PUBLIC HEALTH REVIEWS

Special Edition

Climate Change and Health

Proceedings from the COP21 "Healthy Lives on a Healthy Planet" 2015 Conference in Paris

Edition Editors:
Anneliese Depoux, PhD
Corinne Kowalski, MA
Antoine Flahault, MD, PhD

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Graphic Design: Julien Ricca

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A journal published on behalf of the Association of Schools of Public Health in the European Region (ASPHER). It is an open access public health journal dedicated to promoting public health knowledge and practice, which places a special emphasis on the integration of state of the art knowledge and translational issues, interdisciplinary approaches, innovations, and emerging public health issues. Guest Editors will initiate and conduct theme issues approved by the Editorial Board.

https://publichealthreviews.biomedcentral.com/

ISSN 2107-6952
Printed in France
Not for sale

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Abbreviations

APHRC	African Population and Health Research Center
COP	Conference of the Parties
CRSN	Centre de Recherche en Santé de Nouna
GHG	Greenhouse gas
ENSO	El Niño Southern Oscillations
EPA	Environmental Protection Agency
INDCs	Intended Nationally–Determined Contributions
HDSS	Human Demographic Surveillance System
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Analysis
PM	Particulate Matter
KANs	Knowledge-Action Networks
RVF	Rift Valley fever
SDGs	Sustainable Development Goals
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
WHO	World Health Organization

Contents

Preface

This publication is dedicated to the topic of Climate Change and Health which is a global challenge as climate change has become a worldwide threat to health. The 21st Conference of Parties (COP21) in Paris in December 2015 marks a turning point in the fight against climate change. On this occasion, the Centre Virchow-Villermé was selected to organize a COP21 side event dedicated to ˝Healthy Lives on a Healthy Planet˝ with the aim to promote health as an important argument in the negotiations on climate change. All the contributions gathered in this special edition of Public Health Reviews are available online at https://publichealthreviews.biomedcentral.com/

This initiative was directly supported by the Centre's parent organizations, the Université Sorbonne Paris Cité and Charité Universitätsmedizin Berlin, and academic partners: the University of Geneva, the London School of Hygiene and Tropical Medicine, and the University of Heidelberg, with sponsorship by the World Health Organization, the Rockefeller Foundation and The Lancet.

COP21 assembled thousands of participants from around the world, with the common goal and passion for helping our policymakers to make the necessary and courageous decisions at this critical stage of climate negotiations for the sake of the planet and for global public health. The ˝Healthy Lives on a Healthy Planet˝ event included a program with distinguished lecturers to highlight cutting-edge knowledge and experience in the field of planetary health, climate change and health related issues to engage. The purpose of this conference was to engage and discuss the next steps in an open arena and to debate on the content of research, anticipated in the coming months and years, including the work of young researchers committed to this domain.

The global effort required today will have an impact on many areas that interact with health. This review assembled presentations developed to raise awareness in the public health community with the purpose of promoting the future of research and policy in this global challenge for planetary health.

Editorial

Solving the global climate crisis: the greatest health opportunity of our times?

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Today's substantial global health gains are being undermined by climate change. At the same time, the actions required to confront the climate crisis represents possibly the largest public health opportunity in more than a century. Health benefits from improved air quality may far outweigh the cost of clean energy investments. Upward trends in chronic diseases, such as diabetes and heart disease, are now occurring throughout the world. Herein lies even more golden opportunities for public health through: first, adopting more alternative modes of transportation, especially those that promote "active transport" by foot or by bicycle, alongside of effective public transportation; and second, by reducing meat in the diet. In essence, there is no better time to focus on health as central in the climate negotiations; and in so doing, may we move faster and further with effective actions on climate change and the subsequent health benefits that will arise from a low-carbon society.

The global climate crisis demands a rapid change in policies and collective actions to divert our current path toward a 7°C warmer world by the end of this century. Unfortunately, environmental and economic arguments, while important, are not moving climate change policies quickly enough. Caring about our own health tends to supersede all other priorities. Therefore, focusing on the problems of and solutions to climate change through a health lens not only compliments the environmental and economic efforts, but most importantly, a health framing can bring more focus and resolve to the global climate crisis. According to reports of the IPCC, the Lancet Commission and many more, today's substantial global health gains are being undermined by climate change [1]. A wealth of evidence shows that global health and global climate and ecological conditions are inseparable. Healthy human populations simply cannot be sustained on a sick planet.

