Original Article

Effects of Occupational Heat Exposure on Traffic Police Workers in Ahmedabad, Gujarat

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Abstract

One of the most concerning environmental effects of climate change is rising levels of extreme heat, which already poses serious risks in many parts of the world. In June and July 2015, we collected weekly heat exposure data using area and personal temperature monitoring in Ahmedabad, Gujarat. The study was conducted at four different traffic junctions with a cohort of 16 traffic police. For information on health effects, we administered a baseline survey at the start of the study and prospectively followed up with the officers on prevalence of heat-related symptoms. Wet bulb globe temperature (WBGT) levels ranged from 28.2°C to 36.1°C during the study period. Traffic police workers who participated in this study were exposed to WBGT levels higher than the recommended threshold limit value as per American Conference of Governmental Industrial Hygienists guidelines even beyond the hottest months of the season. Our findings suggest that airport measurements by the Indian Meteorological Department may not accurately capture heat exposures among individuals who work in and alongside high-density traffic junctions. Based on our temperature estimates, traffic police are at risk for heat stress. India is likely to experience warmer temperatures and increased heat waves in the coming decades, fueled by climate change. Therefore, it is important to reduce current and future heat-related risks for traffic police workers and similar occupational risk groups by establishing protection strategies. The protocol established in this study for occupational heat exposure assessment could be applied to a larger cohort.

Keywords: Climate change, exposure assessment, heat, occupational health, traffic police

Introduction

One of the most concerning environmental effects of climate change is rising levels of extreme heat, which already poses serious risks in many parts of the world. Over the past several decades, extreme heat events have increased in frequency, intensity, and duration.[1] Numerous studies have reported that heat wave events are accompanied by increases in hospitalizations due to heat-related illness and cardiovascular, respiratory, and renal diseases.[1] Urban populations experience higher levels of heat exposure due to the urban heat island (UHI) effect, in which temperatures in urban areas are, on average, several degrees higher than those found in surrounding areas.[2,3] As global temperatures and intensity of heat waves continue to increase with climate change, heat wave threats become more dangerous.[1]

Vulnerability to heat stress is highly differentiated by age, socioeconomic status, and occupation.[4] Individuals who work outside in hot conditions are at increased risk of heat strain and heat stroke. Workers in subtropical countries are likely at highest risk of excessive heat exposure due to dense population, urban growth, and projections of substantial temperature increases due to global climate change.[4,5] Heat-related vulnerability is complicated by other workplace factors such as poor hydration, poor acclimatization, lack of rest periods and food breaks, and clothing type.[6]

In May 2010, Ahmedabad faced a heat wave where maximum temperatures reached 46.8°C. A scientific analysis of the temperature–mortality relationship in Ahmedabad reports

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an association between mortality and daily maximum temperature.[7] As one of the fastest growing cities in India, Ahmedabad exemplifies how South Asian cities and climate are coevolving in ways that amplify both the severity of heat stress and the vulnerability of urban populations.[8]

Traffic police are responsible for overseeing and enforcing traffic safety compliance on city roads as well as managing the flow of traffic. They are exposed to changing environmental conditions such as ambient temperature, air pollution, and ultraviolet radiation which play a significant role in the development of various health disorders. Due to the uninterrupted nature of these workers' sun exposure and duration of work outdoors in hot and heavily polluted environments, traffic police workers may be susceptible to heat-related illnesses.

Although the effect of traffic on ambient temperature is largely understudied, one thermal mapping study determined that traffic increased road surface temperature by 1.5°C, primarily due to the input of heat fluxes from vehicles.[9] Epidemiological studies also reveal that traffic police are affected by long- and short-term health problems. A number of studies explore the impact of occupational health hazards on the health of traffic police personnel.[10-15] Traffic police personnel face multiple occupational hazards since they are continuously and simultaneously exposed to vehicular emissions, noise from vehicle honking, harsh weather conditions, and interpersonal stress with drivers and pedestrians.[12,16,17]

