

Public Health Institutes of the World

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CLIMATE CHANGE AND PUBLIC HEALTH:
THE ESSENTIAL ROLE OF NATIONAL PUBLIC HEALTH
INSTITUTES IN TRANSFORMATIVE ADAPTATION TO
EXTREME WEATHER EVENTS

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INTRODUCTION

Climate change significantly impacts human health, and adapting to and mitigating its effects is a recognized public health issue [1, 2]. Extreme Weather Events have become one of the most critical issues with visible impacts on public health. The COP28 climate and health declaration calls for strengthening health systems' capacity to address climate-sensitive health risks. It emphasizes the need for surveillance, early warning systems, response systems, intersectoral collaboration, and worldwide knowledge sharing [2]. The International Association of National Public Health Institutes (IANPHI) contributes to this adaptation through its thematic committee on climate change and public health. This committee advocates for prioritizing health and well-being in climate mitigation and adaptation strategies and for strengthening the role of National Public Health Institutes (NPHIs) as providers of science-based evidence for climate policy development [1].

This resource, developed by the IANPHI thematic committee on **climate change and public health**, aims to frame the need for transformative change to respond to Extreme Weather Events (EWEs).

EXTREME WEATHER EVENTS (EWEs) AND THEIR HEALTH IMPACTS

EWEs are among the most concerning climate-related risks. In its sixth assessment report, the Intergovernmental Panel on Climate Change (IPCC) underlined that health impacts due to EWEs were already observed worldwide and were expected to increase. The IPCC concluded that there is a significant adaptation gap in responding to EWEs [3]. EWEs have a significant impact on public health: the World Meteorological Organization reported that between 1970 and 2021, extreme weather, climate and water-related events caused over 10,000 disasters, 2 million deaths and US\$ 4.3 trillion in economic losses.¹

Thereby, NPHIs have a vital role to play in responding to the human health impacts of EWEs through their work in monitoring, alerting, and supporting crisis preparedness and response [4]. Emergency management during EWEs is an essential public health function. However, other professionals involved in EWEs responses, from decision-makers to researchers, often overlook the critical role of NPHIs. Additionally, the focus of NPHI involvement is often limited to protection of the population,

¹ <https://wmo.int/news/media-centre/economic-costs-of-weather-related-disasters-soars-early-warnings-save-lives>.

immediate surveillance, and early warning actions. Consequently, many essential public health functions, such as health promotion or advocacy to consider health in sectoral policies remain untapped as levers for developing genuine adaptation strategies for EWEs. These adaptation strategies must be part of transformative change strategies.

Transformative change is defined by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services as a fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values. It is essential to act simultaneously on climate change, biodiversity loss, other environmental and social crises, and to support intra and intergenerational health and well-being.

This resource illustrates how NPHIs already contribute to transformative adaptation, tackle challenges, and proposes ways forward. It is not intended to provide a comprehensive review of the impacts and responses to EWEs, related NPHI actions, or their evaluation but rather to provide some key examples of how NPHIs contribute to strengthening health systems' resilience in light of the climate crisis.

Approaches to considering EWEs can vary. One approach focuses on the specific characteristics of each event, such as its spatial and temporal scope, destructive capacity, and types of immediate and deferred risks. Another approach considers the vulnerabilities populations face, like inequities in exposure and adaptive capacities, susceptibility, and access to care. This resource takes a different approach, focusing on the tools that NPHIs can mobilize to prevent public health problems before, during and after EWEs. This aligns with a key priority of the IANPHI roadmap for Action on Health and Climate Change (1): to show how NPHIs can contribute to climate action through their core functions. These functions fall under three complementary priorities: 1) monitoring and evaluation, 2) protecting, promoting and educating, and 3) responding and facilitating action.

