Climate and health: How can informatics help?

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Climate change is an alarming global threat to individual and public health. The acceleration of climate-related exposures such as extreme weather events, rising sea levels, and temperature fluctuations have direct and indirect implications for human health[1]. Increased frequency of health-threatening hot days and poor air quality are associated with a greater risk of heat-related illnesses and respiratory complications, which disproportionately impacts vulnerable populations such as children, older adults, individuals with chronic conditions, and people without homes[1,2]. Increased occurrence and severity of extreme weather events, including hurricanes, floods, wildfires, and heatwaves, cause direct physical and/or environmental harm (i.e., injury, displacement, environmental degradation, and saltwater intrusion)[1]. Additional long-term sequelae of climate change are numerous, including the spread of diseases such as dengue and malaria to areas that were previously non-endemic, alongside the emergence of other pathogenic conditions[3,4]. The most recent report of the Lancet Countdown on health and climate change presents sobering projections for the health and survival of people worldwide unless “profound and immediate systemic changes” are made[1]. Most notably, the report forecasts a disturbing trajectory in key indicators for global progress including: a 370% increase in heat-related deaths; an additional 525M individuals facing moderate-to-severe food insecurity; and a ~36% increase in the transmission of dengue disease (under a 2°C surface temperature scenario) by mid-century[1].

Amidst these escalating health concerns emerges a critical role for the field of biomedical informatics, the application of data, information, and knowledge as related to human health. Quantifying the continued impact of climate change is essential to developing transformative and effective strategies to measure, mitigate, and adapt to a rapidly changing climate[5]. Indeed, the 2023 Lancet Countdown identified 11 priorities for accelerated action to limit climate change and its health impacts. Notably, *all* recommendations anchor on climate-informed data surveillance with four priorities specifically calling for strengthened global capacity to support climate change research and knowledge generation[1]. Addressing the climate crisis requires a dynamic framework that integrates diverse data sources, including, but not limited to meteorologic, geospatial, clinical, public health, and socioeconomic data. Combined with advanced analytics, the amalgamation of these data can foster early awareness; establish real-time alert systems; inform the design and development of predictive models; and ultimately translate to scalable innovations that reduce or eliminate the anthropogenic impact of GHG emissions. However, given its urgency and the public health implications, an undertaking of this magnitude necessitates strategic direction and concerted collaboration.

Biomedical informatics, an academic field focused on data, computer sciences, knowledge, and wisdom as related to human health, is thus essential to support our attempts to understand, mitigate, and adapt to climate change.

To that end, the American Medical Informatics Association (AMIA) hosted a Mini-Summit entitled *Climate and health: How can informatics help?* ("Mini-Summit") on November 11, 2023. Briefly, AMIA is the leading professional association for >5,500 transdisciplinary subject matter experts committed to the practice of informatics as it relates to clinical care, research, education, and policy[6]. The primary aims of the Mini-Summit were to a) initiate dialogue on the impact of climate change on public health and b) facilitate an open forum to identify potential opportunities, solutions, and collaborations at the intersection of climate change and population health.

All attendees were registered to attend the AMIA 2023 Annual Symposium (New Orleans, LA, USA) and invited to participate in the Mini-Summit. Leveraging an Affinity Diagramming methodological approach defined *a priori* (Indiana University IRB Protocol #21183), Mini-Summit staff posed two questions to ~50 attendees (40 in-person; 10 virtual)[7]:

1. **Action/implementation**: What evidence-based practices can individuals, groups and organizations in healthcare apply/implement *now* to help (1) mitigate or (2) adapt to climate change (Please focus on things people can do at work, so no home-recycling, etc.)?[*]
2. **Research**: What research should the informatics community conduct to help healthcare (1) mitigate or (2) adapt to climate change? This research will enable/produce evidence-based practices for action/implementation.

The rationale for posing two separate, but distinct questions was to identify actions that healthcare can take *now* to mitigate or adapt to climate change while acknowledging that additional approaches and solutions will have to be developed. Dedicated informatics-informed research efforts will be pivotal to devise novel strategies for the mitigation of or adaptation to climate change. While we considered the two areas as mainly separate, a certain degree of overlap in the responses was expected and acknowledged. All responses were recorded by Mini-Summit staff (HC, JC, MD, TS) and synthesized below (MB, HC, JC, MK, TS) to identify current- and future-state priorities for implementation and research.

