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A New Integrative Perspective on Early Warning Systems for Health in the Context of Climate Change.

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Abstract

Climate change causes or aggravates a wide range of exposures with multiple impacts on health, both direct and indirect. Early warning systems have been established to act on the risks posed by these exposures, permitting the timely activation of action plans to minimize health effects. These plans are usually activated individually. Although they show good results from the point of view of minimizing health impacts, such as in the case of high temperature plans, they commonly fail to address the synergies across various climate-related or climate-aggravated exposures. Since several of those exposures tend to occur concurrently, failure to integrate them in prevention efforts could affect their effectiveness and reach. Thus, there is a need to carry out an integrative approach for the multiple effects that climate change has on population health. This article presents a proposal for how these plans should be articulated.

The proposed integrated plan would consist of four phases. The first phase, based on early warning systems, would be the activation of different existing individual plans related to the health effects that can be caused by certain circumstances and when possible corrective measures would be implemented. The second phase would attempt to quantify the health impact foreseen by the event in terms of the different health indicators selected. The third phase would be to activate measures to minimize the impact on health, via population alerts and advisories, and additional social and health services, based on the provisions in phase two. Phase four would be related to epidemiological surveillance that permits evaluation of the effects of activating the plan. We believe that this integrative approach should be extended to all of the public health interventions related to climate change.

Keywords:

Early Warning Systems; Integrative Plans; Climate Change and Health.

1. Introduction

Both the drivers of climate change, as well as its impacts, severely affect health at a global level. Fossil fuel burning (a major driver of climate change) crucially contributes to the 7 million annual deaths from outdoor and indoor air pollution, whereas climate-related risks and exposures are bound to threat many aspects of the societies we live in, severely affecting health (WHO, 2018).

The causality between some climate-influenced direct exposures and health outcomes is well-established and understood, such as the impact of heat waves on mortality (Carmona et al., 2016; Martinez et al., 2019; Linares et al., 2020) and -with more heterogeneity- also on population morbidity (Cheng et al., 2019; Linares, Culqui, Carmona, Ortiz, & Díaz, 2017). Others, such as the impact of heat waves on car accidents, work-related accidents, and mental health or violence are still to be fully explained. Mental health disorders, for example, seem to be influenced by climate change mainly in relation to the loss of homes or uninsured economic losses due to extreme weather events, droughts or the rise in sea level but in the practice this issue is largely unexplored (Watts et al., 2018).

Changes in vector borne diseases and their geographic redistribution (Ebi et al., 2018; Linares et al., 2020) are another of the risks of climate change on human health whose influence will be exacerbated in Europe (Cramer et al., 2018), as will food-borne and water-borne, expected to increase in coming years as a consequence of the increase in global temperature (Kovats et al., 2004; Ciscar, Feyen, Lavalle, Soria, & Raes, 2014).

Indirectly, climate change also affects the concentrations of air pollution present in large cities, reducing ventilation and pollutant dispersion or through the elimination of processes of troposphere-stratosphere exchange of ozone (Linares et al., 2020). It influences the increase in forest fires with a clear impact on the health of citizens (Linares et al., 2018), and increases concentrations of tropospheric ozone as a consequence of the temperature increase. Mineral dust advection can also be affected by atmospheric dynamics, especially in Europe, where in recent years an increase has been detected in PM10 concentrations in the Eastern Mediterranean as a consequence of dust storms (Krasnov et al., 2016). These desert dust intrusions have a clear effect on, not only through the increase in PM10 concentrations, but also through the increase in other pollutants (Moreira et al., 2020, Pandolfi et al., 2014).

2. The Need for Integrated Prevention and Action Plans for Climate Change and Health

All of these risks require implementation of health policies aimed at reducing population vulnerability and the design of early warning systems that serve to take action and put in place prevention plans.

For example, in the case of heat waves, prevention plans together with different heat adaptation processes) have proven to have excellent results in terms of reducing the impact of morbidity and mortality related to temperature extremes (Linares et al., 2020).

