Health Policy and Planning, 2025, 40(7), 708–718
https://doi.org/10.1093/heapol/czaf030
Advance access publication date: 28 May 2025
Original Article

Intervention co-design to reduce the impact of heat exposure on pregnant and postpartum women and newborns in Burkina Faso

Kadidiatou Kadio[1,*], Mariam Congo[1], Adama Sana[1], Veronique Filippi[2], Nathalie Roos[3], Fiona Scorgie[4], Sari Kovats[5], Britt Nakstad[6,7], Giorgia Gon[2], Matthew Chersich[4], Jeremy J. Hess[8], Seni Kouanda[1,9]

[1]Institut de Recherche en Science de la Santé, Centre National de la Recherche Scientifique et Technologique (IRSS/CNRST), 03 BP 7192 Ouagadougou 03, Burkina Faso
[2]Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, Keppel Street, London, WC1E 7HT, United Kingdom
[3]Department of Medicine, Clinical Epidemiology Division, Karolinska Institutet, Stockholm 171 77, Sweden
[4]Faculty of Health Sciences, Wits Reproductive Health and HIV Institute, University of the Witwatersrand, 1 Jan Smuts Ave, Braamfontein, Johannesburg, South Africa
[5]Centre on Climate Change and Planetary Health, London School of Hygiene & Tropical Medicine, Keppel Street, London, WC1E 7HT, United Kingdom
[6]Department of Pediatric and Adolescent Health, University of Botswana, Gaborone UB 0022, Botswana
[7]Division of Pediatric and Adolescent Medicine, Institute of Clinical Medicine, University of Oslo, 1171 Blindern 0318, Oslo, Norway
[8]Emergency Medicine, Env & Occ Health Sciences, and Global Health, University of Washington, 325 9th Ave., Seattle, WA 98104, United States
[9]Institut Africain de Santé Publique (IASP), 12 BP 199, Ouagadougou, Burkina Faso

*Corresponding author. IRSS/CNRST/Ouagadougou, 03 BP 7192 Ouagadougou 03, Burkina Faso. E-mail: kadioka@gmail.com

Accepted on 8 May 2025

Abstract

Interventions are needed to reduce the impact of heat on the health and wellbeing of women and newborns in Burkina Faso where seasonal temperatures can be extremely high. In this article, we share our experience and lessons learned from co-designing an intervention to improve maternal and neonatal health, about heat in a rural and an urban district of Burkina Faso. We performed community engagement and a series of workshops with 49 community members (health workers, women group representatives, youth leaders, religious leaders, traditional leader, and mothers-in-law) and 36 implementers, stakeholders and professionals (officials from the Ministry of Health, midwives and related health workers, meteorologists, and environmental health practitioners). Following the discussions and group reflections, emerging intervention priorities were ranked based on their perceived likelihood of success, cost effectiveness, implementation feasibility, and sustainability. The co-design workshops identified behaviour change interventions encompassing raising awareness of the effects of heat through targeted messages on adaptative behaviour to adopt. The effective operationalisation of these interventions was further achieved through co-planning involving health system actors in contact with women and local stakeholders with relevant expertise. We aimed to engage health professionals and community health workers to integrate heat and dehydration messages into their routine work with pregnant and postpartum women with the aim of changing behaviour through communication: educational group talks, interpersonal exchanges in the consultation room and broadcasts of information to the public who attend the clinic (video played on a television set in the waiting room). The co-design workshops were an opportunity to build capacity among facilitators and participants as well as to prioritize and develop interventions to address the impact of heat exposure—amplified by climate change—on pregnant and postpartum women, and on newborns.

Keywords: codesign; climate change; heat exposure; pregnant and postpartum women; newborns; Burkina Faso; intervention

Key messages

- The impacts of heat on the health and wellbeing of a mother and child were a new topic for health professionals in Burkina Faso, whether at the service or policy levels.
- Our intervention is the first to propose the integration of activities related to heat and maternal health into the routine activities of health centers.
- The co-design workshops were an opportunity to build capacity among facilitators and participants as well as to prioritize and develop interventions to address the impact of heat exposure.
- It is important to initiate a reflection at the national level on how to integrate heat and health in the provision of maternal and child health services.

Introduction

Exposure to high ambient temperatures affects the health of pregnant and postpartum women, and their newborns, and increases the risk of adverse birth outcomes (MacVicar *et al.* 2017, Chersich *et al.* 2020). Heat-related child mortality in sub-Saharan Africa is already double what it would be in the absence of climate change and is estimated to double again by 2050 if temperatures rise more than 1.5°C (Chapman *et al.* 2022). Previous research in Burkina Faso found that high temperatures affect the health and wellbeing of women and undermine care of the infant (Part *et al.* 2022, Kadio *et al.* 2024a). Pregnant and postpartum women must therefore reduce their exposure and the exposure of their infants to ambient heat.

Public health interventions are generally needed to reduce the impact of heat on vulnerable populations and also increase resilience to extreme weather.

Over the last few decades, it has become clear that, with the right interventions, the health risks associated with extreme heat events can be alleviated. Studies in high-income countries, where extreme heat is infrequent, have shown considerable reductions in heat-related mortality and morbidity (Chung *et al.* 2018). These reductions are attributed to changes in behaviour, increased awareness of heat risks, public health messaging, and changes in the built environment, mainly focused on cooling indoor spaces. Given the limited resources available in many African settings, heat risk management, as part of community-based adaptation, needs to be grounded on local knowledge and practices (Cuaton and Su 2020, Rahman *et al.* 2023), with co-designing and integrating indigenous knowledge at the forefront of the development of effective adaptation interventions (Kalanda-Joshua *et al.* 2011, Cuaton and Su 2020, Mugi-Ngenga *et al.* 2021, Nyadzi *et al.* 2022, Streefkerk *et al.* 2022, Lusambili *et al.* 2023). To improve the uptake and usefulness of health interventions, the end-user needs to be meaningfully engaged in the design of interventions through knowledge co-creation models (Slattery *et al.* 2020, Coggan *et al.* 2021, Iwama *et al.* 2021).

