



Digital Health Systems for Climate Adaptation

Digital Health for Climate Resilience

Lecture 4

Lecture Outline

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Defining Digital Health Systems for Climate Adaptation

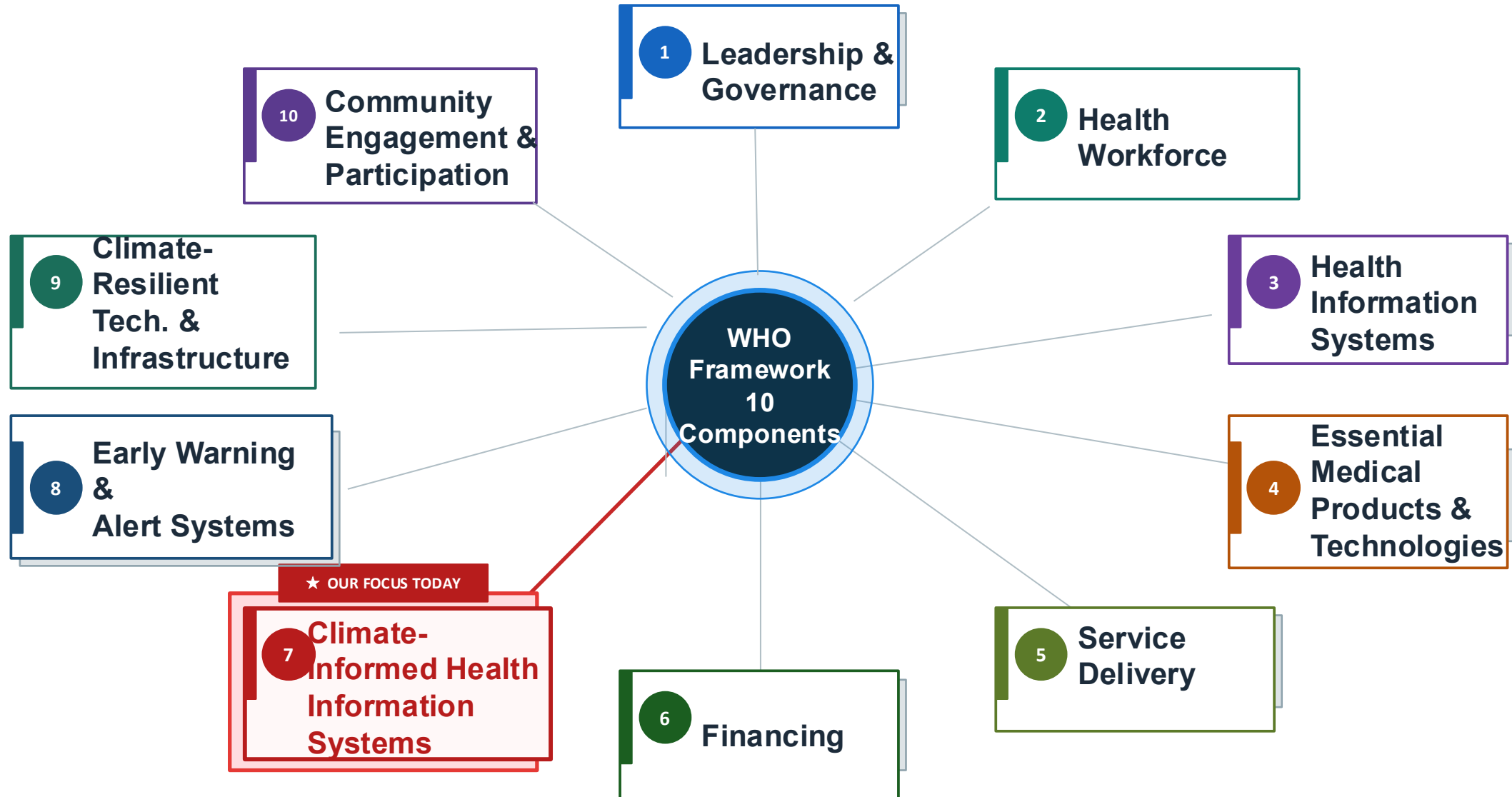
- **Digital Health:** The use of information and communications technologies (ICTs) to support health and health-related fields
- **Climate Adaptation:** Actions taken to manage the impacts of climate change and reduce the risks to human and natural systems
- **Digital Health Systems for Climate Adaptation:** A suite of interconnected digital technologies—including surveillance platforms, early warning systems, telemedicine, data integration tools, and decision-support systems—deployed to anticipate, respond to, and build resilience against climate-related health threats at population and health system levels
- **Goal:** To enable health systems to withstand climate shocks, maintain essential services, and protect populations despite a changing environment

