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Impact of community education on heat-related health outcomes and heat literacy among low-income communities in Karachi, Pakistan: a randomised controlled trial

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ABSTRACT

Background Extreme heat exposure is a growing public health concern. In this trial, we tested the impact of a community health worker (CHW) led heat education programme on all-cause mortality, unplanned hospital visits and changes in knowledge and practices in Karachi, Pakistan.

Methods The Heat Emergency Awareness and Treatment trial was a community-based, open-label, two-group, unblinded cluster-randomised controlled trial that implemented a CHW-led educational intervention between March and May 2018 in Karachi, Pakistan. We randomly assigned (1:1) 16 clusters, each with ~185 households or 1000 population, to the intervention or usual care (control group). We collected data on all-cause mortality, unplanned hospital visits, evidence of heat illness through surveillance and a knowledge and practice survey during the summer months of 2017 (preintervention) and 2018 (postintervention).

Findings We recruited 18 554 participants from 2991 households (9877 individuals (1593 households) in the control group and 8668 individuals (1398 households) in the intervention group). After controlling for temporal trends, there was a 38% (adjusted OR 0.62, 95% CI 0.49 to 0.77) reduction in hospital visits for any cause in the intervention group compared with the control group. In addition, there was an improvement in many areas of knowledge and practices, but there was no significant difference in all-cause mortality.

Interpretation A CHW-led community intervention was associated with decreased unscheduled hospital visits, improved heat literacy and practices but did not impact all-cause mortality. CHWs could play an essential role in preparing communities for extreme heat events.

Trial registration number NCT03513315.

Key questions

What is already known?

- Most studies studying the effectiveness of community-based interventions to target heat-related illnesses are limited to high-income countries that have developed public health management strategies to respond to heatwaves. However, these studies do not show conclusive evidence to highlight the effectiveness of these approaches. There is a lag in planning and response to heat-related illnesses in low-income settings across countries, and the little evidence on population-based estimates was limited to observational studies.

What are the new findings?

- This study designed and tested a heat emergency awareness and treatment (HEAT) intervention, developed using current evidence and relevance to low-resource settings. The HEAT intervention comprises customised health messages coupled with information, education and communication materials to optimise the delivery of those messages, especially for communities with limited access to resources such as water, electricity and air-conditioning. There was a 38% reduction in the primary outcome of unscheduled hospital visits for any illness in the postintervention phase. In addition, there was an improvement in knowledge of the symptoms, risk factors and emergency interventions required to save the lives of victims with heatstroke. Also, the study showed that an educational intervention through community health workers could impact morbidity in poor, urban communities. Longer-term studies will be needed to confirm our findings.

What do the new findings imply?

- A community-based approach to address the heat mortality and morbidity among the most vulnerable could help communities better prepare for heatwaves and potentially reduce the heat-related burden of death and disability in low-income settings.

INTRODUCTION

Heatwaves are prolonged periods of unusually high temperatures that noticeably affect the health of the elderly, those with comorbidities and the urban poor.[1 2] Driven by climate

change, extreme heat exposure is a rapidly evolving global public health issue.[1] During the past 20 years, there has been a 50% increase in heat-related mortality among adults 65 and older.[3] In 2018 alone, 296 000 people died due to extreme heat exposure globally.[1] Extreme heat exposure leads to morbidity and mortality through direct temperature dysregulation causing heat exhaustion and heat stroke though most of the health impact is through exacerbation of illnesses such as diabetes and hypertension resulting in a higher incidence of acute illnesses such as myocardial infarction and stroke.[4] The economic cost of extreme heat on a global level is estimated to be 302 billion work hours lost in 2019.[5] Evidence from primarily high-income cities show that systematic policy level changes to reduce exposure to extreme heat can improve overall mortality and morbidity.[6 7]

City dwellers are at a significantly greater risk for extreme heat exposure. Due to the urban heat island effect, cities have a 3.5°C–12°C higher temperature than surrounding areas.[8 9] Over the years, cities in many high-income countries and a few low-income and middle-income countries (LMICs) have developed 'heat action plans' comprising citywide interventions to reduce heat exposure for those most at risk.[7 10 11] A recent systematic review on the impact of heat adaptation strategies on heat-related mortality and morbidity reported that 90% of published research emanated from high-income countries.[12] These limitations highlight the growing need to develop and test strategies to adapt and protect the most vulnerable in low-income settings from the negative impacts of heat.[13 14]

Within communities, neighbourhoods and individual households have varying levels of vulnerability to extreme heat and require targeted interventions based on household-level risk.[15] Community-based, household-level heat interventions targeting the most vulnerable urban communities have not been tested in LMICs through a controlled trial. Additionally, little data exists on the role of community health workers (CHWs), a critical frontline workforce in many settings in preparing communities for heatwaves.