THE NEED FOR TRANSFORMATIVE CHANGE TO PROTECT PUBLIC HEALTH IN THE FACE OF EWEs

While EWEs are becoming "the new norm" [5], societies remain largely unprepared to adequately address them. The years 2015-2023 were the nine warmest years on record for global temperature, marked by an increase in severe EWEs with serious consequences for human societies and natural ecosystems. Unprecedented land and ocean warming, record-breaking storms, rains, floods, droughts, heatwaves, marine heatwaves, and wildfires have been observed worldwide [6-8]. The 2023 Lancet Countdown documented a sharp rise in the number of people exposed to extreme heat,

drought, or fire danger. For instance, heat-related deaths of people older than 65 years have increased by 85% compared to 1990-2000, with climate change being the primary driver [9]. Some recent EWEs would have been highly unlikely without climate change, such as the extreme heat events in the Mediterranean (April 2023), India (April-June 2023 and March-April 2022), the United Kingdom (July 2022), North America (June 2021), and Siberia (June 2020) [10-14]. Others were significantly aggravated by climate change, such as the 2020-2022 drought in the Horn of Africa [15], the June-August 2022 rainfall and floods in Pakistan [16], and the 2023 forest fires in Eastern Canada [17].

The IPCC's 6th Assessment Report highlighted how human activities influence EWEs and increase the probability of observing compound and/or concurrent events [3]. Unsustainable land use, lack of preparedness and governance, and limited understanding of structural risk factors further exacerbate the adverse impacts of EWEs [3].

EWEs have both immediate and long-lasting severe impacts that require rapid adaptation solutions. While climate change affects the entire planet, the impacts of EWEs are unevenly distributed across regions and populations. Some areas are simultaneously facing other crises, such as socio-economic crises, geopolitical conflicts, or population displacement. Urgent action is needed to address these interrelated and complex crises and to move towards societies where "all members of current and future generations can thrive on a healthy planet" [18].

While the immediate destruction of infrastructure and associated impacts of EWEs on mortality and morbidity attract media attention, the overall health impacts can be much broader and are largely underestimated and underreported. EWEs can have long-lasting physical and mental health consequences, even in locations far from the initial event. Exposure to wildfire smoke, decreased food production, and disrupted livelihoods and economies all contribute to these impacts [3, 19, 20]. Additionally, EWEs can trigger internal and external migration, displacing over 20 million people annually [21]. Despite these widespread effects, a global understanding and vision for addressing EWEs' health impacts and preparedness strategies is lacking. This gap limits our ability to develop efficient long-term transformative strategies. Therefore, a vision for transformative change is urgently needed.

EWEs demand a highly proactive approach in terms of anticipation, warning, and response. The immediate devastation and suffering they cause understandably elevates the importance of short-term solutions. However, the desire for rapid rebuilding can risk neglecting long-term health effects, overlooking psychological trauma, and failing to prioritize equitable and sustainable reconstruction. In the worst-case scenario, maladaptive solutions might be chosen that exacerbate future vulnerabilities or increase greenhouse gas emissions further.

Strengthening disaster preparedness, emergency response, and early warning systems are crucial examples of how NPHIs can help society adapt to EWEs. These actions should be integrated into a more comprehensive strategy known as transformative change. This approach goes beyond simply

adjusting existing practices and aims for "significant changes in structure or function" [22]. From a public health perspective, transformative change focuses on addressing the fundamental determinants of health, reducing health inequities, and strengthening health promotion. Examples of this approach include building climate-resilient health care systems and universal health coverage, as highlighted by the IPCC [22]. Furthermore, a recent analysis of health crises in Canada emphasized health promotion as a key element in adapting to EWEs [23]. Ultimately, transformative change should not only address immediate EWEs impacts but also contribute to the significant changes needed to reduce greenhouse gas emissions, protect biodiversity, and ensure a healthy and equitable future for all as stated in the IANPHI roadmap on Climate Change and Public Health.

ESSENTIAL PUBLIC HEALTH FUNCTIONS AS TOOLS TO SUPPORT TRANSFORMATIVE CHANGE OF EWEs

Table 1 highlights the various actions NPHIs can take before, during and after EWEs as well as their connection to the essential public health functions (EPHFs). EPHFs encompass a broad view of health, spanning emergency response to social mobilization efforts such as health promotion, community engagement, and knowledge sharing [24]. These functions complement primary care and are crucial for building long-term health system resilience, promoting equity, and addressing population health needs [25]. Therefore, EPHFs should be central tools for achieving transformative change.

