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Climate Change and Public Health – Abstracts of the Robert Koch Colloquium 2022

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Climate change – a burning topic for public health

The climate crisis is arguably the greatest threat to human health and well-being. As illustrated by the COVID-19 pandemic, rapid, but sustainable, action is crucial in public health crises and in the climate crisis no individual or health system will be left unaffected. While the world's attention was focussed on the ongoing acute COVID-19 crisis, the health effects of human-induced climate change continue to accumulate [1]. Public health has many opportunities to proactively address the health impacts of climate change and public health experts play a crucial role in the prevention of climate-related diseases [2]. Consequently, as the national public health institute, the Robert Koch Institute (RKI) has an important role to play in climate change adaptation and mitigation.

The RKI has longstanding expertise in the field of One Health which has been guiding the institute's work on zoonotic diseases and antimicrobial resistance as well as wider areas such as environmental health for a number of years. To further strengthen its existing expertise and build new capacities, the RKI has recently extended its focus and is increasing its efforts in the area of effects of climate change on health. In 2022, the RKI established its Office for Climate Change and Health, responsible for coordinating all internal and external activities as well as external requests and cooperation regarding this subject. Under the institute's cross-departmental working group on climate change and health, existing activities will be drawn together, thereby promoting internal exchange, cooperation and cohesion. The goal of the RKI is to strategically intensify its work in the area of climate change and health and to become a 'key climate actor' [3].

There is still much that needs to be done and it cannot be done alone. To address this complex issue, diverse cross-sectoral knowledge and networks are needed, in order to exchange knowledge and approaches. Therefore, the RKI closely collaborates with other national public health institutes through the International Association of National Public Health Institutes' (IANPHI) Committee on Climate Change and Health. To further signal the institute's perception of climate change as a major health threat, for this year's Robert Koch Colloquium (RKC), the RKI put the spotlight on 'Climate change and public health' to share the knowledge of renowned experts in this field. This edition of the Journal of Health Monitoring focusses on the RKC 2022 which addressed the effects of climate change on population health and potential adaptation and mitigation solutions. The Colloquium was composed of five lectures and concluded with a panel discussion. Each lecture touched upon a specific aspect of the relationship between climate change and health.

Sabine Gabrysch from the Potsdam Institute for Climate Impact Research (PIK) spoke about how human health fundamentally depends on the functioning of ecosystems and a stable climate, by diagnosing the planetary health crisis. She concluded by proposing a positive transformation towards healing, well-being and quality of life including the people and the planet (see Gabrysch 2022). Arturo Casadevall of the Johns Hopkins School of Public Health, addressed the connections between microbial virulence, mammals and climate change. The speaker presented the hypothesis that fungal diseases contributed to both the extinctions at the end of the Cretaceous geological epoch that resulted in the demise of the dinosaurs and to the great mammalian radiation that followed in the tertiary era. This lecture touched on possible consequences of climate change for the emergence of new fungal diseases as fungal species adapt to a warmer world (see Casadevall 2022). Lyle Petersen from the Centers for Disease Control and Prevention (CDC) spoke about climate change and vector-borne diseases, using the examples of mosquito- and tickborne diseases. His lecture explored current concepts of how climate change is expected to impact the emergence of vector-borne disease in the context of the many other interacting biological, ecological, and sociological drivers of such diseases (see Petersen et al. 2022). Aleksandra Kazmierczak from the European Environment Agency (EEA) spoke about climate-related hazards and their implications for health and well-being, especially focussing on vulnerable groups in Europe (see Kazmierczak 2022). Lastly, Maria Neira from the World Health Organization (WHO) presented the health argument for climate action, stressing that climate mitigation and adaptation is public health prevention. She reiterated the importance of health co-benefits in climate change mitigation, the importance of health (equity) in all policies and ended with ten prescriptions for action. The RKC 2022 concluded with a panel discussion which brought together Daniela Jacob (Director of the Climate Service Center Germany), Dirk Messner (President of the German Environment Agency), Thomas Mettenleiter (President of the Federal Research Institute for Animal Health) and Lothar H. Wieler (President of the Robert Koch Institute), who discussed possible next steps for climate change and health in Germany. Moderated by Maike Voss (Managing Director of the Centre for Planetary Health Policy), the key aspects addressed included climate change-related challenges facing the public health community in Germany, concrete tasks of the German public health community to protect the climate and mitigate the effects of climate change on health, the importance of cross-institutional and sectoral collaboration, the contribution of the RKI and the recommendations for action for public health from a scientific perspective as well as next steps.

The RKI can be a key actor in the field of climate change and public health through its evidence-based scientific recommendations on topics such as heat mortality, nutrition and physical activity and health behaviour but also through its surveillance and monitoring activities. Health monitoring and surveillance will play a major role in identifying epidemiological developments in time as well as in understanding causes and correlations. Risk analyses, health reporting, communication and collaboration must accompany all of these activities. Finally, it is important to set an example by reducing the institute's CO_2 footprint with the RKI's concept of 'RKI Greening'.