We hypothesised that in populations with extremely limited resources, a contextually relevant, simple, educational intervention aimed at reducing heat exposure and facilitating early treatment, delivered through CHWs, can result in improved knowledge and practices as well as a decrease in the incidence of all-cause deaths and hospitalisations. We called the educational intervention the Heat Emergency Awareness and Treatment (HEAT) intervention.

METHODS

Study design and participants

The HEAT trial was an open-label, prospective, two-armed, unblinded, cluster-randomised, community-based trial conducted in Ibrahim Hyderi, located in Korangi District of the northern part of Karachi, Pakistan. Ibrahim Hyderi is one of the oldest areas of Karachi and is home to many different communities representing various cultural and language groups. These ethnic groups included Sindhis, Katchis, Bengalis, Pakhtuns, Balochis, Muhajirs and Hazara and differed in the language, dietary habits, education level, income level, mobility and predominant occupation.

The Aman Foundation, our local partner, has had a pre-existing CHW programme in Ibrahim Hyderi, providing services to improve maternal and child health through screening and treatment of non-communicable diseases to about 100 000 people in the area. The Aman CHW programme was supported by a telehealth programme to disseminate health messages and provide a telephone-based 24/7 health helpline. The pre-existing CHW programme had divided the area into 30 neighbourhoods (or 'paras') consisting of relatively homogenous ethnic populations of about 3000 each, served by one CHW, usually a female resident of the same community.

The health services available to the Ibrahim Hyderi community included the Ibrahim Hyderi Sindh Government Hospital (IHSGH) and many private and charity clinics. The IHSGH was primarily used for outpatient clinics and some basic inpatient care. For emergency care, the population generally used either a charity hospital about 5 km away or a larger government hospital about 13 km away.

Randomisation and masking

We followed a two-step sampling strategy. First, we randomly selected sixteen paras from 30 through a random draw. To determine which of the paras were cases and controls, we then stratified the paras by ethnicity, and half of the paras from each ethnic group were assigned to either the intervention or control arms using the second random draw. The second draw was carried out to minimise confounding caused by an unequal distribution of ethnic groups. The randomisation sequence was not concealed or blinded. Data collectors were unaware of the intervention and control distribution during the preintervention phase. All paras and households in Ibrahim Hyderi were eligible to be enrolled in the study.

We selected study households using the existing maps of clusters located in the centre of each cluster, starting approximately in the centre of para and enrolling houses clustered around the centre. If a family refused to participate in the study, we enrolled the adjoining house until we reached a sample size of approximately 1200 persons per cluster. There were no provisions for interim data analysis, and there were no guidelines for early stopping

Sample size

To calculate the sample size, we assumed that the all-cause death rate of Korangi district was the same as for Pakistan, that is, 7 per 1000 population.[16] To achieve 80% power to detect a difference between the group proportions of 20% in the primary outcome of all-cause death from the baseline at a significance level of 0.05, a minimum of

7120 people were required in each group, that is, at least 890 subjects in each of the 16 clusters. To account for lost to follow-up, we planned to enrol 1200 individuals per cluster (approximately 170 households) for a total of 19 200 individuals. We excluded all other households from each para once the sample size was reached.

The intervention

The HEAT intervention comprises customised and contextual health messages for (1) the prevention of and (2) early recognition of heat-related illnesses. We developed the intervention through a multistep, iterative process in collaboration with the Aman Foundation. First, we reviewed the literature on community-based interventions for heat illnesses from India, Pakistan, the USA, the UK, and those published by WHO.[4–6 11 17–19] We have published the literature review results elsewhere.[20] Based on the literature, the Aman Community Health Programme team and investigator jointly drafted health messages which were reviewed by ten public health and emergency care experts, four from the USA, one from India and five from Pakistan. We conducted two meetings with international experts (one in-person) and three meetings with local experts in Pakistan (all in-person) to review and finalise the draft messages. The six members of the International Advisory Group represented expertise in heat emergencies, public health, environmental sciences, and earth and planetary sciences. There were five members of the National Advisory Group consisting of a professor of civil engineering department from a local engineering university, a representative of an environmental health advocacy group, head of the largest emergency department in the city, director of the provincial meteorology department and a journalist interested in environment and health. After the initial review by the International and National Advisory groups, we asked six community health nurses (CHNs) working in Ibrahim Hyderi to review and provide feedback regarding the local applicability and acceptability of the key messages. We conducted three focus group discussions and six in-depth interviews with community members, CHWs, and healthcare providers to further inform our intervention.[21] The messages were translated into Urdu and Sindhi by the local team from Aman Foundation. The intervention was pilot tested in a non-study community of Ibrahim Hyderi. The feedback was to simplify the messaging further, using concrete examples during the sessions and removing the use of air conditioners and excessive use of bathing as an intervention due to electric and water scarcity in the community.