In 2022, the Climate, Heat and Maternal and Newborn Health in Africa (CHAMNHA) project co-designed a context-specific intervention to help mitigate the effects of exposure to extreme heat. This project aimed to address knowledge gaps on climate change, and maternal and newborn health from a multi-disciplinary perspective, with a specific focus on Burkina Faso and Kenya.

The CHAMNHA project in Burkina Faso was led by the lead and encompassed three phases: formative qualitative research, co-development of the intervention(s), and evaluation. The key objectives for the formative research were to understand how exposure to extreme heat during pregnancy and postpartum period was perceived by the women and health professionals. The study was carried out in two health districts in Burkina Faso: Bogodogo in the central region and Kaya in the central-northern region. In both districts, maximum temperatures can exceed 40°C for several days at a time. The long heat season lasts from early March to mid-June, with little or no rainfall, and precedes the rainy season (Batté *et al.*, 2017, 2018, https://weatherspark.com/). Data collection took place at the primary healthcare centre, 'Centre de Santé et Promotion sociale' (CSPS) of Wemtenga, in the primarily urban Bogodogo health district and at the CSPS of Delga in the rural Kaya health district. The urban area is densely populated, and most houses have tin roofs which offer little protection against heat (Zoma *et al.* 2022). In rural areas, house roofs are made of tin or straw.

The first stage of the project, formative research, had shown that pregnant women experienced a range of symptoms during periods of high temperatures (including skin problems, low appetites, dizziness, and increased anxiety). Infants were reported to have more frequent episodes of skin rashes, dehydration and irritability during hot periods. The funding summaries presented in Table 1 are described in more detail in Kadio *et al.* (2024a). There was low awareness among women of the relationship between heat and the increased risk of preterm birth and stillbirth, and also of heat effects in infants. Further, some potentially harmful behaviours (such as supplementing breastmilk with herbal teas) were reported as coping strategies to deal with heat. The results highlighted the influence of certain local beliefs and practices relating to heat exposure.

Community-based co-design methods have been used successfully to design an intervention for heat risk reduction in pregnant, postpartum and newborn women in Kilifi, Kenya (Lusambili *et al.* 2023). In this article we share our experience and lessons learned from co-developing a set of interventions (second stage of project) aimed at reducing the impact of heat exposure on maternal and neonatal health in urban and rural settings in Burkina Faso.

Materials and methods

This section presents the overview of the co-design process used in Burkina Faso. We aimed to create discussions, including exchange of knowledge and experience, and jointly work with different stakeholders to ensure that their concerns and aspirations were understood and applied in the research to, identify locally appropriate and feasible interventions to reduce the impact of heat on mothers and their infants. A two-step process was used to co-develop a heat-health intervention. The first step was to organize two workshops to identify interventions. These workshops took place between April and May 2021 in rural and urban areas and involved 49 community members and 36 stakeholders from the health, environment and climate service sectors. The second step, which took place between December 2021 and May 2022, included consultations with health and climate change experts and training for health professionals. This process allowed us to co-create intervention content and communication tools. How each co-design process is carried out, i.e. the

Table 1. Summary of qualitative research findings in Burkina Faso, Bogodogo, and Kaya regions.

	Impacts of heat	Women's beliefs and local practices
Pregnant and postpartum women	Heat affects the social lives of pregnant women: they can no longer live in harmony with the rest of the community (spouse, co-wives, neighbours and even their children), which has negative repercussions on their well-being Reduction in exclusive breastfeeding: High heat makes breastfeeding uncomfortable, which can prevent exclusive breastfeeding and the frequency of breastfeeding Extreme heat affects women's ability to care for themselves, to perform domestic and paid work (formal and informal) Cultural practices, such as the requirement for newborns to remain indoors for up to 40 days, can increase the negative consequences of heat (increases the discomfort of breastfeeding if the inside of the house is hot) Women are often unaware of the effects of heat and the risks to maternal and child health Women are afraid to walk in the sun because of the sweating and discomfort, which prevents them from attending health visits, including antenatal and postnatal consultations	Drinking cool water can increase foetal weight/delay delivery risk of Caesarean section/difficult delivery Drinking cold water during the postpartum period delays a woman's recovery Body heating due to heat is often associated with increased blood pressure and risk of Caesarean delivery
Newborns	Heat causes 'bourbouille' (a small a rash on the baby's body) which makes the baby uncomfortable and cry; latching on can be difficult Insufficient feeding: discomfort and crying cause an inability to express milk properly (a constant demand, without being able to do so properly): this affects growth and hydration of the newborn Reduced skin to skin cares due to discomfort caused by sweating: discomfort caused by heat makes it difficult for the mother to care for the baby, and she interacts less with her/him	During the hot and dry season, dehydration is a risk for the baby, so breastmilk should be supplemented with water more frequently during these periods Mothers give water/feel that the baby needs a lot to drink during periods of high temperatures They believe that: In hot weather, the child cannot go without water in the 0–6-month period In hot weather, the breastfed infant is thirsty and therefore needs extra water (breastmilk is light for some, fat for others)
Home environment and health facilities	Most domestic environments are not equipped with space cooling measures (active or passive) to reduce indoor temperatures Health facilities have high indoor temperatures and are not equipped with cooling elements/systems to reduce/alleviate the heat Health facilities are not built with materials suitable for hot climates and there is lack of outdoor shade	

participants, the summaries of the discussions and the various decisions taken, is described in the 'Results' section.

Results

The results of the implementation of the co-design process are organized in two sections. The first section describes the co-design process to identify the intervention, and the second section describes the co-design process undertaken to design the intervention content and implementation tools.

