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Vulnerability to Heat Stress and its Health Effects among People of Nepalgunj Sub-Metropolitan

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ABSTRACT

Background: Record-breaking temperatures have occurred more frequently worldwide under the trend of climate change. It has increased the number of people at heat related medical conditions resulting in both mortality and morbidity from heat stress. This study aimed to assess factors associated with vulnerability to heat stress, its health effects among people of Nepalgunj Sub-metropolitan, and identify various coping strategies adopted.

Methods: Cross-sectional analytical study was conducted among 366 research participants selected through multi-stage random sampling technique in Nepalgunj Sub-metropolitan. Heat Index was assessed using secondary analysis of meteorological data of Nepalgunj (Airport) station. Chi-square test was done to analyze the primary data.

Results: Out of 366 participants, 224 (61.2%) participants had heat related symptoms in the past 6 months (April to September) from the date of the interview. Sex, education, income, roof construction, Cross-ventilation, working hour per day, presence of chronic disease, and medications use had a significant association with heat related symptoms among the participants ($p<0.05$) The most common coping strategies adopted to manage heat stress were the use of cooling methods, wearing light clothing, and bathing by cold water. The average monthly heat index was highest in August (42 °C) and lowest in April (29°C).

Conclusions: The majority of the participants had heat related symptoms in the study area. In order to mitigate the heat stress in the urban town like Nepalgunj, measures such as tree plantation, reducing vehicle smoke emissions, and developing proper housing ventilation can be applied.

Keywords: Climate change; coping strategy; heat index; heat stress; Nepal

INTRODUCTION

Climate change has led to a significant rise of about 0.8°C in global average surface temperature since the late 19th century increasing the frequency and intensity of heatwaves.[1] According to a study conducted by the department of hydrology and meteorology, the temperature of Nepal is rising by 0.056°C per year.[2] Climate-related extreme heat exposure increases the number of people at risk of heat related medical conditions such as hyperthermia, heatstroke, heat exhaustion, heat syncope, heat cramps, and heat rash.[3,4]

The vulnerability to heat stress varies among different groups due to several factors associated such as age, pre-existing chronic health conditions, medications, socioeconomic status, etc.[5]

This study aimed to determine the health effects of heat stress, assess factors associated with vulnerability to heat stress, and identify various coping strategies adopted by people of Nepalgunj Sub-metropolitan.

METHODS

This was a cross-sectional analytical study conducted in Nepalgunj Sub-Metropolitan from June to December 2019. A sample size of 366 participants was estimated. Our study area, Nepalgunj sub-metropolitan, is divided into a total of 23 wards. In order to draw the required sample size from the city, firstly, 8 wards were randomly selected by preparing a lottery of total 23 wards. Secondly, total households were listed in those 8 wards separately which was the sampling frame for our study. Depending upon the size of households in the individual wards, proportionate sampling procedure was applied to draw the required samples from the respective 8 wards. The individual sampling unit i.e. the household from each ward was selected by using systematic random sampling technique.

Both primary and secondary data collection technique

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was used in this study. As a primary method, structured questionnaire with face-to-face interview technique was adapted whereas as a secondary method, measurement of single daily value of maximum and minimum air temperature and relative humidity per day was taken from Nepalgunj (Airport) Station of April to September to calculate heat index.

The data collection tools were developed after an adequate overview of literature. The tool was developed in English language and then translated into simple and clear Nepali language. A local language interpreter translated the questions from Nepali to local language at the time of data collection. To ensure the content validity of the tool, the developed questionnaire was sent to a panel of five subject matter experts and content validity ratio was calculated using Lawshe's Method.[6] Any items that were insignificant at the critical level were eliminated. Pre-testing was done among 10% of total sample households which didn't fall under the category of randomly drawn households. The pretested data was entered and analyzed using SPSS software. Reliability of the tool was established by the calculation of Cronbach's alpha. The constructs that had Cronbach's alpha value above 0.7 was only considered acceptable and necessary modification in the tool was done accordingly.

