

# **Report of a scoping meeting for the selection of indicators to monitor the impact of extreme heat on maternal, newborn and child health**

**Geneva, Switzerland, 24-25 April 2023**



**World Health  
Organization**



# **Report of a scoping meeting for the selection of indicators to monitor the impact of extreme heat on maternal, newborn and child health**

**Geneva, Switzerland, 24-25 April 2023**

Report of a scoping meeting for the selection of indicators to monitor the impact of extreme heat on maternal, newborn and child health, Geneva, Switzerland, 24-25 April 2023

ISBN 978-92-4-007983-0 (electronic version)

ISBN 978-92-4-007984-7 (print version)

© World Health Organization 2024

Some rights reserved. This work is available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; <https://creativecommons.org/licenses/by-nc-sa/3.0/igo>).

Under the terms of this licence, you may copy, redistribute and adapt the work for non-commercial purposes, provided the work is appropriately cited, as indicated below. In any use of this work, there should be no suggestion that WHO endorses any specific organization, products or services. The use of the WHO logo is not permitted. If you adapt the work, then you must license your work under the same or equivalent Creative Commons licence. If you create a translation of this work, you should add the following disclaimer along with the suggested citation: "This translation was not created by the World Health Organization (WHO). WHO is not responsible for the content or accuracy of this translation. The original English edition shall be the binding and authentic edition".

Any mediation relating to disputes arising under the licence shall be conducted in accordance with the mediation rules of the World Intellectual Property Organization (<http://www.wipo.int/amc/en/mediation/rules/>).

**Suggested citation.** Report of a scoping meeting for the selection of indicators to monitor the impact of extreme heat on maternal, newborn and child health, Geneva, Switzerland, 24-25 April 2023. Geneva: World Health Organization; 2024. Licence: [CC BY-NC-SA 3.0 IGO](https://creativecommons.org/licenses/by-nc-sa/3.0/igo).

**Cataloguing-in-Publication (CIP) data.** CIP data are available at <http://apps.who.int/iris>.

**Sales, rights and licensing.** To purchase WHO publications, see <https://www.who.int/publications/book-orders>. To submit requests for commercial use and queries on rights and licensing, see <https://www.who.int/copyright>.

**Third-party materials.** If you wish to reuse material from this work that is attributed to a third party, such as tables, figures or images, it is your responsibility to determine whether permission is needed for that reuse and to obtain permission from the copyright holder.

The risk of claims resulting from infringement of any third-party-owned component in the work rests solely with the user.

**General disclaimers.** The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by WHO in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

All reasonable precautions have been taken by WHO to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall WHO be liable for damages arising from its use.

# Contents

Acknowledgements . . . . .	v
Abbreviations . . . . .	vi
<b>1</b> Executive summary . . . . .	vii
<b>2</b> Background . . . . .	1
<b>3</b> Aims and objectives of the scoping meeting . . . . .	3
<b>4</b> Overview of the meeting . . . . .	4
<b>5</b> Day 1 - Summary of presentations . . . . .	6
<b>6</b> Day 1 and 2 - Summary of discussions related to indicators . . . . .	17
6.1 Conceptual framework . . . . .	17
6.2 Indicators . . . . .	18
<b>7</b> Day 2 - Summary of presentations on EWSs and measures of thermal stress tailored for MNCH . . . . .	22
<b>8</b> Day 2 - Summary of discussions on EWSs and thresholds tailored for MNCH. . . . .	24
<b>9</b> Conclusions. . . . .	27
<b>10</b> Next steps. . . . .	28
References . . . . .	30
Annex 1: HIGH Horizons project sheet . . . . .	33
Annex 2: List of participants . . . . .	35
Annex 3: Terms of reference of WHO Expert Group. . . . .	38
Annex 4: Agenda . . . . .	42
Annex 5: Feedback on the conceptual framework per subgroup . . . . .	45

## List of figures

Figure 1: Draft conceptual framework of climate change impacts on maternal, newborn and child health. . . . .	7
Figure 2: Potential levels of monitoring of MNCH indicators . . . . .	8
Figure 3: WHO UNFCCC Health and Climate Change Country Profiles . . . . .	9
Figure 4: WHO Health and Climate Change Global Survey . . . . .	10
Figure 5: Heatwave intensity and human thermoregulation measures . . . . .	11
Figure 6: Geographic distribution of studies included in the systematic review on MNH outcomes and heat exposure . . . . .	13
Figure 7: A call to action from the Lancet Countdown to reduce the global “fossil fuel addiction” . . . . .	14
Figure 8: Overview of principal sources of modelled estimates of heat -related mortality . .	15
Figure 9: Overview of HIGH Horizons datasets and additional sources of analysis. . . . .	16
Figure 10: Four elements of people-centred Early Warning Systems . . . . .	22
Figure 11: Weather phenomenon warning-system etymology . . . . .	23

## List of boxes

Box 1 – HIGH Horizons . . . . .	2
Box 2 – Proposed process for indicator selection . . . . .	6
Box 3 – Human thermoregulation indices (or Thermal Stress Indicators) . . . . .	12

# Acknowledgements

This scoping meeting was jointly organized by the World Health Organization Departments of Maternal, Newborn, Child and Adolescent Health and Ageing (WHO/MCA) and Climate Change and Health (WHO/CCH).

Anayda Portela (WHO/MCA) and Francesca Conway (consultant to WHO/MCA) coordinated this effort with the support of the members of the WHO Steering Group: Doris Chou (Department of Sexual and Reproductive Health and Research), Bernadette Daelmans (WHO/MCA), Ayesha De Costa (WHO/MCA), Kirrily De Polnay (Department of Nutrition and Food Security), Theresa Diaz (WHO/MCA), Allisyn Moran (WHO/MCA), Tara Neville (WHO/CCH), Pura Rayco Solon (Department of Quality Assurance of Norms and Standards), Christian Schweizer (WHO/CCH) and Joy Shumake Guillemot (WHO/CCH and the World Meteorological Organization (WMO)). Merve Pillonel (WHO/MCA) provided administrative support. WHO regional staff who contributed to this meeting and report include Adeniyi Aderoba, Mohamed Afifi, Oleg Kuzmenko and Mazen Malkawi.

WHO extends its thanks to the meeting chair, Zulfi Bhutta, for his involvement and contributions to the meeting preparations and proceedings. Our thanks to Anthony Costello for chairing Day 2 discussions. The contributions of the participants in the meeting and the preparation of this report are gratefully acknowledged: Chloe Brimicombe, Matthew Chersich, Louise Tina Day, Olivier Duperrex, Chuansi Gao, Leonidas Ioannou, Debra Jackson, Birgit Kerstens, Amira Khalif Adawe, Ousmane Ndiay, Perpetual Ofori-Ampofo, Nicolas Ray, Jennifer Runkle, Sergey G. Sargsyan, Heather Scott, Yasmin Farah Sheikh Abdulkadir, Abhiyant Tiwari, Peter Waiswa, Gary Watmough and Ralf Weigel. WHO appreciates the contributions of Gagan Gupta and Swathi Manchikanti (United Nations Children's Fund), Eleni Myrivili (United Nations Human Settlements Programme), Michel Brun (United Nations Population Fund) and John Nairn (WMO).

Birgit Kerstens, Francesca Conway, Zulfi Bhutta and Anayda Portela prepared the meeting report, with inputs from the WHO Steering Group and the meeting participants.

WHO gratefully acknowledges the funding received through the HIGH Horizons project under the European Union's Horizon Framework Programme under Grant Agreement number 101057843 and from UKRI Innovate UK under reference number 10038478 for project partner London School of Hygiene and Tropical Medicine.

# Abbreviations

<b>CHAT</b>	Child Health Accountability Tracking
<b>DHS</b>	Demographic and Health Survey
<b>DHIS</b>	district health information system
<b>DOI</b>	disclosure of interests
<b>EWAR</b>	early warning and response
<b>EWS</b>	early warning system
<b>GHHIN</b>	Global Heat Health Information Network
<b>HDSS</b>	Health and Demographic Surveillance Systems
<b>HeLTI</b>	Healthy Life Trajectories initiatives
<b>HI</b>	heat index
<b>HIGH Horizons</b>	Heat indicators for Global Health
<b>ILO</b>	International Labour Organization
<b>LMIC</b>	low- and middle-income country
<b>MNCH</b>	maternal, newborn, and child health
<b>MoNITOR</b>	Mother and Newborn Information for Tracking Outcomes and Results
<b>TSI</b>	thermal stress indicator
<b>PT</b>	perceived temperature
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>UNFPA</b>	United Nations Population Fund
<b>UN-Habitat</b>	United Nations Human Settlements Programme
<b>UNICEF</b>	United Nations Children’s Fund
<b>UTCI</b>	universal thermal climate index
<b>WBGT</b>	wet bulb globe temperature
<b>WHO</b>	World Health Organization
<b>WHO/CCH</b>	WHO Department of Climate Change and Health
<b>WHO/MCA</b>	WHO Department of Maternal, Newborn, Child and Adolescent Health and Ageing
<b>WMO</b>	World Meteorological Organization



# 1 Executive summary

In April 2023 the World Health Organization (WHO) Department of Maternal, Newborn, Child and Adolescent Health in collaboration with the WHO Department of Climate Change and Health (CCH) held a first meeting in Geneva, Switzerland to initiate a process to select indicators to monitor the impact of extreme heat on maternal, newborn and child health (MNCH). The meeting presented an opportunity to also hold a discussion on thresholds that could be used for early warning systems (EWSs) or to alert health systems on extreme heat conditions that could negatively impact on MNCH. The results of this process and the selected indicators will be published in a WHO, United Nations Children’s Fund, United Nations Population Fund and World Meteorological Organization publication.

This document summarizes the discussions and conclusions of the April meeting.

The meeting had two key aims:

- 1) to convene a group of multidisciplinary experts (representing MNCH, monitoring and evaluation as well as environmental epidemiology, thermal physiology and climate science) to start building a community of research and practice reflecting the complex multidisciplinary and multisectoral nature of climate change mitigation and response, specifically with regards to extreme heat and health monitoring and EWSs;
- 2) to identify needs and next steps to reach consensus on a set of priority indicators to monitor the impacts of extreme heat on MNCH as well as on potential thresholds for heat-health EWS that are specific to pregnant and postpartum women, newborns and infants.

The meeting was attended by 39 participants, including representatives from Ministries of Health, United Nation agencies, academia, and professional organizations, working on global MNCH and/or climate change. All participants have extensive experience in either global MNCH, monitoring and evaluation and/or climate epidemiology and science, and they represented research, policy and practice. All external participants were required to declare any potential conflict of interests.

The full report is structured to inform on the presentations and key discussions based on the priority topics: indicators to monitor the impact of heat on MNCH and early warning systems for MNCH.

## Conclusions

### ***Filling the knowledge gaps***

The group concluded that it is crucial to focus on climate change and that the momentum needs to be taken to fill the knowledge gaps. While acknowledging the importance of the existing systematic reviews and meta-analysis, it was agreed that these are not providing information that is granular enough to shed light on the biological mechanisms by which heat impacts on MNCH, as well as on the relationship between heat – and other climate change elements- and other behavioural outcomes (for example care-seeking, infant feeding). Rather than conducting additional systematic reviews, more primary research is needed to fill the knowledge gaps on indicators and EWS thresholds. A research prioritization process to define priorities and achieve common methods and measurements would be important. Collaborations between climate scientists, thermal physiologists and MNCH experts and joint publications should be the way forward. In addition, secondary analysis of data planned are useful but the current geographic scope is limited and should be expanded. WHO could play a role in bringing together researchers to harmonize methods, analysis plans including uniform measurement of heat and health outcomes as feasible.

### ***Data issues***

The two days of presentations and discussions convinced the meeting participants that the health and meteorological ‘sectors’ – and their data – need to be brought together at the country level. Countries will not disclose all their public health data publicly, but working with health management information systems in countries may help to get the relevant disaggregated data available for decision-making.

### ***Involvement of a variety of stakeholders***

Within the organizations of the meeting participants there are people involved in (soon to be) funded research projects which will be looking longitudinally at MNCH outcomes in relation to heat exposure (but other exposures such as water and air pollution can and should be investigated). It was suggested that these groups should be contacted for collaboration to see what could be of contribution to WHOthe process to select indicators. Other groups of researchers and stakeholders can also be brought on board, including professional associations, local government decision-makers and parliamentarians, architects, renewable energy, parent groups, community groups, and other national and international agencies. The group agreed that a variety of stakeholders should be involved to provide balance between research, advocacy and action.

## **Next steps**

Throughout the course of the meeting discussions, the participants identified next steps to be taken, the key steps are summarized below:

### ***Identification of indicators***

WHO will lead work to:

- Revise the conceptual framework on heat and MNCH based on the inputs received during the scoping meeting.
- Conduct a scoping review of available indicators in the literature and/or currently used by countries to track the impacts of heat on health.
- Map the indicators to the conceptual framework and highlight areas where there are measurement gaps.
- Expand the geographical scope of the datasets to be analysed in HIGH Horizons and identify and contact potential databases from other geographical regions and of child health to be included (also consider the addition of secondary data analysis of DHS data).
- Decide on the best process for consensus for indicator selection after the mapping (e.g., Delphi survey and consensus meeting) to complete the process of indicator selection to monitor the impact of extreme heat on MNCH.
- Finalize planned publications and disseminate the findings with the wider climate change and health community.
- Test and validate any of the selected indicators that have not previously been tested and validated.
- Build capacity for analysis of heat and health data in countries.

### ***Selection of thresholds***

WHO will lead work to:

- Conduct a consensus process to identify criteria to consider when adopting thermal stress indicators for MNCH
- Evaluate the efficacy of the TSIs.
- Conduct a process to identify priority messages for MNCH for early notification and warning systems, that health services can use in the case of extreme heat that could impact on MNCH.

## ***Additional***

WHO and partners will work to:

- Contribute to efforts to strengthen the collaboration and dialogue between meteorological services and the health sector and to other research initiatives investigating health and heat exposure, particularly in vulnerable groups.
- Ensure coordination of research efforts across the climate change and health community to avoid duplications and overlap of efforts and integrate with existing climate change and platforms and research communities.
- Determine if and when there are critical windows of exposure for MNCH and thus differential experiences of heat across the diverse MNCH age groups.
- Integrate the learnings and consensus recommendations from this multi-disciplinary meeting into planned exercises for research prioritization for climate change.

## 2 Background

There are currently major challenges in measuring the health impacts of climate change, and the outcomes of policy actions.

Pregnant and postpartum women, newborns and children are uniquely vulnerable to climate risks, owing to a host of physiological, clinical and behavioural factors (1). Pregnancy and maternal status heighten the vulnerability to climate hazards, like extreme heat, poor air quality, drought, heavy precipitation, and wildfires, but for the purpose of this report we will focus only on extreme heat (2). Infants and children are susceptible to greater climate-related health burdens compared to adults, given physiological and cognitive development and their dependence on parents and/or caregivers (3,4). There is compelling epidemiological evidence linking exposure to high temperatures and air pollution to increased risk of adverse outcomes such as stillbirths, preterm birth, low birth weight and infant mortality (1,2). For some of these associations the pathway is clear. For others, there is a need for more research to unpack causal mechanisms and cascading effects and to identify critical vulnerability thresholds.

A major priority in the field of climate change and health is to enhance the ability to track the scale of heat-related health impacts, and to measure the success of adaptation and mitigation solutions, with a focus on vulnerable populations. Many questions remain about the optimum set of indicators needed for tracking heat exposure and maternal, newborn and child health (MNCH)(5). Measuring the health harms of extreme heat in pregnant and postpartum women, newborns and children has been limited due to important climate data gaps, uncertainty about which extreme heat indicators and heatwave definitions best capture exposure risks, and how differential vulnerability, timing of exposure across critical windows, and response is influenced by non-climate factors.

The design of low-cost and efficient adaptation and mitigation interventions and better heat adaptation planning, particularly in the most affected and least resilient countries, are critically important - but greatly depend on the availability of high-quality data to understand the impact of heat on MNCH and ultimately the global burden of heat exposure and its attribution (6).