The final HEAT intervention included key messaging on risk factors, symptoms associated with heat-related illnesses, individual and household level preventative measures, dietary modification, early recognition of heat illness and steps to manage patients with possible heat illness. (See attached brochure in online supplemental material). Some of the key messages used in the communications were (1) wearing lightweight, light-coloured, loosely fitted clothes; (2) carrying a bottle of cold water with you when you are out and about; (3) staying indoors and, if possible, in a well-ventilated place; (4) wearing a hat or if possible or using an umbrella for shade and (5) limiting outdoor activities to morning and evening hours during extreme heat (online supplemental appendices 1 and 2).

The intervention was delivered by a team of ten CHWs, two community health supervisors (CHS), and two CHNs. The team worked full time for the Aman Foundation and did not receive any additional incentive or remuneration besides their regular salary from the Foundation. The investigators trained the CHWs, CHS, and CHNs through a 2-day workshop lasting approximately 12 hours. Topics covered included an introduction to climate change, the global trend of heatwaves, individual-based and community-based risk factors for heat illnesses, the diagnosis and management of heat illnesses at the community and household level. Additionally, sessions were held to demonstrate communication best practices, and mock sessions were held for the household visit and community meetings. The study team evaluated CHWs' understanding of the content and their ability to communicate and answer any questions through a series of mock scenarios. The study leadership held weekly sessions for the implementation team during the intervention period to answer any questions as the intervention was rolled out.

Procedures

We carried out HEAT intervention in March and April of 2018 and divided it into two main activities, individual household visits and neighbourhood meetings. During the individual household visits, the CHWs used the HEAT pamphlets and posters to discuss the risk factors, symptoms, preventive measures, including dietary modifications, recognition and early management of potential health illnesses. Each session lasted about 20–25 min and was attended by everyone available at home at the time of the visit. CHWs answered any questions, discussed potential barriers and solutions. During the 8 weeks of intervention, each CHW visited each household in the intervention clusters four times for a total of 5420 household visits. On average, each CHW visited 13 household visits per day.

Additionally, CHWs conducted 80 neighbourhood meetings to engage those not traditionally at home. The sessions followed a pattern similar to the household visits but lasted longer and were generally more interactive. A total of 80 such sessions were conducted and were attended by a total of 1628 individuals. We did not track how many people attended more than one such session. At the end of both sessions, community members were given pamphlets printed in Urdu and Sindhi languages summarising the discussion (online supplemental appendices 1 and 2).

Activities in control clusters

Table 1 summarises activities in both intervention and control clusters. Control clusters had a similar data

Table 1 Study activities and timelines

Study phase	Timelines	Intervention community	Control community
Pre-intervention	May 2017–February 2018		
Baseline household survey	May 2017	One visit	One visit
Community surveillance	May–July 2017	Household visit every 2 weeks	Household visit every 2 weeks
Baseline KAP	Jan–February 2018	Household KAP Survey	Household KAP Survey
Intervention	March–April 2018		
Community group sessions		Eighty community awareness sessions with 1628 people in attendance.	No Heat intervention. Regular CHW visits for maternal and child health
Household visits		5428 household visits with each house visited four times	
Post-intervention	May–November 2018		
Community surveillance	May–July 2018	Household visit every 2 weeks	Household visit every 2 weeks
Household KAP Survey	Sep–October 2018	KAP survey of all households	KAP survey of all households
Intervention in the control community	November 2018	No activity	HEAT intervention in all households in the control communities by the same CHWs

CHW, community health worker; HEAT, Heat Emergency Awareness and Treatment; KAP, knowledge, attitude and practices.

collection strategy (described below) but did not receive the heat intervention. However, after the postintervention data collection was completed, the control clusters received the same intervention.

Data collection

Table 1 summarises the intervention and control communities' study phases and field activities.

To measure deaths and illnesses requiring hospital visits and monitor symptoms of heat illness, we established a community-based surveillance system during the three warmest months in Karachi (May, June, July in 2017 and 2018). Trained data collectors visited each study household in the intervention and control cluster every other week for a total of five visits per household. The data collectors were from the same community, were employed by Aman Foundation for other health and research-related activities, and were trained in the data collection by the study team. Data was collected through a structured questionnaire, which was peer-reviewed and pretested before final implementation. All data were collected electronically using android tablets. During the first visit, the data collectors obtained detailed demographic and health information on each family member and information about the size of the house, building material, including the material used in the roof, availability of water, electricity, air-conditioning, water cooler, refrigerator and electricity generator. Most homes in Ibrahim Hyderi were built on an 80 sq. yard (<720 square feet) plot of land. The size of the home reflected the socioeconomic status and the crowding in the house and was therefore included as an independent variable.

Similarly, in Karachi, houses or apartments facing west or having windows westward, locally called 'west open,' are considered desirable due to the cooling effect of the eastward breeze. We, therefore, included 'west open' as an independent variable. Similarly, houses without windows were also identified and included in the analysis. We asked about the water source but did not ask if the water was potable.

