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Original Article

Reducing extreme heat impacts on health in pregnant women and infants: a community based intervention in Kilifi, Kenya

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Abstract

High ambient temperatures affect maternal and newborn health outcomes and wellbeing. The Climate Heat and Maternal and Neonatal Health in Africa (CHAMNHA) consortium conducted formative qualitative research in rural Kilifi, Kenya, to examine perceptions of heat risks among women, household members, and community stakeholders. An intervention was co-designed together with community members. This paper presents the development, implementation, and evaluation of a behaviour-change intervention aimed at reducing the burden of heat on maternal and newborn health. The intervention used Digital Audio-Visual (DAV) storytelling (encompassing short videos and a set of photographs) and facilitated group discussions. Intervention groups included pregnant and postpartum women ($n = 10$), mothers-in-law ($n = 10$), male spouses ($n = 10$), and community influencers ($n = 40$). Researchers and local community health volunteers supported pregnant and postpartum women and their household networks weekly for 4 months. At month five, a structured interview, originally administered at baseline, was repeated to evaluate understandings of heat risks and changes in behaviour (reducing exposure to heat by changing daily schedules, reducing heavy workload, and increasing spousal support). Pregnant and postpartum women reported a better understanding of the effects of heat on their health and the newborn, including the importance of staying hydrated, breastfeeding frequently, and avoiding heavy clothing for newborns. They also reported an increase in mothers-in-law and male spouses assisting with household chores and disseminating heat-health messaging to families. However, women noted that male spouses who supported them with chores sometimes reported being stigmatized by their peers. Community approaches to support pregnant and postpartum women during heat periods are feasible, and key community influencers can be trained to include heat-health messaging in their daily routines. Additional research is needed to examine whether repeated training is required to ensure sustainability. Future heat interventions focusing on maternal and neonatal health should consider factors such as employment, age, and depth of support networks.

Keywords: heat exposure; maternal health; newborn health; behaviour change; climate adaptation; implementation research; Kenya

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Key messages

- Addressing household dynamics and entrenched gender norms is critical for the success of community-based behaviour change interventions to improve heats effect on mothers and newborns.
- Pregnant and postpartum women in sub-Saharan Africa, including rural Kilifi, continue to perform heavy workloads in the heat with little protection and no access to heat-health interventions.
- Behaviour change interventions that engage family members can raise awareness about heat's impacts and encourage supportive practices for pregnant and postpartum mothers.
- Heat risk communication strategies must be context-specific, co-designed with users, and tailored to their unique needs to ensure effective adoption and sustainability.

Introduction

High ambient temperatures have been linked to various serious adverse health outcomes in women and children, including preterm birth, stillbirth, and maternal hypertension (Nakstad et al. 2022; Part et al. 2022; Chersich et al. 2023; Conway et al. 2024). Additionally, heat has been found to impact health-related behaviours, reducing time spent breastfeeding (Part et al. 2022; Lusambili et al. 2024b) and bed net use, and undermining antenatal and postnatal care access and utilization (Scorgie et al. 2023; Lusambili et al. 2024b). However, research on these effects of climate change on maternal and newborn health is still limited, especially in sub-Saharan African countries. As part of the CHAMNHA consortium, we conducted qualitative research in 2022 in rural Kilifi to examine community perspectives on the effect of high temperatures on women during pregnancy, childbirth, and the postpartum period (Lusambili et al. 2023, 2024b; Scorgie et al. 2023).

CHAMNHA study found that extreme heat had a direct impact on the health and wellbeing of pregnant women and mothers. Furthermore, heat in the context of multi-year drought increased women's heavy workloads as they spent more time in the heat searching for water, food, and firewood. This additional burden, combined with the lack of established heat coping strategies, directly impacted on the health and wellbeing of pregnant women and new mothers. We also found that pregnancy and the postpartum in this setting are not traditionally viewed as times in one's life that necessitate assistance. The Kilifi community, like many similar communities in rural sub-Saharan Africa, is accustomed to witnessing mothers and pregnant women handle these responsibilities without family support.

In addition, our qualitative research found that heat adversely affected neonates and postpartum women (Lusambili et al. 2024b). For example, mothers found it uncomfortable to breastfeed and care for their neonates. The impacts of heat were made worse by the sustained drought in eastern Kenya, which meant that clean water was scarce and took longer to collect. High indoor temperatures were made even more uncomfortable by the smoke from indoor cooking in poorly ventilated housing. Our findings suggested that mothers and their neonates in rural Kilifi have little protection against extreme heat, and there is low awareness of how to support mothers and their neonates in these circumstances. Following this formative research, a co-design process was conducted with local stakeholders to discuss the findings and select key areas for developing intervention strategies (Lusambili et al. 2023).

There have been no heat-health interventions in rural Kilifi nor are there any risk communication tools for heat health messaging, either in general or specifically for protecting maternal and newborn health (Lusambili et al. 2024a). Despite their effectiveness, there is a lack of behaviour change interventions in Africa that focus on heat protection. In contrast, community-based interventions have demonstrated considerable success in improving maternal and child health outcomes, including increased antenatal care attendance, higher rates of exclusive breastfeeding, and improved immunization coverage (Prost et al. 2013; Lassi et al. 2015) These interventions are particularly effective when they are community-driven, as they engage local knowledge and directly address the social norms, household dynamics, and gender roles that shape health-related decision-making and practices. The involvement of key community influencers—such as male partners, mothers-in-law, and local leaders—plays a critical role in challenging and shifting entrenched gender norms, thereby fostering supportive environments that facilitate behaviour change (Morrison et al. 2005; Jennings et al. 2014). Active community participation in the design and implementation of interventions has been shown to increase ownership, which in turn enhances the acceptability, adherence, and long-term sustainability of health behaviours (Campbell and Cornish 2010). Heat-health warnings systems that are implemented at city or national level have been evaluated, but these are generally targeted at older persons or those with chronic illness, specifically in high-income countries (Williams et al. 2019; De Sario et al. 2023).

