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Research Article

MEASUREMENT OF AMBIENT TEMPERATURE AND HUMIDITY EXPOSURE OF OUTDOOR STREET VENDORS IN ZIMBABWE: AN UNDERRATED PUBLIC HEALTH ISSUE

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ABSTRACT

Extreme climate change induced summer heat events are a cause for concern, particularly for vulnerable groups of people, such as the poor, elderly and those who work outdoors. The occurrence of heat related illness and mortality is predicted to increase in the future. There is lack of evidence about the level of heat exposure outdoor street hawkers are subjected to. This group of informal workers constitute a large part of the self-employed workforce of many developing countries. Public health authorities in Zimbabwe, and many other developing countries in the tropics, need to prepare to cope with the future impacts heat waves could have on their population. Proactive public health approaches towards climate change effects have to be considered by public health professionals to influence policy, education and resource mobilization in an effort to prepare for future weather and climate change heath burdens.

This study measured air temperature and humidity experienced by Zimbabwean street hawkers at their workplaces and homes to quantify their levels of heat exposure during the day, as well as at night. These data were used to assess potential health effects associated with heat during the summer of 2015.

INTRODUCTION

Climate change effects include extreme heat wave events with high temperatures and humidity combining to create conditions that present a significant public health risk to various societal groups. Currently there is no universal approach for assessing effects of climate change impacts, or a conclusive definition of a heat wave. Various studies utilise regional weather–mortality relationships, or comparison with regions with a similar climate using various metrics (Kinney and Bell, 2008). Some use temperature thresholds to evaluate the start and the end of the heat wave (Gosling *et al*, 2009). This study defines a heat wave based on the average minimum temperature of 23°C and a maximum of 31°C or greater during summer in Bulawayo. Thus a heat wave is defined in this study, as an extended period of at least 3 or more consecutive days of extreme maximum day time temperatures above 31°C and minimum night time temperatures of 23°C.Such conditions have health impacts that are considered to be more severe among the poor, especially in developing countries, who do not have access to, or cannot afford electricity for cooling, and/or effective home insulation. Excessive heat exposure due to such a heat wave, particularly when people can't cool down at night, inevitably will result in cases of heat stress and heat related illnesses. The most vulnerable include outdoor workers, particularly those who work in the informal sector, lower socio-economic groups, the elderly, and those with underlying health issues. (Dozet and Oosthuizen, 2017; Kjellstrom *et al*, 2009; Ngwenya *et al*, 2017).

The situation in Zimbabwe is intensified by poor rains due to climate change and the economic decline over the last few decades that caused food insecurity and unemployment. Many subsistence farmers from rural Zimbabwe have now migrated to cities such as Bulawayo where they struggle to find work. Many of these people end up working in the informal sector as street hawkers, usually working in direct sunlight, in environments that are not able to be cooled, and often with no access to adequate housing, which effectively means people do not have opportunities to cool down at night. (Dozet and Oosthuizen, 2017). Working in such extreme heat, it impacts negatively on productivity, health and wellbeing (Frimpong *et al*, 2017; Kjellstrom and Weaver, 2009).This phenomenon is not unique to Zimbabwe, as street hawking (vending) has become the main source of livelihood for many people in tropical countries throughout the developing world(Gosling *et*

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al, 2009; Dozet and Oosthuizen, 2017; Nilsson and Kjellstrom, 2010). There is lack of empirical evidence to quantify the level and impact of high temperatures and humidity on street hawkers and a lack of strategies for managing heat related health effects (Ngwenya *et al*, 2017; Parsons, 2014). The current trend of increasing extreme heat events will impact populations of developing countries located in the tropics. The situation will be exacerbated by poverty and poorly constructed non-insulated dwellings with inadequate ventilation. These vulnerable people are more likely to suffer heat related illness and are unlikely to access adequate medical treatment. Many urban environments also suffer from heat island effects and city planners and councils do not have the necessary skills and resources to develop urban landscapes that are more conducive to coping with global warming (Ngwenya *et al*, 2017; Kjellstrom *et al*, 2009). Many studies concur that heat related illnesses and deaths amongst vulnerable groups in urban areas are due to climate change exacerbated by the urban heat island effect (Kovats and Hajat, 2008; Luber and McGeehin, 2008).