Co-design process to identify the intervention

The objective of the co-design process was to bring together various local maternal and newborn health stakeholders, as well as community members, to review and provide feedback on the findings of the formative research (Table 1). Workshops encouraged participants to discuss and prioritize options for locally appropriate and feasible interventions to reduce the impact of heat stress on pregnant and postpartum women and their newborn babies. Engaging beneficiaries directly was important given that proposed interventions might seek to change aspects of community members' heat coping behaviours or environment. The expected result of the initial co-design process were clear recommendations for a set of co-designed, acceptable, and feasible heat-health interventions to be implemented in Delga (rural health center) and Wemtenga (urban health center).

Co-design workshops

We organized four face-to-face one-day co-design workshops, split between the rural and urban district (Table 2). Successful co-design needs representation from a wide range of stakeholders at different levels, including community influencers, implementers, and end-users (Mulvale *et al.* 2019, Gonzalez *et al.* 2021). Categories of participants included: 49 community members (community-based health workers- ASBCs, women's groups representatives, youth leaders, religious leaders, customary chiefs, mothers-in-law, and women) and 36 potential implementers from the health and other sectors (representatives from the ministry of health, healthcare workers specializing in maternal and newborn health, meteorologists (climate services), and environmental health practitioners) (Table 2). The aim of the workshops was to enable participants to identify heat interventions and then to prioritize, i.e. to rank them by relevance according to their context.

Process to identify and rank interventions

In each co-design workshop, we employed a stepwise approach, starting with a presentation of local impact of heat

Table 2. Number of workshop participants by research site.

Areas and actors	District Kaya (rural)		District Bogodogo (urban)		Total
	Worksop 1 Kaya	Worksop 2 Delga	Worksop 3 Ouagadougou	Worksop 4 Wemtenga	
Implementers stakeholders	17		19		36
Community members		26		23	49
Total	17	26	19	23	85

(Table 1), followed by a presentation of further evidence of impact of heat on maternal and newborn health, and ending with two working group sessions. During each workshop, participants were divided into three to four working groups. Each group designated a rapporteur to present their reflections to all participants. The discussions were recorded and thematically analysed by researchers.

Step 1: working group session 1

Participants focused on discussing the research results and proposing a range of interventions that could be implemented in health facilities to reduce the consequences of extreme heat on pregnant women, mothers, and newborns. The group discussions were based on the results presented and the following group work instructions:

- Based on the preliminary results we have just presented, what are the interventions that can be implemented in health centres to reduce the consequences of heat stress on pregnant women, those who have just given birth and the newborn?
- For each intervention, define the challenges and opportunities for implementation.

Step 2: working group session 2

The working groups were asked to rank by order of importance a list of priority interventions to be implemented in the health facilities. These prioritized interventions were drawn from three sources: interventions proposed by all the three to four groups present in the workshop, CHAMNHA preliminary results (local impact of heat), and the literature review (see Supplementary File 1 for more detail). In each working group, the participants worked towards consensus to rank the interventions based on the following criteria: ability to reach the maximum number of beneficiaries; acceptability within the community; cost/affordability; viability, sustainability, and scalability.

Tables 3 and 4 show the results of the prioritisations by working group and by research site.

Ranking results

A total of 14 working group discussions prioritized interventions during the four workshops. The research team evaluated the number of times an intervention was classified first, second, or third based on the 14 groups' final classification (Table 5).

The co-design discussions found that the overall priority intervention was 'to inform and educate communities about extreme heat impacts on maternal and child health'. Secondly ranked as the most sustainable and effective intervention was 'training of health personnel on the consequences of heat stress on outcomes of health of the mother and child'. These are educational interventions which can be implemented in the community and health facilities with the aims of improving knowledge and inducing behaviour change.

Participants' reflections during the discussions

A major challenge that emerged during the discussions was the relative cost of some of the proposed interventions. Measures to reduce indoor temperature were felt to be important but also costly. On the other hand, it emerged from the discussions that raising of awareness of heat threats (education for behaviour change) was a priority intervention that was less costly, accessible to all, and with the ability to reach many people, even outside the study area.

Further, participants believed that increasing awareness would have a lasting impact, because once the message was understood, it could become an everyday behaviour that lasted over time. Awareness of heat-health outcomes can be delivered by health workers during consultations (during the antenatal and postnatal periods), by community health workers, and even by the community itself. For example, health workers can inform pregnant women during antenatal or postnatal care about the consequences of dehydration on the foetus and newborn, and the importance of drinking plenty of water while pregnant and during the postpartum period, as well as the need for frequent and exclusive breastfeeding, even in hot weather.

Participants suggested using 'boites à images' or 'image box' (a small flipbook with pictures used by providers), 'theatre forums' (plays with an educational focus delivered in the community), and the media (TV, social media) to convey information on the effects of heat. The training of health workers was also prioritized, including refresher training and the upgrading of skills.

The participants thanked the team for choosing their locality, but also for the interest shown in the issue, which they felt was often not considered a problem, even though extreme heat has a negative impact on pregnant women and their babies. The stakeholders stressed the need for this issue to be considered in national policies, to ensure the sustainability of interventions. In their view, this is an important issue, the solution to which could bring great relief to women, health professionals and the community.

Co-design process for the development of the intervention

The operational development of the intervention followed three phases: (i) development of messages, (ii) development of communication tools, (iii) training of providers to integrate

Table 3. Prioritization of interventions in Kaya and Delga.

Priority number	Kaya Health District, CSPS ('Centre de Santé et Promotion sociale') of Delga						
	Implementers in health, environment, NGOs			Community members			
	Group1	Group2	Group3	Group1	Group2	Group3	Group4
1	Planting trees in the CSPS	Community outreach	Awareness through Pictorial health education flipbook 'image boxes' and by health actors	Raising awareness	Planting trees	Raising awareness	Raising awareness
2	Continuous improvement of the living environment	Integrated landscaping with shade trees	Plant and maintain trees in health facilities	Putting in air condition	Awareness through image boxes	Build the "hangars" (shade shelter)	Putting in fans
3	Installation of solar-powered cooling systems	Construction of health centers adapted to a hot climate (large, with materials that do not heat up)	Capping and installing cooling systems in health facilities	Build ventilated facilities	Building sheds	Planting trees	Putting on solar panels

Table 4. Prioritization of interventions in Ouagadougou.