The aim of our co-designed intervention was to inform women on heat effects on health and infant care, encourage heat protective behaviours, and reduce harmful behaviours during periods with high temperatures.

This paper outlines the methodology used to develop a behavioural intervention through a co-design approach with the local community and key stakeholders, as well as the implementation and evaluation of the behaviour-change intervention using key informant interviews and pre- and post-intervention surveys.

Materials and methods

Setting

The intervention was implemented in rural villages in coastal Kilifi Country, one of the poorest parts of Kenya where approximately 70% of people live below the poverty line (Kilifi County Integrated Development Plan 2018-2022). The villages have poor road infrastructure, limited water sources, and low agricultural yields. In addition, the area is hard hit with deforestation, and the lack of outdoor shading means that whenever possible, women's domestic labour, such as fetching water, collecting firewood, and tending to gardens, often requires them to be outdoors for extended periods, increasing their exposure to heat and solar radiation (Scorgie et al. 2023).

Description of the intervention development, implementation and evaluation

Below, we detail four phases undertaken in characterizing, developing, implementing, and evaluating our co-designed intervention.

Table 1. Phases of the intervention.

Steps	Description
Step 1: Qualitative Research	Conduct qualitative research and co-design workshops to gather insights and collaboratively develop the intervention.
Step 2: Phase 1	Implement the first phase of the project based on findings and designs from Step 1.
Step 3: Phase 2	Execute the second phase, building on the outcomes and learnings of Phase 1
Step 4: Phase 3	Progress into the third phase, refining activities and continuing implementation
Step 5: Phase 4	Complete the final phase, consolidating all efforts for comprehensive results

Phase 1: characterising and selecting the intervention

Our intervention was informed by our formative research on the impact of heat (Scorgie et al. 2023; Lusambili et al. 2024b), the co-design process (Lusambili et al. 2023), and reviews of the epidemiological and global health literature. Table 1 summarizes the phases of the intervention implementation.

Our co-design workshop with community stakeholders identified a wide range of potential interventions, including building additional boreholes and similar structural projects (Lusambili et al. 2023). Based on the recommendations of the co-design workshop, the research team prioritized the primary priority which was the development and testing of a behaviour change intervention that aimed to educate, raise awareness, and mobilize pregnant and postpartum women and the wider Kilifi community to select and enact solutions to reduce the burden of heat on women and neonates. The choice of this approach was grounded in several factors, including costs and timeframe. Informed by an intervention mapping approach (Eldredge et al. 2016), the results of the formative research and the co-design workshop were translated into matrices of change objectives by combining behaviours with behavioural determinants, identifying which beliefs should be targeted by the intervention. The research team then selected theory-based intervention methods that match the determinants and translated these into practical applications.

The two targeted behaviours for change among pregnant and post-partum women were: (i) reducing heavy workloads and (ii) reducing exposure to extreme heat through changing daily schedules (so that the hottest periods of the day would be avoided). In addition, we aimed to increase education and awareness of (iii) strategies to reduce heat exposure, including actions to cool the body (e.g. reducing clothing for mother and baby, taking showers), and (iv) the importance of frequent breastfeeding for maintaining healthy infant hydration levels.

Key barriers for the two main targeted behaviours included, for example, the wider community's failure to prioritize time to engage with activities that protected women and newborns from health; gender and religious norms that reinforce unequal roles for women and men; expectations that women continue working in the fields or collect water during pregnancy and the postpartum; and lack of childcare or additional support in the household. It was evident from the formative phase that context-specific norms around gender and family roles were largely responsible for driving these behaviours. In most communities in rural Kilifi, married women are responsible for all household chores, with minimal help from their mothers-in-law and male spouses. Crucially, mothers-in-law and husbands are the key normative referent groups for local gender and family-related social norms in this context.

Table 2. Main intervention theory of change.

Intervention stages	Details
Stage 1: Intervention Development	Formative data collection, co-design process, literature, and intervention mapping.
Stage 2: Inputs	Focus group discussions (FGDs) and Digital Audio-Visual (DAV) tools. Mothers-in-law, husbands, and women agreeing to support pregnant/postpartum women.
Stage 3: Outputs	Mothers-in-law and husbands support pregnant/postpartum women with house chores and childcare. Women shift daily schedules to avoid the hottest periods.
Stage 4: Outcomes	Pregnant/postpartum women reduce heavy workload. Pregnant/postpartum women reduce exposure to heat.
Stage 5: Impact	Better health outcomes for mothers and babies.
Stage 6: Study Data Collection	Study data collection underpins all stages of the intervention.

Given the nature of these barriers and the seemingly normative underpinnings around them, the overall goal of our intervention was to mobilize the community as a whole by empowering and enabling the community members to enact the changes that they believed to be most appropriate in their contexts. Within this, we crafted the intervention with a specific focus on engaging mothers-in-law and husbands to share more of the household chores and childcare tasks to support pregnant and postpartum women in avoiding heavy workloads and reducing exposure to heat in the hottest parts of the day. Table 2 describes the main intervention stages using the theory of change.