Pregnant women, infants and children are ideal populations for monitoring the health impact of climate change, and MNCH programmes serve as an ideal venue for identifying evidence-based interventions and adaptation measures. Firstly, in most parts of the world, robust data are collected on the denominator (e.g., number of births in a population), while for many other health outcomes the denominator is unknown (e.g., number of preterm births). Secondly, several measures of MNCH have well accepted, standardized definitions that have already been applied globally. Thirdly, adverse birth and childhood outcomes are major public health priorities as conditions in these groups signal large, often lifelong health/health systems burdens and thus policy actions are often highly cost-effective. Lastly, considerable investments have been made in establishing MNCH infrastructure and surveillance systems, providing many opportunities for leveraging existing service delivery platforms and personnel. Placing MNCH populations, programme data, and the associated human and other health system resources at the centre of the climate change response is a highly novel –and critically important – approach.

The World Health Organization (WHO) Department of Maternal, Newborn, Child and Adolescent Health (MCA) is a partner in the HIGH Horizons project, a research and innovation project funded by the European Union's Horizon Europe and the United Kingdom Research and Innovation (UKRI) Innovate UK Grant. See Box 1 for a summary and Annex 1 for additional

information regarding HIGH Horizons. WHO is leading work under the HIGH Horizons project to conduct a global process to identify indicators to monitor the impact of extreme heat<sup>1</sup> on MNCH. The project presents a unique opportunity to identify extreme heat and MNCH health indicators and subsequently test them through different HIGH Horizons workstreams, allowing for a final selection of measures.

In April 2023 WHO/MCA in collaboration with the WHO Department of Climate Change and Health (CCH) held a first meeting in Geneva, Switzerland to initiate the process to select these indicators. The results of this process and the selected indicators will be published in a WHO, United Nations Children's Fund (UNICEF), United Nations Population Fund (UNFPA) and World Meteorological Organization (WMO) publication.

The meeting presented an opportunity to also hold a discussion on thresholds that could be used for early warning systems (EWSs) or to alert health systems on extreme heat conditions that could negatively impact on MNCH. Heat-health EWS use climate and weather forecasts and predetermined trigger levels of either temperature or of heat stress to provide public advisory and initiate public health interventions designed to reduce health risks before, during, and after periods of extreme heat. These systems represent critical decision-tools commonly developed and managed jointly by designated public health professionals and meteorologists and are key components in guiding health and social service decisionmaking and protocols for appropriate preparedness, prevention, and response action to extreme heat.

Currently many of these systems use air temperature cut-off thresholds directed to the entire population, and do not adequately stratify warnings by the needs of vulnerable population groups (e.g., outdoor workers, older adults) and do often not consider the different geographical realities within the country. The majority of thermal comfort indices are derived from thresholds defined using fit and healthy populations who are primarily male, without adequate consideration of the actual health outcomes, or are derived from predictive modelling of heat-health relationships, which can only provide crude estimates of actual health risks, and do not account for varying susceptibility by population subgroups, such as pregnant women, children, persons with co-existing morbidities or disabilities or older persons. Therefore, the advice that accompanies warnings is also often generic, rather than tailored to locally-available resources, specific population needs and protective practices. The meeting therefore provided the opportunity to reflect on the needs of MNCH within these EWS.

This document summarizes the discussions of the scoping meeting that took place in Geneva on 25 and 26 April 2023.

### Box 1 – HIGH Horizons



The HIGH Horizons project addresses a number of key knowledge gaps around the quantification and monitoring of direct and indirect impacts of heat exposure on maternal, newborn and child health. In the project, pregnant women, infants, and health workers serve as sentinel populations for tracking climate change impacts, adaptations, and co-benefits. The project will run over four years and includes eleven partners across ten countries in Europe and Africa and encompasses activities in both the European Union and sub-Saharan Africa. The project will quantify and monitor direct and indirect health impacts of extreme heat; test a personalised Early Warning System in Sweden, South Africa, and Zimbabwe; and implement integrated adaptation-mitigation actions in health facilities in South Africa and Zimbabwe. See <https://www.high-horizons.eu/>.

<sup>1</sup> For this report, and subsequent related efforts, the focus is on extreme heat as in acute exposures and not chronic heat, while recognizing that chronic heat exposure also poses detrimental effects to health.

### 3 Aims and objectives of the scoping meeting

The scoping meeting had two key aims:

- 1) To convene a group of multidisciplinary experts (representing MNCH, monitoring and evaluation as well as environmental epidemiology, thermal physiology and climate science) to start building a community of research and practice reflecting the complex multidisciplinary and multisectoral nature of climate change mitigation and response, specifically with regards to extreme heat and health monitoring and EWSs;
- 2) To identify needs and next steps to reach consensus on a set of priority indicators to monitor the impacts of extreme heat on MNCH as well as on potential thresholds for heat-health EWS that are specific to pregnant and postpartum women, newborns and infants.

Specific objectives include:

- To review available information and evidence and determine the additional evidence required to identify priority indicators to monitor the impact of extreme heat on MNCH;
- To discuss a conceptual framework on the impact of extreme heat on MNCH, including the different determinants and pathways of exposure;
- To define the parameters, scope and methods for the selection of indicators to measure the impact of extreme heat on MNCH, including criteria for prioritizing indicators;
- To discuss methodological challenges and possible solutions to monitoring and evaluating the impact of extreme heat on MNCH outcomes;
- To review the information and evidence and determine the additional evidence required to determine thresholds for extreme heat and MNCH that can be included in heat-health EWSs to alert health systems as to extreme heat conditions that could potentially negatively impact on MNCH.
- To define the parameters, scope and methods for the selection of thresholds that could be included in heat-health EWSs for MNCH.

## 4 Overview of the meeting

This meeting represents the first step in a process to identify priority global indicators to monitor the impact of extreme heat on MNCH and was attended by 39 participants, including representatives from Ministries of Health, United Nation agencies, academia, and professional organizations, working on global MNCH and/or climate change. The participants are listed in Annex 2. All participants have extensive experience in either MNCH, monitoring and evaluation and/or climate epidemiology, thermal physiology and climate science. Participants included:

- 17 external experts from 12 countries, including representatives of professional associations and existing measurement advisory groups such as Mother and Newborn Information for Tracking Outcomes and Results (MoNITOR) and Child Health Accountability Tracking (CHAT);
- six participants from United Nations agencies (UNFPA, UNICEF, the United Nations Human Settlements Programme (UN-Habitat) and WMO);
- four technical advisors from the HIGH Horizons project;
- eight participants from WHO Geneva headquarters (including two consultants), four participants from WHO regional offices (one each from WHO Regional Office for Africa (AFRO) and WHO Regional Office for Europe (EURO) and two from the WHO Regional Office for the Eastern Mediterranean (EMRO).

The Terms of Reference for the meeting participants who are proposed to continue in this effort as a working group is included in Annex 3. In accordance with WHO procedures for declaration of interests (DOIs)<sup>2</sup>, all external collaborators were asked to declare in writing any competing interests (whether academic, financial or other) using the standard WHO form, before engaging in the scoping meeting. All DOIs were reviewed and assessed for any conflicts of interest prior to the meeting. No declared conflicts of interest were considered serious enough to oppose any risk to the process.

The meeting was held over two days; the final agenda is included in Annex 4. Themes guiding the two days of meetings were as follows:

- Day 1:
  - Presentation of global monitoring priorities and processes for MNCH and climate change
  - Review of the evidence on the impacts of high ambient temperatures on MNCH
  - Review of a draft conceptual framework on the impacts of extreme heat on MNCH
  - Discussion on parameters, scope and methods for the selection of indicators to monitor impacts of extreme heat on MNCH
- Day 2:
  - Review of the evidence and state of practice of current EWSs
  - Discussion on parameters, scope and methods for the selection of thresholds to be used for EWS tailored for MNCH
  - Group work to provide inputs on the draft conceptual framework on the impacts of heat on MNCH and to identify priority criteria for selecting indicators.

---

<sup>2</sup> Declarations of interest. In: About WHO – ethics [website]. Geneva: World Health Organization; 2020 (<https://www.who.int/about/ethics/declarations-of-interest>, accessed 29 May 2023).



All meeting presentations, together with background materials and resources, were made available to the participants. Key elements of each presentation are provided below. Further details can be found in the presentations available from WHO on request.

This report is structured to inform on the presentations and key discussions based on the priority topics: indicators to monitor the impact of heat on MNCH and early warning systems for MNCH.

# Indicators to monitor impacts of heat on MNCH

## 5 Day 1 - Summary of presentations

### 5.1.1 Overview - Conceptual framework and proposed process

#### **Annie Portela WHO/MCA**

Annie Portela introduced the meeting objectives (see above) to the participants. A quick overview of the HIGH Horizons (Heat Indicators for Global Health) project was then provided, followed by a review of the Terms of Reference for the working group (available in Annex 3). A summary of the proposed process for indicator selection was presented – see Box 2.

#### **Box 2 – Proposed process for indicator selection**

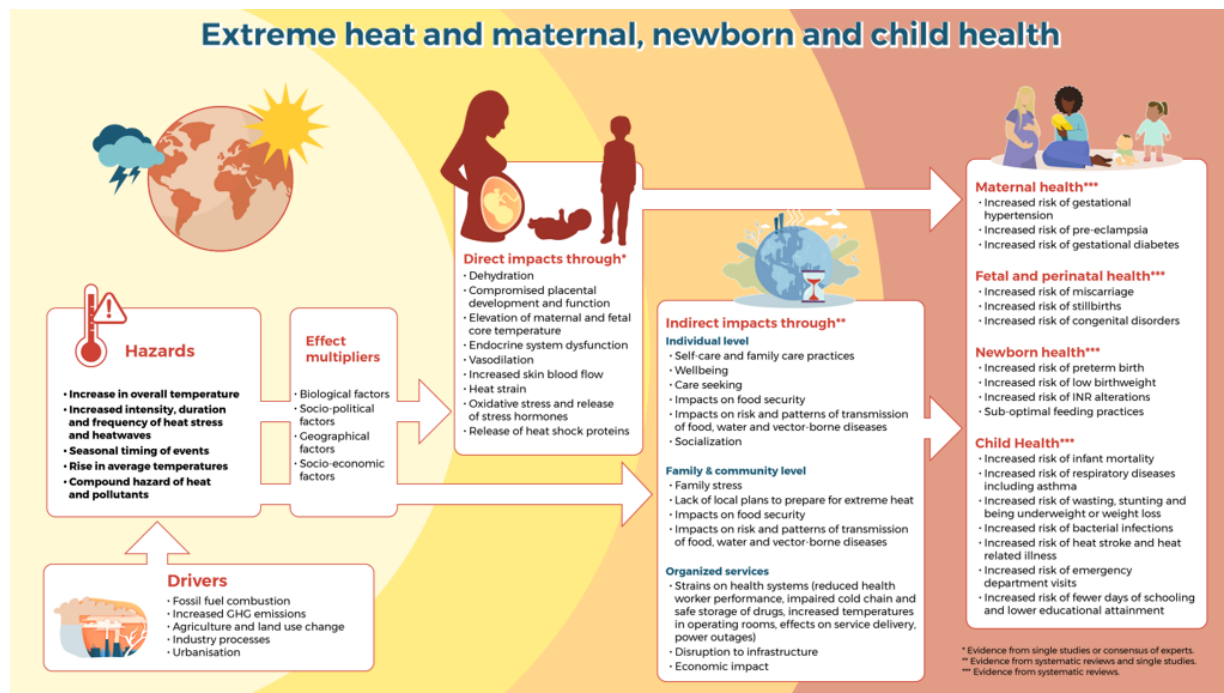
1. Name a WHO internal Steering Group with a Terms of Reference.
2. Develop criteria for selection of members and a Terms of Reference for an External expert group.
3. Designate an external Expert group and ensure disclosure of interests.
4. Hold a scoping meeting to identify a conceptual framework and parameters.
5. Identify existing reviews or conduct scoping reviews for each domain on available measures, including EWS.
6. Map findings to the framework to understand what is collected and validated, where new measures are needed.
7. Identify criteria for prioritization of indicators.
8. Hold a meeting with Expert group to identify indicators to be tested through HIGH Horizons workstreams including what indicators need to be developed.
9. Develop a report on performance and suitability of the proposed indicators.
10. Hold final meeting with Expert group to select indicators.



WHO/UNICEF/UNFPA/WMO publication on Global and National indicators for monitoring the impact of heat on MNCH.

A draft conceptual framework on the impact of heat on MNCH was presented to the group – See Figure 1.

Figure 1 – Draft conceptual framework of climate change impacts on MNCH.



The conceptual framework aims to depict the direct (pathophysiological mechanisms) or indirect (individual, community and health services) pathways through which heat exposure (hazards) can lead to adverse MNCH outcomes. Underlying health conditions, geographical location, socio-economic and socio-political factors can all additionally multiply the effect of extreme heat on MNCH.

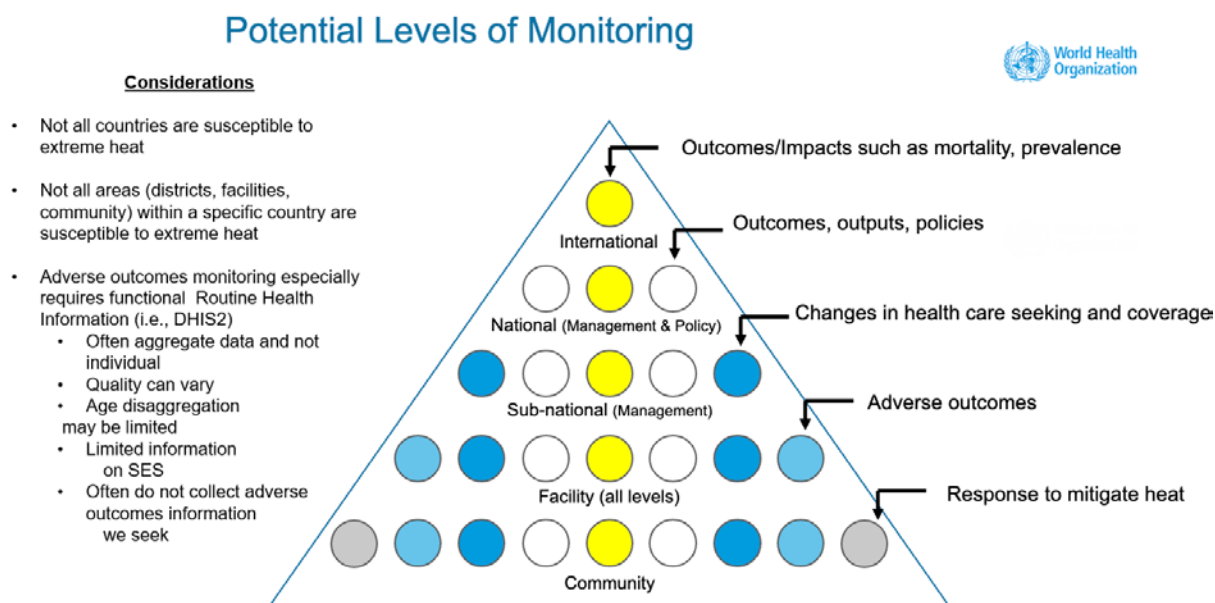
## 5.1.2 Overview of global MNCH indicators

**Theresa Diaz, WHO/MCA**

Theresa Diaz presented an overview of current global MNCH indicators. The presentation touched upon current measurement advisory groups active in MNCH such as MoNITOR, CHAT and the Technical Expert Advisory group on nutrition Monitoring (TEAM). Moreover, she offered a comprehensive list of current monitoring systems to collect indicators and of the potential levels of monitoring (Figure 2). Within this measurement and monitoring landscape there are some key concepts to consider when selecting sets of potential indicators to monitor the impact of heat on MNCH:

- 1) Different areas within a country (district, facilities, communities) are subject to different levels of heat.
- 2) Adverse outcome monitoring requires routine health information, but the data often are aggregate and not individual; quality may vary; age and gender disaggregation may be limited; often the data collected is not sufficient to calculate the intended indicator.
- 3) It is important to weigh the pros and cons of creating new indicators versus leveraging existing; rigorous data quality, testing, and validation is needed when new indicators are proposed.
- 4) Consensus should be reached on sources of data, levels of reporting and methods of triangulation.