The Climate Crisis as a Health System Crisis

- **Climate change simultaneously increases demand for and disrupts supply of health services**
- **Increased Demand:**
 - More patients with heatstroke, respiratory distress from wildfires, injuries from storms
 - Surge in climate-sensitive infectious diseases (malaria, dengue, diarrhea)
 - Growing burden of mental health conditions
- **Disrupted Supply:**
 - Health facilities damaged or destroyed by extreme weather
 - Power and water outages
 - Supply chain interruptions for medicines, vaccines, and equipment
 - Health workforce unable to reach facilities or personally affected
- **Result:** A perfect storm that can overwhelm even robust health systems

WHO Operational Framework for Climate-Resilient Health Systems

| 10 Components



Building Block 1: Climate-Integrated Health Information Systems

- **The Challenge:** Health data (disease surveillance) and climate data (temperature, rainfall) are typically collected and managed by different institutions in incompatible formats
- **The Digital Solution:** Platforms that integrate these data streams to enable analysis and action
- **Key Functions:**
 - **Data Harmonization:** Converting climate and health data into compatible formats and spatial scales
 - **Automated Data Integration:** Linking routine health data (e.g., from DHIS2) with climate datasets (e.g., from meteorological agencies or global gridded products)
 - **Spatial Analysis:** Mapping disease incidence against climate variables to identify hotspots and trends
 - **Visualization:** Dashboards that allow health officials to see, for example, malaria cases plotted against rainfall and temperature
- **Outcome:** Evidence-based decision-making, early outbreak detection, and targeted resource allocation

The DHIS2 Climate App: A Case Study in Data Integration

- **DHIS2:** The world's largest Health Management Information System, used by 80+ low- and middle-income countries for routine health data
- **The Problem:** Even where DHIS2 is used, climate data was not easily accessible within the platform
- **The Solution:** The **DHIS2 Climate App**, developed by the HISP Centre at the University of Oslo
- **How It Works:**
 - Integrates gridded climate datasets (e.g., ERA5-Land, CHIRPS) directly into DHIS2 .
 - Automatically aggregates climate data to the same geographic boundaries used for health data (districts, regions)
 - Provides visualization tools to explore climate and health data together
 - Pilot countries: Uganda, Bangladesh, Cambodia, Grenada, and others
- **Impact:** Enables Ministries of Health to conduct their own climate-health analyses without needing external experts

Building Block 2: Early Warning and Alert Systems

- **Purpose:** To predict climate-related health risks and trigger timely action to prevent or mitigate harm
- **Core Components:**
 - **Data Inputs:** Climate forecasts, environmental monitoring data (e.g., river levels, pollen counts), disease surveillance data
 - **Risk Models:** Algorithms that translate environmental conditions into health risk predictions (e.g., malaria transmission potential based on temperature and rainfall)
 - **Thresholds and Alerts:** Pre-defined risk levels that trigger notifications to health authorities and the public
 - **Communication Channels:** SMS, mobile apps, radio, community health workers
- **Examples:**
 - **Heat-Health Early Warning Systems:** Trigger public health messages, open cooling centers, check on vulnerable individuals
 - **Dengue Early Warning:** Predict outbreaks based on climate and trigger vector control
 - **Flood Early Warning:** Alert communities to evacuate and prepare for water-borne disease risks