It might seem like a paradox, but the actions taken to confront climate change today represents possibly the largest public health opportunity in more than a century. Consider the following realities: 1) WHO estimates 7 million deaths are attributed to air pollution every year; 2) rates of obesity and chronic diseases are rising in nearly

all regions of the world; and 3) greenhouse gas emissions –responsible for the global climate crisis – rose the fastest (~ 2%/yr) in the past decade, approximately twice the rate from the period between 1970 and 2000 according to the IPCC.

Fossil fuel combustion is the common link to these three realities. Fossil fuel combustion accounted for 78% of the total increase in carbon dioxide between 1970 and 2010. Of course burning oil, gas and coal also release pollutants such as fine particulates, e.g. PM2.5, known to be harmful to human health. Cleaner energy can help both reduce the heating of the planet, while saving lives from air pollution. Greenhouse gas mitigation strategies could avoid an estimated 1 to 4 million deaths annually by 2050 [2]. Health benefits may far outweigh the cost of clean energy investments. For example, in the U.S., monetized health benefits associated with improved air quality can offset between 26% to 1,050% of the cost of US low-carbon policies [3]; in other words, the value of health dividends could swamp the costs of striving for an energy efficient, low-carbon economy. This should be of no surprise given the US Environmental Protection Agency (EPA) estimates of a $30 return for every dollar invested in reducing air pollution through the Clean Air Act. And health benefits will be even larger in highly polluted cities across other regions of the world.

Upward trends in chronic diseases, such as diabetes and heart disease, are now occurring throughout the world, as Western lifestyles with automobile-dependent transportation and meat-based diets are being pursued. Herein lies even more golden opportunities for public health through: first, adopting more alternative modes of transportation, especially those that promote "active transport" by foot or by bicycle, alongside of effective public transportation; and second, by reducing meat in the diet.

Studies from across the world show marked health benefits from active transport [4].
Active transport in Shanghai, China, could reduce colon cancer risk by over 44%.
Bike commuting in London could lower ischemic heart disease by 10 to 19%.
In the US, comparing cities with highest versus lowest levels of active transport, obesity rates are 20% lower and diabetes rates are 23% less, and switching short car trips to bike trips would save 1,300 lives annually for just one region of the US. Bicycling commuters in Copenhagen have a 39% reduction in mortality rate compared to non cycling commuters.
While less studied, rapidly growing newer cities, especially in Africa, provide especially unique health opportunities from urban planning; in these locations we have an opportunity to design cities for the health of people, rather than simply for the flow of motorized traffic.

Diet and food systems represent another key focus area for dual benefits to our health and the environment. In the UK, if 50% of meat and dairy in the diet were replaced by fruit, vegetables and cereals, greenhouse gas emissions might drop by 19%, while at the same time potentially 30,192 to 43,592 deaths could be averted per year by the reduction of saturated fat in the diet [5]. However, meat in the developing world provides essential protein and micronutrients – so this recommendation is geared primarily to "supersized" industrialized countries.

Current rates of chronic disease alongside continued rising trends in fossil fuel-based energy consumption that are causing today's global climate crisis present daunting risks to civilization. The interdependence of these challenges, however, affords a golden opportunity to solve both simultaneously. Following the landmark COP21, with the Paris Agreement now officially in force, attention is on COP22 to accelerate actions to mitigate greenhouse gas emissions. There is no better time to focus on health as central in the negotiations; and in so doing, may we move faster and further with effective actions on climate change and the subsequent health benefits that will arise from a low-carbon society.

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1 Introduction

1. The implications of COP21 for our future climate

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Keywords
Climate change, CO_2 emissions, global warming, COP21, health

Abstract
Rising CO_2 in the atmosphere is the main cause of anthropogenic climate change, and the data shows a clear increase in global temperature of about 1° Celsius since pre-industrial levels. Changes in climate extremes are also occurring, with observed increases in the frequency of heat waves, in intense precipitation (rainfall and snowfall) in many places, and in sea level and storm surges. A changing climate with rising extremes has associated risks for food production and other health-related impacts. In order to limit climate change well below 2° Celsius our carbon emissions must rapidly follow a decreasing trajectory to near zero.

Background

Let's start with the data. The increase in CO_2 concentration in the atmosphere was first measured directly at Mauna Loa in Hawaii in 1958. The concentration has just crossed 400 ppm (parts per million), an increase of 44% compared to the pre-industrial levels (around year 1750).