Priority number	Bogodogo Health District, CSPS of Wemtenga, Ouagadougou						
	Implementers in Heath, Environment, NGOs			Community members			
	Group1	Group2	Group3	Group1	Group2	Group3	Group4
1	Training of health personnel on climate change sensitive diseases in pregnant and postpartum women	Raising awareness on good practices and strategies to reduce the impact of extreme heat on pregnant women, mothers, and children	Informing and educating communities about extreme heat and maternal and child health	Raising awareness among women and communities on how to protect themselves and their newborns from impacts of heat stress	Installing cooling systems in health centers	Sensitizing women and communities on behaviours and on how to protect themselves and their neonate from the effects of the thermal stress	Sensitizing women and communities on behaviours and on how to protect themselves and their neonate from the effects of the thermal stress
2	Educating women and the community on behaviours to protect themselves and their newborns from the effects of heat stress	Planting trees in CSPS yards	Strengthening early warning in health centers	Building quality buildings (delivery room and waiting room) in the health centers and large, well-ventilated rooms adapted to the heat	Sensitizing women and communities on behaviours and on how they can protect themselves and their neonate from the effects of thermal stress	Training of health personnel on climate change sensitive diseases in pregnant and postpartum women	Installing cooling systems in health centers (fans, fans, air conditioning)
3	Planting trees in yards and CSPS	Training of health personnel on the consequences of heat stress on the health of the mother and child	Training of health personnel on climate change sensitive diseases in pregnant and postpartum	Training health workers on strategies to provide better care for pregnant women who suffer from heat waves	Training healthcare workers on strategies to provide better care for pregnant women who suffer from heat waves	Raising awareness on good nutrition (nutrition in times of heat, consumption of vegetables, drinking water)	Training of health personnel on climate change sensitive diseases in pregnant and postpartum women

Table 5. Priority interventions proposed by 14 working groups participants.

Ranking after our analyse	Interventions	Ranking	Number quotes/14	
		During prioritization session		
1	Inform and educate communities about extreme heat and maternal and child health	1	10 times/14	**14**
		2	3 times/14	
		3	1 time/14	
2	Training of health personnel on the consequences of heat stress on the health of the mother and child	1	1 time/14	7
		2	1 time/14	
		3	5 times/14	
3	Putting in fans and air conditioners	1	1 time/14	7
		2	3 times/14	
		3	3 times/14	
4	Planting trees in the Primary healthcare	1	2 times/14	6
		2	2 times/14	
		3	2 times/14	
5	Construction of health centers adapted to a hot climate (large, with materials that do not heat up)	1	0 times/14	2
		2	1 time/14	
		3	1 time/14	

Values in bold illustrate the high priority given to the strategy "Inform and educate communities about extreme heat and maternal and child health". In fact, in the 14 working group discussions, this strategy was ranked in first position 10 times.

behaviour change messages on heat and maternal and neonatal health into the activities of routine maternity care.

Identification and formulation of messages

Using the results of formative research, co-design workshops and a review of the scientific literature in Burkina Faso, we further identified women's beliefs, attitudes and practices that we could targeting a behavioural change intervention. We clustered these into three focus areas: breastfeeding, hydration in pregnant and postpartum women, and reducing discomfort (Table 6). Regarding breastfeeding, women and other community members believed that in very hot weather, giving only breast milk cannot quench the baby's thirst. Therefore, they give water to their infants and do not practice exclusive breastfeeding. We developed some messaging to inform women that breast milk contains enough water for the child's needs, even when the ambient temperature is high, and to provide advice on the frequency of breastfeeding in hot weather.

Concerning mothers' hydration, we noticed important local beliefs and practices in hot weather. Women in the setting believe that drinking fresh water is the best way to quench their thirst. However, there are also local beliefs that drinking fresh water during pregnancy is risky as this may result in increased foetal growth leading to a difficult delivery. In addition, there are beliefs that drinking cold water during the postpartum period may delay new mother's recovery. We developed a message to inform women that there is no evidence that the temperature of the water can affect foetal growth or alter postpartum healing.

We noted that high ambient heat makes breastfeeding uncomfortable. Our message was to inform women how to reduce discomfort and make breastfeeding less unpleasant.

The messages were developed using the results of the formative study, including behaviour to be changed, as well as evidence from the scientific literature (e.g. on how to keep hydrated) and the behavioural change approach (Michie 2014, Michie *et al.* 2014) .We concluded this phase after four online workshops involving CHAMNHA team members and two health professionals from Burkina Faso. Travel restrictions during Covid-19 did not allow for face-to-face workshops with team members not based in Burkina Faso. All the messages (Table 6) were then considered the main content of tools and materials (training modules, flipbook, messages) related to exclusive breastfeeding in Burkina Faso (see Supplementary File 2 for more detail), in order to avoid repeating what already exists.

Development of tools

The intervention was intended to be integrated into routine health advice for pregnant and postpartum women. We used the messages (Table 6) in the production of communication tools (flipbook and short videos). The flipbook was used by (i) health workers during group educational talks in health facilities, and during interpersonal exchanges in the consultation room, and (ii) by ASBCs during their awareness-raising activities for maternal and newborn health. The short video was shared via WhatsApp within the community and also broadcasted on television screens in dispensary and maternity ward waiting rooms.