In the case of air pollution, strategies have been designed independently to minimize the impact on health beyond those related to the limitation of emissions. Some cities implement health warning systems for air quality that allow for detection of the percent of population exposed to air pollution levels above the levels recommended by WHO , in addition to the annual mortality attributable to pollution for each pollutant. These types of plans frequently include the periodical determination of the impact of different atmospheric pollutants on morbidity and mortality on a daily basis.

Pollen alert systems are also frequently operated in connection with allergic disorders, which are experiencing an important increase in prevalence around the world and will be intensified in the context of climate change and as a consequence of their synergistic effect with air pollution (Gutierrez-Bustillo & Cervigon-Morales, 2012).

From the point of view of the implications for health, this fragmented perspective is insufficient, given that the majority of risk factors are interrelated. For example, the heat waves in the South of Europe usually take place on days with Saharan dust advection (Garcia-Herrera et al., 2010). On these days, due to the provision of particulate matter, there is less insolation and therefore a decrease in the height of the mixing layer, which brings about a lower dispersion of pollutants and an increase in concentrations, not only of PM but also of primary contaminants such as NO_2 (Moreira et al., 2020, Pandolfi et al., 2014). The advection of dry and hot air produces an increase in temperature favors the formation of tropospheric ozone (Moreira et al., 2020), and the low humidity and high temperatures promote forest fires. In Spain, synoptic scale weather situations that favor Saharan dust intrusion are the same as those present in forest fires (Díaz et al., 2017), adding PM from biomass combustion to that from mineral dust and further exacerbating effects on health (Analitis et al., 2012;

Linares et al., 2015; Linares et al., 2018). Further, if these conditions are prolonged in time, they favor periods of drought with further implications for health (Salvador et al., 2020).

Public health warning systems related to climate change therefore should not focus only on a single indicator that serves to activate a determined action plan; rather they should incorporate different indicators that reflect the relationship that exists between different exposures and related health problems, thus protecting human health in an integral way.

Such surveillance systems and their corresponding action plans must be designed for local circumstances the public health characteristics pertaining to each population. The Barcelona Public Health Agency's planned integrated system is an example of public health surveillance systems that integrate multiple factors related to climate change. Based on prior studies carried out in the city (Villalbi & Ventayol, 2016) the proposed surveillance system brings together in a single framework a variety of aspects that tend to influence population health in the context of climate change (Mari et al, 2019). Some of the indicators that are considered as a part of this system are the following (Table 1).

3. Integrated Prevention and Action Plan on Climate Change and Health

A proposal for an Integrated Prevention and Action Plan on Climate Change and Health would aim at jointly activating individual plans that have already been developed but are not connected. Such integrated plans would include different phases or stages of action (Figure 1).

Phase 1: Activation of the Plan. Based on available forecasts of different selected indicators and exceeding the thresholds defined by the indicators that are a part of the health surveillance system, the Integrated Plan would be activated, with evaluation of the activation of individual plans. Corrective measures would be adopted, when possible, to avoid activating the next phase of the Plan.

For example, a Heat-Health Action Plan is often based on maximum daily temperature predictions, and when temperatures exceed a determined temperature threshold corrective measures could be adopted. But if the heat wave is produced due to Saharan dust advection, as is common in Southern Europe, corrective measures would be activated that aim to diminish the omissions of anthropic origin so that the arrival of natural-origin PM concentrations does not trigger exceeding public health protection levels for chemical air pollutants. Furthermore, in the case of heat waves, surveillance of levels of tropospheric ozone (and, when needed, of exceeding threshold levels) and activation of existing prevention plans is especially important.

Another example of the activation of the Integrated Plan would be in the case of an alert prompted by high predicted levels of a determined pollen species. In this case, exclusive alert protocols for the type of pollen in question should also be activated, in addition to those related to chemical air pollution that exacerbate allergies. In this way, health impacts would be minimized by decreasing the possible effects of other, associated variables on those variables on which it is possible to act.