Case Study: Malaria Suitability Mapping in Uganda

- **Context:** Uganda has one of the highest malaria burdens in the world. Transmission is highly seasonal and climate-sensitive
- **Tool:** DHIS2 Climate App with a Malaria Suitability and Risk Mapping module
- **Data Integrated:**
 - Historical malaria case data from DHIS2
 - Precipitation, temperature, and relative humidity from global datasets
 - **Vegetation data (NDVI)** – added at the request of the national malaria program to better identify mosquito breeding habitats
- **Output:** Dynamic maps showing areas and times of year with high malaria suitability
- **Use:** Enables the malaria control program to target interventions (e.g., distribution of bed nets, indoor spraying) to the right places at the right times

Building Block 3: Telemedicine and Service Continuity

- **The Challenge:** Extreme weather events can disrupt access to healthcare by damaging infrastructure, blocking roads, and displacing populations
- **The Digital Solution:** Telemedicine and mobile health (mHealth)
- **Applications for Climate Adaptation:**
 - **Remote Consultations:** Patients can consult with healthcare providers via video or phone when they cannot reach a facility
 - **Continuity of Care:** Chronic disease management (e.g., for diabetes, hypertension) can continue despite disruptions
 - **Mental Health Support:** Provide remote counseling to populations affected by climate-related disasters
 - **Triage and Information:** During or after an extreme event, hotlines and apps can provide guidance on where to seek care and how to manage minor injuries
 - **Health Worker Communication:** Enable coordination and information sharing among dispersed health workers
- **Co-Benefit:** Telemedicine also reduces the carbon footprint of healthcare by reducing travel

Building Block 4: Digital Tools for Health Workforce Capacity Building

- **The Need:** Health workers need new knowledge and skills to recognize, diagnose, and manage climate-sensitive diseases and to respond to extreme weather events
- **Digital Solutions:**
 - **E-Learning Platforms:** Online courses on climate and health (e.g., WHO training modules)
 - **Mobile Apps:** Point-of-care tools with clinical guidelines for climate-sensitive diseases
 - **Decision Support Systems:** Integrated into electronic health records, alerting clinicians to potential climate-related diagnoses based on location and season
 - **Simulation and Gaming:** Virtual reality or scenario-based training for disaster response
- **Example:** The WHO has developed a comprehensive toolkit for health professionals on climate change and health, available online

Building Block 5: Community Engagement and Citizen Science

- **The Principle:** Communities are not just passive recipients of information; they are essential partners in building resilience
- **Digital Tools for Engagement:**
 - **Mobile Apps for Reporting:** Allow community members to report environmental hazards (e.g., flooding, mosquito breeding sites) or health symptoms
 - **Two-Way Communication Platforms:** Enable communities to receive alerts and provide feedback to health authorities
 - **Citizen Science:** Engaging volunteers in data collection (e.g., using low-cost sensors to monitor air quality)
 - **Social Media:** For risk communication and community organizing
- **Example:** The **AI_r project in South Africa** combines low-cost monitors with AI to provide real-time air quality data to communities, empowering them to advocate for change and take protective action

The Promise of AI and Predictive Analytics

- **Beyond Early Warning:** AI can move us from simple early warning (e.g., "a heatwave is coming") to **predictive analytics** (e.g., "based on this heatwave, we expect a 15% increase in emergency department visits for heart failure, concentrated in these three neighborhoods")
- **Applications:**
 - **Disease Outbreak Prediction:** AI models integrating climate, environmental, and mobility data can forecast outbreaks of dengue, malaria, and cholera with increasing accuracy
 - **Resource Allocation:** Predicting where and when health services will be most needed to preposition staff, supplies, and equipment
 - **Vulnerability Mapping:** Identifying populations at highest risk by integrating environmental, demographic, and health data
 - **Personalized Alerts:** Using individual health data to send targeted warnings to high-risk patients (e.g., someone with asthma during a wildfire smoke event)
- **Key Requirement:** High-quality, integrated data and rigorous model validation