Over the past several decades, cities like Ahmedabad have experienced an overall increase in heat waves, accompanied by an increase in heat-related deaths.[18] In rapidly urbanizing cities, the influx of heat-trapping materials such as concrete and black tar roofs and heat-creating activity such as construction and car traffic contribute to UHI, exposing residents and workers to extremely high temperatures.[2,18]

It is important to develop solutions to reduce the vulnerability of workers by promoting adaptive behavior and preparing for responses to prepare for climate change. Early warning systems have been developed in many areas to prevent adverse health outcomes and alert public and government agencies about climate-related health risks.[1,19] In light of the growing need for climate adaptation strategies, fueled by epidemiological evidence and public awareness, local governments in developed and developing countries are instituting prevention strategies and preparedness plans to minimize the human costs of increasing heat. Many studies have established the effectiveness of heat wave early warning systems in reducing deaths during heat waves. In 2013, Ahmedabad became the first city in South Asia to initiate a climate adaptation and early warning system for extreme heat, known as the Ahmedabad Heat Action Plan.[20]

At the time of this study, a heat exposure assessment among traffic police workers had not been previously undertaken in an Indian city. The aim of this study is to characterize heat exposures, health effects, and coping strategies among traffic police workers. This scientific analysis will be used to inform municipal strategies in the City Traffic Department to protect these vulnerable workers against climate change threats.

Materials and Methodology

Study area and period

This study took place over a 6-week period from 15 June to 23 July 2015 at four different traffic junctions in Ahmedabad, the largest city in the western state of Gujarat.

Selection of study sites

To explore worksite differences in exposures, we selected four geographically diverse traffic junctions to carry out measurements. These include the following: (1) Helmet Circle, located in the newly developing part of the city, intersects a public bus rapid transit (BRTS) stop that experiences frequent bus traffic; (2) Pakwan Crossroads, located in the newly developing part of the city, intersects Sarkhej–Gandhinagar Highway, a major highway on the outer ring of the city boundaries, which experiences high vehicle traffic; (3) Chandkedha Crossroads, which is a highly congested, major hub for rickshaws and public buses; and (4) Lal Darwaza Crossroads, which is an entry point to the old city and close to a major traffic roundabout. These junctions were selected based on geographic location and traffic density, with the aim of capturing a diverse range of locations and exposures [Figure 1].

Study population

We enrolled a convenience sample of 16 traffic police (four participants who work at each of the four traffic junctions) who volunteered to participate in the study and confirmed consistent attendance at the same traffic junction over the 6-week study period. Senior staff supported the team to identify potential participants. All the traffic police chosen for this study were men and traveled to work by motorcycle or public transit. The traffic police ranged in age from 19 to 57 years.

Figure 1: Study area

Wet bulb globe temperature monitoring

The main heat exposure parameter was wet bulb globe temperature (WBGT; °C) measured using the QuestTemp 34, Thermal Environment Monitor (USA), which was set up in a location close to the workers. WBGT variables (dry temperature, globe temperature, wet bulb temperature, air velocity, and percentage of humidity) were measured for each junction on 4 consecutive days each week and used to calculate daily WBGT estimates for each morning work shift. The WBGT monitor was placed in a safe area close to the center of each traffic junction. The temperature was recorded for 5 h a day (approximate shift duration, i.e., 9:30 AM–2:30 PM) at 1-min intervals. WBGT is calculated through the following equation: WBGT = 0.7 Twb + 0.2 Tg + 0.1 Ta.[21]

Personal temperature monitoring

Ambient temperature measurements were recorded and stored every minute using the EasyLog Datalogger (EasyLog, USA), a temperature measurement instrument with internal datalogging capability, worn around the neck and outside of the officer's clothing. The dataloggers were given to each of the four recruited traffic police at each junction over same time as WBGT monitoring occurred. Because of the compact size of these monitors, the recruited participants wore them for the entire shift duration and there were no issues with officers wearing them.