To summarize, in phase 1 the existing single-exposure prevention plans would be activated based on the existing indicators and predictions in the surveillance system. The body in charge of activating the Plan must be the Ministry or National/Federal Department of Health (or otherwise the department responsible for the surveillance system). The Plan would be activated based on the atmospheric or meteorological predictions from the national Meteorological Agency or the responsible institution.

Phase 2: Evaluation and assessment of health impacts. The impact on health related to the phenomenon that provokes plan activation should be estimated as well as all of the possible associated impacts on health. In the case of heat, the incidence in terms of daily mortality and in terms of health indicators such as urgent hospital admissions due to different specific causes or emergency calls would also need to be estimated, and not only those related directly to high temperatures, but also those related to ozone spikes and other air pollutants. In this way, it would be possible to alert health professionals to the possible demand for urgent care as a consequence of this adverse phenomenon and prepare them for the need for health care. In this phase, the overall health impact of the expected event/s is evaluated, taking into account all possible expected implications based on Table 1. The Epidemiological Services within the Ministry or Department of Health will be in charge of estimating and quantifying the health impacts that can be expected from the situation that has led to issuing the alarm.

Phase 3: Actions to minimize the impact on health. In the case of drought in which it is known that there will be a decrease in water quality and access to potable water, a series of actions would be taken directed at guaranteeing access to safe drinking water for the population. At the same time, control and follow-up of diarrheal diseases would be reinforced. Also, given that forest fires would be probable, there would need to be an intensification in surveillance and action in this case. Furthermore, the corresponding alerts and advisories for the population, social services and health services would be activated, based on the predictions from phase two and which would be detailed in each individual action plan. To summarize, the measures that aim to minimize impacts are activated in this phase. These can be mainly of two types: (1) Exposures that can be effectively acted upon, in which case the relevant line ministries would be involved. For instance, in the case of atmospheric pollution of natural or anthropogenic origin, vehicle traffic and the operation of industries that could aggravate the situation should be restricted. Thus, the Ministries or Departments of the Environment, transport and Industry would be involved in the response. (2) In cases where it is not possible to act directly, such as a drought or a heat wave, the Ministry or Department of Health would be in charge of coordinating the necessary public health actions contemplated in the Plan, which would consist of alerting hospitals and emergencies 112 (often times decentralized, thus involving subnational authorities); and social services and civil protection which can be under the jurisdiction of various line ministries or departments, or again, decentralized to subnational authorities. In a case when large scale intervention tasks have to be carried out, as in the case of forest fires, the relevant ministries or departments (e.g. Ministry of the Environment or even the Ministry of Defense if the deployment of the army is necessary) should be in charge of activating the resources.

Phase 4: Monitoring and evaluation of the plan. The objective is to assess whether the expected impact in phase 2 has been mitigated as a consequence of the activation of the Plan. The Epidemiological Services within the Ministry or Department of Health should be in charge of monitoring this impact and determining the actions that have been successful and those that have not. Furthermore, all involved Ministries or National Departments and/or subnational authorities involved must provide information on the difficulties encountered in the implementation of the Plan or what actions were not contemplated. To reach the objective, a network of sentinel hospitals would be established, distributed by geographical location that would permit measurement of the real impact of the activating phenomenon on the population. This would serve to identify the pathologies involved, the groups especially susceptible, and to quantify the incidence observed. Quantification of the real observed incidence also allows for an economic balance (at the societal level) for the plan's implementation. Phase four would also entail the integrated plan's Monitoring and Evaluation of outcomes (processes should be monitored and evaluated throughout implementation), thus serving to improve the design of the plans, their evaluation and the adoption of actions to carry out in future emergencies, such as establishing reinforcement measures and environmental education for the population.

Further specification of roles and responsibilities, flows and timing of information and resources, and specific sub-activities would be highly context dependent, and they would require building institutional and technical capacity, as well as inter-disciplinary and inter-sectoral work. Integrated plans should capitalize on the ongoing efforts within the Sendai Framework for Disaster Risk Reduction 2015 – 2030, which highlights the need to increase the availability of and access to multi-hazard early warning systems.

