 41-54°C. Hence, as per IMD criteria, there were 75 heat wave days during study period. The mean all-cause mortality increased to 20 per cent for heat wave days. With regards to HI, the per day mean all-cause mortality was 43.31 at HI of ≤54°C to 53.21 at HI of >54°C. This is around 23% rise of mean all-cause mortality. This significant rise in the all-cause mortality with rise of maximum temperature is in agreement with various evidences [3, 4, 5]. Findings also shows that moderate increase in maximum temperature may lead to huge rise of all-cause mortality and consistent with study by Mazdiyasni et al. [6]. The lag impact of extreme heat on all-cause mortality for the study period (2006 to 2015) was at highest ($r = 0.283$ at $p<0.01$) and ($r=0.302$ at $p<0.01$) on same day of maximum temperature and HI respectively but continues in decreasing order up to four days. The maximum temperature threshold value for all-cause mortality is 40°C. Gender wise analysis shows that there is a wide difference between male and female all-cause mortality.
4. An Urban Health and Climate Resilience Centre's study for summer months of 2014 and 2015 revealed that presence of spatial variation in all-cause mortality provided the evidence for high risk zones. Spatial (Zone wise) analysis revealed that for the maximum temperature, there is a variation of 3°C to 4°C among zones on same time and same day. Within the city; geography of the zone (sector), river or sea nearby zone, number of industrial units, population density and slum population might redistribute the temporo-spatial pattern of all-cause mortality in relation to high temperature. There is a rise of 61% all-cause mortality for Southeast zone and 30% for East zone at temperature ≥40°C [7]. Deaths are significantly associated with high temperature in Southeast zone. A possible explanation may

be that this zone has the highest population density, predominantly migrant population and more vehicular passage. East zone of Surat shows high percentage of summer all-cause mortality as compared to total zonal deaths. This can be explained by; 1) high population density, 2) more distance from the sea as wind flow is from the South west which has a cooling affect, 3) more heat wave days (42 out of 184 summer days) having temperature ≥40°C, and 4) more settled migrant population.

CONCLUSION

Various local evidences conclude that the maximum temperature of ≥40°C and HI >54°C are the important predictors for rising of all-cause mortality of urbanites of Surat. Deaths due to heat wave are imminent from Surat City as the impact of ambient heat in the increase of all-cause mortality is clearly evident [2, 7]. The influence of extreme heat on all-cause mortality for study period (2006 to 2015) was at highest on same day of the maximum temperature.

The report also indicates that dangerous periods of extreme heat with more frequent maximum temperature spikes and rising humidity are likely to occur more frequently and suggesting the need for measures to reduce population vulnerability.

Every city is unique because of various factors like geographic location; nearby sea / river, population density, number of industries, etc. and needs localized plan as one plan may not be suitable. More so, comparison of the cities will be misleading.

RECOMMENDATIONS

The findings from this case report may lead to the foundation for the development of preventive measures including development of Heat and Health Action Plan to protect lethal effects of extreme heat on populations of Surat city. Heat wave and island pattern within city is not static so regular data analysis and revision of Heat and health Action Plan by authorities will be required.

SOME SPECIFIC POINTS FOR CONSIDERATION

1. Surat already developed the Heat and Health Action plan in 2016 but it needs regular upgradation considering the local factors and temperature threshold assessment from time to time.
2. Heat vulnerability and temperature threshold assessments are prerequisite for updating the city specific heat action plan.
3. IMD may also take into account and consider the heat index for declaring heat wave for coastal cities.
4. Presence of spatial variation in all-cause mortality provided the evidence for high risk zones hence designing the interventions including heat and health action plan at micro level is the need of hour.
5. The city is like human body; one cannot just take care of one part and expect everything else to function rightly. Hence, implementation of Heat action plan is a multi-stakeholder responsibility, therefore Public private partnership model is essential in coping capacity efforts for extreme heat.
6. In addition to focus on accessible quality adaptive measures, heat action plan should focus on extreme high temperature and migrants (55 per cent of Surat's population is migrant).
7. Every city needs to analyse the micro level data and plan accordingly for coping efforts in reducing the heat related health impact.
8. High ambient temperature associated deaths require much more research in future with an eye to decrease the ill-effects among the extremely vulnerable populations of the Surat city.

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