As the natural historian and biologist, David Attenborough, once said 'Self-interest is for the past, common interest is for the future'. To succeed in the task ahead, this has to become the guiding principle.

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A planetary health perspective on the climate crisis

Planetary Health is about the health of humans and other living beings, of populations and ecosystems, and of the whole living planet Earth, appreciating the deep connectedness of all life.

A planetary doctor examining the Earth would find three core symptoms: 1.) the climate heating up, 2.) pollution of air, water and land and 3.) a massive loss of biodiversity. The causative agents are humans who have multiplied their population size and resource use over a short time.

Human living conditions have improved substantially in many parts of the world over the last decades, and so has human health. However, the poorest have been left behind and modern lifestyles have led to new health problems: Too much and unhealthy food, too little exercise and air pollution are causing a sharp rise in obesity, diabetes and cardiovascular disease worldwide. In addition, there are new health risks due to human interventions in nature [1]: Climate change is intensifying weather extremes with deadly heat waves and floods. Droughts cause harvest failures and famines. The destruction of natural habitats makes pandemics more likely.

The diagnosis is serious: This is a planetary emergency. We are transgressing several planetary boundaries and getting close to dangerous tipping points in the Earth system. Humanity is destroying living conditions on the planet, risking its habitability and the survival of our civilisation. It is also a justice issue: The rich are causing the problem and the poor and future generations bear the brunt.

In an emergency one has to act fast and courageously. How can we achieve a radical reshaping of our whole way of living, our way of doing business, a Great Transformation of society at record pace? An unprecedented challenge.

It will require major shifts in our worldview, our relationship to nature, our values [2]. We need to realise that we humans are one component of a highly complex web of life, one part of our living planet, and that we totally depend on it. Our health, our society, our economy all depend on functioning ecosystems, on a stable climate. We need to regain a wisdom many indigenous peoples have preserved over generations.

The good news is that tackling this challenge could be a huge global health opportunity. Plenty of solutions are synergistic: good for the planet and good for our health. A win-win situation! For example, to stop burning fossil fuels can avoid millions of deaths from air pollution. Making cities easy to walk and bike helps people exercise more. And eating less meat and more vegetables would be a huge win for climate, biodiversity, animal and human health.

The fundamental societal change that we need will not happen by itself or from above. It requires many active people pushing for it. Jointly, we can change the structures that are hurting people and nature. We can create a positive vision for a better, healthier, sustainable world which already exists in niches.

As health professionals, we have a particular responsibility to protect health, and also a high credibility. We can play an important role in the public debate on the planetary crisis [3], by warning of the risks, but also pointing to the long-term and short-term health gains.

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On microbial virulence, mammals, and climate change

Virulence is a microbial property that is expressed only in a susceptible host. This raises interesting evolutionary questions: Why are some microbes pathogenic while the majority is harmless? Are pathogenic and non-pathogenic microbes different? How does virulence emerge in environmental microbes that are pathogenic despite having no need for their hosts? Answering these questions requires new conceptual tools. The damage-response framework developed more than two decades ago posits that there are only microbes and hosts and that what really matters is the outcome of interaction. This framework argues that the states of commensalism, symbiosis, latency and disease are all continuous and differ only in the amount of damage incurred by the host from the interaction. To create a quantitative view of virulence, the pathogenic potential concept was developed, which states that all microbes have some inherent pathogenic potential such that host immunity can usually be overcome with large inocula.

The fungal kingdom, with its tremendous diversity, provides insight into potential answers. Of the more than 1.5 million fungal species only about 150 to 300 are pathogenic for humans, and of these, only 10 to 15 are relatively common pathogens. In contrast to the paucity of fungal pathogens of mammals, fungi are major pathogens for plants and insects. Analysis of thermal tolerance in fungi suggests that vertebrate endothermy and homeothermy create a restricted environment for most fungal species. Hence, the combination of vertebrate adaptive immunity with endothermy probably accounts for the remarkable resistance of mammals to fungi [1].

The resistance of mammals to fungal disease based on endothermy in turn raises the question of how such an energetically unfavourable lifestyle was selected for in evolutionary history. There is evidence in the geologic record for massive proliferation of fungi at the end of the Permian and Cretaceous geologic epochs. Fungi, as degraders of organic matter, thrive in conditions of global catastrophe and the fungal proliferation following the bolide that ended the Cretaceous period would have created massive numbers of spores that would have greatly increased the likelihood of fungal disease for any survivors of the catastrophe. The author presented the hypothesis that fungal diseases contributed to both the extinctions at the end of the Cretaceous that resulted in the demise of the dinosaurs and to the great mammalian radiation that followed in the Tertiary era. Hence, the argument goes that mammals are resistant to fungal disease because they were preferentially selected to survive in the post-impact world due to their endothermy [2, 3].