In this study, heat stress was measured in terms of heat related symptoms associated with any kind of heat related illness that the respondent subjectively felt in the last 6 months (April to September) from the date of interview. A single binary variable 'yes' corresponded to ever experiencing one of those symptoms. HRS included dry skin/rashes, rapid pulse, dizziness, muscle cramps or spasms, heavy sweating, difficulty in breathing, unconsciousness, seizure, headache, hyperthermia, confusion, and vomiting. Severe HRS included unconsciousness, seizure, hyperthermia, and difficulty in breathing while the rest of the symptoms were regarded as mild for analysis.

Participant Perceptions in this study as one of the factors associated with vulnerability to heat stress was measured in terms of a 5-point Likert scale. Then, it was categorized into poor, average, and good where poor indicated for a score below 25th percentile, average indicated for a score in between 25th and 75th percentile and good indicated for a score above 75th percentile.

Ethical approval was taken from the Institutional Review Committee (IRC), Pokhara University. Moreover, permission letter was taken from Nepalgunj Sub-metropolitan. At the time of data collection, informed consent was obtained from the participant, and withdrawal from the study was accepted anytime.

Microsoft Excel was used to calculate heat index as per the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) method.[7] This method was based upon multiple regression analysis carried by Rothfusz.[8] The calculated heat index was further classified into four categories (Caution, Extreme Caution, Danger, and Extreme Danger), relating it to the severity of health effects by NWS. All the primary data collected from interview with participants was entered in Epi-data version 3.2 to minimize errors from its jump and check features and transferred to Statistical Package for Social Sciences (SPSS) for further analysis. The data were analyzed by using descriptive statistics such as frequency, percentage, mean, standard deviation, and inferential statistics Chi-square test.

RESULTS

A total of 366 participants were enrolled in this study. The mean age of participants was 42.07 years and almost half of the participants were Male (48.1%). More than half of the participants (61.2%) had Heat Related Symptoms (HRS) in the past 6 months from the date of interview (April to September). However, only 9.3% had severe HRS. Likewise, among the participants who had HRS, only 14.3% visited health institutions while the majority of them (85.7%) didn't visit health institutions (Table 1).

Table 1. Heat related symptoms among the participants.

Variables	Frequency(n)	Percentage(%)
Heat Related Symptoms (n=366)		
Yes	224	61.2
No	142	38.8
*Symptoms (n=705)		
Headache	199	28.2
Dizziness	140	19.9
Dry skin/rashes	95	13.5
Heavy sweating	82	11.6
Muscle cramps/spasms	48	6.8
Hyperthermia	33	4.7
Confusion	24	3.4
Vomiting	23	3.3
Rapid Pulse	19	2.7
Difficulty in breathing	19	2.7
Unconsciousness	11	1.6
Seizures	2	0.3
Fatigue	8	1.1

Others	2	0.3
Degree of HRS (n=705)		
Mild/Moderate HRS	640	90.7
Severe HRS	65	9.3
Visited health institution (n=224)		
Yes	32	14.3
No	192	85.7

**Multiple Responses*

Variables such as sex, educational status, income, material of roof construction, cross-ventilation, working hour per day, presence of chronic illness, and medications use in last 6 months had a significant association with HRS whereas age of participants, employment status, working outdoors in summer, acute illness in past 6 months and participant perception on heat stress didn't show any statistically significant association (Table 2 and 3).

Also, the majority of the participants (64.8%) responded that awareness programs regarding heat stress had never been conducted in their communities while 27.6% didn't know if there had been any heat stress related programs in their communities.

Regarding strategies adopted by participants to cope with heat stress, use of cooling methods, wearing light clothing, bathing by cold water, seeking shade/tree, and drinking plenty of water were most common (Table 4).

Table 2. Association of demographic and household characteristics with HRS (n=366).