Phase 2: intervention development: digital audio-visual storytelling materials and facilitated group discussions

In Phase 2, we developed Digital Audio-Visual (DAV) storytelling materials in local languages that could be used to stimulate discussions in Phase 3. These included messages advocating for support mechanisms to reduce the heavy workload for pregnant and postpartum mothers beyond the project intervention timeframes. The videos also conveyed key messages emphasizing the significance of taking protective measures to avoid impacts of heat, even when working, like hydration and milk production, the advantages of exclusive breastfeeding, the importance of boiling water, the hazards associated with working in the heat while caring for babies, the importance of attending postnatal and antenatal clinics early in the morning. This also included the impact of heat on babies' skin, and the necessity to change harmful social and behavioural practices (e.g. inappropriate practices such as over-dressing babies in the heat, refusing to drink water).

DAV storytelling materials are tools that have been found valuable for information retention and engagement within a range of educational and public health interventions (Park et al. 2021). Digital storytelling has been credited as powerful tool for knowledge translation (KT) interventions, fostering

Table 3. Digital audio-visual storytelling method.

Step 1: DAV participants were identified, and their consent was obtained.	With the help of CHVs, we identified up to 5 pregnant and postpartum women, along with their mothers-in-law and partners. up to 5 representatives from the wider community were also invited to participate. We obtained informed consent from those who were eligible and willing to participate in an identifiable manner. Participants could choose to use pseudonyms instead of their real names.
Step 2: Documented attitudes and behaviours related to heat.	We documented (photos, videos, and audio) the participants' day-to-day lives. • We interviewed participants about their experiences and understanding of heat stress and dehydration in pregnant and postpartum women and neonates. • We photographed and captured scenes related to these interviews and other aspects of heat stress in pregnant and postpartum women and neonates.
Step 3: CHV-led activities	CHVs spent several hours over 1–3 days working with the DAV participants, discussing potential changes to their lives, how to observe and reduce heat exposure, and ways to cope with i
Step 4: Routine building	CHVs met with DAV participants weekly for further problem-solving. These activities and iterative problem-solving continued for 6–8 weeks to help the new behaviours become routine. Photos or videos were occasionally taken, but this was not the main focus during this step.
Step 5: We documented heat-related attitudes and behaviours after changes implemented	After the 6–8 weeks, we documented the participants' experiences using photos, videos, and audio. We conducted video interviews with women, mothers-in-law, partners, and other stakeholders in the wider community, asking questions to build stories about their experiences with heat stress and strategies they found useful in addressing it. The interview questions included: (a) 'How did heat and scarcity of water impact women during and after pregnancy, and how did it affect the neonate?' (b) 'What challenges did hot days or hot weeks present for you? What did you find useful to overcome those challenges?' (c) 'What actions did you take to combat heat stress and dehydration since starting this process?' (d) 'How does the mother's and neonate's health and well-being compare to the time before any of the changes were made?' (e) 'What do you think is the most helpful thing one can do to protect and support pregnant women and neonates during hot periods?' We photographed and captured videos of scenes relevant to these questions, highlighting the changes and positive impacts of the DAV activity, if any. We also documented any negative impacts of the activity or obstacles the women faced in changing their behaviours.
Step 6: Finalize documentation processes and integrate them into the Facilitated Group Discussions	We created a 2–5 minute video with corresponding audio-only content suitable for devices without video screens. All audio was recorded in the local language spoken by the women interviewed, with English subtitles. Consented interviewees were given the opportunity to view the recorded media and provide feedback on any portions they felt uncomfortable with. The audio-visual team edited the media accordingly to respect their wishes. The DAV story contextualized the climate getting hotter and rains becoming less predictable using interview clips and narration. The story explained why the changes were important and included interviews showing women implementing the changes in their daily lives. Additionally, 'scripts' were developed to structure the Facilitated Group Discussions in Phase 3.

shared decision-making in healthcare and raising awareness of patients' health experiences (Lambert 2013).

The DAV storytelling materials were developed in collaboration with Community Health Volunteers (CHVs), pregnant and postpartum women, male partners, mothers-in-law, and key influencers such as community chiefs in Chalani village, Kilifi. The materials included two short videos and a set of photographs depicting participants' firsthand experiences of heat impacts on health, especially during pregnancy, and the measures they were taking to protect against the effects of heat when fetching water, farming, and searching for firewood. The videos were 2 to 3 minutes long and highlighted key influencers' (e.g. local chiefs) messages to the community to support lactating mothers, with interview footage showcasing 'role models' reflecting on the impact of heat stress on their lives. Photos of pregnant and postpartum women engaged in activities such as carrying water, firewood, cooking, and farming were shared with participants to stimulate discussions on heavy workloads and their impact. This multimedia approach was designed to not only facilitate a deeper understanding of the challenges posed by climate change but also to highlight the tangible efforts being made to adapt and promote positive behavioural changes. Table 3 describes the development of this methodology.

DAV materials would then be used to generate discussion and reflection in a series of facilitated discussion groups (DGs), the overall goal of which was to encourage stakeholder-driven problem-solving and community mobilization in the context of heat stress and dehydration. The choice of this approach was grounded in several factors. Firstly, facilitated discussion groups have been shown to be effective in reducing adverse maternal and neonatal health outcomes (Prost et al. 2013). Secondly, from our (AL and MO) many years of experience in the communities in Kilifi County, local people tend to

Table 4. Behaviour change techniques (BCT).