Attendees' ideas were recorded in affinity diagrams, which are visual tools that help organize information from a brainstorming session. Affinity diagramming is an inductive exercise in which individual, specific insights are recorded on Post-it™ notes and gathered into groups. Each group of notes has some similarity in intent, problem, or issue. Groups are then labeled with a descriptive, summary note. Grouping continues until each cluster of notes is summarized and all themes from the original insights are represented. At the Mini-Summit, attendees were asked to consider the aforementioned questions and record their ideas.

The rationale for asking the two questions separately was that there are evidence-based practices *today* that are known to reduce GHG and conserve natural resources. It is important to examine when and how healthcare organizations could apply them. At the same time, research is needed to find out what else we can do to understand how to mitigate or adapt to climate change. While we considered the two areas as mainly separate, we also expected a certain degree of overlap in the responses.

Several themes emerged from the Action and Implementation activity summarized in Table 1. Building a climate-sensitive healthcare economy will require stakeholders to develop a cohesive strategy. This strategy should be multi-pronged, incorporating education, workforce

[*]"Mitigation" means making the impacts of climate change less severe by preventing or reducing the emission of greenhouse gasses. "Adaptation" is the process of adjusting to the current and future effects of climate change (Adapted from: European Environment Agency)

development, policy and regulatory frameworks, operational redesign, standardized metrics for evaluation and analysis, public-private partnerships, community resilience, emergency preparedness, financial stewardship, and clinical decision support. With respect to education, integrating climate literacy into all aspects of healthcare delivery will require a fundamental understanding of the individual and collective carbon footprint, and exploring ways in which humanity can further decarbonize the atmosphere in an equitable manner. Workforce development would involve educating dedicated climate health experts with cross-disciplinary capabilities. Creative policymaking will incentivize climate-friendly practices in the healthcare sector and beyond, such as using resources wisely and incorporating sustainability-focused practices. Transforming clinical operations will require reducing travel emissions from both clinicians as well as patients; switching from fossil fuel-generated power to renewable energy sources; minimizing resource use on all levels including essential supplies; and modernizing IT to support climate-friendly clinical operations. When it comes to measurement and evaluation procedures, it will be vital to establish real-time monitoring of climate impacts and resource utilization in the form of easily navigable dashboards as well as predictive modeling of future impacts. Multi-sectoral partnerships across governmental agencies, research institutions, community organizations, and business entities will be crucial in addressing climate change and adaptation/mitigation efforts (including how to address resource allocation to those most in need and how to advance predictive modeling techniques to anticipate future resource needs). Furthermore, emergency preparedness and data stewardship (which includes IT resilience measures during natural disasters; minimum health record requirements in crisis response scenarios; and effective management of mass human displacement that could arise in a climate event) are essential so that clinical decision support and other informatics tools can guide healthcare providers accordingly.

In the Research exercise, participants focused on the following areas of investigation: (i) emergency preparedness; (ii) climate-centric healthcare delivery models; (iii) carbon footprint and associated costs; (iv) sustainability; (v) data analytics; (vi) finance and return on investment. Two key areas for emergency preparedness research included IT resilience capacity to include the evaluation of the current state of backup power solutions, data protection strategies, and alternative communication streams, and minimum necessary health and social determinants data collection and formatting to ensure that information is shared between first responders, clinicians, and other stakeholders cohesively. To optimize remote patient monitoring and other virtual medicine platforms, more research would need to be conducted exploring the level of electronic support needed; triaging those who need in-person assessment from those that do not, and facilitating interoperability in communication streams. When it comes to carbon-related research, it will be critical to quantify the carbon benefits of a telemedicine platform as well as connect with other like-minded individuals in the field so best practices can be shared. From a sustainability and data analytics perspective, integrating the climate health informatics framework into the healthcare informatics framework; identifying and enhancing clinical coding standards as well as developing new clinical coding standards; and forming a core set of data elements were seen as priorities. The application of biomedical informatics is imperative to measure, mitigate, and adapt to growing challenges owing to the impact of climate change on population health.

The AMIA 2023 Mini-Summit on Climate, Health, and Informatics represents our inaugural initiative to mobilize informaticians to confront the urgent challenge of climate change, laying the groundwork for sustained action and collaboration in this critical domain. The Mini-Summit's affinity diagramming exercise was a valuable tool to engage and harness the collective expertise within our membership and inform priorities for informatics-based research. Immediate next steps involve validating and aligning the results of the Mini-Summit affinity diagramming

exercise with the existing literature. These outcomes will directly shape the charter for a structured AMIA Working Group tasked with creating a strategic roadmap for prioritized climate change research. This community will serve as a network to exchange knowledge; drive innovative solutions; inform evidence-based practices; and foster engagement and mentorship for future informaticians engaged in climate change. Simultaneously, efforts are underway to establish a topical informatics emphasis area for climate change research and issue a call for submissions for forthcoming AMIA conferences, symposia, and summits. These collective endeavors represent the first of many activities required to achieve a broader vision to leverage AMIA's platform for heightened awareness and education, community engagement, and impactful influence on public policy in the face of a rapidly changing climate.