4. Conclusions

Climate change has multiple impacts on human health, both direct and indirect. In the case of heat waves in particular, the connection with factors such as air pollution and multiple implications for health make development of public health surveillance systems that bring together the diverse indicators described in this chapter necessary. There is a need to design and implement action plans that account for the greatest number of environmental factors that are impacted by heat waves and that consider how these factors influence population health. This integrative approach should be extended to all public health interventions related to climate change, and capitalize on ongoing efforts towards integrated early warning systems under the Sendai Framework.

5. Disclaimer

The authors declare they have no actual or potential competing financial interests. This article presents independent research. The views expressed are those of the authors and not necessarily those of the Carlos III Institute of Health, the World Health Organization, or the UNEP DTU Partnership.

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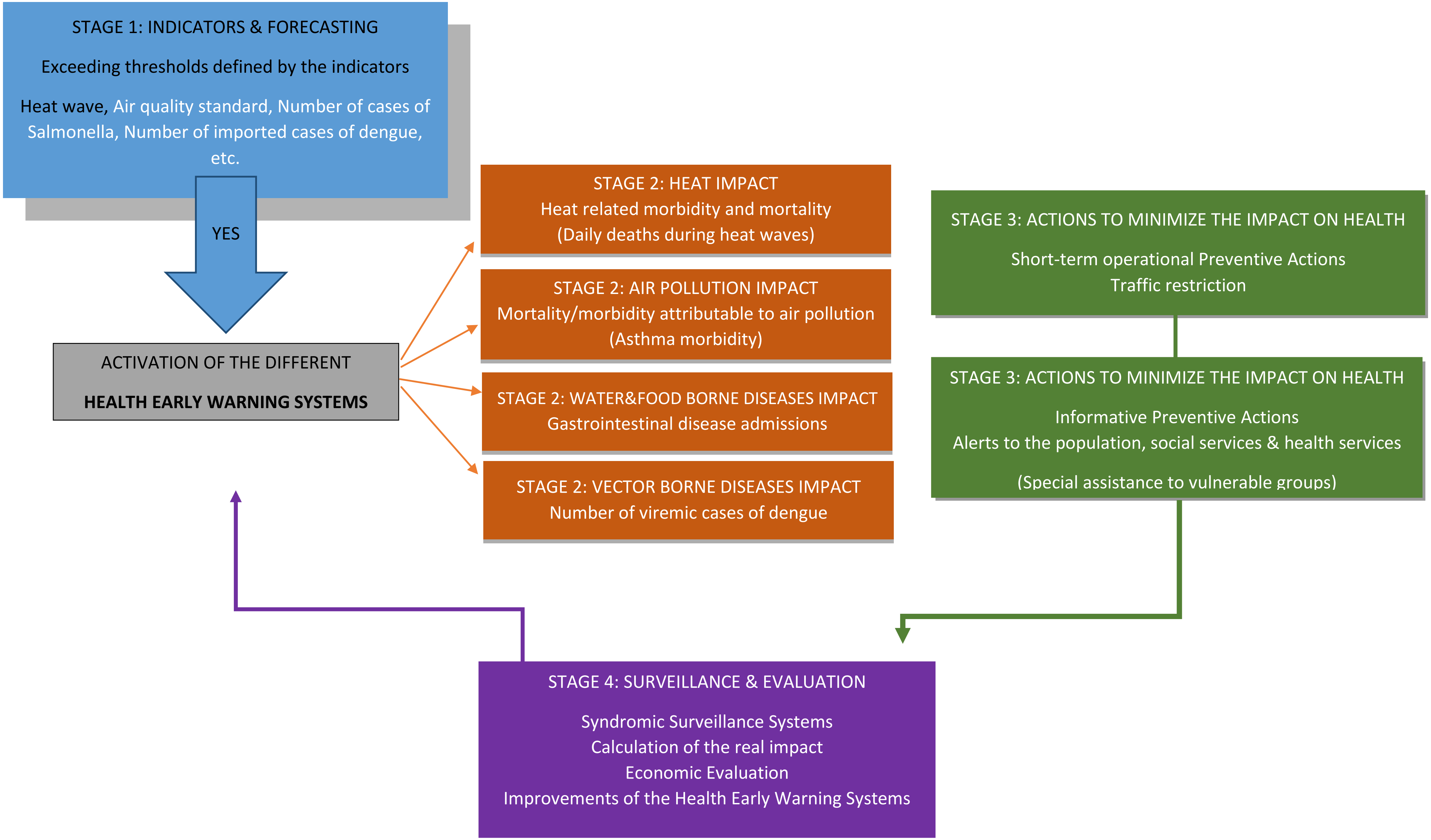
Table