"Boites à image"/flipbook

A flipbook consists of a series of movable sheets with colourful drawings and messages. Each sheet of the flipbook focuses on a specific theme or sub-theme (although some are closely related). The front of the sheet features drawings whereas on the reverse side the corresponding explanations are given. The drawings were designed to stimulate discussion, and to make it easier for women to understand and remember the message. The explanations served as an 'aide-memoire' and guide for the healthcare provider, ensuring that the message was correctly understood. The flipbook we developed covers three key messages (Table 5), illustrated on 15 sheets (Supplementary Files 3 and 6). We chose the flipbook format because it is a visual tool for local communication used in healthcare settings in Burkina Faso; it can help people to learn, analyse their situation and change their behaviour. It is also easy to carry with you and use. We worked with a visual artist from Burkina Faso to develop provisional version of the drawings, which were critically reviewed by health workers and ASBCs at the two research sites, as well as by members of the research team. Following feedback on the images, they were finalized. Figure 1 illustrates one of the images. The final version of the flipbook in which the various amendments and

Table 6. Beliefs, practices, and messages for women.

Women's beliefs and experiences	Themes to be addressed in relation to beliefs	Message about good practice: behaviour and attitudes to promote	Justification according to scientific research
In hot weather, the child cannot go without water in the 0–6-month period In hot weather, the breastfed infant is thirsty and therefore needs extra water (breastmilk is light for some, fat for others) During the hot and dry season, dehydration is a risk for the baby, so breastmilk should be supplemented with water more frequently during these periods	Themes: 1. Breastfeeding Breastfeeding for term and late preterm babies is sufficient in hot weather	During the hot season, the mother should feed her baby frequently. This allows the baby to quench its thirst, as breast milk contains sufficient water Also, some babies prefer short, frequent feedings in hot weather. This is normal and the mother should take this into account. Remember, the more your baby feeds, the more milk your body produces It is important that your baby feeds frequently and does not receive any supplements, including water, so that your body can produce enough milk	Even in warmer and drier climatic conditions, exclusively breastfed infants do not need extra water Because: Breast milk contains enough water to cover the baby's water needs The composition of your breast milk will change according to your baby's needs A baby needs a lot of breast milk and will suckle frequently Giving the baby a fluid other than your milk means that the baby will be filling up on an inferior source of nutrition, but also exposes him to diarrhoea and other infections
In hot weather, the desire to drink fresh water to quench one's thirst is not recommended for pregnant and postpartum women 'Drinking fresh water during pregnancy carries risks (foetal enlargement which can lead to a risk of difficult delivery)' 'Drinking cold water during the postpartum period delays a woman's recovery'	Theme 2. Hydratation It is important to drink enough water both during pregnancy and after giving birth (especially if breastfeeding) Drinking cold water is not harmful	In order to be sufficiently hydrated: For pregnant women and women after delivery, you should not be. You should drink water regularly throughout the day whether the water is hot, cold or normal temperature. All water temperatures are allowed. It is advisable to drink at least two cans of lafi water per day The important thing to remember is that you should drink more water during pregnancy and breastfeeding than at any other time in your life	Pregnant and postpartum women should hydrate properly. She should drink at least one bottle of lafi water per day The temperature of the water has no effect on pregnant or postpartum women
High heat makes breastfeeding uncomfortable and can reduce the frequency of breastfeeding The discomforts are: Sweat dripping all over the mother's body, and the mother may be exhausted by the heat 'Bourbouilles' (small rash on the baby's body) that make the baby uncomfortable and cry, and latching on can be difficult	Theme 3: Reduce discomfort Make breastfeeding moments less uncomfortable, to maintain breastfeeding frequency Reduce discomfort for mother and child Mother: discomfort from sweating Baby: cool skin and avoid rash	To reduce discomfort and increase the frequency of breastfeeding: The mother can breastfeed the baby in an airy place where the air circulates. For example, this can be done under a shed, or under a shady tree. She can also look for a cooler room. That is, a more airy room where the air circulates more She can also use cooling towels, which are towels soaked in water to cool the baby	The woman's body produces milk according to supply and demand. It is important that the baby feeds frequently and does not receive any supplements, including water, so that you have an abundant milk supply It is important to respect the frequency and find ways to reduce discomfort due to heat and perspiration

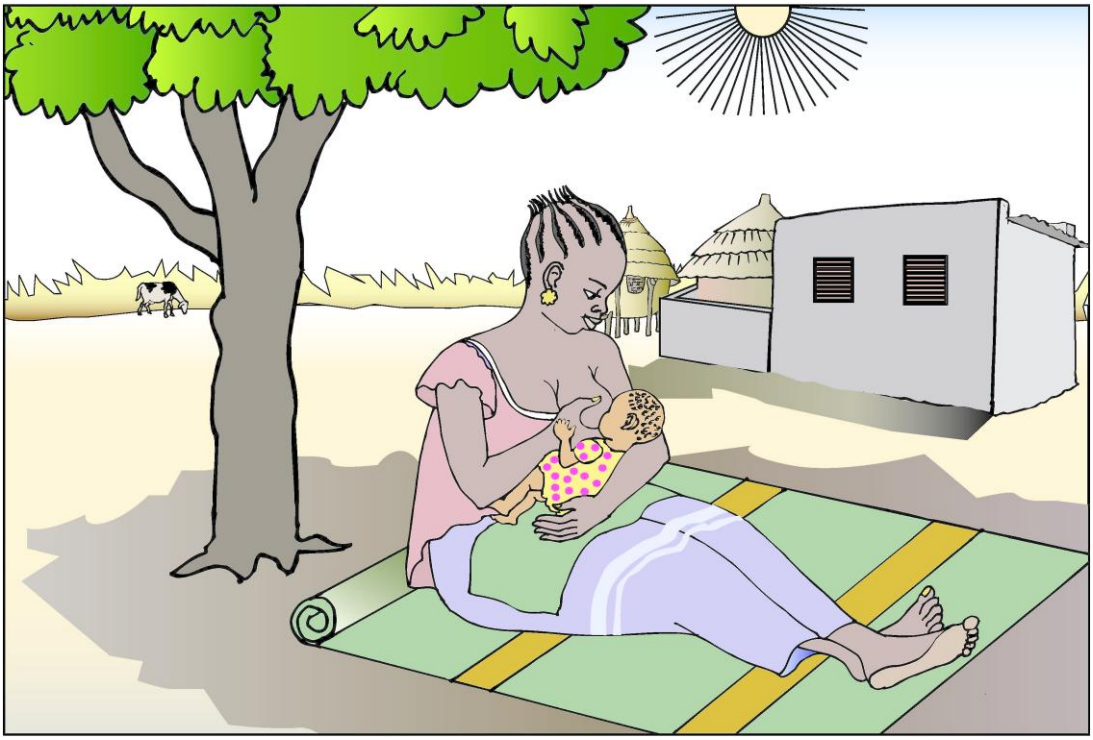

Figure 1. Illustration of a woman breastfeeding her newborn baby in the shade of a shed.

comments have been incorporated, is published elsewhere (Kadio *et al.* 2024b).