**Figure 2 – Potential levels of monitoring of MNCH indicators.**



## 5.1.3 WHO global and national monitoring of progress on climate change and health

### Tara Neville, WHO/CCH

Tara Neville presented an overview of the ongoing work of WHO/CCH on climate change and health, focusing on evidence and monitoring. WHO’s monitoring of health and climate change is comprised of two main initiatives:

- 1) *WHO and United Nations Framework Convention on Climate Change (UNFCCC) Health and Climate Change Country Profiles.* WHO/CCH has transitioned their monitoring activities from global assessments to detailed country profiles which include locally relevant profiles of risk, impacts, opportunities, and progress. The country profiles include country-specific projections and data on heat-related deaths and health risks of heat stress at the national level (Figure 3).
- 2) *WHO Health and Climate Change Global Survey (7)* Another key tool to monitor the health sector’s response to climate change is the 2021 WHO Health and Climate Change Global Survey, a report that provides a valuable snapshot of the overall progress governments have made in addressing the health risks of climate change. The findings on key health and climate change indicators aim to empower policy makers to make informed decisions on the implementation of policies and plans; identify evidence gaps; and better understand the barriers to achieving adaptation and resilience priorities in the health sector, while maximizing the health benefits of sector-wide climate mitigation efforts (Figure 4).

Figure 3 – WHO UNFCCC Health and Climate Change Country Profiles.

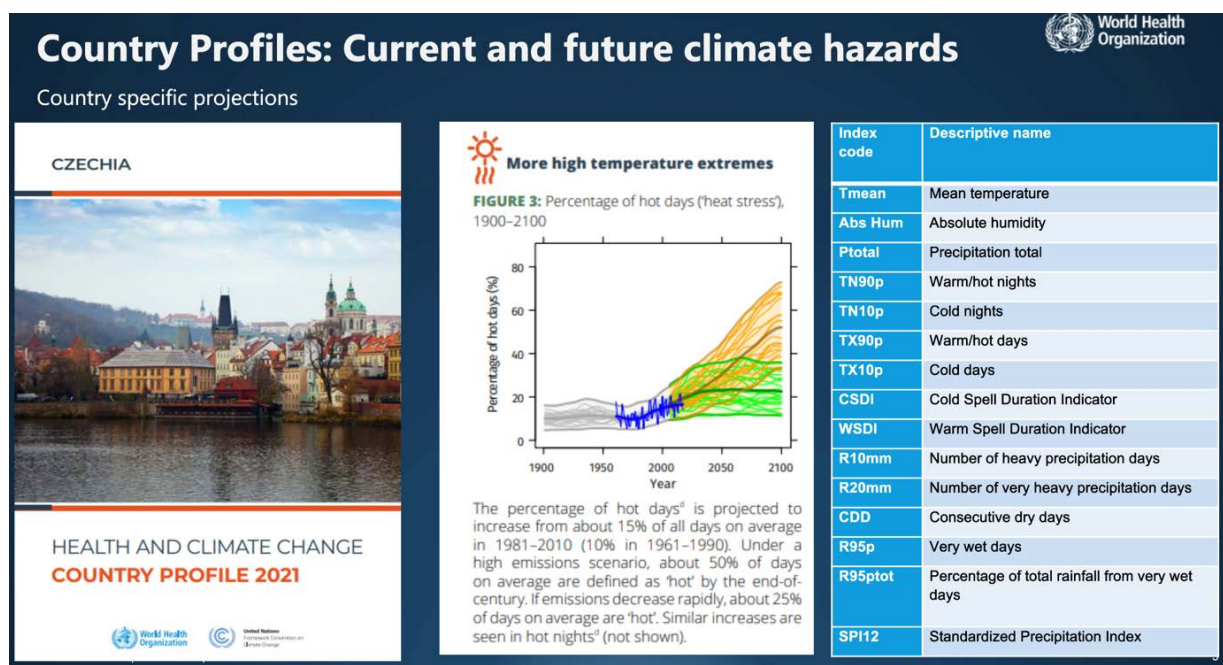
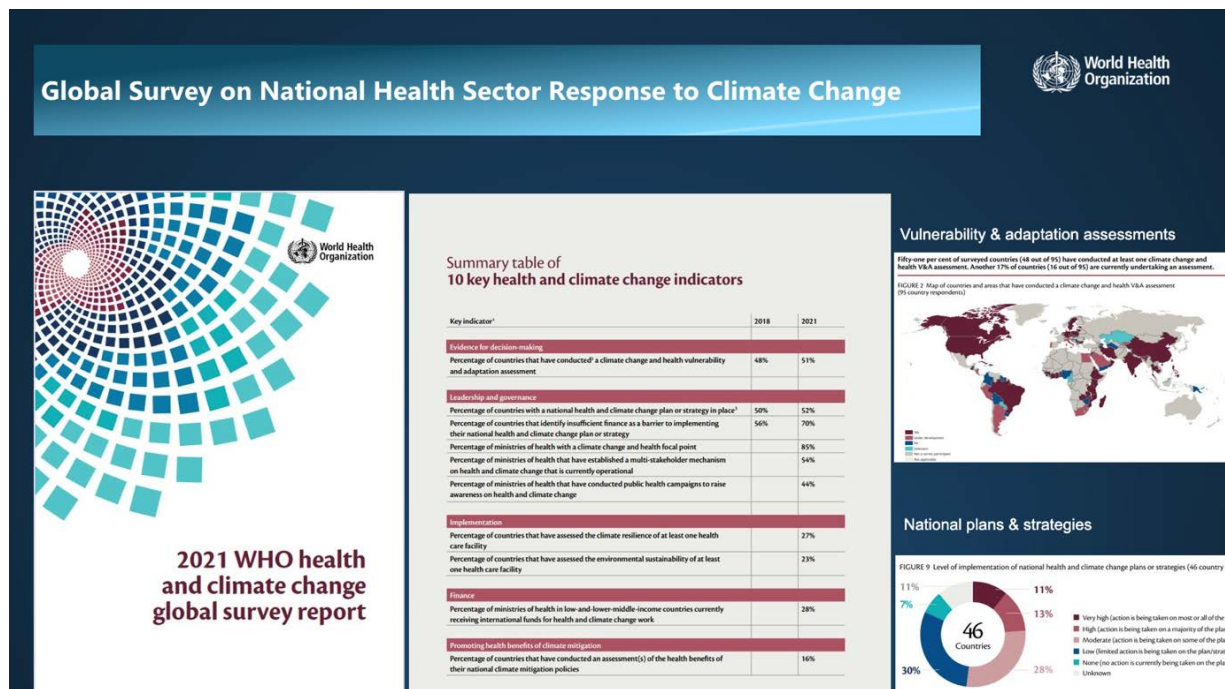


Figure 4 – WHO Health and Climate Change Global Survey.





## 5.1.4 Climate and meteorological indicators for impact monitoring

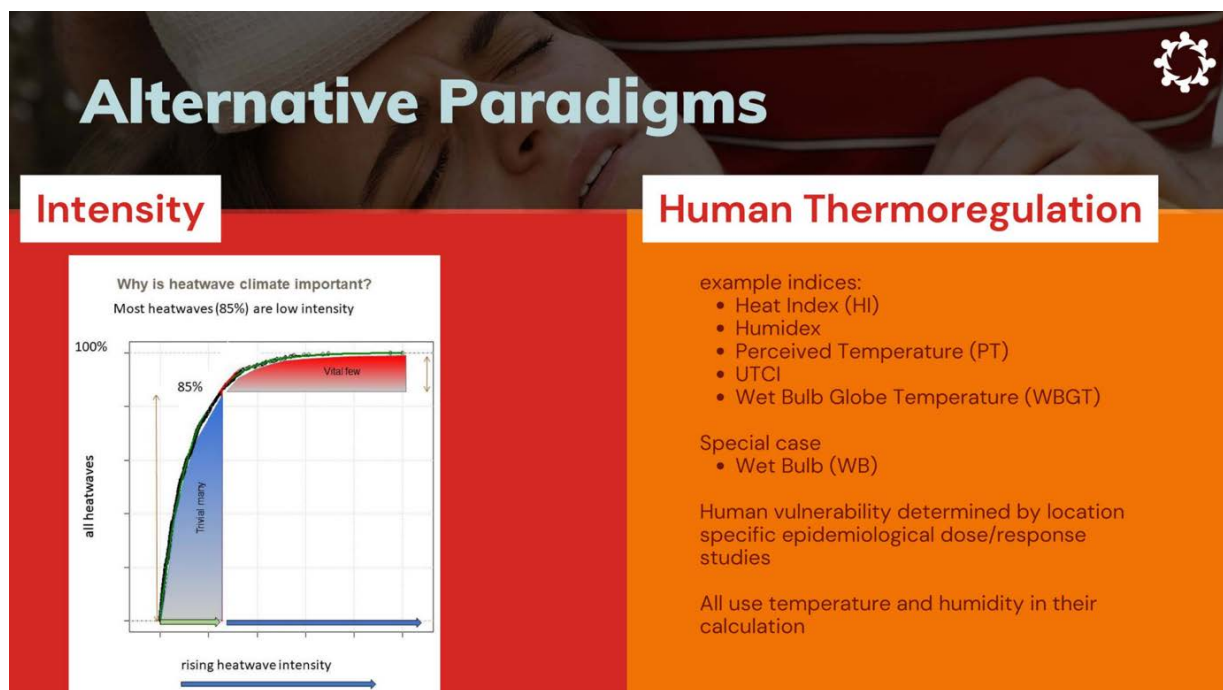
**John Nairn, WMO**

John Nairn started the presentation by focusing on key meteorological terminology that is specific to extreme heat. The terms “heat” and “temperature”<sup>3</sup> are different concepts, with the former representing a transfer of thermal energy and the latter representing a measure of kinetic energy in scales such as Celsius and Fahrenheit. Heatwaves are a local phenomenon, comprised of a sequence of days and nights with unusually high temperatures that cause accumulation of excess heat.

Under this definition, heatwave intensity can be parameterised using dry bulb maximum and minimum temperatures. The parameterisation would be better theoretically with hourly temperatures, but these are rarely available in historical data sets to help establish a climatological norm for each site. Maximum and minimum are commonly available and normally quality controlled over a long period of time. A long climatology of heatwave intensity is a good data source for heat/impact attribution studies, with vulnerability results applied readily to commonly forecast maximum and minimum temperatures.

Human thermoregulation can be investigated through different indices, ranging from the Heat Index (HI) to the Perceived Temperature (PT), Humidex, the Universal Thermal Climate Index (UTCI) and Wet Bulb Globe Temperature WBGT), as illustrated in Figure 5 and summarized in Box 3.

Figure 5 – Heatwave intensity and human thermoregulation measures.



<sup>3</sup> **Heat** is thermal energy transferred from a hotter system to a cooler system. Source: Wikipedia. “Heat”. Wikimedia Foundation. Last modified 8 July 2023. <https://en.wikipedia.org/wiki/Heat>

**Temperature** is the measure of the average kinetic energy of the atoms or molecules in the system, expressing hotness and coldness in terms of any several arbitrary scales like Celsius or Fahrenheit. Source: Glossary of terms for thermal physiology. Second edition. Revised by The Commission for Thermal Physiology of the International Union of Physiological Sciences (IUPS Thermal Commission). Pflugers Arch. 1987;410(4-5):567-87.

### **Box 3 – Human thermoregulation indices (or Thermal Stress Indicators)**

1. **Heat Index (HI)**: is what the temperature feels like to the human body when relative humidity is combined with the air temperature (8).
2. **Humidex**: describes how hot and humid the weather feels to the average person; it combines temperature and humidity into one number to reflect the perceived temperature (9).
3. **Perceived temperature (PT)**: is the air temperature of a reference environment in which the perception of heat and/or cold would be the same as under the actual conditions (10).
4. **Universal Thermal Climate Index (UTCI)**: is a bioclimate index that uses a human heat balance model to represent the heat stress induced by meteorological conditions to the human body (11).
5. **Wet Bulb Globe Temperature (WBGT)**: is a measure of the heat stress which takes into account: temperature, humidity, wind speed, and solar radiation (12).

Additional concepts to consider when discussing extreme heat include “chronic heat” and “humidity”. The presentation then transitioned to issues surrounding meteorological data, which include:

- 1) Issues around position: data observation can be carried out at the synoptic level (continents), at the mesoscale (regions) and at the microscale (individual dwellings) (13).
- 2) Issues around data sources: meteorological data can derive from site observations or from model reanalysis (global, regional, surface reanalysis).
- 3) Data is never free, and collaboration is key to obtaining quality data.

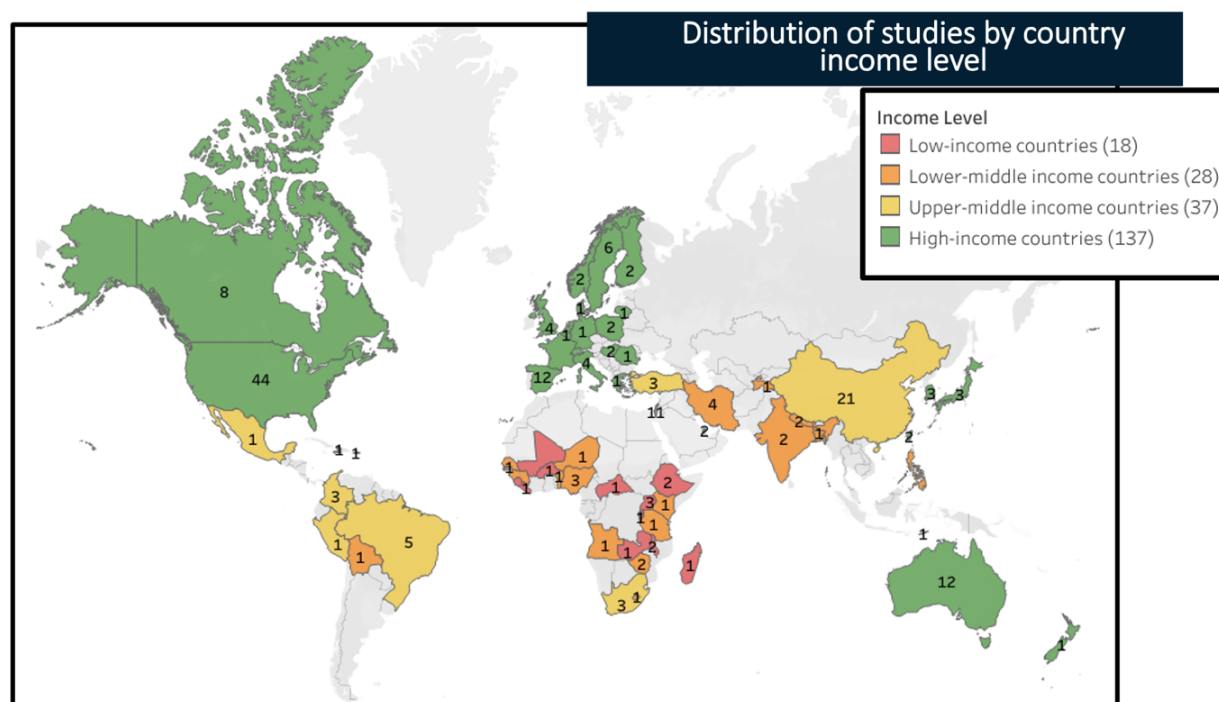


## 5.1.5 Recent systematic reviews and published studies on the impact of high temperatures on MNCH

**Matthew Chersich, University of Witwatersrand**

Matthew Chersich presented the results of an unpublished update of a systematic review of 177 studies (first review published in 2020 (14)) which confirms that exposure to high temperatures in pregnancy is associated with increased risk of preterm birth, low birth weight, and stillbirth. The geographical scope of the studies is limited, with most of the evidence from high-income or upper middle-income countries (see Figure 6). Further, the heterogeneity of the methods used to measure exposures is noted, creating difficulties with comparability of the results across studies. The findings from a published systematic review on high ambient temperatures and infant outcomes, comprised of 21 studies, found evidence of an association between elevated temperatures and infant mortality, as well as weaker evidence of an association with increased risk of emergency department visits and of sudden infant death syndrome (SIDS) (15). The presentation concluded by stating that the evidence base currently supports the validity of arguments, but that studies on causality and targets for interventions are still needed.