We further compared the measured daily ambient temperature (Ta) recordings from the WBGT monitors and personal dataloggers with a written log of daily ambient temperature (Ta) measured at Sardar Vallabhai International Airport, which we collected in-person from the Meteorological Centre, Ahmedabad [Indian Meteorological Department (IMD)].

Survey questionnaire

Preliminary data was collected for all study participants through questionnaire methods. Ethical approval for the study was obtained from the institutional ethics committee of Indian Institute of Public Health, Gandhinagar (IIPH-G) prior to the execution of the study. The protocol also received Institutional Review Board approval by the University of California, Berkeley Committee for Protection of Human Subjects. The questionnaire consisted of structured questions administered by an interviewer. This version was adapted from the High Occupational Temperature Health and Productivity Suppression (HOTHAPS) program, which describes five components of heat exposure and effect studies in workplace settings.[22] The questionnaire was piloted locally prior to this study.[19] The baseline questionnaire was orally administered at the respective worksites for each subject at the start of the study period. The questionnaire was written in English and orally translated by the research team in Hindi or Gujarati depending on the subject's language preference. We collected demographic information on age, sex, height, weight, as well as work structure, heat impacts on productivity, clothing, heat coping mechanisms, toilet access, and heat health awareness. We also asked participants about perception of heat impacts on health by collecting information on prevalence of 25 heat-related symptoms, classifying the severity and frequency using a Likert scale, the integers of which ranged continuously from 1 (*not at all*), 3 (*sometimes*), to 5 (*always*).

After initial administration of the baseline questionnaire during the first week, we conducted six additional weekly follow-up visits to each subject's corresponding worksite for on-site temperature measurements. We also followed up with study participants on a biweekly basis and orally administered a survey on prevalence of heat-related symptoms (total of three follow-ups). This information was individually collected on a written form and attached to the participant's baseline survey. All responses were self-reported, with the exception of height and weight, which were determined by a tape measure and scale for each participant.

We analyzed questionnaire responses and temperature data using Microsoft Excel and STATA software. Each participant had daily averages of individual personal temperature as well as corresponding area–based WBGT data for their worksite and Ahmedabad data for the study period. We present descriptive statistics of temperature parameters and frequency of self-reported health outcomes. We then examine associations between WBGT, datalogger, and IMD data by correlating time-series data of daily average ambient temperature over each work shift recorded by the WGBT monitor with daily average ambient temperature as measured by dataloggers (both calculated as mean of hourly readings of ambient temperature), as well as with the daily average dry bulb temperature at the Ahmedabad airport over each day of the study period (20 days of data from 15 June to 23 July 2015 collected directly from IMD reports).

Results

General demographics and housing/transport characteristics were characterized using responses from the baseline questionnaire. For cooling, most (63%) traffic police had fans, while 13% had air conditioning in their homes. One participant reported having a history of chronic disease (diabetes).

Of the 16 traffic police we recruited, 7 were permanent staff (designated as inspector and constable) and 9 were temporary staff (designated as traffic brigadier and home guard). Employment length varied, with (56% working at their particular traffic junction for less than 1 year. Duty hours also varied between each participant. Most of the permanent staff worked over 8 hours during morning and evening duty. Temporary staff worked only morning or evening duty. According to questionnaire responses, morning and evening duties rotate biweekly for rotating personnel. Our experience indicates that rotation and duty location vary for temporary and lower-level staff each week. 87% of participants worked 7 days per week and one participant reported a lunch break. According to responses, no additional breaks are institutionalized during the heat season.

Table 1 reports the WBGT measurements over the study period. The dry bulb and globe bulb temperature ranged from 31.6°C ± 0.3°C to 36.8°C ± 1.6°C and 34.6°C ± 1.0°C to 49.1°C ± 3.0°C, respectively. Area WBGT heat stress measurements for all four traffic junctions ranged from 28.2°C to 36.1°C during the study period of June and July 2015 and can be expected to be much higher during April, May, and early June.