BCT from Michie's taxonomy	Included in tool	Code	Brief description of what was done in intervention
Goal setting	FGD	1.1	Participants were guided and invited to select what behaviour they intended to change and how
Problem solving	FGD	1.2	Discussion with participants helped them analysing how they could get help/ change to reduce their exposure to heat and heavy workload
Action planning	FGD	1.4	Daily schedules were discussed and how to change them to reduce exposure to heat
Review behaviour goal	FGD/CHW weekly visits	1.5	Behaviour change progression was revised during CHV household visits and during group discussions.
Behavioural contract	FGD	1.8	Verbal pledges to change behaviour were encouraged within the group from all participants
Monitoring of behaviour with feedback	CHW weekly visits	2.1/2.2	Information on behaviour change was monitored during CHV household visits
Social support (practical)	FGD	3.2	Discussions were held to invite and convince mothers in law and husbands to support pregnant/postpartum women in their household chores/childcare to reduce heat exposure and avoid heavy workload
Instruction on how to perform a behaviour	Video & FGD	4.1	Information on dos and don'ts during extreme heat to protect the mother and the baby was provided
Information about health consequences	Video & FGD	5.1	Information about the health consequences for mother and babies to extreme heat exposure were provided
Information about social and environmental consequences	Video & FGD	5.3	Information about the wider consequences of maintaining the status quo in terms of gender and family roles were provided
Social comparison	FGD	6.2	Experiences from different families were shared in group discussion on how to mitigate exposure to extreme heat
Information about other's approval	Video & FGD	6.3	Notable community members were invited to comment about good and bad practices to avoid extreme heat (e.g. husbands who support women were praised by the chief in the video and this was discussed in the FGD)
Credible source	Video	9.1	Notable community members were invited to comment about good and bad practices
Social reward	FGD/CHW weekly visits	10.4	When families changed their behaviour, this was praised in the group discussion or by CHVs when they visited the household
Restructuring the social environment	FGD	12.2	Mothers in law and husbands were guided to re-evaluate their support to pregnant/postpartum women in their household chores/childcare to reduce heat exposure and avoid heavy workload
Incompatible beliefs	FGD	13.3	Local beliefs which were counter-productive for the promoted behaviours were discussed and challenged e.g. giving extra fluids to newborns (beyond breastfeeding) during hot days
Identity associated with changed behaviour	FGD	13.5	Husbands were invited to re-consider their family roles to increase their support to pregnant/postpartum women for house chores and childcare

communicate about health matters using predominantly verbal methods, such as conversations with a CHV, rather than through pamphlets or handout-driven interventions. Thirdly, East African cultures hold prominent oral traditions of proverbs, songs, narratives, and prayers as forms of communication and history-keeping. The audio-visual based storytelling that was used in the DGs resonate with this history of oral traditions (Somjee 2000; Finnegan 2007). Lastly, Bandura's social learning theory suggests that learners are most apt to adopt new behaviours when the suggestion comes from 'role models' with whom they share values, beliefs, and life experiences (Corby et al. 1996; Bandura and Walters 1977). Role model stories have been used widely and with success in the public health sector (Njogu 2009). Unlike statistical or didactic health communication, role-model stories share information in a non-threatening manner by fostering identification with story characters and experiences, engaging recipients with storyline messages, appealing to personal values and interests, reducing counterarguments against key messages, and improving information retention (Shen et al. 2015).

Women were recruited from Kamkomani, a rural village 70 kilometres away from where the DAV materials were originally developed. Eligibility criteria required that participants be either pregnant women in their third trimester or postpartum mothers 6 weeks after delivery. Recruitment occurred through a local dispensary during antenatal and postnatal visits. To ensure a supportive environment for the intervention, participation was contingent on the willingness of male spouses/partners and mothers-in-law living in the homestead of the recruited women. These family members were required to attend weekly sessions with researchers and Community Health Volunteers (CHVs), to encourage discussions and support the intervention. The four population groups were: pregnant women in the second or third trimester, and postpartum women six weeks post-delivery ($n = 10$), mothers-in-law ($n = 10$), male partners ($n = 10$), and influencers in the wider community (public health officers, local chiefs, religious leaders, and Community Health Volunteers) ($n = 40$).

In Table 4, we report the key behaviour change techniques (BCT) used across the intervention and coded according to Susan Michie's internationally recognized used taxonomy for public health interventions (Prost et al. 2013).

Phase 3: implementation of intervention package

Community entry and facilitated group discussions with key stakeholders

The research team met with the group of 40 influencers mentioned above, including Kilifi County officials from the Ministry of Health, local health professionals, local chiefs,

religious leaders and a wide range of community members. During the facilitated group discussions, the research team explained the objectives of the intervention, delineated the intervention timelines, and implored those present to lend their support by committing to disseminate information regarding the dangers of heat exposure to the broader community. The DAV storytelling materials developed in Phase 2 on heat risks for mothers and newborns were shown to the group to facilitate discussion about how the heat affected mothers and children and what actions they were able to take to support mothers and newborns.

The significance of this meeting lies in the fact that local leadership and heads of households were made aware of our interventions in this community, and throughout the interventions, they reinforced heat health risk messages to the wider community in the churches and at times when the local community came together, such as at funerals, health days, and christenings. These messages included information on heat dangers, the benefits of breastfeeding, and how to manage body temperature. They suggested ways to reduce overall exposure to heat, and to advocate for social support mechanisms to reduce the heavy workload for pregnant and postpartum mothers beyond the project intervention timeframes.

Recruitment of CHVs

We recruited 15 CHVs, five men and 10 women, who had no prior knowledge of heat-related issues, and trained them in group facilitation skills. CHVs are not formally employed but serve as trusted community advocates and frontline health workers, bridging the gap between healthcare providers and the community. The selection of CHVs as facilitators was deliberate owing to their proficiency in local languages, skills in fostering a comfortable, conversational environment for the participants, and their residence within these communities, which ensures a localized approach to engagement.

In the Facilitated Group Discussions described above, the CHVs were proficient in facilitating discussions regarding the risks posed by heat and the challenges faced by women in their daily tasks. But their role extended beyond the facilitated group discussions as the CHVs were tasked with conducting weekly follow ups with the women in the intervention to deliver heat health messages and reinforce the impact of the interventions by working with women and their support networks. They were also tasked with including these messages in their daily work with community members and disseminating them in health forums, particularly to other CHVs and households that were not part of the training.