Table 1 – Key actions taken by NPHIs in response to EWEs

		Continuous process, before and after EWEs	Response during EWEs
Monitor and evaluate	Key needs	<ul style="list-style-type: none"> Assess the potential risk and impacts Understand the determinants of risks Anticipate emerging risks Evaluate adaptive interventions Avoid maladaptation 	<ul style="list-style-type: none"> Assess health risks Monitor health impacts
	Related EPHFs	<p><i>Public health surveillance and monitoring: monitoring and surveillance of population health status, risk, protective and promotive factors, threats to health, and health system performance and service use.</i></p> <p><i>Public health research and knowledge: advancing public health research and knowledge development.</i></p>	

Protect, Promote and educate	Key needs	<p>Assess health care and adaptation capacities</p> <p>Reduce the structural determinants of vulnerability</p> <p>Build knowledge on relevant interventions, and disseminate actionable knowledge and guidelines through building a climate-smart health workforce</p> <p>Raise public awareness</p>	<p>Provide advice to the general population and to (health) professionals</p> <p>Organize emergency response and access to key resources</p>
	Related EPHFs	<p><i>Disease prevention: prevention and early detection of communicable and non-communicable diseases including mental health conditions, and injuries.</i></p> <p><i>Health promotion: promoting health and well-being as well as actions to address the wider determinants of health and inequity.</i></p> <p><i>Community engagement and social participation: strengthening community engagement, participation and social mobilization for health and well-being.</i></p> <p><i>Public health workforce development: developing and maintaining an adequate and competent public health workforce.</i></p> <p><i>Health service quality and equity: improving the appropriateness, quality, equity in provision and access of health services.</i></p> <p><i>Access to and use of health products, supplies, equipment and technologies: promoting the equitable access to and rational use of safe, effective and quality assured health products, supplies, equipment and technology.</i></p>	
Respond and facilitate action	Key needs	<p>Develop relevant early warning systems</p> <p>Train public health workforce and relevant stakeholders</p> <p>Develop tools to strengthen population resilience against EWEs at regional and local level (capacity building)</p>	<p>Communicate timely information</p> <p>Collaborate/Contribute to early warning systems</p>
	Related EPHFs	<p><i>Public health emergency management: managing public health emergencies.</i></p> <p><i>Public health stewardship: establishing effective public health institutional structures, leadership, coordination, accountability, and regulations and legislations.</i></p> <p><i>Multisectoral planning and financing for public health: supporting effective and efficient health systems and multisectoral planning, financing and management for public health.</i></p> <p><i>Health protection: protecting populations against health threats, including environment and occupational hazards, communicable and non-communicable diseases including mental health conditions, food insecurity, chemical and radiation hazards.</i></p>	

HOW NPHIs CAN BETTER CONTRIBUTE TO THE RESPONSE AND CHANGE TO CLIMATE-DRIVEN EWEs: SELECTED CASE STUDIES

The following section explores key actions undertaken by NPHIs, drawing on real-world examples from various institutions. These case studies are not intended to be an exhaustive list, but rather illustrate the range of situations NPHIs encounter. It is important to remember that NPHIs operate within their specific national contexts and core missions, which influence their activities. Additionally, each country has its own definitions and classifications for EWEs, leading to variations in the specific actions taken. The case studies illustrating the diverse ways NPHIs contribute to public health transformative change during EWEs demonstrate the vital role they play in protecting public health in the changing climate.

NPHIs CAN MONITOR AND EVALUATE THE SHORT AND LONG-TERM IMPACTS OF EWEs

NPHIs operate specialized syndromic surveillance systems that deliver regular and timely updates on population health. These systems collect data directly from healthcare providers (e.g., emergency departments, general practitioners, hospitals) typically with a very short delay (around 24 hours). They capture detailed information on diseases, symptoms, demographics like age and sex, and even the timing of consultations. This near-real-time data is crucial for several reasons: assessing potential risks, informing real-time crisis response, and evaluating the health impacts after an event.

Surveillance data also plays a vital role in attracting media attention and raising public awareness of the risks and impacts of EWEs. Additionally, this data serves as a key foundation for further research into the determinants of risk, enabling the development of evidence-based prevention strategies. Surveillance data can also be used as evidence of impact and thus for the evaluation and improvement of policies.