About 94% of participants reported that summer is the most uncomfortable season to work. Figure 1 depicts prevalence of self-reported heat-related symptoms at baseline (reported retrospectively for April, May, and beginning of June) and over the course of the study period (reported retrospectively for three biweekly periods during the second half of June through end of July). Sample size reduced by 50% of the original sample size for each follow-up on symptoms. Prevalence of heat-related symptoms decreased after the period of April, May, and the start of June during subsequent follow-up periods at the end of June and July. Heavy sweating (94%), intense thirst (94%), dry mouth (81%), loss of work capacity (69%), and loss of coordination (56%) were reported most frequently at baseline. These symptoms were consistently high during follow-up, particularly for heavy sweating (44%) and intense thirst (38%–44%). Other symptoms experienced by traffic police workers during duty in the summer include breathlessness, chest pain, loss of appetite, red eyes, headache, and stomach acidity [Figure 2].

In terms of heat impacts on productivity, 63% of workers reported lost wages (in terms of not being able to come to work) that they perceived to be due to heat exposures. Lack of sufficient staff and intensity of traffic load were reported as reasons for sustained work even when they fell ill. Other workplace stressors reported include air pollution, honking, and standing position.

In terms of clothing perception, 38% of participants perceived their uniform as uncomfortable. For uniform changes, most (81%) perceived the uniform color as acceptable, but 50% of participants noted that improvements could be made

Table 1: Weekly comparison of average and maximum temperature over study period

	Ambient temperature (Ta)		Wet bulb temperature (Twb)		Globe temperature (Tg)		WBGT	
	Max Ta	Avg Ta	Max Twb	Avg Twb	Max Tg	Avg Tg	Max WBGT	Avg WGBT
Week 1								
6/15	39.0	35.4±2.0	29.6	28.4±0.5	53.4	45.1±4.3	34.9	32.4±1.3
6/16	39.5	35.3±1.6	29.7	28.2±0.5	57.8	46.2±5.5	36.1	32.5±1.5
6/17	37.6	34.7±1.5	29.6	28.2±0.5	52.9	44.6±4.0	34.9	32.1±1.2
6/18	39.0	34.8±2.0	30.2	28.3±0.6	52.3	41.3±4.5	35.4	31.5±1.4
Week 2								
6/22	35.5	33.8±1.0	32.8	28.0±1.0	44.8	37.9±1.7	33.8	30.6±0.8
6/23	34.6	32.7±1.3	28.6	27.2±0.5	45.7	38.6±2.9	32.4	30.1±1.0
6/25	36.0	33.7±1.6	30.1	28.9±0.6	47.4	41.6±3.9	33.9	31.9±1.3
Week 3								
6/29	35.5	33.3±1.6	28.9	27.9±0.4	45.4	40.1±3.0	32.7	30.9±1.0
6/30	37.7	34.3±1.7	28.8	27.8±0.4	50.9	45.3±3.5	33.9	32.0±1.1
7/1	39.5	37.2±1.4	30.2	28.9±0.4	55.1	49.1±3.0	35.7	34.0±0.9
7/2	38.8	36.4±1.0	29.0	28.0±0.4	52.4	48.2±2.5	34.5	32.9±0.7
Week 4								
7/6	35.2	33.6±0.8	28.6	27.5±0.3	45.1	40.5±2.3	32.2	30.7±0.7
7/7	37.8	36.3±1.1	29.2	27.5±0.6	45.6	34.8±3.1	32.1	29.2±0.5
7/8	36.8	34.4±1.1	30.2	28.4±0.6	50.1	41.0±3.3	34.7	31.5±1.8
7/9	38.4	35.4±1.8	29.3	27.4±0.6	49.2	41.2±7.3	34.1	31.0±2.0
Week 5								
7/13	38.0	35.6±1.3	29.9	28.6±0.5	51.7	47.1±3.0	34.7	33.0±1.0
7/14	39.0	36.3±1.9	28.7	27.6±0.4	53.5	47.3±3.0	34.4	32.4±0.9
7/15	39.9	36.8±1.6	29.5	28.0±0.6	55.2	47.1±3.8	35.4	32.7±1.3
Week 6								
7/20	32.2	31.6±0.3	27.8	26.8±0.3	36.6	34.6±1.0	29.5	28.8±0.3
7/21	36.9	33.7±1.2	29.9	28.5±0.4	53.9	44.4±3.7	35.3	32.2±1.1