Discussion groups with pregnant and postpartum women

During the DGs, researchers and CHVs worked closely with women to identify potential solutions to reduce heat health risks. Women watched the videos and narratives developed in Phase 2. These narratives had been developed in their local language, with some key messages coming from influencers such as the local chiefs, public health officers, male spouses, and mothers. Pregnant and postpartum women were given time to reflect on and discuss these videos and narratives in pairs and devise strategies to counter the impacts of high temperatures. The groups aimed to identify the potential solutions each woman may find effective. CHVs and researchers collaborated with mothers, assisting each of them in identifying three key behaviours to address during the intervention. Examples of suggested changes included rescheduling of tasks, such as working in the morning and resting during the heat, reducing the layering of babies' clothing, increasing water consumption, performing frequent breastfeeding, refraining from walking with babies in the heat, seeking social support to avoid heavy workload, and emphasizing the use of mosquito nets.

Following the reflective session in pairs, all the women convened, with each sharing the solutions they had identified. At the end of the group discussions, women were requested to provide the contact details of their male partners and mothers-in-law, both of whom were subsequently invited to participate in a facilitated DG.

Discussion groups with influencers in the household

Two distinct DGs were conducted involving the mothers-in-law and male partners of the pregnant women who participated in the initial DGs, in separate groups, as described above. Similar to the groups involving pregnant and postpartum women, DAV materials and narratives were shared with mothers-in-law and male partners to initiate discussions on how they can support women and their neonates during heat periods, including facilitation of water access and breastfeeding.

The discussions explored whether existing attitudes and behaviours among these influencers hinder women from safeguarding themselves or pose potential harm in extreme heat conditions. Each participant was then asked to pledge three actions they would take to assist mothers in their households. Within this group, pledges encompassed helping women with tasks such as childcare, cooking, fetching water, and firewood, encouraging mothers to attend post- and antenatal care early in the morning, and assistance with farming to provide mothers with opportunities to rest and nurture for their newborns.

Engaging with the wider community

During the course of the intervention, researchers actively engaged with the broader community twice per week for the duration of the intervention to disseminate information about our interventions by enlightening the community about the hazards of heat, underscoring the necessity of implementing solutions and providing support to pregnant and postpartum women. These interactions took place in various forums, including monthly local chiefs' meetings ('Barazas') with attendance exceeding 200 people, as well as at church events, and health facilities during antenatal and postnatal health days.

Additionally, researchers conducted meetings with CHVs, both those who had undergone training and those who had not, to educate them about heat risks and encourage the incorporation of heat danger messages during their home visits. Lastly, researchers held a policy consultation meeting with 20 policymakers from different ministries (health, meteorological, housing, water, forestry, agriculture, gender, infrastructure). The purpose of this meeting was to inform them of our research and intervention so as to create awareness that could support policy changes at the macro level. This comprehensive approach aimed to reach the entire community.

Phase 4. Pilot evaluation

We used several methods to undertake a preliminary evaluation of the intervention.

- Progress reports from implementers.
- Qualitative interviews at baseline and 5 months follow-up.

Progress reports/templates

A template was created to report progress, outlining the commitments made by male partners and mothers-in-law, in order to provide assistance and reinforce the specific changes pledged by pregnant and postpartum women. Each CHV was assigned two households, which they visited twice weekly to oversee implementation progress. Participants collaboratively filled in the templates with the help of the CHVs to document progress. Researchers conducted home visits and took detailed notes to review templates and assess CHVs' progress. They evaluated whether women were adopting positive behaviours, the support they received from mothers-in-law and male partners, and identified challenges and opportunities in the process. Additionally, women shared their experiences since adopting new behaviours and the impact these changes had on their lives.

Endline meetings and interviews with the community

In the fifth month, we held an exit meeting with local leaders and about 100 community members to attend a close-out meeting. Researchers explained the progress achieved with the intervention and the importance of continued observations of these changes. They thanked the community for their support during the intervention. CHVs and the local leaders spoke to the local community members and encouraged them to continue practicing positive behaviours that protect women and babies. Mothers who had participated in the interventions and interviewed at baseline were also interviewed at the endline using the same tool that asked questions on their perceptions of climate change, knowledge and awareness of heat-related risks, breastfeeding and hydration, coping mechanisms, workload and social support.

Data analysis

We analysed and synthesized the findings from the facilitated DGs, progress reports, and structured questionnaires. Field notes from researchers and CHVs and discussions from women were coded and analysed using NVivo 12 software. The analytical process involved an initial identification of themes and categories. The data were coded separately at baseline and endline, followed by a comprehensive review and segmentation based on various factors such as behaviours and household dynamics. A blend of both inductive and deductive methods was used to identify themes in the data while also facilitating the identification of patterns based on our primary criteria, understanding who was receiving more support and who was not.

Results

Table 5 describes the mothers who participated in the intervention. The mothers, male spouses, and mothers-in-law all participated in all sessions. After implementation of the intervention, there was heightened awareness of the risks of heat during pregnancy and postpartum in the community as described below. There was evidence of changed behaviours to reduce the heavy workload of women in the heat, through engaging male partners and mothers-in-law, and some evidence of changes in organisation of daily tasks to avoid the hottest part of the day. Sociodemographic characteristics of pregnant and postpartum mothers and their living conditions is presented in Table 5.

Table 5. Sociodemographics and living conditions of mothers at the endline.