Case Study 1

Monitoring Forest Fire Impacts in Quebec, Canada

The Quebec Public Health Institute (INSPQ) has extensive experience monitoring and communicating risks of climate change impacts on population health, particularly heatwaves, floods, ice storms, pollen allergies and zoonoses. They initiated in 2019 the conduct of vulnerability assessments and are in the process of identifying public health adaptation measures to be prioritized. They also work to reduce health inequities through social determinants of health (SDOH). In 2023, Quebec faced an unprecedented forest fire season. INSPQ actively evaluated air quality throughout the province several times a day during the acute phase, communicating risks to public health authorities and monitoring health indicators such as visits to emergency departments for respiratory and cardiovascular issues in real-time. They also played a crucial role in supporting regional health authorities with decisions regarding evacuations, particularly for vulnerable populations. In the first half of 2024, INSPQ is assessing the short-term as well as longer term health impacts of these evacuations through physical, psychological and socioeconomic indicators, with a focus on vulnerable populations. These assessments will help decision making to improve interventions before, during and after such EWE.

Case Study 2

Monitoring Heat-Related Health Effects in Germany

In July 2023, the German Federal Ministry of Health adopted its first heat protection plan for health in response to increasing concerns about the risks that heatwaves pose to health and wellbeing. The Robert Koch Institute (RKI), Germany's NPHI, was one of several key contributors to the plan. A central focus of the plan is monitoring heat-related mortality to provide timely information and identify trends throughout summer 2023. The RKI published weekly reports on heat-related mortality by age group and gender, generating significant media interest and leading to over 10,000 downloads. To support informed interpretation by the media, public and stakeholders, RKI also published Frequently Asked Questions (FAQs) on heat and heat-related mortality reporting on their website. The RKI continues to support the German Ministry of Health with national heat protection planning and ongoing monitoring efforts. Additional monitoring of heat-related morbidity and reporting of regional heat-related mortality in future will be explored.

Case Study 3

Responding to Climate-Induced Flooding in Skopje, North Macedonia

North Macedonia established a National Climate Change Health Adaptation Strategy and Action Plan (2011) to proactively address health risks and challenges arising from climate change. This strategy involved collaboration between various stakeholders, including the Ministry of Health, the National Public Health Institute, and the Institute of Occupational Health.

In August 2016, Skopje, the capital city, experienced a devastating flood caused by an extreme weather event. The torrential rain led to flash floods, causing significant property damage and tragically claiming 22 lives. While the Crisis Management Center coordinated emergency response efforts, the Ministry of Health and the Institute of Public Health focused on providing healthcare and addressing stress-related consequences among those affected. Additionally, essential supplies were distributed, and disinfection and pest control measures were implemented in impacted areas. The Institute of Public Health played a critical role in these efforts through epidemiological surveillance, environmental pollution investigation, well disinfection, activity coordination, and overall evaluation of the response. This case study highlights the importance of a robust public health sector capacity for implementing preventative interventions and collaborating with other sectors to mitigate health risks associated with climate change and EWEs.

NPHIs CAN ORGANIZE RAPID ACCESS TO BASIC HEALTH CARE DURING AND IN THE AFTERMATH OF EWEs

Extreme weather events (EWEs) can cause widespread disruption to healthcare infrastructure and services. This can leave communities struggling to access basic medical care precisely when it's needed most. NPHIs play a vital role in ensuring people receive the healthcare they need during and after EWEs.

Case Study 4

Rapid Healthcare Access after Hurricane Irma in the French territories of Saint-Martin and Saint-Barthelemy

Hurricane Irma, one of the most powerful Atlantic hurricanes ever recorded, struck the French territories of Saint-Martin and Saint-Barthelemy on September 6, 2017, registering as a Category 5 storm on the Saffir-Simpson Hurricane Wind Scale. The devastation extended beyond infrastructure damage, significantly impacting health and social conditions. Santé Publique France, the French national public health agency, actively engaged in the response, providing logistical, pharmaceutical, health, and epidemiological support. This included deploying expertise and reinforcements through the Health Care Reserve, a program that strengthens local healthcare capacity by mobilizing professional resources.