Variables	Heat Related Symptoms		Total		p-value
	No (%)	Yes (%)			
Sex					
Female	57 (30%)	133 (70%)	190	12.879	<0.001***
Male	85 (48.3%)	91 (51.7%)	176		
Age					
<60	116 (39.6%)	177 (60.4%)	293	0.389	0.533
>60	26 (35.6%)	47 (64.4%)	73		
Education					
Literate	127 (44.6%)	158 (55.4%)	285	18.016	<0.001***
Illiterate	15 (18.5%)	66 (81.5%)	81		
Income					
Less than average	76 (33.9%)	148 (66.1%)	224	5.765	0.016*
More than average	66 (46.5%)	76 (53.5%)	142		
Roof construction					
Concrete/ Cement	123 (42.3%)	168 (57.7%)	291	7.202	0.007**
Others	19 (25.3%)	56 (74.7%)	75		
Cross-ventilation					
Yes	126 (42.1%)	173 (57.9%)	299	7.686	0.006**
No	16 (23.9%)	51 (76.1%)	67		

**p<0.05, **p<0.01, ***p<0.001*

Table 3. Association of occupational characteristics, health status and perception of participants with HRS.

Variables	Heat Related Symptoms		Total		p value
	No (%)	Yes (%)			
Employment status (n=366)					
Yes	81(39.7%)	123(60.3%)	204	0.160	0.689
No	61(37.7%)	101(62.3%)	162		
Working hour per day (n=204)					
< 8 hours	54(45.8%)	64(54.2%)	118	4.289	0.038*
> 8hours	27(31.4%)	59(68.6%)	86		
Work outdoors in summer (n=204)					
Yes	27(32.5%)	56(67.5%)	83	3.010	0.083
No	54(44.6%)	67(55.4%)	121		
Chronic illness (n=366)					
Yes	47(32.4%)	98(67.6%)	145	4.122	0.042*
No	95(43%)	126(57%)	221		
Acute illness (n=366)					
Yes	9(26.5%)	25(73.5%)	34	2.399	0.121
No	133(40.1%)	199(59.9%)	332		
Medications (n=366)					
Yes	45(30.6%)	102(69.4%)	147	6.932	0.008**
No	97(44.3%)	122(55.7%)	219		
Participant's Perception (n=366)					
Poor	53(42,1%)	73(57.9%)	126		
Average	62(39.7%)	94(60.3%)	156	2.191	0.334
Good	27(32.1%)	57(67.9%)	84		

**p< 0.05, **p<0.01, ***p<0.001*

The average heat index was highest in August (42°C) and lowest in April (29°C). The maximum heat index of May, June, July, August, and September fell under the class of 'Danger' which indicates heat cramps and heat exhaustion were likely and heat stroke was probable

with continued activity as per NWS Classification (Table 5).

Table 4. Coping strategies adopted(n=366).

Variables	Always (%)	Sometimes (%)	Rarely/ Never (%)
Stay indoors	176(48.1%)	107 (29.2%)	83 (22.7%)
Drink plenty of water	215 (58.7%)	110 (30.1%)	41 (11.2%)
Avoid sugar/ coffee	102 (27.9%)	176 (48.1%)	88 (24%)
Seek shade/ tree	322 (88%)	32 (8.7%)	12 (3.3%)
Wear light clothing	338 (92.3%)	19 (5.2%)	9 (2.5%)
Wear hat/cover head	123 (33.6%)	70 (19.1%)	173 (47.3%)
Adapt cooling methods	335 (91.5%)	24 (6.6%)	7 (1.9%)
Reduce outdoor activity	104 (28.4%)	196 (53.6%)	66 (18%)
Bath by cold water	329 (89.9%)	28 (7.7%)	9 (2.5%)
Using sunscreen	49 (13.4%)	47 (12.8%)	270 (73.8%)

Table 5. Monthly heat index related information.