Short videos

Six short videos of 5 min each were produced with the help of a journalist (three in French and three in Moore, a local language). Each video addressed the three key messages and used locally relevant figures to illustrate them. For example, the video on hydration used a person dressed as a midwife to talk to pregnant and postpartum women about the importance of drinking enough water, irrespective of temperature. The videos on discomfort and breastfeeding used illustrative images over which a voice was heard. The videos were also critically reviewed by health workers and ASBCs.

Training of health professionals and community health workers

We aimed to engage health professionals and community health workers to integrate heat and dehydration messages into their routine work with pregnant and postpartum women. Two workshops were organized per research site to train health providers in delivering health education messages to women on heat and maternal and newborn health. The first was for health workers from the research sites and those in charge of Maternal and Child Health Officer in the districts and was run by the local research team. The second was for ASBCs from each research site, and was run by the midwife and head nurse, with support from the project team. A total of 65 people were trained to use the intervention tools (images and videos), including 40 healthcare professionals and 25 ASBCs. (Supplementary File 4)

Training materials were developed for health professionals. The objectives and content of the training material were conceived and discussed within the research team as part of the co-design process. Discussions focused on the impact of heat on maternal and newborn health and coping strategies with the following objectives: (i) informing health workers about the evidence base on the consequences of extreme heat on maternal and child health, (ii) informing health workers about women's perceptions of heat and maternal health (qualitative survey results and first co-design results), and (iii) presenting the communication tools and key messages (see above).

Each site proposed a plan of action for integrating these messages into their routine activities, whether in the consultation room (for health workers), in the community (for community health workers) or in any other contact with pregnant women and mothers. In group work, and as part of the co-design process, healthcare workers in each site proposed a plan of action for integrating these messages into their routine activities, whether in the consultation room (for health workers), in the community (for community health workers) or in any other contact with pregnant women and mothers (Supplementary File 5). These plans for integrating messages were not new activities; rather, they involved integrating heat messages into existing maternal and child health activities. The communication tools served as a visual aid during the information and knowledge sharing periods with women and community members.

Discussion

Some important lessons were learned about the co-design process and its focus on the impact of heat on maternal and newborn health. The impacts of heat on the health and wellbeing of mothers and children were a new and undiscovered topic for health professionals in Burkina Faso, whether at the service or policy levels.

Initially, even health professionals in this study admitted they were unaware of the health consequences of heat

exposure for pregnant women or newborns. The formal training that health professionals receive in Burkina Faso does not address this issue, although several training courses exist on exclusive breastfeeding and how to address socio-cultural barriers. Our intervention is the first to propose the integration of activities related to heat and maternal health into the routine activities of health centers.

We received positive comments on the co-design process. The implementers (health workers and ASBCs) found the evidence on heat risks compelling. The co-design workshops were an opportunity to build capacity among implementers and community members, as well as help developing the intervention (communication tools). Health professionals mentioned the need to reflect at the national level regarding addressing heat risks. Some recommended that the Ministry of Health and Higher Education should revise the training curricula for health professionals to integrate information on climate change and health.

There were some challenges relating to specific messages that conflicted with current beliefs. For example, during the training workshops, some ASBCs expressed concern about the messages discouraging women from drinking hot water, because they felt this advice was being imposed externally by politicians. They believed that for generations, postpartum women have been advised to consume hot water in addition to having a hot bath to facilitate recovery. Even though we explained them that the message is supported by research findings, they felt that this was a cultural practice from elsewhere and politicians are trying to transpose into the context of research sites and everywhere in Burkina Faso. We explained that, before the discovery of antibiotics, the use of hot water did indeed protect women against infections. However, this is no longer true today, as women give birth in health facilities and take medication to prevent infection. As a result, the use of hot water is no longer an absolute necessity, and women can drink and bathe in cold, warm, or hot water without any problem. These explanations were welcomed by the ASBCs, as they made the message easier to understand and appropriate.

Our findings show that there is no 'one-size-fits-all' intervention, and that interventions may vary according to the context to which they are adapted. In Kenya (Lusambili *et al.* 2023), for example, communities wanted to prioritize interventions such as cooling systems and air conditioning in homes and health facilities (Adebayo 2022). However, such interventions are perceived as expensive, although passive cooling measures may be cheaper to install. Air conditioning requires reliable access to electricity, which is not always available in rural Burkina Faso and in most urban low-income households. This situation highlights the importance of the co-design process in adapting intervention strategies to the local context. It is important that the various actors and stakeholders at different levels are consulted in order to make the decisions they consider appropriate in their own communities.

We developed a multifaceted behaviour change intervention that will target several of these barriers simultaneously (Squires *et al.* 2014). As our formative research findings show, many barriers to behaviour change are social and physical, leading to an 'inability' to adopt desired behaviours Education and the provision of information are not enough to bring about sustained behaviour change (Corace and Garber 2014). In addition, once the education messages and materials have been carefully developed and tested, repetitive education and awareness courses need to be put in place, in our context preferably led by community members and health workers who are in close contact with pregnant and postpartum breastfeeding women. Furthermore, it is important that the intervention is carefully evaluated.