Rising CO_2 in the atmosphere is the main cause of anthropogenic climate change. To stop the planetary warming, CO_2 concentration needs to stop rising. In turn to stop the rise in CO_2 concentration, our carbon emissions must go down to near zero. It is thus no surprise that the global surface temperature has increased, by about 1° Celsius above pre-industrial levels. However there are important inter-annual variations in global temperature that are caused by natural climate cycles. For example, the El Niño of 2015-2016 contributed to warming the climate recently, on top of the general trend due to CO_2 and other greenhouse gases. It is clear though that the climate change trend dominates the recent warming, and our starting point is that human-induced climate change already cause about 1° Celsius warming. Keep this in mind when we speak about the objectives of the future.

Where do we stand as far as CO_2 emissions are concerned? Emissions must decrease to near zero to stop the rise in atmospheric CO_2 concentration. We have just published a report which shows that the global emissions of CO_2 from fossil fuel burning have increased 2-3% per year on average since the year 2000 [1]. However the last year of emissions data – 2014 – and our projection for this year – 2015 – suggest that emission growth has stalled, and maybe even decreased a little in 2015 [2]. So a small pause in the long-term emissions growth. We are expecting the global emissions to start growing once again, but maybe not as fast they have grown since the year 2000. This is good news. The pause in the last two years is mainly due to the economic rebalancing in China and to the very rapid deployment of renewable energies in the world – a signature of global actions to tackle climate change.

In order to limit climate change well below 2° Celsius our emissions must follow a decreasing trajectory to near zero. A large number of scenarios consistent with the two-degree limit include technologies that can actually capture CO_2 out of the atmosphere and store it below ground. These so-called 'negative emissions' rely on unproven technologies and are in competition with agriculture. They are not a safe bet [3]. At the other extreme, scenarios based on intense use of fossil fuels lead to very high climate change – with a range of related high risks in addition to warming, for example risks of floods from sea level rise and increased heavy rainfall, stress on access to drinking water from salt-water contamination, and droughts, and a range of associated health risks.

What are we expecting from the Paris Agreement on climate change? On the one hand, we have what the countries bring, the 'INDCs' for Intended Nationally–Determined Contributions. The implementation of the INDCs as they stand would lead to an increase of around 3° Celsius, somewhere between the 1° Celsius we are already observing and a planet with a very risky climate future. But the Paris Agreement does set clear ambitions to keep the warming well below 2° Celsius and to pursue efforts to limit the warming to 1.5° Celsius, with a roadmap revision for each country every 5 years. There's a conflict between the promised contributions and the level of ambitions, and the outcome for future warming will depend on what individual countries will do next.

We have been working with the World Health Organization (WHO) and other institutes worldwide to do a country-by-country analysis of the implications of climate change [4]. We compared recent temperature observations with warming projections over the country, so people can see the consequences of climate change in their own context. They can relate what a projection of a global temperature rise below 2° Celsius implies for them compared to a future would in a high-risk climate change. I have spoken a great deal about average temperature, but changes in climate extremes could have the greatest impact on health. Changes in climate extremes have been summarised in a table of the Intergovernmental Panel on Climate Change (IPCC)[5] and the WHO report [4]. Three extremes are particularly clear and well documented: increases in

heat waves, increases in intense precipitation (rainfall and snowfall), and increases in sea level and storm surges. The last two have associated increased risks of floods. All have associated risks for food production, and possibly pests and disease outbreaks. Even when limiting climate change to 2° Celsius, understanding regional impacts and adapting to a changing climate will be essential.

Conclusions

A wise way to respond to the current state of knowledge on climate change would be to prepare to deal with a high-risk climate change future, but to work to mitigate climate change well below 2° Celsius by reducing global emissions to zero. Adopting this double strategy could help prepare for all eventualities, while working for the outcome with the lowest risks for current and future generations.

Acknowledgements - I thank Clare Goodess and Colin Harpham who did most of the analysis of climate data in the Climate and Health Country profiles presented here, which was funded by the Wellcome Trust.