In contrast to developed countries, there is little evidence of studies assessing heat related illnesses due to climate change in the agricultural areas of Africa (Frimpong *et al*, 2017; Kenyon and Hegerl, 2008; Gleeson, 2008.) and for outdoor street hawkers(Costello *et al*, 2009; Basu, 2009). Therefore, it is considered vital to gain an understanding of the heat and humidity exposure faced by outdoor street workers during extreme heat events and the ways in which they adapt to alleviate associated health risks (Huang *et al*, 2011; Ngwenya *et al*, 2018), and to determine the adaptation strategies to heat stress by this cohort of street vendors in urban Bulawayo during summer.

This assessment of temperature and humidity in the streets and homes in the City of Bulawayo, Zimbabwe provides empirical data on the levels of exposure that street vendors working in the informal sector are exposed to. The results provide baseline data on which to develop practical solutions to mitigate the health risks faced by this vulnerable population, and to guide the development of a heat stress policies which are currently lacking. (Ngwenya *et al*, 2018) This study was conducted in Bulawayo, Zimbabwe during the summer months of September to November 2015. Historically, Bulawayo had the country's heavy engineering and manufacturing firms and was the feeder city for export to South Africa, Botswana and Zambia by rail network. The industries employed the majority of its population of over half a million. During the turnaround of the country's economy, the majority of the working class lost their jobs and joined the informal sector industry that includes street hawking to make a living. Their operations are illegal and have no support from both the government and the local authority. The conditions in which they operate, expose them to heat related illnesses and other environmental hazards which can lead them to contracting other communicable diseases.

Prior to commencement, ethics approval was gained through the Edith Cowan University Human Research Ethics Committee and the Zimbabwe Medical Research Council.

The objectives of this study were promoted to potential participants along with an explanation of the purpose and use of the Lascar data loggers was provided prior to gaining their consent to participate. Information letters written in their native languages were left with potential participants for a week so that they could discuss the project and have time to make a decision regarding their involvement.

MATERIALS AND METHODS

Lascar EL-USB -5 and Quest, Tempstress heat stress monitors were used to assess the thermal environment. The Lascar sensors were programed to record air temperature (°C) relative humidity (RH%) and dew point (°C) (absolute humidity) every 30 minutes. The instruments have a battery life of 11 months and they are small and portable. Each study participant (n=30) was given two sensors, one to be kept at their workplaces and the other in their homes, for the duration of the study (September – November 2015). The workplace data loggers were programed collect measurements from 9 am to 9 pm, and those positioned in bedrooms were set to log data from 10 pm to 5 am. The sensors were deployed in 3 areas of Makhokhoba, Lobengula and Cowdray Park (Bulawayo North) suburbs' as shown in figure 1 and are 18 km apart.

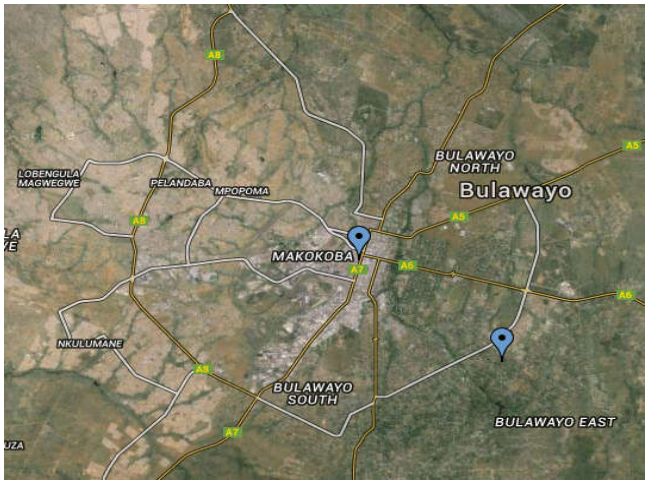

Figure 1 Map of Bulawayo

Source: http://www.maplandia.com/zimbabwe/bulawayo/bulawayo-urban/bulawayo

A convenience sample of 30street hawkers (vendors) who had make shift sheds in a set location for their business for the period of the study were the focus of this study; whereas those who moved around during the day peddling their wares were excluded. The Lascar recordings included data collected over 91 days considered the peak of summer, (1st September to 30th November 2015). Weather conditions were typical for the region with a combination of dry and wet days. Data loggers deployed at both the work sites and houses of street vendors recorded temperature, humidity and dew point every 30 minutes, resulting in 4 344 logged data points. Traditional heat stress monitors, QUESTemp QT-34 Wet Bulb Globe Temperature (WBGT) monitors, were also deployed in close proximity to the vendors during the same summer period of 2015, randomly at different times during the day, to provide random assessments of WBGT as a means of validating the lascar measurements.