Between September 7 and December 30, 2017, the Health Care Reserve deployed 548 professionals, ranging from logisticians to emergency doctors, in three phases: initial situation assessment, reinforcement of healthcare services in affected facilities, and long-term support for healthcare delivery in Saint-Martin.

Additionally, Santé Publique France utilized the national strategic health stockpiles to send 12 tons of vital supplies (vaccines, medicines, etc.) and support vector control and water purification efforts. The agency also played a crucial role in monitoring the health impacts of the hurricane. It established a targeted epidemiological surveillance system focusing on 18 health conditions identified as potential risks post-Irma. Furthermore, Santé Publique France developed and disseminated prevention messages through local radio broadcasts and flyers to raise public awareness of health risks. Its long-term commitment extended to monitoring the mental health of healthcare professionals who participated in managing this exceptional health crisis.

NPHIs CAN DEVELOP EARLY WARNING SYSTEMS IN COLLABORATION WITH INTERDISCIPLINARY PARTNERS

EWEs pose a significant threat to public health. NPHIs are playing a crucial role in mitigating these risks through the development of early warning systems and fostering collaboration among various stakeholders.

Case Study 5

The UK Health Security Agency's Adverse Weather and Health Plan

In 2023, the UK Health Security Agency's Extreme Events and Health Protection team launched the Adverse Weather and Health Plan (AWHP). This ambitious initiative represents a significant step forward in protecting public health from the risks associated with extreme weather events (EWEs). The AWHP builds upon existing measures implemented by the government, NHS England, and local authorities. It streamlined previous standalone plans for heatwaves and cold weather into a comprehensive program aligned with the UK's National Adaptation Programme (NAP), ensuring a coordinated national response. Thus, the plan integrated, built on and replaced the Heatwave and Cold Weather Plans for England, including an overview of the scientific evidence underpinning the AWHP, associated guidance materials for flooding and hot and cold weather, and the new impact-based Weather-Health Alerting system.

A cornerstone of the AWHP is the innovative Weather-Health Alerting System (WHA), launched in June 2023. This system moved beyond simply providing warnings for adverse weather conditions. It integrates weather data with potential health impacts to deliver alerts categorized by severity (green, yellow, amber, red). This allows local authorities to make informed decisions about preparedness and response activities.

The decision-making process utilizes temperature thresholds as decision-making aids, considering various factors such as concurrent risks, time of year, event duration, and likelihood of escalation amongst many other contextual factors. This flexibility allows for a detailed assessment of the potential impacts due to adverse weather. The system collaborates with the National Severe Weather Warning Service (NSWWS) for extreme heat, ensuring alignment and providing a cohesive message to users.

Case Study 6

Mozambique NPHI's Seasonal Risk Mapping and Disease Forecasting

In Mozambique, the rainy season triggers predictable increases and potential outbreaks of climate-sensitive diseases, such as malaria and diarrheal diseases. To proactively address these risks, the Mozambique National Public Health Institute (INS) has implemented a robust seasonal risk mapping and disease forecasting program. A central element of this program is the Climate, Environment and Health Platform. This virtual platform fosters collaboration between various stakeholders, including meteorological agencies, water

resource agencies, disaster management agencies, and other relevant experts. By integrating climate data with epidemiological data, they can forecast potential outbreaks of these diseases. Furthermore, INS utilizes a mathematical model that analyzes historical climate and disease data. This model allows them to predict the likelihood of outbreaks during the rainy season with a high degree of accuracy (90% precision as evaluated). These predictions are then incorporated into national contingency plans for the rainy and cyclonic seasons, enabling a proactive approach to resource allocation and preventative measures.

NPHIs CAN DEVELOP STUDIES TO UNDERSTAND THE DETERMINANTS OF RISKS

NPHIs play a crucial role in managing health risks associated with EWEs. Their expertise extends beyond treating illnesses to identifying the underlying environmental and social determinants of these risks. This knowledge empowers them to develop targeted responses, including *ad hoc* surveillance system, mapping of vulnerable populations, and targeted risk communication.