In the subsequent four visits, the data collectors obtained information on any illness, including signs, symptoms, exposure to heat and whether hospital-based care was sought during the past 2 weeks. In case of death, the cause of death was obtained from the head of the household. To assess knowledge, attitude and practices (KAP), we surveyed each household in the control and intervention cluster and interviewed the head of the household. In households where men worked as fishermen and were not present at the time of the survey, the female head of the household was interviewed. This survey was conducted in Jan and February of 2018, before the intervention, and in September and October of 2018, after the postintervention data collection (table 1). The questionnaire for the KAP survey was developed by the research team based on the literature review and feedback from the international and national advisory groups. No prior example of heat KAP survey was available from our literature review. The questionnaire was peer-reviewed by the International and National Advisory Committees and was pretested on 12 individuals from clusters that were not part of the study. Formal validation of the KAP questionnaire was not conducted. The KAP survey was an android-based questionnaire with 117 questions, of which 71 were knowledge questions, 41 were practice questions and 5 were attitude questions (online supplemental appendix 3).

For community surveillance and KAP data, several data quality checks were included in the e-questionnaire, minimising the chances of entering incorrect or irrelevant data and maximising data integrity. Data underwent two verification levels, and the data management team cleaned the data and ensured its completion.[22] First, field supervisors checked all the data to ensure their completion and accuracy. Second, the data management team cleaned the data, identified any missing information and ensured that the data on the household matched with the Global Positioning System (GPS) location obtained automatically at the time of data collection.

For May, June and July in 2017 and 2018, the team maintained a log of publicly available average, maximum and minimum temperature provided on the Pakistan Meteorological Department website.[23]

Outcomes

The study's primary outcomes were a composite of all-cause mortality and all-cause emergency hospital visits. Many studies on heat interventions have used all-cause mortality and hospital visits as outcomes.[6 24–26] Since our focus was on severe illnesses requiring visits to the hospital emergency departments, we excluded visits to an outpatient clinic or a primary care physician

The study's secondary outcomes were any change in KAP towards heat-related illnesses within the community. Only those messages that were part of the HEAT intervention were included in the analysis. A more specific measure of heat illness, such as the presence of heat stroke or heat exhaustion, was not included as the outcome measure because of the non-specific nature of symptoms and lack of reasonable certainty in making these diagnoses at a population level based on available information.

Statistical analysis

All data were analysed using STATA V.15.1 quantitative statistical software.[27] Descriptive statistical analyses reflected the distribution of socio-demographic characteristics of the sample population on the household level across control and intervention groups in the form of counts and proportions. Mortality rates were calculated for the 3 months of the data collection and annualised by multiplying with a factor of 4. χ^2 tests were applied to test the association between pre-and post-intervention outcomes for all-cause mortality, admission to a healthcare facility due to an illness, and presence of any symptoms of heat-related illnesses.