Two separate heat waves were experienced during the sampling period in October and November. This was indicated by the Lascar measurements which recorded, a maximum average temperature for the three regions of 38.3°C in November; along with an average minimum temperature of 18°C. Relative humidity ranged from 19.5 % to 76.5%, and dew point from 0.5°C to 13°C, (see figure 2).

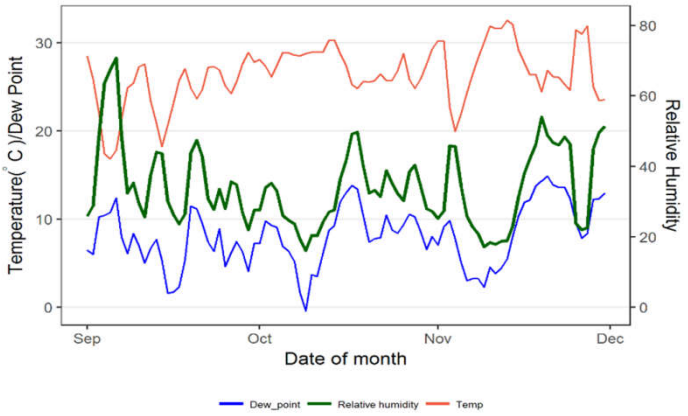

Figure 2 Average Outdoor Temperature, Relative humidity and Dew point measures for the 3 regions

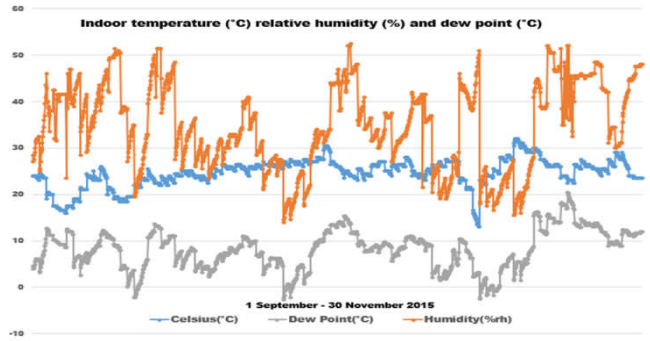

Figure 3 Lascar indoor temperature, relative humidity and dew point measures

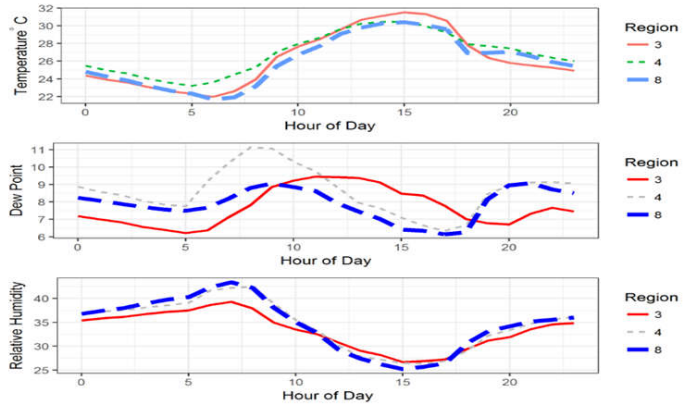

Figure 4 Peak temperature, relative humidity and dew point measurements and regional comparison

Indoor average temperature, relative humidity and dew points results were consistent for the 3 sites studied. The generally average air temperature was 23 ℃ with a maximum of 31.5℃, whilst the relative humidity was also between 14% - 52% as shown in figure 3 above.

In all three regions the average temperature increased after 10 am from between 28 °C – 32°C, reaching a peak at 3pm which from observation appeared to be the vendors' busiest time for selling their products. The ambient environmental temperature started to cool down after 8 pm while the dew point and RH was higher in the mornings before 10 am as shown in figure 4 above.

Comparison of the Lascar derived temperature, dew point, and relative humidity measurements for the three regions, (Lobengula – Magwegwe – (Region 3) = 31°C ,9.5°C and RH 37%; Cowdray Park -Bulawayo North – (Region 4) = 29°C, 11°C and RH 44%; Makhokhoba – (Region 8). = 28°C, 11°C and RH 45%). All three parameters were relatively consistent, with Lobengula - Magwegwe showing a lower dew point and relative humidity in the middle of September as compared to the other two regions.

WBGT Measurements

The Lascar outdoor results were correlated with the QUESTemp QT-34 Wet Bulb Globe Temperature (WBGT outdoor) data. Table 1 shows day time average temperature levels. WBGT is currently the internationally recognised measure of the heat stress and was used for assessment and to substantiate empirical evidence.