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2

Environmental change and health: key challenges and next steps

2.1 Climate Change and Infectious Diseases

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Keywords
Climate Change, infectious diseases, global health, El Niño/La Niña, emerging infectious diseases

Abstract
Global changes are major determinants for infectious diseases, although attributable, part of climate change remains debatable. Vector borne diseases are prone to be impacted by global warming, although other factors may play a substantial role, evidenced by the dramatic decrease in malaria in the last decades in places where climate change has deep and significant effects. There is now evidence that in some areas of the world, e.g. Horn of Africa, warm El Niño Southern Oscillations (ENSO), which are observed in the South Pacific Ocean, are associated with higher risk of emergence of Rift Valley fever, cholera and malaria, and during cold La Niña events, dengue fever, chikungunya and yellow fever. This has been observed for these and other diseases in other parts of the world. For example, seasonal influenza outbreaks have been more intense (i.e. higher number) and more severe (i.e. higher mortality) when concomitant with La Niña events. Since climate scientists have recently observed that climate change is tied to more frequent and more intense ENSO events, we may foresee increases in frequency and severity in emerging infectious diseases in the world.

Background
Links between climate change and communicable diseases are complex. Climate change is amongst many other determinants, such as environmental, social and political factors

that act on transmissibility of diseases. One example, which illustrates this complexity is malaria, for which the number of cases has dramatically decreased during the past decades [1]. This decrease was observed due to large financial investments in the fight to eliminate malaria, although climate change undoubtedly hinders the progress towards elimination. Climate in the future might become more suitable for malaria transmission in the tropical highland regions, as modelled by Caminade et al. [2]

We see how El Niño Southern Oscillations (ENSO) in the Southern Pacific may affect the climate in many parts of the world and as a consequence, also affect communicable diseases. Recent papers[3,4] have highlighted the risk that climate change may have an influence in increasing intensity and frequency of the El Niño/La Niña phenomenon. The Pacific Ocean is the largest mass of water in the world, so any variations in its temperature have a repercussion on climate in many points of the planet. For example, El Niño has been associated with heavy rainfalls in the horn of Africa over several years and with anomalies in vegetation (wetter than usual) observed from satellites. Linthicum et al. (Science, 1999) have shown a strong correlation between the El Niño effects and outbreaks of Rift Valley fever (RVF) in the Horn of Africa [5]. RVF is a very severe, arboviral, mosquito transmitted disease affecting both cattle and humans. In the Horn of Africa, excessive humidity observed from remote sensing, alongside the El Niño phenomenon, is linked to higher probabilities of RVF epidemics.

At the end of 2015 we experienced a strong El Niño phenomenon. If these events happen more frequently and intensely due to climate change, there is a risk of a greater number of outbreaks of emerging or re-emerging infectious diseases. In 2007, El Niño has been found associated with an increase in probability of RVF, cholera, and malaria6 in the Horn of Africa. In other parts of the world such as Bangladesh, temperature rises in the waters of the Gulf of Bengal are tied to re-emerging cholera; for similar reasons the risk of cholera in Peru has also been increasing. Reversely, El Niño causes drought and heat waves in North-East Brazil and Southeast Asia increasing risks of dengue fever [6].

La Niña is the reverse climatic phenomenon to El Niño. Surprisingly, since it is known as a "cold oscillation", La Niña will probably also increase in intensity and frequency as a result of climate change[3]. This climatic oscillation is also associated with the emergence of epidemics that have been reported in the recent past.

In May 2004, heatwave and droughts were observed in the coastal areas of Kenya, towards Lamu and Mombasa, two large coastal cities. That period was also the beginning of a large outbreak of chikungunya in these two cities (with reported attack rates of 75%) prior to its spread to the Indian Ocean [7]. Entomologists have explained how

and why droughts can be associated with increases in Aedes-borne diseases, such as chikungunya, as well as dengue, Zika and yellow fever[8]. During droughts, due to water scarcity, people are prone to store larger amount of water, outside, in the shadow of their house, for longer time periods, providing shelters to mosquitos' eggs and larvae.

Vector-bone diseases are not the only maladies linked to El Niño and/or La Niña. Recent studies show that 20th Century pandemics, such as influenza pandemics, were associated with the La Niña phenomenon [9]. This link has been previously studied through seasonal influenza epidemics, and a statistical correlation was found with La Niña, both in the United States and Europe [10]. There is indeed a strong synchronization of seasonal influenza epidemics between Europe and the USA as data collected over several decades demonstrates less than half a week in time difference in epidemic peaks between France and the USA[11]. In addition, there is a correlation between the size of the seasonal influenza epidemics between France and the USA. This intercontinental synchronism points to the possibility that a climatic force could be a factor. Indeed, a positive correlation was found between the size and severity (in terms of mortality) of influenza epidemics in Europe and the USA and La Niña cold oscillations in the South Pacific Ocean [11].