Color	Recommendation
	Unrestricted physical activity with breaks
	Acclimatized for 10 days or more with breaks
	Acclimatized for 12 days or more with breaks
	No physical activity

WBGT: wet bulb globe temperature

by switching to breathable cotton material and 43% indicated that the cap could be improved by providing a peak cap that provides shade to the face. In response to how heat affects them during the summer, 50% of participants claimed absenteeism increases, irritation, and effects on personal life.

Participants further highlighted that 94% of them cope with heat exhaustion by taking rest breaks and 31% of them cope by drinking a cold drink like lassi or buttermilk. 50% of participants responded that water was accessible at work. Participants reported of drinking an average of 4–5 L of water during working hours. Some said that due to increased traffic and workload they could not drink water when they were thirsty at work. These responses were variable with all four participants at Chandkheda indicating that water was not available, while all participants at Helmet Circle indicated that water was available at least at some times. About 56% of participants did not bring water bottles to work. Heavy traffic load was indicated as a reason for not drinking water even when the participant is thirsty. Traffic police utilize a variety of traditional methods to cope with heat including drinking lemon water and sugarcane juice, as well as placing a handkerchief over the face.

At the time of the study, 14% of participants had heard of the Ahmedabad Heat Action Plan and 43% had seen heat protection advertisements. About 94% received temperature warnings through the newspaper. Three participants (19%) participated in an information session on heat-related illness by IIPH-G. Workplace suggestions to improve heat coping mechanisms, included shaded umbrella at the intersections, cool jackets, proper rest places, rotation of personnel standing directly in the heat, lightweight shoes, quality goggles, water facility at junction, and oral rehydration .

Threshold limit values and heat stress

The American Conference of Governmental Industrial Hygienists (ACGIH) WBGT threshold limit value (TLV) for light, continuous work was calculated at 30°C.[23] According to this standard, our results indicate that there is risk of heat stress at all four traffic junctions during each week of the study period with the exception of Helmet Circle (Site 001) during Week 6 [Figure 3]. On that particular day of measurement, there were cloudy skies and light drizzle, resulting in cooler conditions for the duration of the sampling time. During the other days of measurement in all four sites, there were clear skies or partly cloudy skies. No measurement was conducted during rainy days. With the exception of the rain day, The average WBGT was above the TLV on all days in all four traffic junctions.

Figure 4 compares ambient temperature trends averaged daily as measured by three different temperature predictors. These include area ambient temperature as measured by the WBGT monitor located near traffic junctions, personal ambient temperature as measured by dataloggers worn around traffic police workers' necks, and ambient temperature at the city airport as measured by the IMD. WBGT and datalogger measurements appear more closely correlated with each other than IMD measurements.

Two paired *t*-tests were run on daily average ambient temperature values as measured by these temperature predictors to determine whether there was a statistically significant difference in means between each. The highest average ambient temperature was recorded by the personal dataloggers (35.7°C ± 0.31°C). The mean of daily ambient temperature recorded by WBGT monitor over the study period was 34.5°C ± 0.35°C. The mean of daily ambient temperature over the study period according to IMD data measured at the airport was 29.76°C ± 0.22°C. When compared with WBGT values, ambient temperature as measured by personal dataloggers led to a statistically significant increase of 1.15°C [95% confidence interval (CI), 0.42–1.88], t (19) = 3.29, $P < 0.001$. When compared with WBGT values, ambient temperature as measured by the IMD led to a statistically significant decrease of −4.77°C (95% CI, −5.45 to −4.09), t (19) = −14.65, $P < 0.001$ [Figure 4].