Table 1 Monthly WBGT day time average temperatures range for summer

Variable	Region	Month		
Averages WBGT outdoor in the shed		September	October	November
	Lobengula - Magwegwe 3	28.4	39.5	40.0
	Cowdray Park - Bulawayo North 4	28.3	38.2	39.1
	Makhokhoba 8	29.3	39.1	38.5

The difference in WBGT results from the 3 sites was minimal and correlated well with the results derived from Lascar heat monitoring. The temperatures ranged from 28°C to 40°C which is higher than the normal outdoor ambient temperatures during this season in Bulawayo. The peak temperatures of between 31°C - 38°C over several days constituting a heat wave event occurred in October and November.

DISCUSSION AND CONCLUSION

The results of this study provide evidence of the extremes of heat endured by the street vendors at work during the day time, and during their rest and relaxation period at night time. The city was hit by two heat waves during the months of October and November and the excessive temperatures and high humidity conditions were experienced by the population, with the outdoor workers being hit the hardest. Such empirical measures are important in determining ways to prevent heat related illnesses and develop future plans of managing heat related situations. Interventions to prevent heat stress are necessary, particularly in developing countries in the tropics, especially as heat wave events are predicted to be on the increase. The findings highlight need for consideration of a health surveillance programs, and to prepare cities to protect citizens from heat related illnesses due to excessive heat and humidity.

This study also established that Lascar Easy Log USB monitors are an effective and precise device for local health authorities to determine the potential for heat stress for specific cohorts in the community, especially for outdoor workers. They are less bulky than the traditional QUESTemp QT-34 Wet Bulb Globe Temperature (WBGT) heat stress monitors, easier to use, and certainly far superior than utilising generic data from meteorological stations to develop prevention strategies. The Lascar monitor provides a simple and practical way for surveillance of temperature, humidity and dew point. They are inexpensive and particularly suited for use in developing countries. They are user friendly. Although in this instance it

was necessary to overcome concern of some street vendors that the "gadgets" with their flickering light had some sinister ulterior purposes. This was a particularly sensitive issue due to the political instability in the area, and with Satanism churches and levels of suspicion among people who know they were engaged in illegal work. However, these concerns were conquered and consent to participate was gained with an explanation of the workings of the instruments and the purpose of the study.

The results from this study are consistent with other studies which indicate that there were prolonged exposures of over 12 hours to temperature range of 28°C – 30°C accompanied by days of high humidity which are conducive to heat stress, heat related illnesses, heat exhaustion, and potentially heat related deaths. Although the street vendor's physical activity while working is considered insignificant, just sitting in one place under these extreme conditions is considered to present a significant health risk, particularly as during their rest and relaxation period at night time there is no respite as their accommodation is not equipped with cooling systems. The temperatures of 23°C - 31°C is debilitating particularly at night without good cooling systems.Such prolonged periods of exposure to excessive heat and high humidity are conducive to heat stress and heat related illnesses, which will be exacerbated due to climate change.

Despite the counter argument that this population will acclimatize over time, this study results indicates a possible significant health risk to this cohort of workers particularly for children, elderly workers or those with chronic pre-existing disease.

This study demonstrates that there is a practical way to monitor for heat stress using the Lascar temperature, dew point, and relative humidity data loggers particularly for outdoor occupations like street hawkers in developing countries. It removes the reliance on the local meteorological data which is imprecise for determining heat stress. The use of the lascar monitor is a user friendly way for environmental health and safety practitioners to predict the risk in cities like Bulawayo, to produce evidence based long-term heat stress prevention strategies and health awareness programs. Such a risk assessment coupled with epidemiological evidence of heat-related morbidity and will inform policy formulation and infrastructure design for the future and foreseeable climate change impacts.

Various national climate change mitigation strategies have been developed in the developed countries. Developing countries face challenges such as scattered vulnerable populations living in underdeveloped areas with no systems in place. This study indicates that there is a heat stress issue and the need for public health action on the climate change effects on human health. Zimbabwe, the subject of this study, and other developing countries need to engage health professionals to conduct health risk assessments in order to build response strategies to climate change. This will perhaps require extensive training of public health workers and medical carers to assist in environmental monitoring, and risk assessment to help develop and implement climate change mitigation strategies. These professionals have the crucial role in informing, educating and empowering the local population about climate change. It may be necessary to call on international institutions to influence the local policy makers on climate change mitigation strategies such as the World Health Organisation (WHO) to influence minority groups such as the street vendors of Bulawayo ({McGushin *et al*, 2018; Frumkin *et al*, 2008).

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