Conclusions

In conclusion, for over 50 years [12], there has been an increase in outbreaks of emerging infectious diseases, and climate change is probably one of the key drivers of this increase. Vector-borne diseases are among those enduring the greatest impact by climate conditions and global warming but airborne transmitted diseases may also be affected. It appears, however, that climate change is not the single determinant for emerging communicable diseases.

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2.2 Sustainable, healthy cities: making the most of the urban transition

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Keywords
Global environmental change, healthy cities, systems thinking, urban policy, sustainability, urban transition, urban health, planetary health

Abstract
The world is undergoing a massive urban transition, which is now both the greatest driver of global environmental change and the most significant influence on human health. Cities offer real opportunities for improving health, but managed poorly they can also create or reinforce significant health deficits, while putting severe stresses on the natural systems which support human civilization. Management of urban problems is rarely straightforward, as complexity across scales and sectors, in causal structures, actors and incentives, can lead to ineffective policies and unintended consequences. Systems thinking offers a promising way forward in its ability to deal with non-linear relationships and simultaneous actions and outcomes. Encompassing, on the one hand, analytic frameworks and methods that can provide important causal insights and a test bed for urban policy, and on the other, broad processes of inter- and trans-disciplinary engagement to better define problems and feasible solutions, systems approaches are critical to the current and future design and management of sustainable healthy cities.

The current moment of urban transition offers a unique opportunity to consider how to live healthier lives on a healthier planet. Cities, and the process of urbanization, are critical moderators of the interplay between human health and sustainability.

It's clear that the urban touches on nearly every aspect of environmental change and virtually every facet of the modern human condition. It is only in the last few generations that substantial fractions of the human race began living in cities, yet we are now in the middle of an unprecedented urban transition. Although the timing of this transition

has varied from place to place, the great-grandparents of the vast majority of people alive today were born in rural areas, as has been the norm throughout history. Yet the last century has seen a dramatic shift of people to cities, and during the last decade, we passed the point where most human beings are urban beings.[1] Based on the expected growth of urban populations through the middle of the twenty-first century, close to 0.2 million people will move to or be born in cities around the world today, like any other day. By 2050, 2.4 billion people will be added to the global urban population, and two-thirds of all humans will live in cities.[2] This transition is economic, social, cultural, and, perhaps most of all, ecological. It may indeed be the most radical shift in habitat the human species has ever experienced.

The urban transition manifests not only in people but also in space, on a scale which is perhaps less easy to appreciate. It has been estimated that global urban extents will increase by 185% in the interval between 2000 and 2030.[3] That is to say: in one generation, humanity will nearly triple the urban area that accumulated over seven thousand years of civilizational growth. In parts of the world, we have already experienced such transitions. To compare the lives of the residents of Shanghai or Dubai or Kuala Lumpur today to those of a quarter-century ago is to acknowledge vast differences in sensory, aesthetic, physical and cognitive experiences, not to mention influences on health. The urbanization of the generation to come will echo this vivid transformation but will also be strikingly novel, as people interact with new technologies and social movements and ideas, and increasingly with the consequences of global environmental change.

It is evident that the urban transition coincides with massive shifts in the planetary systems which support human life.[4] Warning signs are clear across a range of planetary systems, from rising temperatures and sea level to ocean acidification, loss of forests and biodiversity, and increased impacts from extreme events.[4] And yet, we also see strong net improvements in the human condition: less poverty, longer lives, better health, more opportunity. The concurrence of these varied trends is no fluke. Cities cover just 3% of the land surface of the Earth, but are responsible for as much as 80% of all greenhouse gas emissions, three-quarters of natural resource consumption, and half of all waste.[5] And yet cities also generate 80% or more of global economic output, providing livelihoods and opportunities, and offering many the chance to lift themselves out of poverty—though they also exacerbate poverty in some circumstances. Cities act to concentrate the vast majority of human innovation, including in medical, green and other technologies, art and architecture, culture, politics, and science—indeed, over 90% of global patents originate in metropolitan urban settings representing just 23% of the global urban population.[6] Essentially, cities have come to drive the world, in all its goods and bads.