**Figure 6 – Geographic distribution of studies included in the systematic review on MNH outcomes and heat exposure.**

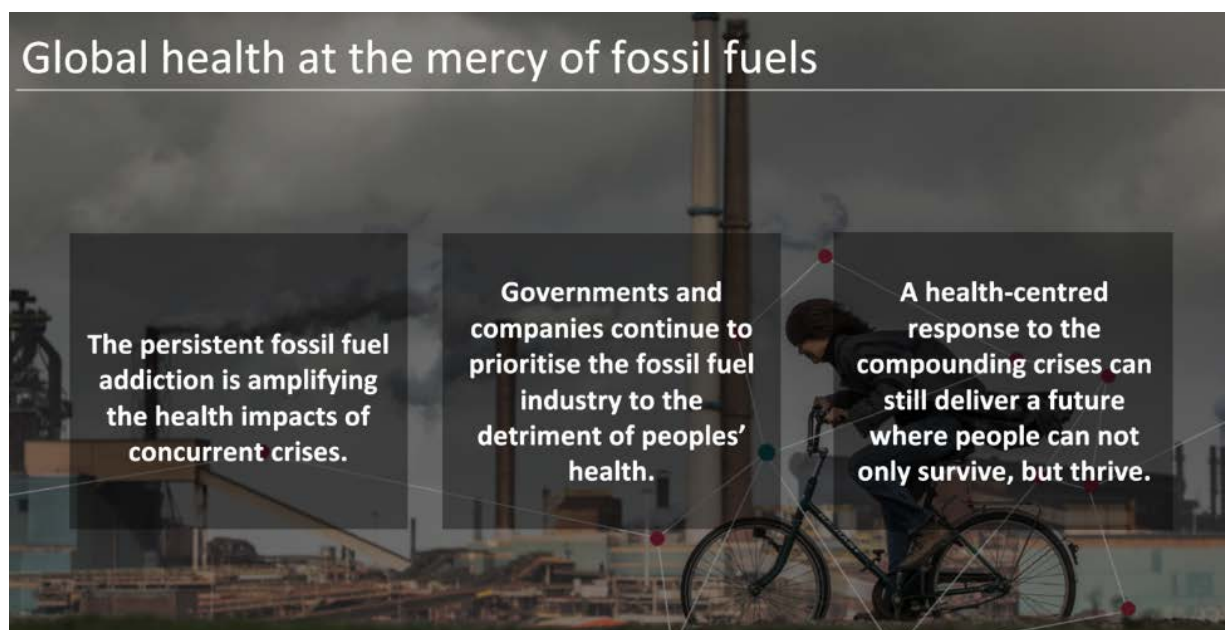


## 5.1.6 Lancet Countdown on health and climate change

### **Anthony Costello, *The Lancet Countdown***

Anthony Costello provided an overview of the Lancet Countdown’s work on health and climate change. The presentation touched upon the Countdown’s estimations of heat-related mortality globally, of the costs of global heat-related mortality (estimated to be US\$144 billion in 2021), as well as the loss of earnings from heat-related reduced labour capacity (16). Crucial linkages between rising temperatures and nutrition were also outlined as well as the incompatibility of the current fossil fuel company strategies with the Paris Agreement (see Figure 7).

*Figure 7 – A call to action from the Lancet Countdown to reduce the global “fossil fuel addiction”.*

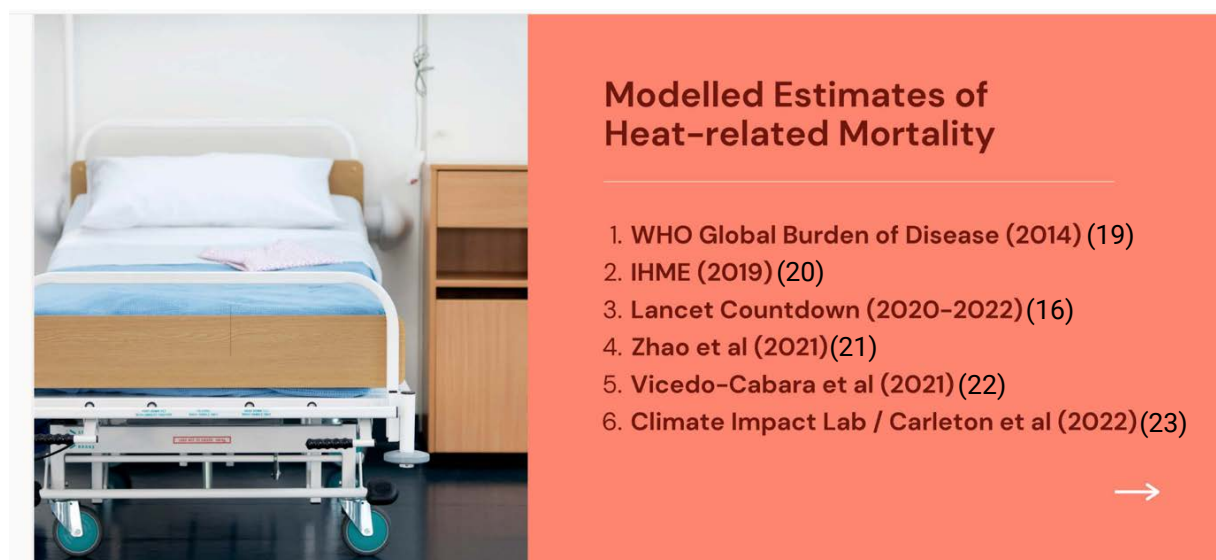


## 5.1.7 Overview of existing heat health indicators

### **Joy Shumake-Guillemot, WHO/ WMO Joint Office in Geneva**

Joy Shumake-Guillemot presented the current approaches for measuring the impacts of heat exposure on health, including the various sources for modelled estimates of heat-related mortality (see Figure 8) and an overview of current monitoring systems of heat-related mortality and morbidity with examples from various European countries, India, and the United States of America. The [Global Heat Health Information Network \(GHHIN\)](#) (17) is in the process of developing heat and health metrics for the general population, to inform both in season and long-term interventions, accounting for age, location and socio-economic modifiers, heat amplification from comorbidities, lag-times and aiming for standard measurements to ensure harmonization and comparability across different contexts. Therefore, the MNCH indicators selection experience is key to GHHIN to leverage lessons learned using well-established principles for indicator selection and monitoring from the MNCH world and re-applying the learnings to the monitoring of the health of the broader population. Further, GHHIN is in the process of developing a Heat Health Action Research Framework, which could in turn be useful for the indicator selection. The current WHO guidance on heat-health action planning (18) is being updated and a new version will be published soon. Lastly, new International Classification of Disease-11 (ICD-11) codes have been developed to include the health effects of heat, with some specific to MNCH (including “environmental hyperthermia of the newborn”); this represents an important advancement in tracking heat health illness, nonetheless appropriate training among health workers will be key in ensuring heat-related illness is appropriately recognized, treated, and classified.

**Figure 8 – Overview of principal sources of modelled estimates of heat-related mortality.**

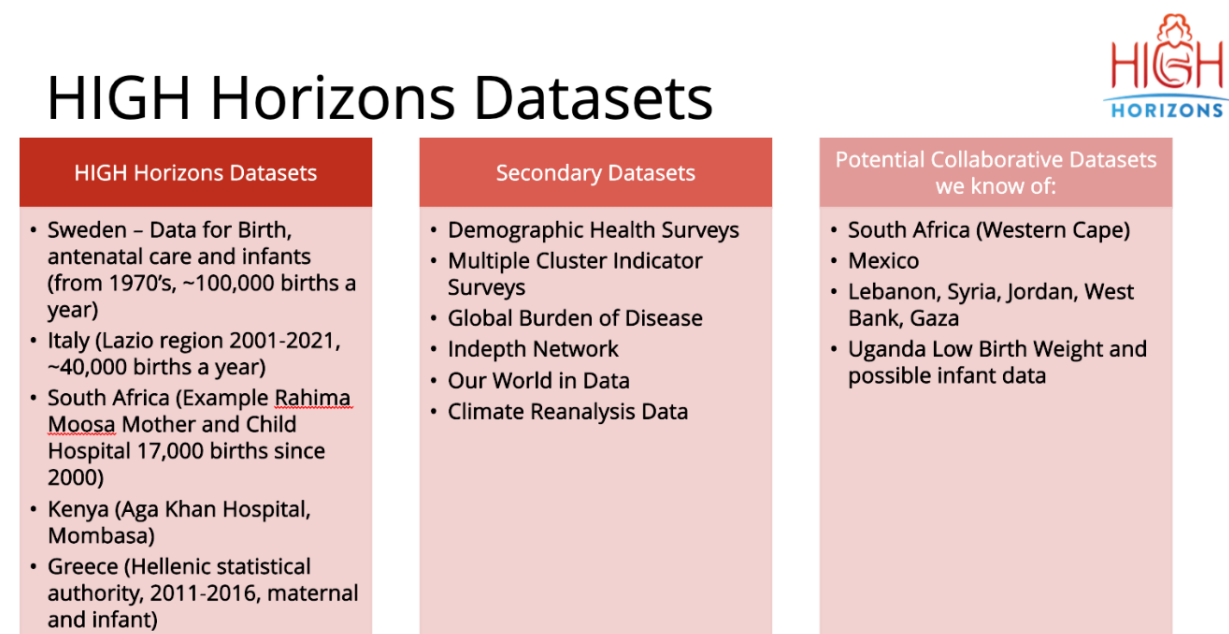


## 5.1.8 Overview of planned analyses on extreme heat and MNCH

### Chloe Brimicombe, University of Graz

Chloe Brimicombe gave an overview of analyses on extreme heat and MNCH which are planned within the context of the HIGH Horizons research project. HIGH Horizons currently has access to 5 datasets (from Greece, Italy, Kenya, Sweden, South Africa, ) that include data on maternal and newborn health, with the potential for collaboration on further longitudinal databases as well as secondary data sources such as the Demographic and Health Survey (DHS) (see Figure 9). In addition, secondary analyses are planned of available surveys. The type of environmental heat data that will be used for the analysis was then presented ranging from HI to WBGT to UTCI, as well as environmental air pollution data, as this aspect will also be looked at. Analysis will be carried out with methods ranging from regression modelling to time-series and machine learning methods.

Figure 9 – Overview of HIGH Horizons datasets and additional sources of analysis.



## 6 Day 1 and 2 - Summary of discussions related to indicators

The discussions focussed on the following items:

- 1) A **conceptual framework** that demonstrates how climate change, and particularly extreme heat, directly and indirectly affects MNCH.
- 2) Defining the parameters for selecting the **indicators** to monitor the impact of extreme heat on MNCH.
- 3) Identifying the parameters for selecting **measures of thermal stress** for MNCH to be used in systems for early notification and early warning related to extreme heat.

### 6.1 Conceptual framework

A draft visual on the pathways through which climate change may impact on MNCH was presented (see figure 1 above). Unlike a logical framework or theory of change, this framework does not show interventions, but only lists causal and potential mechanistic pathways through which exposure to extreme heat which may hinder the health and well-being of pregnant, postpartum, and lactating women, newborns and children. The group suggested referring to the visual as **a conceptual framework**, rather than a theory of change. However, it was recognized that the core framework could also form the basis for a theory of change with interventions or mitigation strategies.

On the second day the participants split up in five groups, based on their areas of expertise (maternal health, newborn health, child health, monitoring and evaluation, climate science) to revise and discuss the conceptual framework and make suggestions on the terminology used and on any missing pathways or expected outcomes. Each group came up with amendments and improvements to the draft visual (see Annex 5) which will result in a revised conceptual framework. Among the various suggestions, the following two overarching recommendations emerged:

- To reflect on how heat exposure may lead to differential outcomes for MNCH based on the window of exposure, particularly when assessing pregnant women: in fact, extreme heat may lead to different outcomes if experienced in the first trimester compared to the third trimester (24);
- To reflect on how different age groups may experience heat differently, particularly when considering the different stages of early childhood development and the complexity of differential factors at play (i.e., limited ability to communicate the perception of heat and discomforts from heat or heat-related dehydration, dependency on others for cooling and shade, etc.).

## 6.2 Indicators

The discussion of the group focussed on potential indicators to capture the impact of extreme heat on MNCH, parameters for the indicator selection, level of analysis and monitoring, and key populations. During the discussion ongoing efforts of data collection and analyses were identified and listed.

### ***Which indicators are best measures of heat health?***

The participants noted that countries generally do not want to add additional indicators to the ones that are already routinely collected. Suggestions to add indicators can be made to countries, but they will not necessarily comply. It was agreed by the group that the concept of leveraging existing indicators that are routinely collected should be a guiding principle throughout the heat indicator selection process, a crucial decision to facilitate data harmonization and avoid overburdening countries. However, indicators for research and studies to understand the biology and relationships of heat with health outcomes can be considered.

Choosing indicators to monitor the impact of extreme heat on MNCH is challenging and a number of challenges were unpacked throughout the discussion.

The first challenge is understanding the true burden of heat-related negative health. Although there is a wealth of health data across the globe which could be extrapolated and linked up to meteorological data, it remains hard to attribute heat exposure to health outcomes. The thermal responses deriving from exposure to heat in human physiology studies have been investigated, but only in healthy male populations. Therefore, for the general population and particularly for vulnerable groups, understanding the physiological responses from extreme heat exposure and thus measuring the attribution of that exposure to a health outcome can only be very approximate. It would be ideal to find a way of aligning the meteorological data and the routine health system data to avoid burdening the health workers with additional reporting

The second challenge is selecting indicators that not only provide a snapshot of the health effects of exposure to heat but can trigger preventive actions. Capturing mortality from extreme heat is important, but ideally indicators should act as “sentinel” measures, triggering action to prevent adverse outcomes, including mortality. Examples of individual “sentinel” measures could include increased hospitalization due to dehydration; nonetheless, it might be challenging to capture these at national, sub-national or even global level.

Therefore, the group recommended that two to three indicators be selected that are already routinely collected and that are also able to provide an early signal to trigger actions, and to then test and validate these measures. Indicators such as preterm births only capture adverse outcomes and not necessarily warn anyone, unless knowledge that heat may result in increased risk of preterm birth will trigger any specific recommendations to women, families, communities, health workers and health facilities. Alternative indicators which were suggested for consideration include: hospital admissions disaggregated by age and sex, if pregnant, and identifying dehydration. Other suggestions include using data of ‘older persons being hospitalized’ or ‘disruption of referral’ as a proxy signal for levels of extreme heat, or to measure fragility as is done in conflict settings and emergencies. There was also mention of the need to reflect on the potential use of geospatial indicators to capture the impacts of heat within communities, prior to any admission into a health facility.



A third challenge is heat measurement. There are currently multiple ways to measure heat, and these vary from simply measuring air temperature to expressing heat stress. Consensus on the best way to measure heat exposure still has not been achieved within the biometeorological and thermophysiological communities (25) and among climate epidemiologists, and this is reflected in the heterogeneity of measures used across the different studies that investigate the impacts of heat exposure on MNCH. Therefore, the group recommended that a better definition of what is meant by heat measurement be sought. Further, since there are issues and concerns around how health workers recognize and classify manifestations of heat-related illnesses, the suggestion from the group was to avoid a sole focus on facility-based measures as these might not be telling the entire story. Lastly, it is noted that the magnitude of heat exposure varies between countries, but also within countries and this should also be accounted for when reflecting on the selection of indicators.

There are several groups (i.e., Lancet Countdown Europe, and the Center for Disease Control and Prevention) and countries which have already identified certain indicators pertaining to heat and health and use them for surveillance purposes – these should be compiled and reviewed to determine which could be most relevant for MNCH.

### ***Which parameters and criteria should guide the selection of heat-related exposure data and health outcome data?***

As shown above there are several steps in the process to select indicators. Once indicators have been mapped to the conceptual framework and to the priority global and national indicators, a consensus process will be undertaken to select priority indicators which can be integrated within routine information and early warning systems. Prior to that future step, the concept of criteria for selection was discussed with the group.

All participants were asked to review the criteria from previous technical consultations for indicator selection, either led by WHO or externally. The criteria presented to the group as well as information on the ranking process can be found in Annex 6.

Meeting participants were asked to review the suite of proposed criteria and to rank the criteria deemed most relevant to guide the scoring of potential indicators in sequential steps of the process. The ranking processes was individual and feedback from participants was collected.

In summary, the following criteria were ranked with the highest number of votes from the participants:

1. **Feasible:** it should be feasible to collect the data required for the indicator in the relevant setting, notably through existing tally sheets or feasible additions to tally sheets (e.g. item already in register).

The group suggested using existing MNCH indicators that are very well defined, have been routinely collected in countries for many years and therefore are relatively easily available. Although there are still weaknesses in the routine data collection systems, introducing new measures in health management information systems can be difficult. Therefore a simple set of existing MNCH indicators is the best possible choice. It is nevertheless essential to assess how much we can leverage to link these MNCH indicators to heat indicators.

2. **Relevant:** The indicator measures a specific construct in a priority area of interest and there is a clear, demonstrated relationship between the indicator and MNCH.

Some of the health outcome data, such as prematurity and birth weight, have been mentioned in the presentations and seem to be relevant although much of them such as stillbirths and maternal and infant morbidity are aggregated and mostly available at the national level. Countries certainly do not want to add more indicators, but the group questioned the need to investigate additional indicators which are not yet collected routinely but could be relevant to link heat exposure to MNCH.