Overall, rising temperatures due to climate change are having a direct and indirect impact on women during pregnancy and childbirth in Africa (Roos *et al.* 2021). These circumstances threaten to undo the hard-won gains made by maternal and child health programmes in Africa over recent decades (Garcia and Sheehan 2016, Chersich *et al.* 2023). However, investment in building maternal and child health infrastructure offers opportunities to leverage existing health systems and environmental service delivery platforms. For example, during workshops, participants suggested priority interventions such as building well-ventilated health infrastructures, i.e. with large openings to the outside and using appropriate materials, planting trees, and developing green spaces around health centres. It is fundamental to plan for the use of these adaptive strategies, as most low- and middle-income countries lack financial prioritization, sociocultural barriers, and lack of awareness programmes to support adaptation.

Conclusion

The threat of heat exposure to pregnant and postpartum women and their babies in Africa, which is worsening as the climate changes, is only recently being understood and addressed. This paper reports on a co-design process to develop interventions to reduce the risks associated with heat exposure in pregnancy and during the postpartum period. Groups of diverse stakeholders were actively engaged in the process of identifying and prioritizing adaptation interventions based on pre-set criteria, and in the development of the intervention tools. The stakeholders considered extreme heat as a result of climate change a new but relevant health issue and stated that it is important to initiate a reflection at the national level on the integration of heat and health in the provision of maternal and child health services. The co-design workshops were an opportunity to build capacity among facilitators and participants as well as to prioritize and develop interventions to address the impact of heat exposure on pregnant and postpartum women and newborns. We productively utilized the co-design model in co-creating contextualized acceptable intervention to reduce the risk of heat on maternal and neonatal health. Our approach can serve as a model for co-designing heat-health adaptation in sub-Saharan Africa.

Acknowledgements

We acknowledge all participants in this co-design process: those from the Kaya health district, the Bodogogo health district, the village of Delga in the commune of Kaya, the Wemtenga neighbourhood of Ouagadougou, the Ministry of Health, the Ministry of the Environment, associations, and NGOs.

Supplementary data

Supplementary data is available at *Health Policy and Planning* online.

Author contributions

Conception or design of the work (K.K., V.F., N.R., F.S., B.N., S.Kov., S.Kou.), Data collection (K.K., M.Co., A.S.),

Data analysis and interpretation (K.K., M.Co., A.S.), Drafting the article (K.K.), Critical revision of the article (all authors).

Reflexivity statement

The study was designed as part of a collaboration between southern and northern research centers to study the impact of heat on women and their children. The study was led by the research team in Burkina Faso: data collection, analysis, and writing of this article. Virtual meetings and workshops allowed collaborators to contribute. The author is from a low and middle-income country and a high-income country. There were no specific restrictions on authorship, and all members of the Burkina Faso teams who participated in the research are listed as co-authors. Women's participation is important.

Ethical approval

The study obtained ethical approval from the National Ethics Committee for Health Research (CERS) of Burkina Faso (No 2020-03-053) and from the Research Ethics Committee of the London School of Hygiene and Tropical Medicine (No 21869).

Conflict of interest

None declared. 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.

Funding

The study is funded by the Natural Environment Research Council (grant numbers NE/T013613/1 and NE/T01363X/1), the Research Council of Norway (grant number 312601) and The Swedish Research Council for Health, Working Life and Welfare in collaboration with the Swedish Research Council (Forte) (grant number 2019-01570) and the National Science Foundation (NSF) (grant number ICER-2028598), coordinated through a Belmont Forum partnership.

Data availability

Data may be obtained from a third party and are not publicly available. Full transcripts cannot be shared publicly due to potentially identifying information. The content and words of respondents in interviews could potentially be used to identify individuals. Even anonymisation could pose risks to confidentiality. Data are available on request to the Comité d'éthique pour la recherche en santé in Burkina Faso (+226 72757187) or from from the Research Ethics Committee of the London School of Hygiene and Tropical Medicine.

References

Adebayo AL. Mitigating climate change effects on maternal and prenatal health in Nigeria. In: *The Nature, Causes, Effects and Mitigation of Climate Change on the Environment*. IntechOpen, 2022. https://doi.org/10.5772/intechopen.101267

Batté L, Ardilouze C, Déqué M. *Monthly and Seasonal Predictability of Heat Waves in West Africa with CNRM-CM*, p. 8173. (2017). https://ui.adsabs.harvard.edu/abs/2017EGUGA..19.8173B (18 March 2023, date last accessed).

Batté L, Ardilouze C, Déqué M. Forecasting West African heat waves at subseasonal and seasonal time scales. *Mon Weather Rev* 2018;**146**: 889–907. https://doi.org/10.1175/MWR-D-17-0211.1

Chapman S, Birch CE, Marsham JH *et al.* Past and projected climate change impacts on heat-related child mortality in Africa. *Environ Res Lett* 2022;**17**:074028. https://doi.org/10.1088/1748-9326/ac7ac5

Chersich MF, Pham MD, Areal A *et al.* Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: systematic review and meta-analysis. *BMJ* 2020;**371**:m3811. https://doi.org/10.1136/bmj.m3811

Chersich MF, Scorgie F, Filippi V *et al.* Increasing global temperatures threaten gains in maternal and newborn health in Africa: a review of impacts and an adaptation framework. *Int J Gynaecol Obstet* 2023;**160**:421–9. https://doi.org/10.1002/ijgo.14381

Chung Y, Yang D, Gasparrini A *et al.* Changing susceptibility to non-optimum temperatures in Japan, 1972–2012: the role of climate, demographic, and socioeconomic factors. *Environ Health Perspect* 2018;**126**:057002. https://doi.org/10.1289/EHP2546

Coggan A, Carwardine J, Fielke S *et al.* Co-creating knowledge in environmental policy development. An analysis of knowledge co-creation in the review of the significant residual impact guidelines for environmental offsets in Queensland, Australia. *Environ Chall* 2021;**4**: 100138. https://doi.org/10.1016/j.envc.2021.100138