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Conflicts of Interest: AZ and KJTC are employed by CVS Health® Corporation and receive equity and own stock.

References

1. Romanello M, Napoli CD, Green C, et al. The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *Lancet*. Dec 16 2023;402(10419):2346-2394. doi:10.1016/S0140-6736(23)01859-7
2. Aguilera R, Corringham T, Gershunov A, Benmarhnia T. Wildfire smoke impacts respiratory health more than fine particles from other sources: observational evidence from Southern California. *Nat Commun*. Mar 5 2021;12(1):1493. doi:10.1038/s41467-021-21708-0
3. Kulkarni MA, Duguay C, Ost K. Charting the evidence for climate change impacts on the global spread of malaria and dengue and adaptive responses: a scoping review of reviews. *Global Health*. Jan 3 2022;18(1):1. doi:10.1186/s12992-021-00793-2
4. Mora C, McKenzie T, Gaw IM, et al. Over half of known human pathogenic diseases can be aggravated by climate change. *Nat Clim Chang*. 2022;12(9):869-875. doi:10.1038/s41558-022-01426-1
5. Coiera E, Magrabi F. What did you do to avoid the climate disaster? A call to arms for health informatics. *J Am Med Inform Assoc*. Nov 14 2022;29(12):1997-1999. doi:10.1093/jamia/ocac185
6. American Medical Informatics Association. Accessed on December 22, 2023 From: https://amia.org/about-amia#:~:text=AMIA's%205%2C600%2B%20members%20are%20subject,dentists%2C%20pharmacists%2C%20and%20other%20clinicians
7. American Society for Quality. "What is an Affinity Diagram." Available at: https://asq.org/quality-resources/affinity. Accessed 29 December 2023.

Additional Resources:

Department of defense climate risk analysis report to the national security council. Office of the Undersecretary for Policy (Strategy, Plans, and Capabilities). 2021.

Yuan F, Fan C, Farahmand H, et al. Smart flood resilience: Harnessing community-scale big data for predictive flood risk monitoring, rapid impact assessment, and situational awareness. *Environmental Research: Infrastructure and Sustainability*. 2022;2(2):025006. https://dx.doi.org/10.1088/2634-4505/ac7251. doi: 10.1088/2634-4505/ac7251.

Kedia T, Ratcliff J, O'Connor M, et al. Technologies enabling situational awareness during disaster response: A systematic review. *Disaster Medicine and Public Health Preparedness*. 2022;16(1):341-359. https://www.cambridge.org/core/article/technologies-enabling-situational-awareness-during-disaster-response-a-systematic-review/4B303623ECEF3F0413C68F1462DFC00F. Accessed 2023/10/06. doi: 10.1017/dmp.2020.196.

Phuong J, Riches NO, Calzoni L, et al. Toward informatics-enabled preparedness for natural hazards to minimize health impacts of climate change. *J Am Med Inform Assoc*. 2022;29(12):2161-2167. https://doi.org/10.1093/jamia/ocac162. Accessed 10/6/2023. doi: 10.1093/jamia/ocac162.

National Academies of Sciences, Engineering, and Medicine. Motivating Local Climate Adaptation and Strengthening Resilience: Making Local Data Trusted, Useful, and Used. The National Academies Press; 2021

U.S. Government Accountability Office (GAO). COVID-19:
Pandemic lessons highlight need for public health situational awareness network. 2022.

Sun W, Bocchini P, Davison BD. Applications of artificial intelligence for disaster management. Nat Hazards. 2020;103(3):2631-2689. https://doi.org/10.1007/s11069-020-04124-3. doi: 10.1007/s11069-020-04124-3.

Lokmic-Tomkins Z, Block LJ, Davies S, et al. Evaluating the representation of disaster hazards in SNOMED CT: Gaps and opportunities. J Am Med Inform Assoc. 2023;30(11):1762-1772. https://doi.org/10.1093/jamia/ocad153. Accessed 10/24/2023. doi: 10.1093/jamia/ocad153.

Assistant Secretary for Preparedness and Response, (ASPR). HHS emPOWER program platform. U.S. Department of Health and Human Services Web site. https://empowerprogram.hhs.gov/. Accessed Oct 22, 2023.