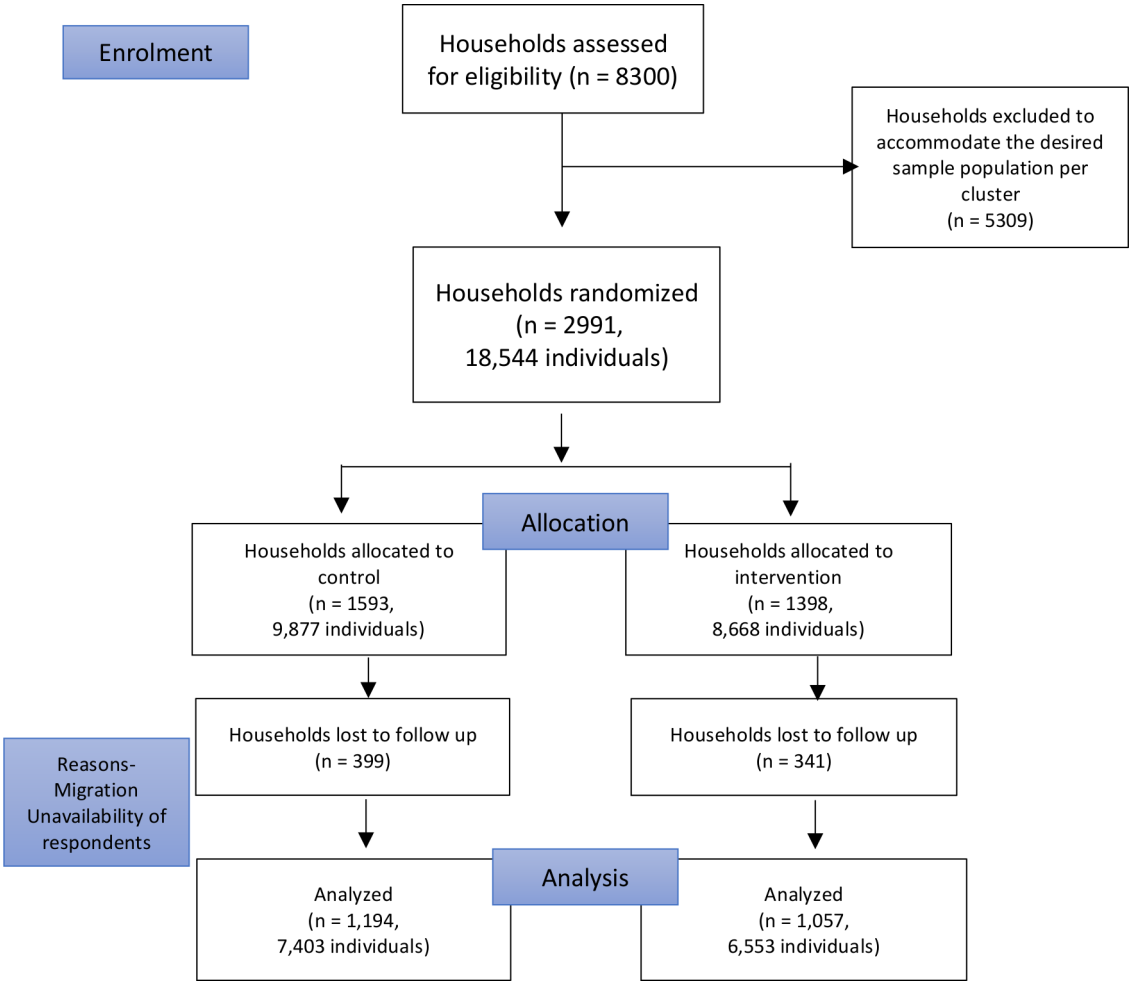

Figure 1 Study design and sample size.

Table 2 Baseline demographic and housing structure characteristics of the population, March 2017

Characteristics	Total population	Control	Intervention	P value
Sex* (n=16 203)				
Male	8538 (52.69)	4426 (52.79)	4112 (52.59)	0.136
Female	7665 (47.31)	3958 (47.21)	3707 (47.41)	
Age* (n=15 792)				
<5	1814 (11.48)	921 (11.41)	893 (11.57)	0.331
5–18	4599 (29.12)	2350 (29.11)	2249 (29.14)	
19–45	7380 (46.73)	3751 (46.46)	3629 (47.01)	
46–64	1770 (11.21)	918 (11.37)	852 (11.04)	
>65	229 (1.45)	133 (1.65)	96 (1.24)	
Education level of the head of the household† (n=2906)				
No	2250 (77.43)	1174 (77.80)	1076 (62.12)	0.251
Any	656 (22.57)	335 (22.20)	321 (37.88)	
Family size				
Four members or less	903 (33.30)	503 (35.05)	400 (31.35)	0.045
Five to 6 members	781 (28.80)	418 (29.11)	363 (28.45)	
More than six members	1028 (37.91)	515 (35.86)	513 (40.20)	
Household income (US$, daily)† (n=2304)				
Less than US$2	1127 (48.91)	498 (43.38)	628 (54.37)	<0.001
US$2 or more	1177 (51.09)	650 (56.62)	537 (45.63)	
House description and size† (n=2707)				
Hut	31 (1.15)	18 (1.25)	13 (1.02)	0.327
House (<80 sq. yards)	1838 (67.87)	995 69.29)	843 (66.33)	
Houses (>80 sq. yards)	481 (17.76)	245 (17.06)	236 (18.57)	
Flats/apartments	357 (13.19)	178 (12.40)	179 (14.08)	
Any window in the house, yes	2448 (90.17)	1264 (51.63)	1184 (48.37)	<0.001
Westward facing house, yes	1308 (48.18)	744 (56.88)	564 (43.12)	<0.001
Roof type (n=2710)†‡				
Non-concrete	547 (20.18)	359 (25.02)	188 (14.75)	<0.001
Concrete	2163 (79.82)	1076 (74.98)	1087 (85.25)	
Water source (n=2699)†§				
Outside home	1240 (45.94)	626 (43.84)	614 (48.31)	0.020
Inside home	1459 (54.06)	802 (56.16)	657 (51.69)	
Other resources†				
Electricity, yes	2416 (88.99)	1279 (52.94)	1137 (47.06)	0.938
Telephone, yes	30 (1.10)	18 (60.00)	12 (40.00)	0.438
Cellphone, yes	2139 (78.78)	1127 (52.69)	1012 (47.31)	0.578
Generator, yes	137 (5.05)	69 (50.36)	68 (49.64)	0.531
Room cooler¶, yes	15 (0.52)	6 (40.00)	9 (60.00)	0.313
Television, yes	1947 (71.71)	1059 (54.39)	888 (45.61)	0.018

*Number of individuals.
†Number of households.
‡Non-concrete includes thatch/bamboo/wood/mud/cardboard/plastic/iron sheets/asbestos; concrete includes T-iron/wood/brick/reinforced brick cement/Reinforced cement concrete (RCC)/tile beam.
§Inside home—tap, hand pump, well, boring: outside home—community tap, community hand pump, tanker, others.
¶Coolers that work on the evaporative cooling where evaporated water is used to cool the air.