Case Study 7 Multisectoral Response to Cholera Outbreak in Zambia

Zambia recently faced a severe cholera outbreak, the worst in over five decades, with over 14,000 cases and 500 deaths reported by January 25, 2024. While cholera is primarily viewed as a health issue, the Zambia National Public Health Institute (ZNPHI) recognized the significant role environmental factors play in outbreaks and the need for a multisectoral approach to disease outbreak response.

One crucial element contributing to the outbreak was El Niño's impact on weather patterns. The Zambia Meteorological Agency (ZMA) had previously issued an advisory predicting El Niño-induced increased rainfall. Studies have shown a correlation between such increased rainfall and cholera outbreaks.

The ZNPHI, leveraging its expertise in environmental determinants of health, actively incorporated this information into its response strategy. Furthermore, recognizing the importance of clean water access in preventing cholera transmission, the ZNPHI factored in the potential for flooding to contaminate water sources.

Case Study 8

Mapping Vulnerable Populations in the Netherlands

Extreme weather events (EWEs) can disproportionately impact certain populations. Recognizing this, the Netherlands Institute for Public Health and the Environment (RIVM) embarked on a project to identify vulnerable populations in the context of climate change. A particular concern in the Netherlands is the potential for heatwaves to endanger older people. To address this, RIVM collaborated with other organizations to identify which neighbourhoods have the most vulnerable older residents, so adaptation measures can be targeted accordingly. This resulted in the mapping of frailty in those aged 65+ for all neighbourhoods in the Netherlands. Frailty is a common condition in older people and refers to a decline in one or more health domains (i.e. physical, psychological or social) which can increase the risk of adverse health outcomes e.g. due to heatwaves. To map frailty, RIVM used the frailty index developed by Kleinenberg-Talsma et al., (2023) which was based on the results of the Dutch public health monitor [28]. This index goes beyond simple demographics. Thirty-seven questions regarding physical, psychological and social health were used to construct the frailty index which was subsequently mapped. The resulting online maps depict the percentage of residents aged 65+ classified as frail across various geographic levels (municipality, district, neighborhood) and across the three frailty domains (physical, psychological and social frailty). This granular detail allows municipalities to identify suitable interventions and target these towards neighborhoods with the highest concentrations of frail older residents. Furthermore, the maps can be overlaid with additional data layers, such as green spaces or urban heat islands. This allows for a more comprehensive understanding of vulnerability and facilitates the development of targeted adaptation measures.

The value of the frailty index was demonstrated in a recent study by municipal public health services [29]. The study found a strong correlation between frailty and limited ability to cool down during the 2020 summer heatwave. Regarding poor ability to cool down in the home, the association was greater with social and psychological frailty than with physical frailty. Regarding poorer opportunities for cooling down in the garden or neighbourhood, there was a greater association with physical frailty than with the other frailty domains. This underscores the importance of identifying vulnerable populations and tailoring heat adaptation strategies accordingly. Municipalities should also align their adaptation measures with existing policies on tackling loneliness, healthy ageing and reducing health inequalities [29].

Case Study 9

Risk Communication for EWEs-Related Diseases in Nigeria

The Nigeria Centre for Disease Control and Prevention (NCDC) is Nigeria's National Public Health Institute responsible for the prevention of and response to public health emergencies. While not currently involved in crafting national climate policies, the NCDC leverages its communication expertise to raise awareness about the link between climate and disease outbreaks. Nigeria faces a recurring challenge with cholera outbreaks, often following periods of heavy rainfall and flooding [30]. Recognizing this connection, the NCDC integrated climate risk mitigation messaging into its communication strategies for cholera. They emphasized the importance of proper sanitation and hygiene practices to prevent the spread of waterborne diseases during floods. Similarly, Nigeria experiences increased risk of Lassa fever outbreaks during dry seasons. The NCDC highlights the connection between dry seasons, bush-burning practices, and the displacement of rodent populations, which are natural reservoirs of the Lassa fever virus. This knowledge empowers communities to take preventive measures such as proper food storage and avoiding contact with rodents. By integrating climate information into its communication strategies, the NCDC empowered Nigerians to understand and mitigate the health risks associated with EWEs. Additionally, the NCDC's established partnerships with various levels of government, the private sector, and communities position them for a potentially expanded role in future climate adaptation and mitigation efforts.