Month	Maximum (˚C)	Minimum (˚C)	Average (˚C)
April	32	21	29
May	46	28	33
June	52	26	36
July	48	29	38
August	49	36	42
September	47	25	37

DISCUSSION

This study was conducted among 366 participants of Nepalgunj Sub-Metropolitan. Our findings revealed that 61.2% of participants had Heat Related Symptoms (HRS) which is slightly higher than another study conducted in the Terai region that had 58% of participants with HRS.[9] As per the results of this study, the major HRS were headache, dizziness, and rashes whereas another study conducted among the farmers in Bardiya and Banke districts of Terai showed that the most common reported symptoms relating to heat was fatigue followed by dizziness, headaches, and nausea.[10]

The findings in the present study indicated that the females had more HRS than males which is in agreement with the previous study conducted in South Australia.[11] A study suggests that this might be because females have higher core body and skin temperatures which makes them more vulnerable to heat stress than males.[12]

No significant association was seen between age category and HRS which is consistent with the findings of the study conducted in Canada[13] and Australia[14] However, most studies also show that the elderly are at higher risk of heat related illnesses.[15-17]

Present study also revealed that participants with lower income levels had more HRS which was similar to the findings of a study in the Hongkong .[18] This result can be explained as the lower socio-economic group were more likely to live in the context with less adequate housing forms or more likely to have other diseases or medical risk factors that will manifest their vulnerability to heat stress.

As per the findings of this study, people who worked for more than 8 hours a day had more HRS which was similar to the findings of a study conducted in the Terai Region of Nepal.[19] This might be because when people work for more than 8 hours continuously, their body may not get a chance to cool down which ultimately will increase their vulnerability to heat stress.

Our findings depicted that people with no cross-ventilation in their houses had more HRS than the ones who did which is consistent with the findings of a population-based cohort study in France.[20] This might be because the orientation of cross-ventilation helps to remove heat and humidity from the environment as it promotes the air movement.

In this study, people with pre-existing chronic diseases had more HRS than those who didn't. This result supported the finding of a study conducted in the slum dweller of India.[21] This finding might be because of the limitation of mobility and awareness, and dehydrating effects of medications in people with chronic medical conditions.

Present study showed that regular medications intake increased the risk of HRS which was similar to findings of the study in Cincinnati.[22] Similarly, in another study in South Australia, results indicated that relevant pre-existing illnesses requiring prescribed medications were associated with heat stress.[11] The rationale behind this can be explained as certain medications exacerbate heat risk by decreasing the body's ability to cool itself down, removing water and electrolytes from the body, decreasing the amount of blood that flows to the skin, or causing the body to produce more heat.

Roof Construction was significantly associated with HRS in this study. This might be because different kinds of materials have different thermal properties such as heat capacity and thermal conductivity and radiative properties such as reflectivity and emissivity which ultimately affects the vulnerability to heat stress.

Some of the most common coping strategies were wearing light clothing, bathing by cold water, adapt cooling methods, and drink plenty of water which was consistent with the findings from a study in India except the finding that in our study participants rarely or never covered their heads as a coping strategy. [21]

This study has some limitations. As the respondents had to recall the heat related symptoms of the past 6 months, there may have been recall bias. Also, as the study was conducted in context to the Terai Region of Nepal, its result cannot be generalized in hilly and mountainous regions of Nepal. In the future, researches should focus more on interventional approaches to heat stress.

CONCLUSIONS

Despite heat stress does not have significant symptoms like other diseases, the people with heat stress have much risk of serious physical harm or even death. There is a significant difference between sex, education status, income level, housing structure, working hours, presence of chronic disease, and medications use with HRS experienced by the people of Nepalgunj. People have been found to adopt different coping strategies such as using cooler/fridge, bathing by cold water, and drinking plenty of water to protect themselves from the adverse effects of heat. In order to mitigate the heat stress in the urban town like Nepalgunj, measures such as tree plantation, reducing vehicle smoke emissions, and developing proper housing ventilation can be applied. As heat stress symptoms are easily recognized, it can be used as a tool for early identification and prevention of severe impacts like heat stroke.

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