Table 3 Health outcomes across the preintervention and postintervention periods

Variables	Control, (%)		Intervention, (%)		Adjusted OR (95% CI)*
	Preintervention	Postintervention	Preintervention	Postintervention	
Deaths from any cause (rate per 1000 per year)	17 (2.29)	16 (2.47)	21 (2.93)	17 (2.80)	0.86 (0.34 to 2.19)
Unscheduled hospital visit (rate per 1000 per year)	231 (124.7)	377 (233.0)	311 (173.6)	311 (204.8)	0.62 (0.49 to 0.77)

*Adjusted odds of the outcome in the intervention group compared with the control group in the postintervention group.

The data on knowledge, preventive measures and actions during an emergency based on the key messages from the intervention were retrieved from the more extensive KAP data. Change in the proportion of household representatives who responded 'yes' to a variable between the control and intervention groups preintervention and postintervention was calculated to represent secondary outcomes. Adjusted OR (aOR), accounting for the change in positive responses in the postintervention period for the intervention group compared with the change in responses in the preintervention group for the control group, were calculated to measure differences in primary and secondary outcomes between the intervention and the control groups.

We developed a logistic regression model to test for association between the rates of an unscheduled hospital visit and several household indicators such as the size of family, size education of the head of household, water source, electricity and television and building material used in the house and the roof.[28] An interaction term for the group (control/intervention) and time (preintervention/postintervention) was also included in the regression to test whether the change seen across each outcome variable was actually due to the intervention.

Written consent was obtained from the heads of each household for the households to be included in the study. We used verbal consent where participants were unable to read and write. The consent process occurred at the household level, and the Aman foundation's research team was responsible for the consent process. The consent process occurred before the community surveillance began within the community.

Public involvement

We organised community meetings to discuss the project before launching it. CHWs were from the Ibrahim Hyderi community and were involved in the design of the intervention and the study's conduct as data collectors. Community members were not directly involved in the study design, recruitment or conduct of the study. We conducted multiple session with the community members in Karachi to inform them of the results. A HEAT policy document was developed as part of the study and disseminated to the city government and a dissemination seminar was also organised in the federal capital of Islamabad. There was no burden of intervention on the study participants or larger community.

RESULTS

We enrolled 18544 individuals from 2991 households from the sixteen clusters (figure 1). Of these, 1593 households (9877 people) were from the control clusters, and 1398 (8668 people) were from the intervention clusters. Just over half (52.69%) of the population were males, 87% were below 45 years, while only 1.5% of the population was over the age of 65 years (table 2). More than three-fourth (76.13%) of the population had no education, and the distribution was similar for heads of households (77.4%). About half of the households had an income of less than US$2 per day (US dollar to Pakistani Rupees currency exchange rate of June 2018). Twenty per ent of households had a non-concrete roof type, and about half had potable water inside their homes (54%). Electric power was available to 89% of the households. Overall, the intervention and control populations were similar except for the proportion with an income level of <US$2 per day (56.6 vs 45.3, p<0.00) and the percentage of homes with a non-concrete roof (65.5% and 34.4%, p<0.00). Less than 1% of households refused to participate in the study.

Health outcomes

Complete follow-up data were available for 2251 (75.25% of the initial sample) households, of which 1194 were from the control group (74.5% of the initial sample) and 1057 (75.6% of the initial sample) from the intervention group. In the preintervention phase, the annualised rate of all-cause mortality in the intervention group was 11.72 deaths per 1000 population (2.92 per 1000 population over the 3 months), while in the control group, it was 9.18 per 1000 population (2.29 per 1000 population over the 3 months). In the postintervention phase, the annualised all-cause mortality rate in the intervention group decreased to 11.2 per 1000 population (2.80 per 1000 over the 3 months), while in the control group, it increased to 9.88 per 1000 population (2.47 per 1000 population over 3 months). The adjusted odds of death in the intervention group decreased following the intervention (OR

Table 4 Results of health outcomes following community-based educational intervention

Characteristics	Hospital visits/deaths
Group	
Control	Reference
Intervention	1.20 (0.92–1.57)
Time	
Preintervention	Reference
Postintervention	0.99 (0.81–1.22)
Family size	
Size of family (four or less)	Reference
4–6 members	1.20 (0.89–1.60)
More than six members	1.31 (1.02–1.71)*
House type	
House (<80 sq. yards)	Reference
Hut	1.22 (0.49–3.06)
House (>80 sq. yards)	1.32 (1.01–1.73)*
Flats	1.28 (0.93–1.75)
Education of head of household	
No	Reference
Any education	1.19 (0.93–1.52)
Roof type†	
Non-concrete	Reference
Concrete	1.24 (0.93–1.65)
Ventilation	
No	Reference
Yes	0.90 (0.63–1.29)
Open towards west	
No	Reference
Yes	1.05 (0.85–1.31)
Water source	
Inside home	Reference
Outside home	1.11 (0.89–1.38)
Electricity	
No	Reference
Yes	1.01 (0.72–1.42)
Television	
No	Reference
Yes	0.84 (0.66–1.06)