**3. Important:** The indicator and data generated will make an important contribution to determining how to best respond to and prevent heat-related MNCH problems effectively.

All meeting participants agreed on the need to select indicators that can trigger national or sub-national responses and adaptive actions, as this is crucial to monitor progress once interventions are in place. Next steps with the expert group were identified.

### ***At what level of the health system should data be collected, and indicators monitored?***

Discussions ensued regarding if indicators should be defined for global monitoring or for national and district level monitoring. See Figure 2 above. At a national-level, indicators could assess outcomes (e.g. mortality) or focus on outputs (e.g. existing actions and policies around heat)? At a district-level, indicators would be designed to inform a district manager of the needs and feasibility of taking action related to care-seeking behaviours and health service coverage. At the health facility level, issues related to quality of care and management of adverse events would be highlighted. At the community level, indicators would serve to assess the local government's responses to prevent and mitigate heat.

The group suggested that the selected indicators could be grouped at different levels: some at global and country level, while others at health facility and community level, but there is consensus that the unit of analysis should be the subnational level, which (administratively) corresponds to district, county or state level depending on the country. Reference is made to the District Health Information System (DHIS), which disaggregates at any level, while its unit of measurement is the district. DHIS can be utilized in a very granular manner and is in most places available in the public space for research, analysis, and implementation purposes. Moreover, DHIS2 provides data on hospitalization with breakdown by cause and age, so the hospital admission rates previously mentioned as one of the priority indicators can be extracted from the DHIS2 for many countries (including direct admissions due to heat and excess admissions for other known conditions). DHIS2 is currently exploring how to bring climate data in a systematic way into the platform and is discussing how to scale-up to the district or national level.

The meteorological indicators should be collected at subseasonal level, i.e. weekly intervals up to 5 weeks out. The question was asked if anyone has done the data scan to determine what data exists at subnational scale and if there is at least a quarterly reporting.

### ***Which populations should the indicator monitoring focus on?***

The indicators for the Global Strategy on Women's, Children's and Adolescents' Health (26) covers mainly women of reproductive age, children under 5 years of age, school-age children and adolescents. Within these populations, the group suggested prioritising pregnant and lactating women, infants and young children under the age of 5.

Some advocated to include school children and adolescents too, because the exposure effects of heat should be assessed across the entire continuum. The group acknowledged that heat exposure affects everyone, nonetheless within this process there is a clear intention



to prioritize MNCH with the future aim of possibly building upon this experience to select indicators for other vulnerable groups including older people. Indicators for school age children and adolescents (such as absences or heat-related events) could also be captured across other sectoral information data bases.

### ***Identification of additional analyses required and linking to other ongoing efforts***

Discussion ensued to identify other available evidence that had not been identified.

In summary, the group considered the analysis currently being planned under HIGH Horizons and suggested the following:

- a) Additional databases need to be identified to expand the geographic scope and to ensure child health data is better captured.
- b) Different countries and global or regional groups i.e., the Lancet Countdown: Health and Climate Change in Europe have already identified indicators to monitor the impact of heat, although not for MNCH. These should be gathered and reviewed to determine which if any would be pertinent or could be adapted for monitoring the impact on MNCH.
- c) Ongoing cohort studies and research should be identified that could be opportunities to capture additional data on MNCH and heat. WHO should work with partners to convene researchers and discuss the need for harmonized data and the way forward. For organizing future research, WHO can collaborate with partners in a global research prioritization exercise as per past exercises conducted or MNCH to ensure optimal investment in future research.

Many ongoing (cohort) studies were mentioned, as well as potentially useful databases with child health information. An example is the Healthy Life Trajectories initiatives (HeLTI) project (27). HeLTI was developed to address the increasing burden of non-communicable diseases, including obesity, diabetes, cardiovascular disease and poor mental health around the world. There are four separate, but harmonized projects in South Africa, China, India and Canada. Harmonized studies are implemented in the four countries to test if an integrated continuum of care intervention starting pre-conception and continued across the pregnancy, infancy and childhood phases will reduce childhood adiposity, impact maternal health and ultimately improve child development. In each of these countries, longitudinal multi-sectoral lifestyle interventions are initiated during the preconception phase and then tailored to respond to the specific needs of the family during pregnancy, infancy and early childhood.

Another example of a study network is the INDEPTH network (28), which conducts longitudinal research based on Health and Demographic Surveillance Systems (HDSS) field sites in Africa, Asia and Oceania, and produces reliable longitudinal data from low- and middle-income countries. The HDSSs increasingly link population and health facility data to implement the new Comprehensive Health and Epidemiological Surveillance System (CHESS). The Network has gathered a multitude of robust data, on health, population dynamics and development, as well as evidence on the impact of interventions. The group also recognized longitudinal cohorts that were planned under ongoing projects (such as the recent heat adaptation grants by the Wellcome Trust) and the cash transfers and nutrition cohorts (BNP) in Pakistan supported by the Bill & Melinda Gates Foundation.

Further, the Chair acknowledged the possibility of linking the work conducted to select the indicator to existing and ongoing efforts, such as the Lancet Series on “Small and Vulnerable Newborns” (29).

# 7 Day 2 - Summary of presentations on EWSs and measures of thermal stress tailored for MNCH

## 7.1.1 EWSs for extreme heat and MNCH

**Chuansi Gao, Lund University**

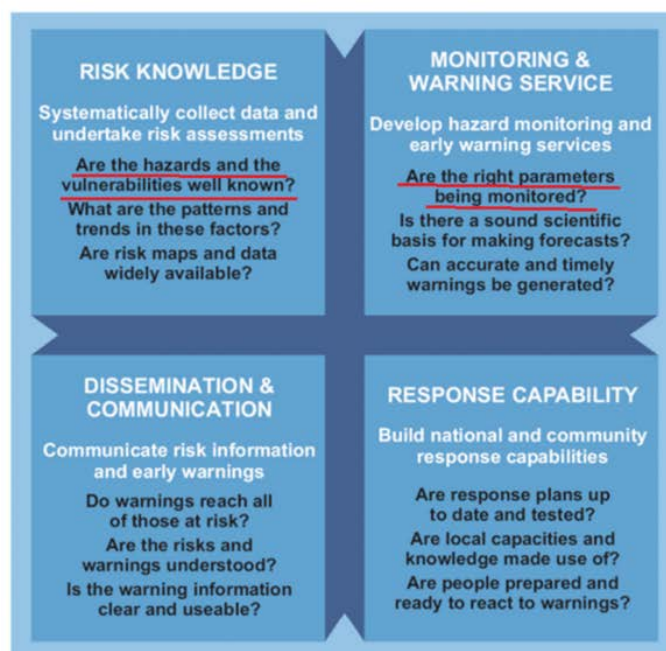
Chuansi Gao gave a presentation on Early Warning Systems. Broadly defined, an EWS is an adaptive measure for climate change, using integrated communication systems to help communities prepare for hazardous climate-related events. A heat-health EWS is designed to alert decision-makers and the general public to impending dangerous hot weather and to serve as an advisory or warning on avoiding negative health outcomes associated with hot-weather extremes. People-centred EWS are based on 4 pillars: risk knowledge, monitoring and warning service, dissemination and communication and response capability (see Figure 10). An overview of existing heat-health warning systems was then provided, based on the 2019 systematic review by Casanueva (30), that includes information on 16 European EWS and heat-health action plans. The presentation also touched upon examples of integrated heat stress indices used in EWS and on integrated heat stress indices and thresholds.

Figure 10 – Four elements of people-centred EWSs.

### Four Elements of People-Centred Early Warning Systems

Source: UN/ISDR Platform for the Promotion of Early Warning

<https://www.unisdr.org/2006/ppew/>




## 7.1.2 Weather phenomenon warning system-etymology

**John Nairn, WMO**

John Nairn provided a brief presentation on the etymology of weather phenomenon warning, as shown in Figure 11. The left column in the image refers to what the weather is doing. The centre columns describe what the health community requires of weather data compared with what they get from a climate/weather service; lastly the right column shows what the climate and weather services are doing. Noting that climate services data assists the health community in understanding vulnerability, which can build the desire to use vulnerability in forecast services. And that the weather/warning services are usually disconnected from climate services, which can pose a data compatibility challenge when the health community wishes to create impact-based (forecast and warning) services.

Figure 11 – Weather phenomenon warning-system etymology.



weather impact terminology	what users want	what users usually get	weather service (NMHS) terminology, BAU
has done (past)	lessons learnt	historical parameter data	climate
is doing (now)	situation awareness, <b>impact</b> diagnostics	weather data	weather/climate analysis/diagnostics
will do (heads up)	when to act (now!)	one or two days lead in	warning
is likely to do (fcst)	to see it coming	multi-day lead in	forecast
might do (scenarios)	to take early actions	multi-week/month scenarios	early warning (new)

**Annotations:**

- vulnerability** (dark red box) spans across 'what users want' and 'what users usually get' in the 'has done (past)' row.
- early detection** (dark red box) spans across 'what users want' and 'what users usually get' in the 'will do (heads up)' row.
- impact services** (dark red box) spans across 'what users want' and 'what users usually get' in the 'is likely to do (fcst)' row.
- Early Warning** (vertical dark red box) spans across 'warning', 'forecast', and 'early warning (new)' in the rightmost column.
- IBFWS (Impact)** (vertical dark red box) spans across 'warning' and 'forecast' in the rightmost column.
- A red arrow points from 'vulnerability' down to 'early detection'.
- A red arrow points from 'early detection' down to 'impact services'.
- A red arrow points from 'IBFWS (Impact)' up to 'warning'.
- A dark red vertical bar on the left side of the table has a white downward arrow.

## 8 Day 2 - Summary of discussions on EWSs and thresholds tailored for MNCH

### 8.1 Heat-health EWS and thresholds

The EWS [in HIGH Horizons] aimed for a people-centred, individualized system. The colleagues from WMO indicated it was preferred that these types of applications should be referred to as an 'early notification system'. A heat-health EWS is defined by the WHO/WMO/United Nations Environmental Programme (31) as: "to alert decision-makers and the general public to impending dangerous hot weather and to serve as a source of advice on avoiding negative health outcomes associated with hot-weather extremes".

Early warning represents a component of the broader Early Warning, Alert and Response (EWAR). EWAR is a system that provides an early warning of acute public health events and then connects this function to an immediate public health response. It is one of the most immediate and important functions of a surveillance system (32). National Meteorological and Hydrological Services (NMHS) are conscious of their authority to warn as well as of the need for full collaboration with other common authorities and mechanisms to ensure a common message to the community.

EWAR is legally-defined concept: national jurisdictions have a legal obligation to warn, and national bodies conduct this work across subnational states and in agreement or alignment with governments. Given the abundance of individualized systems now appearing, this calls for an approach on how to coordinate with health and meteorological authorities, when aiming for individualized systems, whose operationalization may be very hard in LMICs or at a sub-national level.

Nonetheless, it was recognized that health is not on the table once these forecasts are out. EWS which highlight risks for specific populations, including pregnant women and children, will require greater discussion with health and meteorological authorities to ensure coordination. Wearables and apps, such as Fitbit® - a wearable activity tracker, provide personal monitoring of temperature experience, notify and raise awareness about an individual's heat limits, but there is no legal mandate in place to ensure resultant warning thresholds are properly defined.

The group discussed sources of information and parameters for the EWS threshold selection. Additional analyses required for the EWS threshold selection and other efforts were identified.

#### ***What is the gold standard to measure heat stress?***

The climate change and thermal physiology community have developed several heat stress indices, which may not be fit for all populations, because they are usually developed for healthy young adults, (and largely tested with males, particularly military and athletes, and healthy young students). Despite its weaknesses, the best performing indicator for heat stress within occupational settings is the indoor and outdoor WBGT followed closely by the UTCI, according to a study funded by the European Commission and the International Labour Organization (ILO) that tested all available thermal stress indicators in occupational settings (33). None were found to be optimal, but those including all four environmental parameters (temperature, humidity, wind speed, and solar radiation) performed best (33). Field experiments supporting this statements were conducted across nine countries and observations in 372 experienced and acclimatized workers (33). Therefore, there seems

to be a certain degree of consensus that the gold standard for heat stress should include temperature, humidity, radiation, and preferably wind speed.

The metabolic rate (body internal heat production) is also one of the drivers of physiological heat strain and not the environment. Regrettably, it is not easy to accurately measure the metabolic rate in studies conducted in the field. Different studies look into different body responses and some ongoing studies look into heat perception indices, others into physiological responses. Devices such as skin temperature sensors have been used to measure thermal exposure in workers, and heart rate and body core temperature are suggested as indicators of thermal physiological responses.

Additional work needs to be done to harmonize what is used in countries and in research to measure heat stress. WHO and WMO should further discuss how to move forward.

### ***Which parameters can help to select individual and general thresholds which provide information on the level of risk in indoor environments?***

The suggestion to focus on **indoor air temperature**, e.g. in maternity wards, labour and waiting rooms led to a discussion on feasibility of measuring and controlling indoor temperature:

- Measuring indoor temperature is feasible: if air-conditioning is not affordable the natural environment can be used to warm up or cool down health facilities, where the temperature inside is usually 4-5°C higher than outside;
- WHO has guidance on building climate-resilient health facilities (34), including a checklist on heat which is mainly informed by carbon footprint reduction, but does not necessarily suggest what is best for people within the health facility;
- Unfortunately not all health facilities meet the requirements of built environment and temperature measures that are required to comply with potential standards, but it would be a great opportunity to have a by-product of this scoping exercise, the development of standards within facilities (e.g. structural changes, building materials) and recommendations for health facility's low-cost adaptation solutions.

### ***What are the challenges for selecting thresholds that are specific to MNCH and what is the possible way forward?***

A general challenge in selecting thresholds for heat-health warning systems is related to the fact that focusing on heat-related mortality or morbidity during high heat stress periods translates to using the thresholds of heat-related health outcomes. The focus should not be solely on the health outcomes but rather the effort should be identifying the temperature levels that cause the body to start experiencing heat strain, in order to issue a warning that supposedly avoids an adverse outcome. In fact, depending on the individual's vulnerability, some negative health impacts may be experienced long before any warning is issued. In practice, the thresholds of the heat-related increases in mortality or morbidity may not be appropriate thresholds for issuing a heat warning that prevents the health outcomes altogether. This is particularly evident when reflecting on the development of a heat-health warning system that is specific to MNCH.

The group agreed that the selection of health-meaningful thresholds should take into account not just air temperature, but also other parameters, such as humidity, radiation, windspeed (for outdoor, non-sheltered environments) to capture the levels of thermal stress induced from the environment onto the human body. Thermal stress can undermine the human body's ability to maintain its core temperature within the range of optimal physiological performance leading to heat strain and is an ideal snapshot of the responses of the body to heat exposure (35).

In fact, selecting thresholds from epidemiological studies may not be ideal, as most use measures such as air temperature, and this does not represent an integrated heat index that is able to capture heat stress and provide valid information on the potential levels of heat strain. There are large data gaps for humidity measures globally; it's very difficult to obtain valid and reliable humidity metrics at subdistrict or district-level scales.

There currently are existing thresholds that identify levels of heat stress, issued by the International Standards Organization and used in occupational settings (36). Levels of WBGT from 27.8 °C to 29.4 °C correspond to low levels of heat stress, from 29.5 °C to 31.0 °C to moderate levels of heat stress and from 31.1 °C to 32 °C to high levels of heat stress (36). Nonetheless, these thresholds are inadequate for vulnerable populations as they derive from studies of thermophysiological responses conducted mainly in healthy groups (such as athletes and military service members).

Although there is some evidence to show that temperature control in pregnancy is conserved (37), there remain concerns regarding prolonged exposure to extreme heat (38); at the same time, information on thermoregulation in newborns and children is scarce (39).

Heat stress exposure is measured through thermal stress indicators (TSIs), indices that use information from the environment to assess the magnitude of physiological heat strain. There are currently many TSIs available, mostly used for applications in occupational settings (25). Previous efforts have identified higher performing TSIs for individuals that work in the heat (40), nonetheless there is no information on which would be best suited to express heat strain within vulnerable populations, such as pregnant and postpartum women, newborns and children (41).