The Paradox of Digital Health: Environmental Footprint

- **The Paradox:** Digital health tools are deployed to help health systems adapt to climate change, but the digital infrastructure itself has a significant environmental footprint
- **Sources of Environmental Impact:**
 - **Energy Consumption:** Data centers and network infrastructure consume vast amounts of electricity, much of which still comes from fossil fuels
 - **Water Usage:** Data centers require significant water for cooling
 - **Resource Extraction:** Manufacturing hardware (sensors, smartphones, servers) requires mining rare earth metals and other finite resources
 - **Electronic Waste (E-Waste):** The fastest-growing waste stream globally; devices contain toxic materials and are often not recycled properly
- **The Challenge:** We must consider the full life-cycle environmental impact of digital health solutions
- **The Imperative:** Sustainable digital health design—energy-efficient algorithms, renewable-powered data centers, recyclable hardware, circular economy principles

Challenges and Barriers to Implementation

- **Data Silos and Interoperability:** Health and climate data remain fragmented across institutions
- **Infrastructure Gaps:** Lack of reliable electricity, internet connectivity, and digital devices, especially in low-resource settings
- **Technical Capacity:** Limited skills to manage, analyze, and interpret complex data
- **Financial Constraints:** Cost of deploying and maintaining digital systems; competing priorities
- **Sustainability:** Many pilot projects fail to scale or are not maintained after donor funding ends
- **Governance and Policy:** Lack of clear mandates, data-sharing agreements, and regulatory frameworks
- **Digital Divide:** Risk that digital health benefits will accrue to wealthier, more connected populations, exacerbating inequities
- **Privacy and Security:** Collection of personal health and location data raises significant ethical and security concerns

Conclusion and Key Takeaways

- **Climate change is a health system crisis**, simultaneously increasing demand for care and disrupting its supply
- **Digital health systems are essential for climate adaptation**, enabling climate-integrated surveillance, early warning, service continuity, workforce capacity building, and community engagement
- **Integration is the foundational challenge and opportunity**—bringing together climate and health data to enable evidence-based action
- **Tools like the DHIS2 Climate App** demonstrate that climate-health integration is achievable, even in low-resource settings
- **AI and predictive analytics offer the promise of proactive, targeted interventions**—moving from reaction to anticipation
- **We must confront the digital health paradox** by designing and deploying sustainable, low-carbon digital solutions
- **Equity must be central**—digital health systems must be designed to reach and benefit the most vulnerable populations, not just the connected
- **Success requires more than technology**; it demands political will, sustained investment, multisectoral collaboration, and genuine community engagement

Q&A / Discussion

Thank you.

Questions?

- How can we ensure digital health systems are designed to be sustainable and low-carbon?
- What are the most urgent priorities for investment in climate-resilient digital health?
- How do we balance the benefits of data integration with the imperative to protect privacy?
- In your context, what would be the first step toward building a climate-integrated health information system?

References

- Li, Y., Wu, G., Gong, P., Liu, C., Liang, L., Gong, M., & Zeng, Z. (2025). Harnessing Digital Health Technologies to Combat Climate Change-Related Health Impacts. *Health care science*, 4(4), 235–242. <https://doi.org/10.1002/hcs2.70032>
- Jasmin Bhawra, Sheriff, Tolulope Ibrahim, Jamin Patel, Anuradha Vaman Khadilkar, Tarun Reddy Katapally. Climate Care India: A protocol for digital transformation of health systems for non-communicable disease management and climate change adaptation. medRxiv 2025.05.25.25328322; <https://doi.org/10.1101/2025.0.25.25328322>