*P<0.05.
†Non-concrete include thatch/bamboo/wood/mud, cardboard, plastic, iron sheets, asbestos, t-iron, wood, brick; concrete include reinforced brick cement/Reinforced cement concrete, tile beam.

0.86 95% CI 0.34 to 2.19) though the reduction was not statistically significant.

For an illness requiring an unscheduled visit to a hospital, we found an overall increase in the frequency of hospital visits during the post-intervention phase (n=542, 3.72% vs n=688, 5.48%; p<0.001) in both control and intervention groups. The AOR for hospital visits in the intervention group was 0.62 (95% CI 0.49 to 0.77) (table 3).

The logistic regression model results for the association between the unscheduled visit to a hospital and various demographic and household variables showed that except for a family size of more than six members, there was no statistically significant difference between the groups (table 4). There was no association between the education level, house size, type of roof, water availability, electricity and ownership of a television, and risk of an unscheduled hospital visit.

Knowledge and practice outcomes

In our preinterventionand postintervention KAP survey, we found an improvement in the knowledge and practices in both control and intervention groups. However, for the most critical messages delivered during the intervention, we found greater improvement in knowledge and practices among the intervention group than the control. For example, households in the intervention arm in the post-intervention phase were 2.37 times more likely to be aware of high temperature as a symptom of heat illness than those in the control group in the pre-intervention phase. Similarly, there was higher recognition of symptoms such as weakness (OR: 1.72) and tachycardia (OR: 1.31) as symptoms of heat illness. Taking a shower to reduce body temperature (OR: 0.68); changing lifestyle such as avoiding going outside in the afternoon (OR: 2.78)) and modifying time to cook (1.94) were also more acceptable in the postintervention phase in the intervention group (table 5).

DISCUSSION

We found that a CHW-led, community-based educational intervention was associated with no reduction in mortality and a 38% relative reduction in unscheduled hospital visits in the intervention group compared with the control group when adjusted for the differences at baseline. We also found an improvement in the community's ability to recall many of the signs and symptoms of heat exhaustion and heatstroke, identify risk and preventive strategies, and recall steps to ensure life-saving emergency care. However, these results have to be considered in the context that, despite the randomisation, intervention and control populations had different baseline rates of mortality and hospital visits, and in the postintervention period, there was an overall increase in hospital visits not explained by temperature differences between the two time periods.

Our study population likely represents some of the most climate-vulnerable population groups worldwide and highlights the challenges of developing and implementing potential extreme heat interventions in populations with limited infrastructure. The most frequently recommended heat mitigating interventions require water and electric power. However, these utilities were

Table 5 Change in knowledge, attitude and practice outcomes for heat illness preintervention and postintervention between control and intervention groups

Variables	Control n (%)		Intervention n (%)		
	Preintervention (n, %)	Postintervention (n, %)	Preintervention (n, %)	Postintervention (n, %)	Adjusted OR (95% CI)
Age >65 is a risk factor	1172 (90.6)	1119 (84)	851 (83.4)	1068 (89)	0.88 (0.79 to 1.04)
High temperature is a symptom	361 (27.9)	622 (46.7)	345 (33.9)	674 (56.2)	2.37 (2.10 to 2.67)*
Increased weakness is a symptom	503 (38.9)	585 (43.9)	273 (26.9)	608 (50.7)	1.72 (1.53 to 1.93)*
Worsening mental status is a symptom	125 (9.7)	183 (13.7)	175 (17.2)	246 (20.5)	1.88 (1.62 to 2.21)*
Increased heart rate is a sign	210 (16.3)	292 (22)	92 (9.1)	266 (22.2)	1.31 (1.12 to 1.55)*
Working outside is a risk factor	256 (19.8)	144 (10.8)	260 (25.6)	152 (12.7)	0.47 (0.40 to 0.55)*
Avoid going outside between 11:00–15:00 hours	80 (6.2)	199 (14.9)	87 (8.8)	256 (21.3)	2.78 (2.29 to 3.37)*
Reduce time in kitchen during afternoon	1051 (81.3)	931 (69.8)	745 (73.4)	808 (67.3)	1.94 (1.59 to 2.38)*
Victim should be moved to a cooler area	254 (19.6)	189 (14.2)	234 (23.1)	230 (19.2)	0.73 (0.63 to 0.85)*
Heavy clothing should be removed	175 (13.5)	146 (11)	142 (14)	148 (12.3)	0.82 (0.68 to 0.96)*
Helpline should be called	54 (4.2)	47 (0.1)	67 (6.6)	41 (3.4)	0.66 (0.49 to 0.88)*
Wet sponging should be considered	160 (12.3)	126 (9.4)	159 (15.7)	118 (9.8)	0.65 (0.54 to 0.78)*
Shower should be considered	1012 (78.3)	857 (64.3)	738 (72.7)	863 (72)	0.68 (0.61 to 0.78)*