Variable	Categories	Frequency
Age	21–30	9
	31–40	1
Education	Primary school	6
	High school	4
Marital status	Married (Civil)	3
	Married (Customary)	7
Co-Wives	Yes	4
	No	6
Employment	Domestic work	7
	Full-time employment	2
	Part-time/self-employed	1
Hours worked by husband	0 to 5 hours	2
	6 to10	1
	11 to 15	5
	No work at all	2
Housing	Mud with iron sheet roof	8
	Stone with thatched roof	1
	Stone with iron sheet roof	1
Windows	Yes	7
	No	3
Electricity	Yes	6
	No	4
Kitchen location	Inside the house	3
	Outside	7
Household members	1 to 3	3
	4 to 6	6
	7 and above	1
Number of pregnancies	0 to 2	4
	3 and above	6
Pregnancy outcomes	Live birth	8
	Stillbirth	2
	Miscarriage	2
Pregnancy status	Pregnant	2
	Postpartum	8

Changes in behaviour regarding heat awareness

When introducing the intervention, participants openly acknowledged their lack of awareness regarding the challenges that the women may face in the heat. The intervention was considered an important eye-opener. All the women recruited in the intervention reported enhanced awareness of the impact of extreme heat related to their own health, especially the importance of protective measures, including staying hydrated by boiling and consuming more water. Women reported adopting additional precautions, such as wearing lighter clothes and dressing their babies with fewer items of clothing, seeking shade, cooking outdoors, taking more cold showers, and breastfeeding their infants more frequently than before.

> I used to go to the river during the day, I now understand that walking in extreme heat harms both me and my newborn. When it is hot I don't go out and I keep the door open. Now, my mother-in law don't allow me to wear [dress] baby [in] a lot of things (clothes).(Postpartum woman 9, Endline interview).

> The mother says she now breastfeeds more than ten times in a day and that she boils the water and drinks all the time. (Documented by CHVs weekly logs, for postpartum woman 6.)

Changes in household behaviour regarding reductions in workload in the heat

At baseline, the mothers participating in the intervention expressed concerns about the increased workload and fatigue resulting from drought and heat conditions. The women emphasized the necessity of avoiding heavy tasks, which they linked to '*miscarriage*' or '*prolonged bleeding in the postpartum period*.' Women identified both maternal and paternal mothers-in-law as support systems, although only mothers-in-law in the male partner's or spousal homestead were included in our intervention. Before the start of the intervention, one woman told us:

> 'I am not happy with the help I get from my spouse. The spouse does not necessarily help me.'
> (Postpartum Woman 7, Baseline Interview).

At the endline, she reported improved household support from her partner, noting that after his participation in DGs, he started helping with tasks like fetching water, allowing her to focus on the baby.

> 'It has to be that I leave him [male partner] with the baby, I go fetch water, or he should readily go and fetch for me. I stay with the baby. It (the baseline discussion groups) helped him (the male spouse) because he did a lot of household work, and he wasn't helping me. But now he is.' (Postpartum Woman 7, Endline Interview)

Narratives from mothers suggested that the gendered nature of caregiving tended to distance male spouses from fully grasping the lived experiences of women and infants in the heat. The findings also implied that men could alter ingrained behaviours with adequate communication and awareness, even in traditional communities with clear role divisions, as seen in the following quote: The training helped her partner understand how sun exposure can harm a child, leading to changes in their behaviour to protect the baby.

> 'Because he didn't know how a child might get affected by the sun…But he came for the training we had (baseline group discussions) …that is when he knew aaah, so someone working with that child under the sun like going to find firewood with a child …and the sun is shining …the sun will affect this child …' (Postpartum Woman 8, Endline interview)

> …He has changed and is now helping me with those tasks. At first, he would sleep until midday, and when he woke up, he would go out to do other things, but nowadays, he will wake up and sweep outside; then he takes the jerricans and goes to fetch water, and when he comes back finds me doing other tasks, he cooks tea, yeah (Postpartum woman 10, Endline Interview)

Another women reported not receiving help from her mother-in-law, who had previously declined to help her as she believed that pregnancy was not an ailment and therefore pregnant women should not expect special treatment. Following the training, the male spouse took positive steps by hiring someone to help with physically demanding tasks and the mother-in-law now helps and talks to other older mothers advocating within the community to support pregnant women burdened with heavy workloads (Documented by researchers and CHVs weekly logs).

Changes in the scheduling of daily activities

The intervention impressed on community members the need for women to avoid harmful behaviours such as walking or working in the heat with newborns as direct heat exposure caused exhaustion and affected the newborn's skin and hydration condition. Performing heavy workloads early in the morning and resting in the afternoon when it was hot had been recommended and agreed upon by participants. In spite of living in the same household, the women faced limited support by mothers-in-law and by employed male partners prior to the intervention.

Following the intervention, women reported that they had changed the schedule of their daily chores, through rising early to complete tasks while their spouses watched over their babies. Thus, women were able to rest and focus on lighter tasks while their husbands were at work, avoiding the scorching heat of the day.

> 'I have learned to task shift my work within the day as sometimes the mother-in-law and male spouses are not available when they are at work. I leave the baby with the male spouse early at 5.00 a.m. before he goes to work so that I can fetch water and do farming. When I get back home, my husband prepares to go to work, and he leaves having prepared breakfast. All I need to do is wash clothes and dishes.' (Postpartum woman 6; home visit conversation with the researcher).

Men agreeing to take care of the babies early in the morning to allow their wives to do some of the household chores was seen as a significant shift in behaviour. Initially reporting no assistance at baseline, these women reported a positive change in their households post-training. The awareness instilled during the sessions prompted husbands to provide early morning support despite their work commitments.

Despite women engaging in shifting their daily schedules, CHVs' discussions with researchers underscored the challenges pregnant and mothers face with working husbands. Mothers in this category needed support from other mothers, as their days often started as early as 5 a.m. and extended until 11 p.m.. While task shifting provided some relief by sparing them from walking or working in the sunshine, it only offered limited support. These mothers, who were often alone, found that their older mothers-in-law or working partners could not contribute as much compared to those with younger mothers-in-law and unemployed partners. CHVs observed that this was the prevailing reality within some families in the community, acknowledging the genuine variations in family settings when considering household support.