Discussion

Traffic police workers and heat exposure

Based on our average temperature measurements, study participants experienced high heat exposures during the

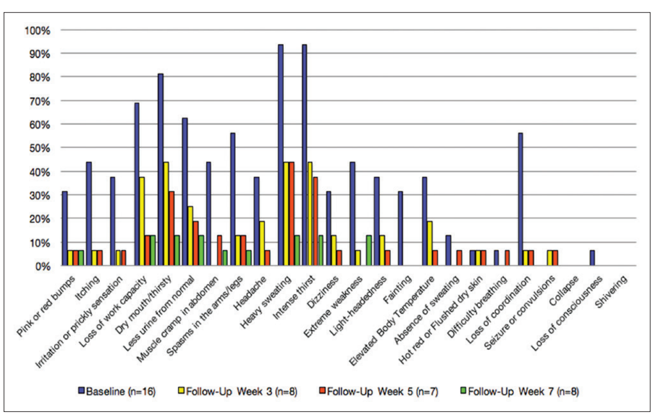

Figure 2: Percentage of participants reporting heat-related symptoms

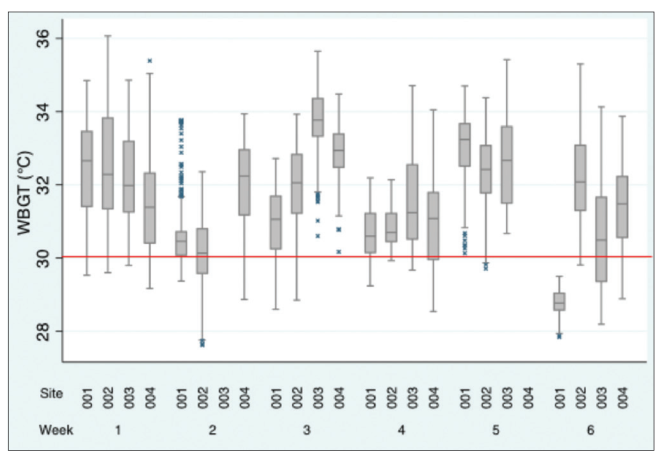

Figure 3: Weekly wet bulb globe temperature measurements by work site and threshold limit value (30°C)

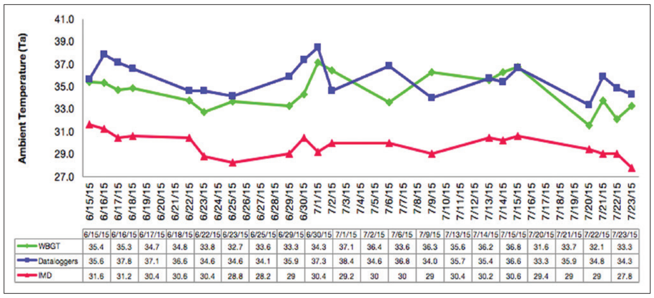

Figure 4: Ambient temperature (°C) trends as measured by wet bulb globe temperature, personal dataloggers, and Indian Meteorological Department

study period and heat load persisted during most work shift hours. Daily WBGT measurements, on average, exceeded the recommended heat TLVs designated for the observed work intensity and degree of acclimatization at each of the four outdoor worksites (measured WBGT = 30°C). Given that the end of June and July are generally considered the cooler part of the heat season due to the approaching monsoon (as opposed to April and May), these trends should be further explored.[24] Both the International Organization for Standardization (ISO) and ACGIH-recommended WBGT values are heat stress standards that set maximum hourly limits for work in hot environments. These standards identify maximum WBGT levels for continuous hourly work and variously hourly rest periods. Based on this preliminary analysis, future analysis should identify hourly periods in the day that pose the highest risk for heat exposure. This information will enable employers to operationalize additional protection strategies during risky time frames.

This study has highlighted health impacts due to excessive heat exposure. It indicates that occupational heat stress exposure resulting from outdoor work at traffic junctions is likely to have implications for adverse health outcomes. The high baseline heat-related morbidity observed is likely due to the fact that it was reported cumulatively over a 3-month period (presumably when temperatures are hottest). A larger sample of temperature data over a longer study period could be used to quantitatively explore the association between temperature and heat-related symptoms in future study by modeling the probability of prevalence of heat-related symptoms as a function of various temperature exposure predictors. Moreover, further assessment is needed to refine this relationship between quantitative assessments of exposure and physiological responses.