*P<0.05.

not consistently available in many households in our study site. The concept of vulnerability to extreme heat needs to evolve with an improved understanding of the epidemiology of heat illnesses and their physiological, social, and environmental determinants.[24 29] We believe traditional measures of heat exposure and risks, such as temperature, humidity, and age, may overlook other, more complex household-level social and economic risks such as the affordability and availability of water and electricity, number of people per household, the design of the housing unit and access to emergency healthcare.[15 30 31] Similarly, age >65 is the focus of most interventions that may not have the same impact in our study population, where only 1.5% of the total population was in that age group.

There is growing evidence supporting government-run, regional interventions for reducing the health impact of extreme heat.[20 32 33] Analysis of the heat action plans from multiple European cities showed a significant decrease in deaths during heatwaves and improved communities' KAP.[34–36] Further, targeted interventions focusing on high-risk groups such as the elderly and those with known chronic medical conditions through door-to-door checks, focused health messaging and close follow-up with primary physicians have also shown a significant reduction in mortality rates.[37 38] In Ahmedabad, India, the city-wide implementation of a heat warning system coupled with a widespread communication effort led to a decrease in the number of heat-related deaths reported to the hospital.[39] A quasi-experimental study from Chongqing, China, tested a broader set of interventions, including a heat-specific healthcare network, early warning system and preparation, a 24-hour health helpline and doctors' training on heat illnesses. The study found a significant improvement in the incidence of heat-related illnesses in the subset of rural populations measured through two surveys 1 year apart.[40] In another community-based study set in Jinan City, China, the elderly in two urban and two rural settings were randomised to receive government-sanctioned subsidies during high-temperature periods to keep workers home and flexible scheduling versus no intervention.[41] The study found improved KAP scores in the intervention group.

Our study, however, focused on enhancing the community's response through existing community resources, independent of government-sanctioned reliefs and interventions. Thus, we attempted to replicate circumstances that exist in many similar LMIC cities where local governments, often strapped for resources, have limited ability to enforce heat intervention plans. Yet, we believe that a government-run, heat-health action plan would likely have a much more significant impact, be more cost-effective and sustainable, and potentially, have synergistic effects when combined with community-based household-level interventions.

Our findings have several implications for future preparedness for extreme heat exposures. We demonstrated that CHWs could provide necessary community education leading to a potential change in behaviour and health outcomes. CHWs are recognised as critical to many health systems, especially those in LMICs, and are beginning to be recognised as agents of change for planetary health.[42] The study served as a proxy to suggest that with some additional training in heat prevention, CHWs can create behaviour change within communities to reduce heat exposure and blunt the effects of extreme heat while other system-wide, resource-intensive interventions are implemented.[32]

Our study has several limitations. First, like most heat intervention studies, we focused on all-cause morbidity and mortality as the primary outcome instead of specific heat-related mortality and morbidity. This was due to the difficulty in diagnosing heat illnesses in communities, especially where febrile infectious illnesses are common.[43–45] Second, our study did not collect information on the prevalence of non-communicable diseases such as diabetes or hypertension for the population. We only collected that information once someone the in community reported the symptoms of heat illness. Third, across assumed equal distribution of individual level exposure to heat, and we did not measure changes in the exposure between the 2 years. Personal heat exposure data collection has been conducted in athletes and military personnel but less in civilian settings.[5 46] We believe, measuring individual-level exposure to heat stress would help standardise the exposure and is possible with the available technology.[47] Fourth, while encouraging, our results are based on only two-point estimates and do not prove with certainty the cause-and-effect relationship. Further, our intervention lasted only 1 year, making it difficult to study the effects of confounders between the 2 years. For example, average maximum temperatures during preintervention months were slightly higher than post-intervention, while minimum temperatures were the same (35.2 and 28.2 in the preintervention phase vs 36.0 and 28.2 'C in the postintervention phase).[48] Similarly, in the postintervention period, the city of Karachi had a significant epidemic of chikungunya infection. It is not clear how this affected our study area.[43] Finally, it is also important to recognise that the KAP questionnaire was designed specifically for the local context and needs validation in other settings.

CONCLUSION

Our study identified a potentially promising role for CHWs in improving the resilience of highly vulnerable low-income urban communities against extreme heat. If proven through longer-term studies in multiple settings, the HEAT intervention developed through this study could lead to significant public health benefits for the most vulnerable populations globally.

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