The current literature addressing temperature control in pregnant and postpartum women, newborns and children does not provide a robust understanding of their thermophysiological responses to extreme heat (38,39); therefore questions remain unanswered regarding the appropriateness of current TSIs to capture heat stress in these groups (41). To the best of the knowledge of the group that participated to the scoping meeting, at the current time no modifications have been specifically developed to the existing TSIs to account for the peculiar characteristics of temperature control among vulnerable populations.

Identifying thresholds that are meaningful for MNCH and that adequately express the heat stress experienced by these groups would ideally require additional primary thermophysiological studies to achieve a greater understanding of heat stress responses. There are various constraints to this (time constraints, ethical constraints). Therefore, thresholds defined by currently available TSIs will need to be selected, although there is uncertainty with regards to what TSI to use.

To ensure use of a TSI that correlates well with the physiological heat strain experienced by pregnant and postpartum women, newborns and children, a step-wise approach could be employed, to investigate what parameters of the currently existing TSIs should be prioritized when trying to capture the responses to heat strain with regards to MNCH. In fact, different TSIs correlate with a number of different physiological responses, from core body temperature to heart rate to hydration state, for example, the question remains open to which of these body responses better express heat strain in vulnerable groups, including MNCH.

WHO can adapt existing methodologies, as previously done for TSIs to be used in occupational settings (40), to identify the criteria to consider when adopting a TSI to protect MNCH from extreme heat exposure.



## 9 Conclusions

### *Filling the knowledge gaps*

The group concluded that it is crucial to focus on climate change and that the momentum needs to be taken to fill the knowledge gaps. While acknowledging the importance of the existing systematic reviews and meta-analysis, it was agreed that these are not providing information that is granular enough to shed light on the biological mechanisms by which heat impacts on MNCH, as well as on the relationship between heat – and other climate change elements- and other behavioural outcomes (for example care-seeking, infant feeding). Rather than conducting additional systematic reviews, more primary research is needed to fill the knowledge gaps on indicators and EWS thresholds. A research prioritization process to define priorities and achieve common methods and measurements would be important. Collaborations between climate scientists, thermal physiologists and MNCH experts and joint publications should be the way forward. In addition, secondary analysis of data planned are useful but the current geographic scope is limited and should be expanded. WHO could play a role in bringing together researchers to harmonize methods, analysis plans including uniform measurement of heat and health outcomes as feasible.

### *Data issues*

The two days of presentations and discussions have convinced the meeting participants that the health and meteorological ‘sectors’ – and their data – need to be brought together at the country level. Countries will not disclose all their public health data publicly, but working with health management information systems in countries may help to get the relevant disaggregated data available for decision-making. WMO is already testing the interoperability of DHIS2 data and currently works in the countries with health management information systems to analyse the data. More data analysis and testing of the data validity is required and reaching out to other partners, such as the Lancet Countdown on health and climate change, the Global Financing Facility (GFF) and DHIS2 may be opportune.

### *Involvement of a variety of stakeholders*

Within the organizations of the meeting participants there are people involved in (soon to be) funded research projects which will be looking longitudinally at MNCH outcomes in relation to heat exposure (but other exposures such as water and air pollution can and should be investigated). It was suggested that these groups should be contacted for collaboration to see what could be of contribution to WHO, UNICEF, and UNFPA and WMO. Other groups of researchers can also be brought on board. Potential stakeholders to involve are: professional associations, trade unions, city planners, municipalities and local government decision-makers and parliamentarians, architects, renewable energy, parent groups, user groups, community groups, child health and education associations, and international agencies such as the United Nations Educational, Scientific and Cultural Organization (for schools), ILO (to cover the working environment), the Food and Agriculture Organization of the United Nations, the International Fund for Agricultural Development and the World Food Programme (for nutrition and food systems) and lastly the water, hygiene and sanitation community. The group agreed that a variety of stakeholders should be involved to provide balance between research, advocacy and action.

## 10 Next steps

Throughout the course of the meeting discussions, the participants identified next steps to be taken, summarized below:

### ***Identification of indicators***

WHO will lead work to:

- Revise the conceptual framework based on the inputs received during the scoping meeting.
- Conduct a scoping review of available indicators in the literature and/or currently used by countries to track the impacts of heat on health.
- Map the indicators to the conceptual framework and highlight areas where there are measurement gaps.
- Expand the geographical scope of the datasets to be analysed in HIGH Horizons and identify and contact potential databases from other geographical regions and of child health to be included (also consider the addition of secondary data analysis of DHS data).
- Decide on the best process for consensus for indicator selection after the mapping (e.g., Delphi survey and consensus meeting) to complete the process for the indicator selection to monitor the impact of extreme heat on MNCH.
- Finalize planned publications and disseminate the findings with the wider climate change and health community.
- Develop a Theory of Change for monitoring the impacts of heat on MNCH.
- Test and validate any of the selected indicators that have not previously been tested and validated.
- Contribute to efforts to identify indicators to monitor the impact of heat for other groups (e.g., adolescents and older people).
- Build capacity for analysis of heat and health data in countries.

### ***Selection of thresholds***

WHO will lead work to:

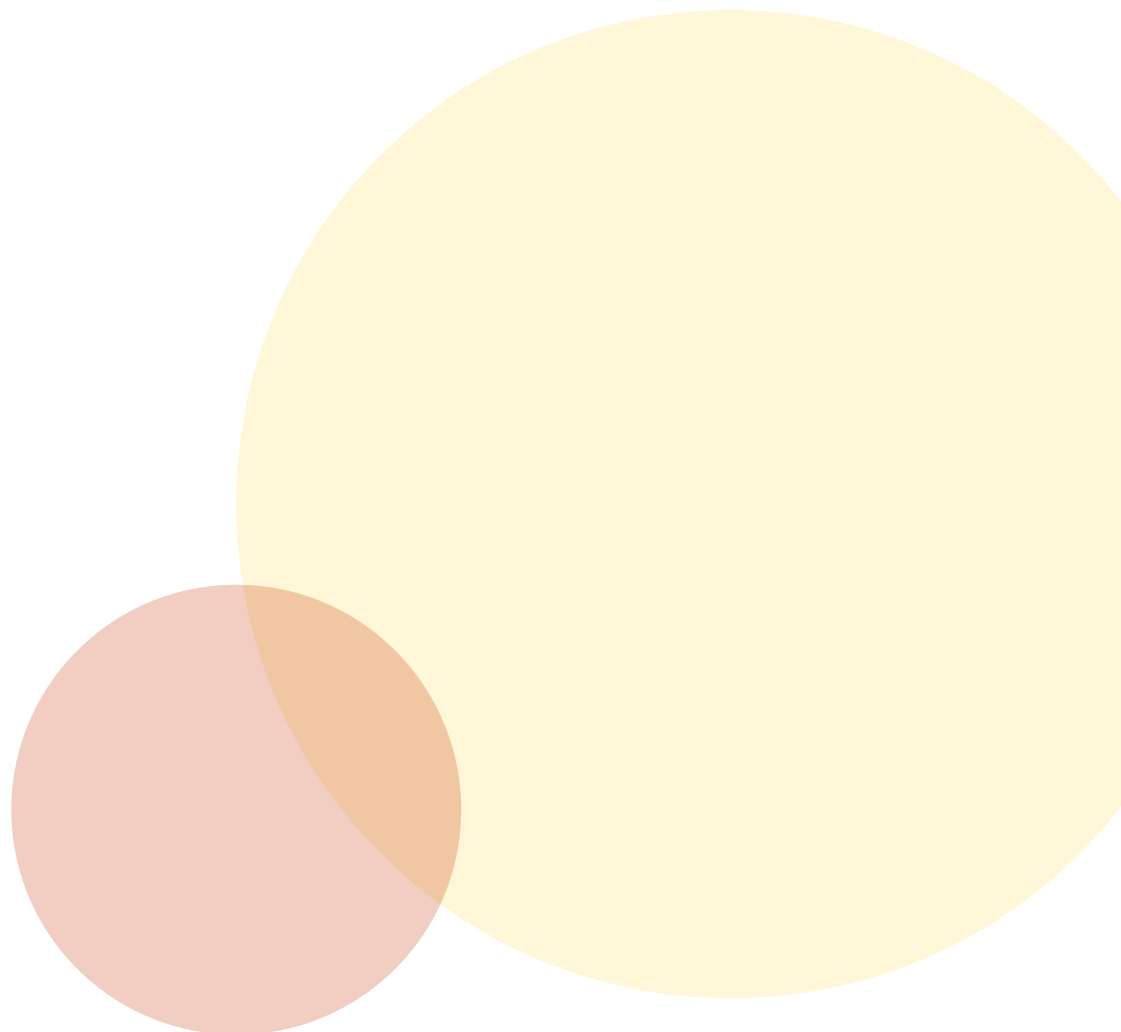
- Conduct a consensus process to identify criteria to consider for adopting TSIs for MNCH.
- Evaluate the efficacy of the TSIs.
- Conduct a process to identify priority messages for MNCH for early notification and warning systems and that health services can use in case of extreme heat conditions that could impact on MNCH.



## ***Additional***

WHO and partners will collaborate to:

- Contribute to efforts to strengthen the collaboration and dialogue between meteorological services and the health sector and to other research initiatives investigating health and heat exposure, particularly in vulnerable groups.
- Ensure coordination of research efforts across the climate change and health community to avoid duplications and overlap of efforts and integrate with existing climate change and platforms and research communities.
- Determine if and when there are critical windows of exposure for MNCH and thus differential experiences of heat across the diverse MNCH age groups.
- Integrate the learnings and consensus recommendations from this multi-disciplinary meeting into planned exercises for research prioritization for climate change.



## References

1. Roos N, Kovats S, Hajat S, Filippi V, Chersich M, Luchters S, et al. CHAMNHA Consortium. Maternal and newborn health risks of climate change: A call for awareness and global action. *Acta Obstet Gynecol Scand*. 2021;100(4):566-570. doi: 10.1111/aogs.14124.
2. Rylander C, Odland JØ, Sandanger TM. Climate change and the potential effects on maternal and pregnancy outcomes: an assessment of the most vulnerable—the mother, fetus, and newborn child. *Glob Health Action*. 2013;6:19538. doi: 10.3402/gha.v6i0.19538.
3. Nakstad B, Filippi V, Lusambili A, Roos N, Scorgie F, Chersich MF, et al. How Climate Change May Threaten Progress in Neonatal Health in the African Region. *Neonatology*. 2022;119(5):644-651. doi: 10.1159/000525573.
4. Perera F, Nadeau K. Climate Change, Fossil-Fuel Pollution, and Children’s Health. *N Engl J Med*. 2022;386(24):2303-2314. doi: 10.1056/NEJMra2117706.
5. Liu AY, Trtanj JM, Lipp EK, Balbus JM. Toward an Integrated System of Climate Change and Human Health Indicators: A Conceptual Framework. *Clim Change*. 2021;166(3-4):49. doi: 10.1007/s10584-021-03125.
6. Chersich MF, Scorgie F, Filippi V, Luchters S. Climate Change and Heat-Health Study Group. 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(2):421-429. doi: 10.1002/ijgo.14381.
7. WHO Health and climate change global survey report. Geneva: World Health Organization; 2021. (<https://www.who.int/publications/i/item/9789240038509>, accessed 6 June 2023).
8. National weather services [website]. National Oceanic and Atmospheric Administration. United States of America. (<https://www.weather.gov/ama/heatindex>, accessed 22 June 2023).
9. Seasonal weather hazards [website]. Government of Canada (Gouvernement du Canada); 2019. (<https://www.canada.ca/en/environment-climate-change/services/seasonal-weather-hazards/warm-season-weather-hazards.html>, accessed 22 June 2023).
10. Staiger H, Laschewski G, Grätz A. The perceived temperature - a versatile index for the assessment of the human thermal environment. Part A: scientific basics. *Int J Biometeorol*. 2012;56(1):165-76. doi: 10.1007/s00484-011-0409-6.
11. Błażejczyk K, Jendritzky G, Bröde P, Fiala D, Havenith G, Epstein Y, et al. An introduction to the universal thermal climate index. *Geogr Pol*. 2013; 86(1):5–10
12. Wet Bulb Globe Temperature [website]. National Oceanic and Atmospheric Administration. United States of America. (<https://www.weather.gov/car/WBGT>, accessed 22 June 2023).
13. Magarey RD, Seem RC, Russo JM, Zack JW, Waight KT, Travis JW, et al, Site-Specific Weather Information Without On-Site Sensors. *Plant Dis*. 2001; 85(12):1216-1226. doi: 85.1216-1226. 10.1094/PDIS.2001.85.12.1216.
14. Chersich MF, Pham MD, Areal A, Haghighi MM, Manyuchi A, Swift CP, et al. Climate Change and Heat-Health Study Group. 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. doi: 10.1136/bmj.m3811.
15. Lakhoo DP, Blake HA, Chersich MF, Nakstad B, Kovats S. The effect of high and low ambient temperature on infant health: a systematic review. *Int J Environ Res Public Health*. 2022;19(15):9109. doi: 10.3390/ijerph19159109.

16. Lancet Countdown on health and climate change data explorer [website]. The Lancet and Wellcome Trust (<https://www.lancetcountdown.org/data-platform/>, accessed 6 June 2023).
17. Global Heat Health Information Network [website]. World Health Organization & World Meteorological Organization (<https://ghhin.org/>, accessed 22 June 2023).
18. Heat health action plans: guidance. Copenhagen: WHO Regional Office for Europe; 2012 (<https://www.who.int/publications/i/item/9789289071918>, accessed 6 June 2023).
19. Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. Geneva: World Health Organization; 2014. (<https://www.who.int/publications/i/item/9789241507691>, accessed 22 June 2023).
20. Global Burden of Disease 2019 Cause and Risk Summary. Institute for Health Evaluation and Metrics, University of Washington, 2020. ([https://www.healthdata.org/results/gbd\\_summaries/2019](https://www.healthdata.org/results/gbd_summaries/2019), accessed 22 June 2023)
21. Zhao Q, Guo Y, Ye T, Gasparri A, Tong S, Overcenco A, et al. Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019: a three-stage modelling study. *Lancet Planet Health*. 2021;5(7):e415-e425. doi: 10.1016/S2542-5196(21)00081-4.
22. Vicedo-Cabrera AM, Scovronick N, Sera F, Royé D, Schneider R, Tobias A, et al. The burden of heat-related mortality attributable to recent human-induced climate change. *Nat Clim Chang*. 2021;11(6):492-500. doi: 10.1038/s41558-021-01058-x.
23. Carleton T, Jina A, Delgado M, Greenstone M, Houser T, Hsiang S, et al. Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits. *QJ Econ*. 2022; 137, (4), 2037-2105.
24. Ren M, Zhang C, Di J, Chen H, Huang A, Ji JS, et al. Exploration of the preterm birth risk-related heat event thresholds for pregnant women: A population-based cohort study in China. *The Lancet Regional Health - Western Pacific*. 2023; 100785. <https://doi.org/10.1016/j.lanwpc.2023.100785>
25. Ioannou LG, Mantzios K, Tsoutsoubi L, Notley SR, Dinas PC, Brearley M, et al. Indicators to assess physiological heat strain - Part 1: Systematic review. *Temperature (Austin)*. 2022;9(3):227-262. doi: 10.1080/23328940.2022.2037376
26. Global strategy for women's, children's and adolescents' health data portal. [website]. Geneva: World Health Organization (<https://platform.who.int/data/maternal-newborn-child-adolescent-ageing/global-strategy-data>, accessed 6 June 2023).
27. Healthy life trajectories initiatives. [website]. 2019. (<https://helti.org/>, accessed 6 June 2023).
28. INDEPTH network: better health information for better health policy). [website]. (<http://www.indepth-network.org/>, accessed 6 June 2023).
29. Ashorn P, Ashorn U, Askari S, Black RE, Hofmeyr J, Klein N, et al. The Lancet Small Vulnerable Newborn Series. *Lancet*. 2023. doi: [https://doi.org/10.1016/S0140-6736\(23\)00354-9](https://doi.org/10.1016/S0140-6736(23)00354-9)
30. Casanueva A, Burgstall A, Kotlarski S, Messeri A, Morabito M, Flouris AD, et al. Overview of existing heat-health warning systems in Europe. *Int J Environ Res Public Health*. 2019;16(15):2657. doi: 10.3390/ijerph16152657.
31. Heatwaves and health: guidance on warning system development. Geneva: World Health Organization and World Meteorological Organization; 2015. ([https://library.wmo.int/index.php?lvl=notice\\_display&id=17215](https://library.wmo.int/index.php?lvl=notice_display&id=17215), accessed 6 June 2023).