Corace K, Garber G. When knowledge is not enough: changing behavior to change vaccination results. *Hum Vaccin Immunother* 2014;**10**:2623–4. https://doi.org/10.4161/21645515.2014.970076

Cuaton GP, Su Y. Local-indigenous knowledge on disaster risk reduction: insights from the Mamanwa indigenous peoples in Basey, Samar after Typhoon Haiyan in the Philippines. *Int J Disaster Risk Reduct* 2020;**48**:101596. https://doi.org/10.1016/j.ijdrr.2020.101596

Garcia DM, Sheehan MC. Extreme weather-driven disasters and children's health. *Int J Health Serv* 2016;**46**:79–105. https://doi.org/10.1177/0020731415625254

Gonzalez M, Phoenix M, Saxena S *et al.* Strategies used to engage hard-to-reach populations in childhood disability research: a scoping review. *Disabil Rehabil* 2021;**43**:2815–27. https://doi.org/10.1080/09638288.2020.1717649

Iwama AY, Araos F, Anbleyth-Evans J *et al.* Multiple knowledge systems and participatory actions in slow-onset effects of climate change: insights and perspectives in Latin America and the Caribbean. *Curr Opin Environ Sustain* 2021;**50**:31–42. https://doi.org/10.1016/j.cosust.2021.01.010

Kadio K, Filippi V, Congo M *et al.* Extreme heat, pregnancy and women's well-being in Burkina Faso: an ethnographical study. *BMJ Glob Health* 2024a;**8**:e014230. https://doi.org/10.1136/bmjgh-2023-014230

Kadio K, Sana A, Congo M *et al. Boîte à image chaleur et santé de la mère et de l'enfant*, *Hub IRSS*, 15 May. (2024b). https://hubssr.org/actualite/boite-a-image-chaleur-et-sante-de-la-mere-et-de-lenfant/ (11 June 2024, date last accessed).

Kalanda-Joshua M, Ngongondo C, Chipeta L *et al.* Integrating indigenous knowledge with conventional science: enhancing localised climate and weather forecasts in Nessa, Mulanje, Malawi. *Phys Chem Earth Parts A/B/C* 2011;**36**:996–1003. https://doi.org/10.1016/j.pce.2011.08.001

Lusambili A, Khaemba P, Agoi F *et al.* Process and outputs from a community codesign workshop on reducing impact of heat exposure on pregnant and postpartum women and newborns in Kilifi, Kenya. *Front Public Health* 2023;**11**:1146048. https://doi.org/10.3389/fpubh.2023.1146048

MacVicar S, Berrang-Ford L, Harper S *et al.* Whether weather matters: evidence of association between in utero meteorological exposures and foetal growth among Indigenous and non-Indigenous mothers in rural Uganda. *PLoS One* 2017;**12**:e0179010. https://doi.org/10.1371/journal.pone.0179010

Michie S. Implementation science: understanding behaviour change and maintenance. *BMC Health Serv Res* 2014;**14**:O9. https://doi.org/10.1186/1472-6963-14-S2-O9

Michie S, Atkins L, West R. *The Behaviour Change Wheel: A Guide to Designing Interventions*. London: Silverback Publishing, 2014 https://www.behaviourchangewheel.com/

Mugi-Ngenga EW, Kiboi MN, Mucheru-Muna MW *et al.* Indigenous and conventional climate-knowledge for enhanced farmers' adaptation to climate variability in the semi-arid agro-ecologies of Kenya. *Environ Chall* 2021;**5**:100355. https://doi.org/10.1016/j.envc.2021.100355

Mulvale G, Moll S, Miatello A *et al.* Co-designing services for youth with mental health issues: novel elicitation approaches. *Int J Qual Methods* 2019;**18**:1609406918816244. https://doi.org/10.1177/1609406918816244

Nyadzi E, Werners SE, Biesbroek R *et al.* Towards weather and climate services that integrate indigenous and scientific forecasts to improve forecast reliability and acceptability in Ghana. *Environ Dev* 2022;**42**:100698. https://doi.org/10.1016/j.envdev.2021.100698

Part C, Filippi V, Cresswell JA *et al.* How do high ambient temperatures affect infant feeding practices? A prospective cohort study of postpartum women in Bobo-Dioulasso, Burkina Faso. *BMJ Open* 2022;**12**:e061297. https://doi.org/10.1136/bmjopen-2022-061297

Rahman MF, Falzon D, Robinson S-A *et al.* Locally led adaptation: promise, pitfalls, and possibilities. *Ambio* 2023;**52**:1543–57. https://doi.org/10.1007/s13280-023-01884-7

Roos N, Kovats S, Hajat S *et al.* Maternal and newborn health risks of climate change: a call for awareness and global action. *Acta Obstet Gynecol Scand* 2021;**100**:566–70. https://doi.org/10.1111/aogs.14124

Slattery P, Saeri AK, Bragge P. Research co-design in health: a rapid overview of reviews. *Health Res Policy Syst* 2020;**18**:1–13. https://doi.org/10.1186/s12961-020-0528-9

Squires JE, Sullivan K, Eccles MP *et al.* Are multifaceted interventions more effective than single-component interventions in changing health-care professionals' behaviours? An overview of systematic reviews'. *Implement Sci* 2014;**9**:152. https://doi.org/10.1186/s13012-014-0152-6

Streefkerk IN, van den Homberg MJC, Whitfield S *et al.* Contextualising seasonal climate forecasts by integrating local knowledge on drought in Malawi. *Clim Serv* 2022;**25**:100268. https://doi.org/10.1016/j.cliser.2021.100268

Zoma V, Kiemd A, Sawadogo Y. Principaux défis de la croissance urbaine de Ouagadougou. *Regardsuds* 2022;**2**:77–92. https://regardsuds.org/%EF%BF%BCprincipaux-defis-de-la-croissance-urbaine-de-ouagadougou/