Comparison between three separate temperature predictors over the study period highlights significant differences between each estimate. We observed the largest difference in average daily ambient temperature (up to 9°C) between personal ambient temperature measurements and ambient temperature measured at the airport on 13 July. Urban temperatures are expected to be higher than the surroundings areas because of heat trapped in roads and buildings, that is, UHI.[2,3] Temperature trends evidence this phenomenon and imply that airport measurements by the IMD may not accurately capture heat exposures among individuals who work in and alongside high-density traffic junctions.

Traffic police who work at the center of traffic junctions in close proximity to vehicles may be exposed to higher heat exposures due to heat fluxes from the engine and exhaust as well as frictional heat dissipation from tires and rapid breaking.[9] Heat emitted from asphalt road surfaces may also contribute to high personal exposures. Furthermore, the mean of daily area WBGT measurements at the traffic junction and personal measurements were also dramatically different. This indicates that area measurements may not accurately capture the variability of heat exposures experienced by a traffic police worker over the course of a work shift.

To assess risk, WBGT measurements are critical to compare to occupational exposure limits. However, our findings suggest that heat-measuring instruments with data-logging capability worn by individuals provide a more detailed characterization of ambient temperature exposures and variability among traffic police workers. These results also indicate that, compared with the general population, traffic police personnel may experience higher heat exposures and are thus at higher risk for related adverse health effects. As a result, our exposure data represent a high vulnerability scenario that can be extended to pedestrians, other drivers, and passengers in open vehicleslike rickshaws, outdoor workers like street vendors, construction workers, and slum dwellers. Future data collected at this work site should analyze these peaks over the course of an entire day to characterize specific shift times to establish more breaks and protective measures.

Prevention methods

Existing policies are often inadequate to support adaptive capacity or to mitigate the negative impacts of heat on employment. Researchers have considered traffic police as a hazardous occupation due to physical, environmental, and psychosocial stress.[17] The questionnaire responses provided insight on workplace needs, coping mechanisms, and intervention priorities for this occupational cohort. Most workers reported the ability to drink fluids and access toilets as needed during the course of their work shift. They noted that when they did feel ill from prolonged heat exposure, they were able to take rest most of the time. However, high traffic load during particularly high commuting hours and lack of sufficient staff on duty restrict workers' ability to take rest and hydration breaks. Furthermore, not all traffic junctions were equipped with shaded break areas and/or water canteens designated for workers.

The current uniform material provided by the government may reduce the effectiveness of sweating by decreasing the amount of evaporative cooling that can take place. Specific changes to clothing suggested by the participants include using light, breathable cotton material for uniforms, as opposed to khaki or polyester material. They also suggested providing a peak cap to traffic personnel for facial cooling and shade.

Few participants had heard of the Ahmedabad Heat Action Plan, although many of them had seen advertisements on prevention strategies. The most important form of awareness was relayed through temperature warnings in the newspaper, signifying a key location for targeted outreach.

Most workers reported health problems due to heat exposure, especially during April, May, and early June, including intense thirst, heavy sweating, work capacity loss, dry mouth, and loss of coordination. Several reported problems with less urine from normal, extreme weakness, elevated body temperature, dizziness, and fainting. This is worrisome because these symptoms indicate higher risk for heat-related illnesses, which, if untreated, can be fatal.

Traffic police use a variety of traditional methods to cope with heat including drinking lemon water, sugarcane juice, and buttermilk (fermented yogurt drink) as well as placing a handkerchief over the face, which was also used to protect themselves from smoke from vehicle exhaust.

This study demonstrates the need to work toward strategies to protect workers from the negative health and productivity effects of heat exposure under current conditions. The study period is generally considered a cooler time of the season. Predicted temperature increases indicate that there is an even greater need to establish protection strategies. The current measures by the City Traffic Department are insufficient and highly variable across junctions.