32. Early Warning Alert and Response in Emergencies: an operational guide. Geneva: World Health Organization; 2022 (<https://www.who.int/publications/i/item/9789240063587>, accessed 14 July 2023).
33. Ioannou LG, Tsoutsoubi L, Mantzios K, Vliora M, Nintou E, Piil JF, et al. Indicators to assess physiological heat strain - Part 3: Multi-country field evaluation and consensus recommendations. *Temperature (Austin)*. 2022;9(3):274-291. doi: 10.1080/23328940.2022.2044739.
34. Checklists to assess vulnerabilities in health care facilities in the context of climate change. Geneva: World Health Organization; 2021 (<https://www.who.int/publications/i/item/9789240022904>, accessed 7 June 2023)
35. Di Napoli C, Pappenberger F, Cloke HL. Assessing heat-related health risk in Europe via the Universal Thermal Climate Index (UTCI). *Int J Biometeorol*. 2018;62(7):1155-1165. doi: 10.1007/s00484-018-1518-2.
36. Ergonomics of the thermal environment - Assessment of heat stress using the WBGT (wet bulb globe temperature) index - ISO 7243:2017. Geneva: International Standards Organisation; 2017. (<https://www.iso.org/obp/ui/#iso:std:iso:7243:ed-3:v1:en>, accessed 8 June 2023).
37. Smallcombe JW, Puhenthirar A, Casasola W, Inoue DS, Chaseling GK, Ravanelli N, et al. Thermoregulation During Pregnancy: a Controlled Trial Investigating the Risk of Maternal Hyperthermia During Exercise in the Heat. *Sports Med*. 2021;51(12):2655-2664. doi: 10.1007/s40279-021-01504-y.
38. Samuels L, Nakstad B, Roos N, Bonell A, Chersich M, Havenith G, et al. Physiological mechanisms of the impact of heat during pregnancy and the clinical implications: review of the evidence from an expert group meeting. *Int J Biometeorol*. 2022; 66(8):1505-1513. doi: 10.1007/s00484-022-02301-6.
39. Smith CJ. Pediatric Thermoregulation: Considerations in the Face of Global Climate Change. *Nutrients*. 2019;11(9):2010. doi: 10.3390/nu11092010.
40. Ioannou LG, Dinas PC, Notley SR, Gofa F, Gourzoulidis GA, Brearley M, et al. Indicators to assess physiological heat strain - Part 2: Delphi exercise. *Temperature (Austin)*. 2022;9(3):263-273. doi: 10.1080/23328940.2022.2044738. PMID: 36211947; PMCID: PMC9542877.
41. Bonell A, Sonko B, Badjie J, Samateh T, Saidy T, Sosseh F, et al. Environmental heat stress on maternal physiology and fetal blood flow in pregnant subsistence farmers in The Gambia, west Africa: an observational cohort study. *Lancet Planet Health*. 2022;6(12):e968-e976. doi: 10.1016/S2542-5196(22)00242-X.



# Annex 1: HIGH Horizons project sheet



**Heat Indicators for Global Health (HIGH Horizons):**  
**Monitoring, Early Warning Systems and health facility interventions for pregnant and postpartum women, infants and young children and health workers**

HIGH Horizons addresses a number of key knowledge gaps around the quantification and monitoring of direct and indirect impacts of heat exposure on maternal, newborn and child health. Pregnant women, infants and health workers serve as sentinel populations for tracking climate change impacts, adaptations and co-benefits. Protecting these key populations is critical for creating a living and working life that is health promoting, and for ensuring a healthy future for the next generation.

We quantify and monitor direct and indirect health impacts of extreme heat; test a personalised Early Warning System (EWS); and implement integrated adaptation-mitigation actions in health facilities.

Systematic reviews, analyses of heat impacts and data science predictive modelling using health data from Sweden, Italy, Greece, Kenya and South Africa increase our understanding of the relationships between heat and maternal-child health outcomes, and inform testing and selection of global, EU and national indicators as well as cut-off thresholds for the EWS, stratified by risk groups. Specific biomarkers are measured during pregnancy and in infants in a prospective mother-child birth cohort in Greece to explain the role of heat exposures on adverse health effects. These analyses and systematic reviews Through a smartphone app (ClimApp-MCH) the EWS delivers notifications and setting-specific messages, co-designed locally. The app will be evaluated among 600 mothers and their infants in Sweden, South Africa and Zimbabwe, from pregnancy until 12 months of infant age.



Photo credit: Samuel TURPIN/ICRC - Burkina Faso

Simultaneously, we document impact of heat exposure on health worker wellbeing, health, productivity and quality of care. Modifications to health facilities are co-designed and modelled to reduce heat exposure for health workers and to limit facilities' carbon emissions. Health worker outcomes and facility emissions are compared before and after the mitigation and adaptation interventions, including cost-effectiveness evaluation. Throughout we engage relevant stakeholders in both conduct of the research and dissemination of project findings, prioritising country partners, EU and global policy makers and leveraging existing networks.

The project includes eleven partners across ten countries in Europe and Africa and encompasses activities in both the EU and sub-Saharan Africa.

## Project information



Funded by  
the European Union



Innovate  
UK

HIGH Horizons is funded by the EU's Horizon Research and Innovation programme (9.255.941,25 €), grant agreement number 101057843. Project partner LSHTM is funded by UKRI Innovate UK (1.726.790 GBP), reference number 10038478. The project runs from 1 September 2022 till 31 August 2026.

## Consortium partners



Karolinska  
Institutet



LONDON  
SCHOOL of  
HYGIENE  
& TROPICAL  
MEDICINE



World Health  
Organization



Aga Khan Health Services



University of the Witwatersrand  
WITS RHI

## Follow us



[www.high-horizons.eu](http://www.high-horizons.eu)



HIGH Horizons EU: Overview | LinkedIn



HIGH Horizons (@highhorizonseu) • Instagram photos and videos



HIGH Horizons | Facebook



HIGH Horizons (@HIGHhorizons\_EU) / Twitter

## Annex 2: List of participants

Name	Affiliation
<b>External Experts</b>	
<b>Zulfiqar A. Bhutta</b> (Chair)	SickKids Centre for Global Child Health, Toronto, CANADA/ Institute for Global Health and Development, Aga Khan University Karachi, PAKISTAN
<b>Louise Tina Day</b>	London School of Hygiene and Tropical Medicine London, UNITED KINGDOM
<b>Anthony Costello</b>	The Lancet Countdown/University College London London, UNITED KINGDOM
<b>Leonidas Ioannou</b>	Jozef Stefan Institute Ljubljana, SLOVENIA
<b>Amira Khalif Adawe</b>	Ministry of Environment and Climate Change Government of Somalia Mogadishu, SOMALIA
<b>Ousmane Ndiaye</b> (Day 1 only)	Agence Nationale de l'Aviation Civile et de la Météorologie Dakar, SENEGAL
<b>Nicolas Ray</b>	Institute of Global Health/Université de Genève Geneva, SWITZERLAND
<b>Jennifer Runkle</b>	North Carolina Institute for Climate Studies Asheville, North Carolina UNITED STATES OF AMERICA
<b>Sergey G. Sargsyan</b>	Arabkir Medical Centre/Institute of Child and Adolescent Health Yerevan, ARMENIA
<b>Yasmin Farah Sheikh Abdulkadir</b>	Ministry of Environment and Climate Change Government of Somalia Mogadishu, SOMALIA
<b>Abhiyant Tiwari</b>	Health and Climate Resilience/Natural Resources Defense Council India New Delhi, INDIA
<b>Peter Waiswa</b>	Makerere University School of Public Health Kampala, UGANDA
<b>Gary Watmough</b>	Data for Children Collaborative/University of Edinburgh Edinburgh, Scotland, UNITED KINGDOM
<b>Professional Associations</b>	
<b>Olivier Duperrex</b>	International Society for Social Pediatrics and Child Health Geneva, SWITZERLAND
<b>Perpetual Ofori-Ampofo</b>	Ghana Registered Nurses and Midwives Association Okponglo, GHANA

Name	Affiliation
<b>Representatives for Mother and Newborn Information for Tracking Outcomes and Results (MoNITOR) and Child Health Accountability Tracking technical advisory group (CHAT)</b>	
<b>Debra Jackson</b>	London School of Hygiene and Tropical Medicine London, UNITED KINGDOM
<b>Ralf Weigel</b>	Witten/Herdecke University Witten, GERMANY
<b>Technical Advisors</b>	
<b>Chloe Brimicombe</b>	Wegener Center for Climate and Global Change, University of Graz Graz, AUSTRIA
<b>Matthew Chersich</b>	Wits Reproductive Health and HIV Institute, University of Witwatersrand Johannesburg, SOUTH AFRICA
<b>Chuansi Gao</b> (virtual – Day 2 only)	Department of Design Sciences, Lund University Lund, SWEDEN
<b>Birgit Kerstens</b> (Meeting report)	International Centre for Reproductive Health, Ghent University Ghent, BELGIUM
<b>United Nations Agencies</b>	
<b>Michel Brun</b>	United Nations Population Fund (UNFPA) New York, UNITED STATES OF AMERICA
<b>Gagan Gupta</b>	United Nations Children’s Fund (UNICEF) New York, UNITED STATES OF AMERICA
<b>Swathi Manchikanti</b>	UNICEF New York, UNITED STATES OF AMERICA
<b>Eleni Myrivili</b>	United Nations Human Settlements Programme (UN-Habitat) Athens, GREECE
<b>John Nairn</b>	World Meteorological Organization Geneva, SWITZERLAND
<b>World Health Organization (WHO) Regional Offices</b>	
<b>Adeniyi Aderoba</b>	WHO Regional Office for Africa (AFRO) Brazzaville, CONGO
<b>Mohamed Afifi</b>	WHO Regional Office for the Eastern Mediterranean (EMRO) Cairo, EGYPT
<b>Oleg Kuzmenko</b>	WHO Regional Office for Europe (EURO) Copenhagen, DENMARK
<b>Mazen Malkawi</b>	WHO/EMRO Cairo, EGYPT



Name	Affiliation
<b>WHO Geneva</b>	
<b>Francesca Conway</b>	consultant WHO/Department of Maternal, Newborn, Child and Adolescent Health and Ageing (MCA)
<b>Kirrily De Polnay</b> (Day 1 only)	WHO/Department of Nutrition and Food Security (NFS)
<b>Theresa Diaz</b>	WHO/MCA
<b>Allisyn Moran</b>	WHO/MCA
<b>Tara Neville</b>	WHO/Department of Climate Change and Health (CCH)
<b>Anayda Portela</b>	WHO/MCA
<b>Christian Schweizer</b> (Day 1 only)	WHO/CCH
<b>Heather Scott</b>	Secondment from Dalhousie University, Halifax, Nova Scotia working with WHO/MCA
<b>Joy Shumake-Guillemot</b>	World Meteorological Organization/World Health Organization/ Joint Climate and Health Office Geneva, SWITZERLAND

# Annex 3: Terms of reference of WHO Expert Group

## The selection of indicators to monitor the impact of extreme heat on Maternal, Newborn and Child Health

### *Introduction*

The World Health Organization (WHO) Departments of Maternal, Newborn, Child and Adolescent Health and Ageing (WHO/MCA) and Climate Change and Health (WHO/CCH) are leading a process to identify population-level indicators to monitor the impacts of extreme heat on maternal, newborn and child health (MNCH).

An external group of multi-disciplinary experts, from disciplines such as climate science and environmental epidemiology, MNCH and nutrition, monitoring and evaluation, representing different geographical regions and gender, will be formed to participate in the process described herein and the results of the deliberations of the expert group and the selection of indicators will be published in a WHO, UNICEF, UNFPA and WMO publication<sup>4</sup>.

This work is funded through the European Union and the United Kingdom UKRI Innovate UK Grant to the HIGH Horizons project, and projects a unique opportunity to identify indicators and test them through different HIGH Horizons workstreams, which then allow for a final selection of feasible and valid measures.

### *Rationale*

There are currently major challenges in measuring the health impacts of climate change, and the outcomes of policy actions. A major priority in the field of climate change and health right now is to enhance the ability to track the scale of heat-related health impacts, and to measure the success of solutions, with a focus on vulnerable populations. Many questions remain about the optimum set of indicators needed for tracking heat and health burdens. The current global, regional and country-level measures of overall progress on climate change focus on excess heat-related mortality in people older than 65 years and on enumerating the number of heatwaves in different settings. However, the indicators only measure particular types of heat exposure, cover a limited number of population groups, and require further testing in a systematic manner. Within low- and middle-income countries (LMICs) the District Health Information System (DHIS), which lies at the core of health information systems, has not yet incorporated climate and health indicators. Current indicators that capture the health impacts of 'classic' heatwaves are inadequate, unable to measure the harms of new temperature patterns, or the harms in priority, heavily-affected population groups. Current heat indicators mostly measure acute, short-term impacts of heatwaves (e.g., admissions of elderly people during a heatwave). While this helps guide service provision during a heatwave, it may not address other important dimensions of extreme heat. Indicators are needed, for example, to track the sequelae of exposure to prolonged periods of raised temperatures over weeks in summer periods, or to repeated periods of intense heat which are increasingly the norm worldwide. Though heat can have acute physical effects on pregnant women (increased emergency admissions during a heatwave, for example), chronic or repeated exposure to high temperatures may be especially detrimental for foetal and maternal health.

---

<sup>4</sup> United Nations Children's Fund (UNICEF), United Nations Population Fund (UNFPA), World Meteorological Organization (WMO)

Indicators also need to measure the delayed impacts of heat exposure, such as those that can occur in pregnant women, infants and outdoor workers. These groups are ideal populations for monitoring impact and building an evidence-base on climate change impact and health adaptation measures. Firstly, in most parts of the world, robust data are collected on the denominator (e.g., number of births in a population), while for many other health outcomes the denominator is unknown. Secondly, several measures of MNCH have well accepted, standardized definitions applied globally. Thirdly, adverse MNCH outcomes are often major public health priorities as conditions in these groups signal large, often lifelong health burdens and thus policy actions are often highly cost-effective. Lastly, considerable investments have been made in establishing MNCH infrastructure, surveillance and information systems providing opportunities for leveraging existing platforms and personnel.

## **Objectives**

The aim is to select indicators suitable for tracking heat impacts of global relevance which can be adapted for regional, national or sub-national level.

## **Proposed process**

A brief overview of the steps that will be followed is described below:

The expert group will be invited to take part in *technical discussions to select the indicators*:

- 1) A first consultation will be held in April 2023 to review a conceptual framework on the impact of extreme heat on MNCH, including the pathways and drivers; define the scope of the work including specifications for the population groups, and determine the information that needs to be gathered to facilitate the expert group's selection of indicators.
- 2) A second consultation will be held in January 2024 (to be confirmed) to rank and prioritize indicators that have been identified through literature reviews and that correspond to different components of the conceptual framework. Criteria<sup>5</sup> for indicator prioritization will be proposed by a WHO-UNICEF-UNFPA-WMO steering group and reviewed by the expert group. (The indicators can subsequently be tested and validated through work conducted under the HIGH Horizons project.)
- 3) A third and final consultation will be held in early 2025 to review the results of the testing and validation exercises, review any additional literature identified, and reach consensus on a core set of indicators for global, European Union (EU) and national monitoring of climate change and MNCH, based on the results of the field testing and of the updates of the systematic reviews.

## **Tasks**

The expert group will undertake the following tasks:

- Participate in meetings (virtual and in person) to achieve the identification and selection of population-level indicators to quantify and monitor progress and health impacts of extreme heat on MNCH;
- Provide independent and evidence-based advice within their area of expertise to support the indicator selection process;

---

<sup>5</sup> For example: Criteria used in previous indicator prioritization exercises include: 1) relevance for MNCH priorities; 2) validity (measures what it is supposed to measure); 3) feasibility (feasible to measure routinely through household surveys, health facility assessments, or routine information systems); 4) degree of data availability across countries; and 5) whether the indicator strengthens or complements existing monitoring frameworks.

- Advise on challenges with monitoring and measurement, data collection and analyses for tracking the effects of heat on MNCH;
- Support the identification of a conceptual framework that will guide the indicator selection process, comprised of pathways and drivers as well as inputs, processes, outputs, and outcomes;
- Review the findings of reviews and analyses that will inform the indicator selection process;
- Review drafts of the final WHO-UNICEF-UNFPA-WMO publication for monitoring the impacts of heat on MNCH;
- Promote the dissemination of the WHO-UNICEF-UNFPA-WMO publication for monitoring the global and national impacts of heat on MNCH.