NPHIs CAN DEVELOP OR CONTRIBUTE TO LONG-TERM INTERSECTORAL CHANGE STRATEGIES

NPHIs are at the forefront of efforts to prepare for and adapt to the health risks associated with EWEs. Several NPHIs are actively engaged in ambitious planning to combine multiple EPHFs and engage with a wide range of stakeholders to support the work of adaptation to EWEs.

Case Study 10

Heat Health Action Plan in Austria

Aligned with World Health Organization (WHO) standards, Austria's national heat health action plan serves as a framework for developing more localized plans at the state and

municipal levels. This comprehensive plan outlines a set of standard measures, including the implementation of early warning systems and targeted public awareness campaigns. These campaigns prioritize informing vulnerable populations about the health risks associated with heatwaves and promoting protective behaviors.

The revision process of Austria's national heat action plan underscores the importance of intersectoral collaboration and expertise. Led by the National Public Health Institute, this effort involves a diverse group of stakeholders, including the Austrian meteorological service, state health funds, the national Austrian Agency for Health and Food Safety, the Austrian Chamber of Pharmacists, the Austrian Broadcasting Corporation, and representatives from various healthcare professions. This collaboration ensures access to essential data, diverse perspectives, and effective communication channels, all of which are crucial for developing and implementing a comprehensive heat action plan. [32, 33] To ensure a complete public health response during heatwaves, Austria's updated national heat action plan emphasizes the development of integrated health-climate information systems. This system will achieve the following:

- Improved heat stress monitoring and evaluation: timely and accurate weather alerts from the Austrian Meteorological Service (GeoSphere Austria) will be integrated with healthcare structures at various levels (federal states and beyond).
- Targeted data for at-risk populations: the system will provide healthcare providers with relevant data on pre-defined vulnerable groups.
- Structured heat protection measures: healthcare settings will implement structured protocols for protecting patients and staff during heatwaves.
- Comprehensive public communication: effective information and communication strategies will be employed to educate the general population about the risks and protective measures.

Case Study 11 Finland's Climate Change Adaptation Plan

Finnish Institute for Health and Welfare (THL) played a critical role in developing a robust Climate Change Adaptation Plan of the Ministry of Social Affairs and Health (2021-2031) [34]. This plan serves as a cornerstone for systematic adaptation measures, ensuring the continued effectiveness of healthcare and social welfare systems in the face of a changing climate.

The Adaptation Plan outlines a multi-pronged approach encompassing over 90 specific actions. A key component is the establishment of a heatwave warning system, allowing for timely interventions to mitigate the health risks associated with extreme heat events. Additionally, the plan emphasizes the development of clear guidelines and actionable

plans, equipping healthcare and social care sectors with the tools and strategies necessary for effective adaptation. Recognizing the importance of ongoing evaluation, the plan incorporates research initiatives to assess the health impacts of climate change and the effectiveness of implemented adaptation measures. This data-driven approach allows for continuous improvement and ensures strategies remain relevant in the face of evolving threats. Furthermore, the plan fosters intersectoral collaboration, acknowledging that a coordinated response across various sectors is crucial for successful adaptation. By working together, different government agencies, NGOs, and public health experts can combine their expertise to develop and implement comprehensive solutions. Education, training, and communication are also prioritized within the plan. Raising public awareness about the health risks associated with climate change empowers individuals to take protective measures. Likewise, building capacity within the healthcare system ensures healthcare professionals are well-equipped to address the health challenges posed by the changing climate.

THL's contributions extend beyond the Ministry's plan. They were also instrumental in developing the National Climate Change Adaptation Plan until 2030 [35]. This broader plan establishes a national framework for adaptation across all sectors, including a risk and vulnerability assessment, long-term goals, and a monitoring system to track progress. With a specific focus on health protection, the national plan aims to achieve several key objectives. Recognizing the dangers of heatwaves, the plan prioritizes raising awareness about their health impacts. Additionally, it emphasizes the importance of multi-level adaptation, fostering the development of effective strategies at various levels of governance (national, regional, local). Finally, the plan highlights the need for enhanced monitoring, calling for the establishment of a robust heat mortality monitoring system to track heat-related deaths.