Sustained support for pregnant and postpartum women with unemployed male spouses and mothers-in-law

Mothers who reported that they were already receiving some help with household chores and daily workloads from their male spouses and mothers-in-law at baseline reported an increase in this support after the intervention. For example, at the endline, pregnant woman who had just given birth reported increased assistance in the last days of her pregnancy

and during her postpartum period. In her own words, she observed that her spouse was waking up very early to do most of the chores, allowing her to rest more, as seen below.

> 'I have seen that he can wake up early in the morning and start doing work before I wake up so that when I wake up, I finish the other jobs left and rest.' (Pregnant Woman 1, Endline Interview).

We also found that pregnant women received increased help in families with similar settings. Anecdotally, researchers' communications with CHVs and older women in the community revealed that young mothers married in families where household spouses or mothers-in-law were not engaged in formal work, were likely to be supported compared to those who did not. During the intervention period, male spouses who attended the training on heat impacts took the initiative to disseminate to other male spouses/partners in the community who had pregnant and postpartum wives to support their wives.

Unintended consequences of spousal support

Towards the end of the project, some women reported that their male spouses found it challenging to perform activities traditionally associated with women owing to stigmatization by their male partners.

> 'They say to my husband and mother-in-law, why are you helping her (postpartum mother) nowadays? They (male spouses and mother-in-law) respond that they had some training and were taught to help mothers because of the harsh heat, and that is why they help me with these tasks when they are available. So, the villagers (community) talk negatively'. (Postpartum Woman 10, Endline Interview)

> 'My husband is being despised by his peers even when he stays with his peers, they tell him, 'Your wife, you do this [for] her (cooking) instead of her doing it'.' (Postpartum woman 7, Endline Interview)

Some community members who opposed the involvement of mothers-in-law and male spouses in supporting pregnant and postpartum women did not participate in the baseline DGs, and some may not have been aware of our interventions. Some women also highlighted the dangers of peer pressure on their husbands and recommended that such teachings should continue so that their husbands can remain attuned to supporting mothers.

> 'The teaching was enough, but to just encourage him to continue to help because he admits that the training (DGs) he got is already in him, but in the future, he may claim that since the organisation stopped or went away, then even he can stop helping me or when the baby grows up then he will just say he doesn't need to continue helping' (Postpartum Woman 8, Endline Interview)

Discussion

Our intervention aimed to improve knowledge and awareness regarding the health risks of heat during pregnancy and the postpartum period, as well as mobilizing the community to assist pregnant and postpartum women facing heavy workloads during periods of extreme heat and reducing exposure to heat at the hottest times of day. We sought to empower the local community and establish a sustainable support system by mobilizing the support networks of pregnant and postpartum women, especially male partners and mothers-in-law, along with other influential figures in the community. We integrated innovative and evidenced-based approaches, digital audio-visual storytelling, use of pictures and facilitated group discussions, to raise awareness about the impact of heat on pregnant women, new mothers and newborns and encourage the adoption of new behaviours to support this vulnerable group. A formative phase characterized by data collection, literature, and co-design approach was able to inform the design of a targeted intervention using multiple behaviour change techniques to shift local norms around gender and family roles.

Our findings reveal a positive shift in awareness levels with an understanding of the challenges posed by extreme heat. Moreover, involving male partners at the baseline and other key influencers, chiefs and male religious leaders to disseminate these heat health messages in their forums and encourage fellow men to support women in the heat contributed to increased support post-intervention for pregnant and postpartum women. From our previous work experience, we know that male partners in this setting influence maternal and child health practices, including childbirth customs, place of birth, postpartum care, and infant feeding practices (Lusambili et al. 2021a; 2021b). Including them was seen as critical to the sustainability and replicability of the interventions beyond the project time frame. Indeed, a wealth of evidence demonstrates that engaging males in rural Africa can shift behaviours that are harmful to maternal and neonatal health (Ditekemena et al. 2012; Tokhi et al. 2018; Lusambili et al. 2021a; Mulugeta et al. 2024), especially when interventions are culturally and sensitively designed. However, male involvement intervention in reproductive health must be designed carefully to ensure that women are empowered in their decision-making (Michie et al. 2011; Mulugeta et al. 2024). Our approach to use a normative framework meant that the appropriate reference groups and behaviour change techniques could be chosen to ensure the community could re-evaluate ingrained norms around gender and family roles. In addition, role modelling can effectively influence behaviours among peers (Bandura and Walters 1977); and engaging respected and authoritative figures like chiefs and religious leaders, whose guidance carries significant weight, is a key strategy for raising awareness of the dangers of heat.

A key finding with regard to the patterning of support provided to pregnant women in this rural community brought insight into how future interventions dealing with household gender relations can be designed. Families with unemployed male partners and mothers-in-law received more help compared with the households where male partners were employed, thereby highlighting the influence of socioeconomic factors and the availability of additional household labour on the success of our intervention. Future interventions of this nature should tailor approaches based on family and employment dynamics. A further finding was that our interventions positively impacted mothers' knowledge of breastfeeding and hydration and nudged them to employ other coping strategies, such as re-arranging their daily schedules to reduce working when it is hot.

There were unintended consequences related to societal norms, however, as some male spouses who actively participated in traditionally feminised roles faced stigma from their peers.