Not all traffic junctions were equipped with shaded break areas and/or water canteens designated for workers. In addition to variation in cooling resources, our observations of four different junctions indicate high variability between traffic junctions in terms of traffic density and heat-contributing infrastructure. In addition to heat, other significant workplace stressors that should be addressed include air pollution, noise from honking, and prolonged standing position.

Based on questionnaire responses, we identify multiple strategies to protect traffic police from heat exposures. These include the following:

- Provisioning of an umbrella for shade and properly shaded rest areas at each intersection
- Providing cool jackets, lightweight shoes, and quality goggles for each staff member
- Rotation of personnel standing directly in the heat and oral rehydration at junctions
- Operationalizing formal water canteen and/or personal water bottles and oral rehydration.

Limitations

The feasibility of the proposed methodology required verification in the field. A key objective of this study was to critically reflect on the practicality of the study design to improve the protocol for future study.

The ideal study period for this research is April–June, which represents the hottest part of the summer season and thus the worst-case scenario. This study took place at the end of June and July. This led us to ask about prevalence of heat-related symptoms retrospectively for April and May, estimates of which may be subject to outcome misclassification.

There is also possibility for selection bias since we enrolled a convenience sample, consisting of 16 traffic police (four at each of four traffic junctions) who volunteered to participate in the study. In particular, this may introduce healthy worker bias, since we selected traffic police personnel who were present at the junctions and consented to participate.

A major challenge of this study was categorizing perception of heat impacts on health. The use of a Likert scale is largely untested in terms of validity for use in classifying heat-related symptoms. For analysis, we collapsed the 5-point scale into simply presence or absence. Weekly follow-up visits for heat-related symptoms and personal ambient temperature exposures were affected by high attrition rates due to rotation of traffic police personnel and absenteeism. Of the 16 participants, we were able to follow-up with about half each week. This led to data gaps and incomplete measurements among specific participants, which makes the analysis of exposures and outcomes, and the associations between them, limited in terms of statistical power.

In terms of analyzing WBGT values, we compared average exposures to the ACGIH TLV. However, this limit is designed by a U.S. institution and may not be applicable to the worker populations in subtropical countries. An alternative limit is ISO 7243, which comes from an international regulating agency; under these guidelines, 30°C is still the appropriate exposure limit. Nevertheless, specific guidelines developed for this region and climate area may be different.

Conclusion

The results of this study indicate that occupational heat stress exposure resulting from outdoor work at traffic junctions is likely to have implications for health. This study demonstrated a clear risk of heat stress for traffic police workers in June and July at four traffic junctions in Ahmedabad. This risk is likely an underestimate of the occupational risk in the heat season since July is generally considered the cooler month of the heat season for workers. Moreover, occupational heat stress in the summer season when the temperature reaches its maximum may pose even greater danger to the workers' health and productivity. Furthermore, this study is novel in determining the correlation between three distinct temperature predictors: personal dataloggers, WBGT, and airport monitoring.

Our results also illustrate the localized impacts of urban traffic proximity on heat exposures. Personal heat exposures in transportation microenvironments (on and near roadways) far exceeded area and airport measurements. Thus, exposures of people who work or live near roadways may not be well characterized by conventional temperature monitoring stations.

This study aimed to establish a protocol for future studies to monitor and evaluate risk from ambient heat exposure with this occupational cohort. This study offers one of the first data sets on ambient heat exposure of traffic police workers in an urban context. The protocol established in this study for heat exposure assessment could feasibly be applied on a larger scale. As a next step, this type of exposure assessment study should be extended to a larger cohort in other rapidly urbanizing cities in India.

South Asia is likely to experience warmer temperatures and increased heat waves in the coming decades. It is therefore important to take action to decrease current and future heat-related risks faced by traffic police workers in the summer season. It is also important to improve guidelines and occupational health standards for protecting worker health and productivity in the region.

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Conflicts of interest

There are no conflicts of interest.

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