Finally, the seminar considered possible consequences of climate change, which include the emergence of new fungal diseases as fungal species adapt to a warmer world. The emergence of *Candida auris* could represent the first example of this new threat.

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Climate change and vector-borne disease in North America and Europe

Global surface temperature, which has already increased approximately 1°C relative to that in 1850 to 1900, may increase another 2 to 4°C by the next century. Precipitation in the United States (US), Canada and Europe will mostly increase, while the southwestern US and southern Europe will become drier. These changes are expected to alter the ecology and transmission dynamics of West Nile virus (WNV), the leading mosquito-borne infection in these regions [1], and Lyme disease and tickborne encephalitis, the respective leading tickborne diseases.

Temperature and rainfall differentially influence many factors related to WNV transmission. For example, increased temperature can increase mosquito development rate and vector competence but can also increase mosquito mortality and decrease the quantity of mosquito breeding sites. Rainfall can increase mosquito breeding sites, but excessive rain eliminates them [2]. Region-wide analysis suggests WNV incidence is highest in areas of the US and Europe with average summer temperatures of 23 to 25°C and that within these areas, heat waves promote outbreaks. In 2018, the largest outbreak in Europe occurred during the hottest summer on record and recent temperature increases have accompanied WNV's northward spread into Germany and the Netherlands. However, the largest local WNV outbreak occurred in 2021 in Phoenix, Arizona, an area typically experiencing summer temperatures over 30°C, during a period of exceptional summer rainfall. Overall, evidence suggests that increased temperature and rainfall promote WNV incidence in cooler and drier areas, and increased rainfall decreases incidence in wetter areas.

Ixodes spp. ticks, the vectors of Lyme disease and tick-borne encephalitis, have multi-year life cycles influenced by temperature and precipitation. Warmer temperatures increase tick reproductive capacity, lengthen seasonality, and promote questing, while increased humidity increases survival. Conversely, excessive temperatures and low humidity may increase tick mortality. Climate-related increased temperatures in northern US and Europe have correlated with dramatic northern spread of *Ixodes* spp. ticks and accompanying increase in disease incidence. In Europe, increased temperatures have led to tick migration to higher altitudes. However, in the US, *Ix. scapularis* has also migrated southward, indicating the importance of other ecological factors such as increasing deer populations [3].

In summary, accumulated data indicate that climate change has already impacted vector-borne disease incidence and distribution in the US and Europe and will continue to do so. However, the uncertainty of climate models combined with the differential effects of temperature and rainfall on vector transmission hamper our ability to model future WNV climate-related scenarios. Further investments in environmental data collection and disease/climate modelling efforts applicable to future climate scenarios should be a priority.

Disclaimer: The findings and conclusions in the presentation are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

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Impacts of climate-related hazards on health and well-being of vulnerable groups in Europe

Human-induced climate change is causing widespread impacts on human health and well-being. However, the magnitude of these impacts varies among individuals, communities and locations, and is driven by a combination of vulnerability and exposure. For example, older people, children, people experiencing poverty, and those in bad health or living with disability tend to be more vulnerable to climate change impacts than the general population. In addition, people's ability to avoid, or cope with, climate hazards depends on their financial resources, extent of their social networks, home ownership, and other factors. Exposure is the likelihood of coming into contact with climate hazards, e.g., through residence in flood risk area, living in an easily overheated house, or through one's occupation. Individuals and communities can often simultaneously experience different aspects of vulnerability and be exposed to various climate-related hazards; these compounding factors increase the chances of negative impacts on their health and well-being [1].

The unprecedented rise in temperatures since the 1990s, combined with the ongoing urbanisation, population ageing and disease prevalence in Europe, results in high and increasing exposure of vulnerable populations to heat. In particular in south and south-eastern Europe, the regions with lower socioeconomic status populations or higher percentages of elderly people correspond to areas affected by high temperatures. In European cities, nearly half of healthcare and educational facilities are in locations with a strong Urban Heat Island effect. In addition, approximately ten percent of schools and eleven percent of hospitals across Europe are in potential flood-prone areas [2].

The climate adaptation measures in place do not benefit all people to the same extent. For example, the most vulnerable groups tend to have lower access to green space and are least able to pay for flood insurance or flood-proofing of their homes. Thus, without consideration of equity in adaptation, the existing inequalities may be reinforced, or new inequalities may arise [2].

Although EU and national climate policies draw attention to vulnerable groups [3] and emphasise the need for equitable adaptation solutions, the practical implementation of such solutions remains scarce. Examples include development of heat health action plans with the most vulnerable groups in focus; targeted urban greening actions; or built environment improvements [2].

Ensuring that no one is left behind requires a meaningful engagement of vulnerable groups and the social care and health sectors in adaptation. At the same time, increased awareness of climate change among public health professionals and medical practitioners is crucial. Further, involvement in addressing climate change impacts of public administration, civil society and private sector from various fields, including public health, but also spatial planning or construction is needed to enable development of equitable adaptive actions [2].

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