Overall, this can be expected when entrenched norms are challenged; early adoption may face social consequences (punishment) for deviating from the norm. Barriers to male engagement in maternal health, such as culturally ingrained norms and gender roles, societal stigma/labelling, and fear, are well discussed in the literature from low- and middle-income countries (Ampt et al. 2015; Lusambili et al. 2021a). Resnicow and Baranowski (Resnicow et al. 1999) observed the importance of cultural sensitivity in tailoring interventions to align with societal mores. Attempting to shift long-lasting norms like the ones underpinning gender roles may have unpredictable consequences. Future interventions should consider the consequences of shifting the role of gatekeepers and what this means for social equilibria across a wide spectrum of behaviours. There may also be isolating or ostracising effects on those who cannot comply (for structural reasons) with the new norm. Establishing a new norm may create a new form of vigilante justice (punishment), which may disproportionately impose severe punishments on norm non-compliers (Igras et al. 2021). We recommend that future projects engage with communities to reflect on such consequences before they start to avoid negative consequences as a result of peer pressure and stigmatization. Continuous education in communities about why men are being encouraged to take on traditional feminised roles must be undertaken in advance through local forums, to encourage acceptance and understanding across the community.

Strengths and limitations of our study

Our intervention offers a valuable model for structuring future heat adaptation strategies in traditionally local settings within rural Africa.

However, it does have a few limitations that should be considered. First, as the evaluation was qualitative, we are not able to say what proportion of the broader community supported the interventions or quantify its impact. Second, our evaluation did not capture the perspectives of women's support networks, including mothers-in-law and male partners/spouses, to assess how the interventions affected them. However, in two videos co-developed with the community on the impacts of heat and potential adaptations, mothers-in-law and male spouses reported that the intervention influenced their perceptions of heat-related impacts and highlighted their role in supporting women in coping with these challenges (Igras et al. 2021; Video 1). Third, the endline evaluation was conducted in the fifth month of the intervention, which was possibly too early to determine whether the intervention had worked or not. Fourth, the sustainability of this improved behaviours depends on the CHVs and their social networks. Considering the busy schedules of CHVs and their involvement in multiple and unremunerated projects, behaviour change efforts in the future should be extended over a longer period, allowing for different evaluations to assess sustainability over time. Importantly, the CHVs in the community have committed to incorporating messages on heat dangers into their daily activities and key figures such as the chief, policymakers, and leaders from religious and health facilities have committed to extending the dissemination of our findings beyond the project's timeline. Fifth, there may be response bias as researchers were involved in both the design and the implementation of the intervention as well as its evaluation. Finally, our findings may not be generalizable to other settings as the study was conducted in one specific community and the selection of participating individuals and households was not randomized.

Reflections

Creating the DAV materials was a journey of both challenge and growth. It demanded time, effort, and dedication from the CHAMHA field researchers, but the experience proved to be a powerful learning opportunity. At the heart of this success was community collaboration. By working closely with community health workers, and key influencers, and mothers, the team ensured that messages about the impact of heat on mothers and the necessary behavioural changes were not just scientifically accurate but also culturally meaningful. These messages came to life through visual storytelling, where mothers saw their own realities reflected in the experiences of leaders, health workers, and fellow mothers. This local connection made the information more relatable and encouraged whole community participation. However, such an intensive, participatory approach placed significant demands on researchers. Looking ahead, future projects should plan for ongoing support by allocating budget for follow-up sessions and recruiting more community health volunteers and researchers for follow-up sessions.

Conclusion

We developed a community-based intervention to reduce the impact of heat on pregnant and postpartum women and newborns in a rural setting in Kenya. Five months after the intervention, pregnant and postpartum women reported improved understanding and knowledge of the effects of heat; receipt of greater assistance with household chores; re-scheduling of physical labour to the cooler parts of the day; and the dissemination of heat-health messaging to families beyond the intervention groups. However, there was also evidence that male spouses faced stigma from their peers when stepping in to help to reduce the heavy workload of pregnant spouses. Shifts in behaviour may take time to become entrenched and further research is necessary to determine whether changes in behaviour are sustained over time. Future research on heat impacts of vulnerable groups should consider using a larger sample to investigate how socio-demographic factors—such as age, education, marital status, employment type, and housing conditions influence the level of support received by families as well as exploring strategies to tailor community behaviour interventions to fit the composition of different households. Research is also needed to identify locally relevant strategies to mitigate stigma and promote positive acceptance of new heat adaptation behaviours in response to anthropogenic climate change.

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Author contributions

A.L., F.S., M.O., G.G., V.F., B.N. performed conception or design of the work. A.L., M.O., and K.M. performed data collection. A.L., F.S., V.F. performed data analysis and interpretation. A.L. and B.N. performed drafting of the article. A.L., S.K., V.F., F.S., M.C., and B.N. performed critical revision of the article. All authors performed final approval of the version. S.K., M.C., and B.N. performed funding acquisition and idea development

Reflexivity statement

This study was conducted by a diverse team from Kenya, Zimbabwe, South Africa, Botswana, the UK, and the USA, with most lead authors based in low- and middle-income countries (LMICs), representing diverse genders and career stages.

Ethical approval

The studies involving humans were approved by Aga Khan University Ethics Committee ref. 2020/IERC-94 (v2) and National Commission for Science and Technology and Innovation Ref BAHAMAS ABS/P/20/7568, London School of Hygiene and Tropical Medicine Ref: 22685 and from Kilifi County Office ref. DOM/KLF/RESCH/vol.1/66.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Data availability

Our intervention used social behavioural methods, involving a small group of participants from rural areas. Due to the sensitive nature of the data and our commitment to confidentiality, publicly releasing the data could risk identifying individual participants. Therefore, data access will be considered upon reasonable request through the Aga Khan University Research Ethics Office. For inquiries, please contact the Aga Khan University Research Ethics Office via email at research.office@aku.edu.

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