Case Study 12

India's National Programme on Climate Change and Human Health

India's National Public Health Institute stands at the forefront of implementing the National Programme on Climate Change and Human Health. This program utilizes a multi-tiered approach, leveraging nodal officers and multisectoral task forces at state and district levels. This structure facilitates seamless integration of various health sector adaptation measures.

Public awareness campaigns are a core aspect of the program, educating communities about the health risks associated with EWEs. The NPHI takes a proactive stance through annual pre-summer training programs, equipping healthcare workers with the skills

necessary to manage and monitor heat-related illnesses, and develop effective heat action plans. Additionally, seasonal measures like establishing heat stroke rooms and ORS distribution points are implemented to address specific climate threats like extreme heat [36].

Proactive public health communication is another key component. Public health advisories and guidance documents on health sector preparedness are disseminated before the start of key seasons (summer, monsoon). The program further strengthens community resilience by providing health departments with content for routine and enhanced campaigns addressing various EWEs risks, including heatwaves, floods, and cyclones. Recognizing the importance of infrastructure resilience, the program facilitates the implementation of green and climate-resilient infrastructure measures within public health facilities through technical and financial support. This ensures the uninterrupted delivery of essential services during EWEs [37].

Flood resilient family health centers and solarized primary health care facilities from a southern and a central state, respectively have emerged as models of quality, holistic, primary health care delivery through climate change focused health system strengthening.

STRENGTHENING NPHIS FOR CLIMATE ADAPTATION: A CALL TO ACTION

NPHIs play a vital role in anticipating, assessing, and preventing the health impacts of EWEs, positioning them as key players in climate adaptation. To further empower NPHIs in this crucial task, the IANPHI thematic committee on climate change and public health urges action on several strategic points:

SECURING RESOURCES FOR NPHIs

Organizing, advocating for and securing sufficient and permanent human resources and funding to enable NPHIs to address EWEs effectively. These resources are essential for developing long-term strategies, fostering intersectoral partnerships, and transitioning from reactive to transformative change.

BRIDGING KNOWLEDGE GAPS THROUGH INTERDISCIPLINARY RESEARCH

Developing evidence-based change strategies, several critical knowledge gaps require attention:

- Monitoring and investigating the impacts of extreme heat, particularly in the Southern Hemisphere and low-income countries.
- Understanding the health effects of EWEs on specific populations (such as pregnant women, workers) and implementing effective strategies to mitigate these impacts.
- Harmonizing labeling criteria, monitoring, and reporting of EWE's mortality impacts worldwide.
- Building a better understanding of the medium- and long-term health effects of EWEs, including indirect and systemic impacts on food systems and ecosystems. This research should encompass high, middle and low-income countries.
- Conducting economic evaluations of systemic health impacts to bolster investments in change and mitigation strategies.
- Shifting research towards action-oriented solutions, focusing on operational issues, facilitating experience feedback, and promoting good practice sharing. This includes research on preparing for cascading crises, maintaining health surveillance during infrastructure damage, and limiting public warning fatigue.
- Increasing skills of public health professionals on climate adaptation.
- Engage professionals in NPHIs to prioritize transformative change to respond to climate adaptation.

FOSTERING COLLABORATION AND KNOWLEDGE EXCHANGE

With adequate resourcing, NPHIs and IANPHI, aligning with the IANPHI climate change and health roadmap, can continue to play a crucial role in facilitating knowledge exchange and capacity building through meetings, webinars, and working groups.

Developing strategic partnerships with institutions relevant to transformative change and climate adaptation should continue to be fostered.

BUILDING STRATEGIC PARTNERSHIPS

With adequate resourcing, NPHIs and IANPHI can continue to actively initiate discussions, including through its thematic committees, with key organizations like the European Environment Agency, World Health Organization, World Meteorological Organization, and the Global Heat Health Information Network. These partnerships aim to build alliances, develop joint projects, and streamline information sharing.

AUTHORS

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