Table 1. Proposed categories and indicators for a Public Health Surveillance System for Climate Change (adapted from Mari et al, 2019).

CATEGORIES	INDICATOR	
Climate Data	Temperature	• Minimum daily temperature • Maximum daily temperature
	Precipitation	• Amount of precipitation (daily, monthly) • Number of rainy days • Drought severity index
	Heat	• Actual number of heat waves • Duration of heat waves (days involved) • Number of forecasted heat waves
	Saharan dust intrusion	• Number of days with Saharan dust intrusion
Health Impacts *All these indicators are to be obtained by sex and major age groups, and whenever numbers allow it also by social strata or small area*	Heat related morbidity and mortality	• Heat stroke cases and heat stroke deaths • Daily deaths during heat waves • Daily deaths during heat waves • Daily births, premature births and low birth weight births during heat waves • Mortality attributable to heat waves (total and cause specific mortality) • Morbidity attributable to heat waves (hospital discharge/ emergencies/ primary health care) • Suicide deaths and death rates. Homicide deaths and death rates
	Vector-borne diseases and vectors (selected examples of both)	• Number of imported and autochthonous cases of dengue, chikungunya, zika, malaria, and leishmania • Aedes albopictus activity period (annual number of weeks with vector activity) • Number of viremic cases of dengue, chikungunya and zika during periods of vector activity • Number and proportion of viremic cases for which Aedes albopictus activity • Number of pools of Aedes albopictus captured of a viremic case which were positive for dengue, chikungunya, and zika virus • Detection of new competent vectors (Aedes aegypti)
	Air quality	• Annual mean concentration and number of days exceeding standards for NO2, PM10, PM2.5 and O3 • Proportion of population exposed to air pollution • Mortality and morbidity attributable to air pollution • Pollen counts • Asthma morbidity
	Water & Food quality	• Number of outbreaks related to drinking water, recreational water, and food • Number of cases reported by Laboratories of Salmonella, Campylobacter and enterotoxigenic Escherichia coli • Trihalomethanes and other physicochemical parameters in drinking water that may be influenced by droughts and heavy rain • Microbiological parameters in drinking water that may be influenced by droughts and heavy rain

Figure


STAGE 1: INDICATORS & FORECASTING
Exceeding thresholds defined by the indicators
Heat wave, Air quality standard, Number of cases of Salmonella, Number of imported cases of dengue, etc.
YES
ACTIVATION OF THE DIFFERENT
HEALTH EARLY WARNING SYSTEMS
STAGE 2: HEAT IMPACT
Heat related morbidity and mortality
(Daily deaths during heat waves)
STAGE 2: AIR POLLUTION IMPACT
Mortality/morbidity attributable to air pollution
(Asthma morbidity)
STAGE 2: WATER&FOOD BORNE DISEASES IMPACT
Gastrointestinal disease admissions
STAGE 2: VECTOR BORNE DISEASES IMPACT
Number of viremic cases of dengue
STAGE 3: ACTIONS TO MINIMIZE THE IMPACT ON HEALTH
Short-term operational Preventive Actions
Traffic restriction
STAGE 3: ACTIONS TO MINIMIZE THE IMPACT ON HEALTH
Informative Preventive Actions
Alerts to the population, social services & health services
(Special assistance to vulnerable groups)
STAGE 4: SURVEILLANCE & EVALUATION
Syndromic Surveillance Systems
Calculation of the real impact
Economic Evaluation
Improvements of the Health Early Warning Systems