### **Composition**

- 1) The expert group shall have up to 25 members, who will serve in personal capacities to represent the broad range of disciplines relevant to the project. In the selection of the expert group, consideration shall be given to attaining an adequate distribution of technical expertise, geographical locations and gender representation.
- 2) Members of the expert group, including up to two co-chairs, shall be selected by WHO. The co-chairs functions include the following: a) chairing the expert group meeting; b) liaising with the WHO focal point between meetings.
- 3) Expert group members must respect the impartiality, independence and confidentiality required of WHO. In performing their work, members may not seek or accept instructions from any Government or from any authority external to the Organization. They must be free of any real, potential or apparent conflicts of interest. To this end, proposed members shall be required to complete a declaration of interests form for their participation, which shall be subject to the evaluation of completed forms by the WHO steering group, determining that their participation would not give rise to a real, potential or apparent conflict of interest.
- 4) Experts participating throughout the process have an ongoing obligation to inform the WHO of any interests real or perceived that may give rise to a real, potential or apparent conflict of interest.
- 5) WHO may, from time to time, request expert members to complete a new declaration of interest form. This may be before an expert group meeting or any other expert group -related activity or engagement, as decided by WHO. Where WHO has made such a request, the expert group member's participation in the activity or engagement is subject to a determination that their participation would not give rise to a real, potential or apparent conflict of interest.
- 6) Expert group members do not receive any remuneration from the WHO for any work related to the expert group. However, when attending in-person meetings at the invitation of WHO, their travel costs and per diem may be covered by WHO in accordance with the applicable WHO rules and policies.

- 7) WHO may, at its sole discretion, invite external individuals from time to time to attend the open sessions of an advisory group, or parts thereof, as “observers”. Observers may be invited either in their personal capacity, or as representatives from a governmental institution/intergovernmental organization, or from a non-state actor. WHO will request observers invited in their personal capacity to complete a confidentiality undertaking and a declaration of interests form prior to attending a session of the advisory group. Invitations to observers attending as representatives from non-state actors will be subject to internal due diligence and conflict of interest considerations in accordance with FENSA.
- 8) Observers invited as representatives may also be requested to complete a confidentiality undertaking. Observers shall normally attend meetings of the expert group at their own expense and be responsible for making all arrangements in that regard. At the invitation of the co-chairs, observers may be asked to present their personal views and/or the policies of their organization.
- 9) The expert group may decide to establish smaller working groups (sub-groups of the expert group) to work on specific issues.
- 10) All recommendations from the expert group are advisory to WHO, who retains full control over any subsequent decisions or actions regarding any proposals, policy issues or other matters considered by the expert group.
- 11) The selection of indicators and other recommendations by the expert group shall be made by consensus –defined as the agreement by three quarters or more of the participants –provided that those who disagree did not feel strongly about their position. Strong disagreements would be recorded as such in any final document. If the participants are unable to reach consensus, the disputed recommendation, or any other decision, will be put to a vote.
- 12) Expert group members shall not speak on behalf of, or represent, the expert group or WHO to any third party.

### ***Information and documentation***

- 1) Information and documentation to which members may gain access in performing expert group related activities shall be considered as confidential and proprietary to WHO and/ or parties collaborating with WHO. In addition, by signing the confidentiality undertaking, expert group participants undertake to abide by the confidentiality obligations contained therein and also confirm that any and all rights in the work performed by them in connection with, or as a result of their expert group -related activities shall be exclusively vested in WHO.
- 2) Expert group participants and Observers shall not quote from, circulate or use expert group documents for any purpose other than in a manner consistent with their responsibilities under these Terms of Reference.
- 3) WHO retains full control over the publication of the documentation of the expert group-related activities.

# Annex 4: Agenda

## Scoping Meeting

The selection of indicators to monitor the impact of extreme heat on maternal, newborn and child health

**Venue: Hotel Royal Manotel  
Geneva, Switzerland  
25-26 April 2023**

### Agenda

25 April 2023

Time	Session
<b>Setting the stage</b>	
09.00 – 09.45	<p>-Introductions</p> <p>-Presentations and Declaration of interests</p> <p>-Presentation of the Meeting Chair (Zulfi Bhutta, Hospital for Sick Children, Toronto, Canada, Co-Director of the SickKids Centre for Global Child Health and the Founding Director of the Center of Excellence in Women and Child Health, the Aga Khan University, Pakistan)</p> <p>(Allisyn Moran, Director a.i., Department of Maternal, Newborn, Child and Adolescent Health and Ageing (MCA), World Health Organization)</p> <p>(Annette Prüss-Ustun, Director a.i. Department of Environment, Climate Change and Health (ECH), World Health Organization)</p>
09.45 – 10.05	<p>-Meeting Objectives</p> <p>-Overview of HIGH Horizons project and proposed process for indicator selection</p> <p>-Terms of reference for the expert group</p> <p>-Draft conceptual framework (Annie Portela, WHO/MCA)</p> <p>-Discussion</p>
10.05 – 10.45	<p>Overview of global and national monitoring and indicators for maternal, newborn and child health (Theresa Diaz, WHO/MCA)</p> <p>WHO global and national monitoring of progress on climate change and health (Tara Neville, WHO/ECH)</p> <p>Meteorological and Climatological measures of heat (John Nairn, World Meteorological Organization (WMO))</p> <p>Questions</p>
10.45 – 11.00	<i>Break</i>

Time	Session
<b>Extreme heat and MNCH</b>	
11.00 – 11.45	Impact of extreme heat on MNCH and recent systematic reviews and published studies (Matthew Chersich, University of Witwatersrand) Theory of Change and Outcomes (Annie Portela, WHO/MCA) Discussion
11.45 – 12.15	Heat Health Metrics and Surveillance Systems – Joy Shumake-Guillemot WMO/WHO - Joint Climate and Health Office Lancet Countdown on health and climate change (Anthony Costello, The Lancet Countdown)
12.15 – 13.00	Overview of planned analyses on extreme heat and MNCH (Ilona Otto (virtual) and Chloe Brimicombe, University of Graz) Questions and Discussion
13.00 – 14.00	<i>Lunch</i>
<b>Defining next steps for indicator selection</b>	
14.00 – 17.30	-Reminder of the proposed process -Defining the parameters for the indicator selection:
<i>Break at 15h30</i>	-Defining key populations -Global, national, output and outcome -Heat measurement -Identification of any additional analyses required and other ongoing efforts -Criteria for selecting indicators -Other



26 April 2023

Time	Session
08.30 – 08.45	Recap of Day 1
<b>Early Warning Systems for extreme heat and maternal, newborn and child health</b>	
08.45 – 09.45	Early warning systems for extreme heat and health (Chuansi Gao, Lund University) Questions and Discussion
Defining next steps for threshold selection	
09.45 – 13.00	Weather phenomenon warning system-etymology (John Nairn, WMO)
<i>Break at 10h45</i>	-Defining the parameters for the early warning system threshold selection: low risk and high risk, individual thresholds and broad thresholds -Defining sources of information -Identification of any additional analyses that are required for the early warning system threshold selection and other efforts -Criteria for selecting early warning system threshold -Other
13.00 – 14.00	<i>Lunch</i>
<b>Next Steps</b>	
14.00 – 17.00	-Group work – Feedback on the conceptual framework -Group work – Ranking of priority criteria for indicator selection -Plenary discussion: feedback from Group work
<i>Coffee at 15h30</i>	-Linking with other efforts to identify indicators and early warning systems thresholds for MNCH -Experts that should be added to the group -Next steps -Session closure

# Annex 5: Feedback on the conceptual framework per subgroup

The feedback from each subgroup is listed in the table below and will be used to improve the current conceptual framework.

Subgroup	Feedback
<b>Climate Change subgroup</b>	<p>Title: Extreme heat and maternal, newborn, and child health outcomes.</p> <p>Hazards</p> <ul style="list-style-type: none"> <li>● Remove "Increase in overall temperature"</li> <li>● Remove "Compound hazard of heat and pollutants"</li> <li>● Add "Future climate scenarios"</li> <li>● Add "solar radiation", "humidity", "wind", "physical activity", "intensity", "clothing", "acclimatization"</li> </ul> <p>Effect Multipliers</p> <ul style="list-style-type: none"> <li>● Add "Compound hazards (e.g., pollution, drought, wildfire, flash flood, and drought)"</li> <li>● Add "Displaced persons"</li> <li>● Expand upon "Geographical factors (e.g., urbanicity, greenspace)"</li> <li>● Add "Occupation"</li> <li>● Add "Cultural factors"</li> </ul> <p>Direct impacts [consider changing to "Impact mechanisms"]</p> <ul style="list-style-type: none"> <li>● Add "sleep disturbances"</li> <li>● Add "Impaired cognition"</li> <li>● Add "cardiac strain"</li> <li>● Add "hyperventilation/ hypotension"</li> <li>● Add "lactation/lactation practices"</li> </ul> <p>Indirect impacts</p> <ul style="list-style-type: none"> <li>● Under Family &amp; Community level</li> <li>● Add family stress (e.g., income security)</li> <li>● Add "domestic violence/ community violence"</li> <li>● Add "migration/immigration"</li> <li>● Consider changing "Organized Services" to "Disruptions to Health Infrastructure"</li> <li>● Under Organized Services consider adding "school closures"</li> </ul> <p>**Consider adding "Critical Windows of Exposure" or "Sensitive periods" on top of the line that connects Direct impacts to Maternal and child health box; consider that air temperature alone does not capture the heat load.</p> <p>Maternal health</p> <ul style="list-style-type: none"> <li>● Add "mental health and well-being"</li> </ul> <p>Child health</p> <ul style="list-style-type: none"> <li>● Add "physical/cognitive development"</li> </ul> <p>Drivers</p> <ul style="list-style-type: none"> <li>● There is really no mention of policy landscape; consider adding "Lack of political will"</li> </ul>

Subgroup	Feedback
<b>Child Health subgroup</b>	<p>Effect multipliers</p> <ul style="list-style-type: none"> <li>● Add “physical activity and infrastructural materials + habitations/ planning”</li> <li>● Need to consider geography, ethnicity, race, gender, rural vs urban</li> <li>● Direct impacts</li> <li>● Add “sleep, mental health, severe dehydration”</li> <li>● Indirect impacts</li> <li>● Add to “schools” to organized services as areas of overheating; add “social cohesion and networks”</li> <li>● Child health outcomes</li> <li>● Add all types of infection, not just bacterial</li> </ul> <p>Other notes</p> <ul style="list-style-type: none"> <li>● The challenge for children is that different age groups experience heat differently</li> </ul>
<b>Maternal Health subgroup</b>	<p>Effect multipliers</p> <ul style="list-style-type: none"> <li>● Consider elaborating this section more: “Biological factors” probably include such things as BMI, maternal age, gestational age, other co-morbidities such as hypertension, diabetes, pre-existing respiratory diseases; geographical factors could be expanded to include urban/rural, altitude, access to water, etc</li> </ul> <p>Direct and Indirect Impacts</p> <ul style="list-style-type: none"> <li>● Consider connecting these two with an arrow</li> <li>● Consider adding “lactation” to the direct impacts</li> <li>● Consider restructuring the levels included in the indirect impacts to “individual, family and community, health care worker and facility”- the three delays impact at all levels and need to be addressed as cross cutting impacts; further, seeking care, recognition of the concerns about the impact of heat and appropriate referrals are important at all levels</li> <li>● Add “temperature in the birth unit and in birthing rooms” to the indirect impacts</li> </ul> <p>Maternal health outcomes</p> <ul style="list-style-type: none"> <li>● Add “postpartum haemorrhage, mental health, antenatal care and postnatal care attendance”</li> </ul> <p>Other notes</p> <ul style="list-style-type: none"> <li>● Consider adding an action plan to the framework</li> </ul>

Subgroup	Feedback
<b>Newborn Health subgroup</b>	<p>Effect multipliers</p> <ul style="list-style-type: none"> <li>● Add “security, equity and human rights of the newborn”</li> </ul> <p>Indirect impacts</p> <ul style="list-style-type: none"> <li>● Add “cultural practices/beliefs”</li> <li>● Add “poor water, sanitation and hygiene quality”</li> </ul> <p>Maternal health outcomes</p> <ul style="list-style-type: none"> <li>● Add “skin disorders”</li> <li>● Add “mental health”</li> <li>● Add “urinary tract infections”</li> </ul> <p>Newborn health outcomes</p> <ul style="list-style-type: none"> <li>● Add “jaundice”</li> <li>● Remove “INR”</li> <li>● Expand the list on infections</li> <li>● Add to dehydration the following specification “&gt;10% birth weight loss in the first week”</li> <li>● Consider mentioning “multiple gestations”</li> <li>● Consider tracking birthweight heaping</li> </ul>
<b>Monitoring subgroup</b>	<p>Drivers</p> <ul style="list-style-type: none"> <li>● Consider changing the name to “Heat drivers”</li> </ul> <p>Hazards</p> <ul style="list-style-type: none"> <li>● Consider changing the name to “Heat hazards”</li> </ul> <p>Effect multipliers</p> <ul style="list-style-type: none"> <li>● Consider changing the name to “Adaptation Capacity/Contextual Factors/Vulnerability Factors”</li> </ul> <p>Direct and Indirect Impacts</p> <ul style="list-style-type: none"> <li>● Consider connecting these two with an arrow</li> <li>● Add “poor water, sanitation and hygiene quality”</li> </ul> <p>Maternal health outcomes</p> <ul style="list-style-type: none"> <li>● Add “mental health”</li> <li>● Add “malaria”</li> </ul> <p>Child health outcomes</p> <ul style="list-style-type: none"> <li>● Add “diarrhoea”</li> <li>● Add “malaria”</li> </ul>

## Annex 6: Ranking of criteria for indicator prioritization

The criteria for prioritization of indicators presented during the meeting were from the following previous technical consultations:

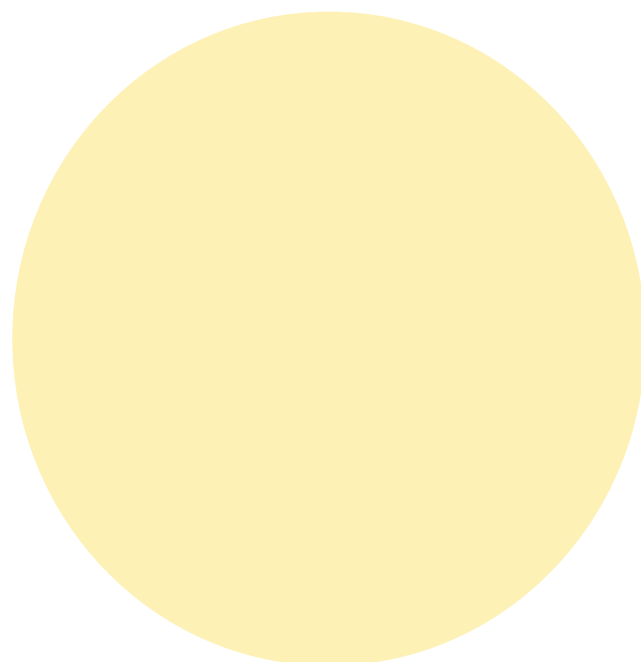
1. WHO Consultation on Improving measurement of the quality of maternal, newborn and childcare in health facilities, 2013
2. Global Core Indicators for measuring WHO’s paediatric quality of care standards in health facilities, 2022.
3. Priority indicators for Adolescent Health measurements by Global Action for Measurement of Adolescent health (GAMA) Advisory Group, 2022.
4. Family Planning Indicators (USAID/ Data for Impact).
5. UNAIDS Operational Guidelines for selecting indicators for the HIV response (Indicator Assessment tool-Indicator Standards), 2015.
6. Williams M, Eggleston S. Using indicators to explain our changing climate to policymakers and the public. World Meteorological Organisation Bulletin, 2017.

Table A.1 includes the results of the preliminary ranking of criteria for prioritization:

Priority Criteria	# of votes
Feasibility	14
Relevance	6
Importance	5
Actionability	1
Timeliness	1

Total votes: 27

Null votes: 2





**For further information, please contact:**

**World Health Organization**

**20 Avenue Appia, 1211 Geneva 27**

**Switzerland**

**Department of Maternal, Newborn, Child and Adolescent Health and Ageing (MCA)**

**E-mail: [mncah@who.int](mailto:mncah@who.int)**

**Website: [www.who.int/maternal\\_child\\_adolescent/en/](http://www.who.int/maternal_child_adolescent/en/)**