The urban push has brought improved health, and city dwellers tend to be healthier than others, and yet a broad range of urban health challenges remain or are emerging. This includes a rising tide of non-communicable diseases,[7] mental health problems,[8] issues related to exposure to growing climate risks,[9] drug-resistant pathogens,[10] substance abuse,[11] crime,[12] and others. Table 1 briefly reviews some of these challenges, for many of which the particular role of the urban environment remains incompletely understood.

Table 1: Selected urban health challenges

Health challenge	Description
Non-communicable diseases (NCDs)	Where urban form is associated with sedentary lifestyles or increased consumption of unhealthy foods, city dwellers are at higher risk for obesity and associated NCDs, including heart disease and stroke, hypertension, diabetes, some cancers and others. Urban air pollution can impair lung function and give rise to or exacerbate cardiovascular and respiratory diseases, including asthma, in acute and chronic forms. It can also contribute to development of allergic disease or cancer and cause adverse pregnancy outcomes.
Infectious diseases	The high concentration of humans in cities naturally promotes increased transmission of some infectious diseases, such as tuberculosis. Growing mobility within and between cities and urban expansion into natural habitats contribute to ever-more-rapid emergence and spread of infections.
Accidents and injuries	City forms that encourage automobile use, often in combination with inadequate safety regulation, contribute to higher rates of road traffic accidents and deaths.
Mental Health	The urban built environment can adversely affect mental health. For example, lack of public space for recreation and socialization can lead to isolation and depression. Noise pollution and commuting can create significant stress.
Disaster Risk	Cities are often built in high-risk areas, such as along coastlines and rivers or on hill slopes. In particular, poor informal settlements often take hold and expand on otherwise unwanted land at high risk, such as on floodplains. Urban expansion can compromise fertile agricultural land, decreasing food security.
Climate Change	Long-term urban impacts on climate can harm health directly (e.g., through increases in acute heat waves or other extreme climatic events) or indirectly (e.g., through shifts in vector ranges or resource availability)

Just as is the case for wealth, there is also a great deal of inequity in the distribution of good health. In some cases, poor, informal or transitional urban neighbourhoods experience health outcomes worse than those observed in rural areas.[13] Often, urban ill health reflects a mismatch between the forms and functions of cities and the evolved needs of the human species. Cities are designed for narrow economic goals or technical efficiencies—for automobiles, in some cases, rather than for people. In other cases, these persistent problems are the result of unrecognized or unaddressed complexity.

One characteristic of many of these interlinked challenges is their intractability. A recent study found that, of 180 countries examined, not one had reduced its rates of obesity and overweight in the preceding three decades.[14] This belies a mass of research on the causes and control of obesity and overwhelming incentive—obesity costs over US$2 trillion per year globally.[15] Why should this challenge be so difficult to address? One problem is that scientific analysis and policy action tend to be reductive. They often aim to identify causal effects between individual inputs and outcomes, controlling for all other factors, and then to act on this narrow understanding. Yet reality is not simple—in fact, it's quite slippery. In the case of obesity, many different mechanisms entangle in complex feedback loops to generate the observed outcomes.[16] Each variable may imply many different potential interventions, while convoluted pathways and multiple connections often lead to unintended consequences. Within this framework, simultaneous decisions are made by actors at all scales. Moreover, the causal system that generates obesity and overweight is just one of numerous sets of systems of interest in the urban context. Traditional approaches tend to perform less than optimally in the face of such complexity.[17]

Fortunately, there are ways forward. Systems thinking is increasingly recognized as a framework that allows us to address complex issues of urban health and sustainability.[18–20] In particular, this involves analytical methods that can handle feedbacks and complex non-linear relationships among variables, as well as broad processes of engagement: among different disciplines and between researchers, decision-makers, individuals and communities. It has become apparent that health in cities is deeply connected and interlinked with sustainability. Systems thinking offers a way to attack intractable health issues, while also addressing a set of deeper challenges related to the speed and scale of growth, equity in a world of scarce resources, sustainability, resilience and governance. Recognition of the integrated nature of such challenges has already led, in some contexts, to the identification and application of actions that produce co-benefits for a wide range of urban health and sustainability challenges, such as promoting active public transport over private car use.

The year 2015 was momentous, highlighted by major agreements on disaster risk,[21] sustainable development,[22] development financing[23] and climate change.[24] This process was marked by a more direct recognition of the crucial role that cities play in human affairs than ever before—this is particularly evident in the adoption of Sustainable

Development Goal 11 on sustainable cities and communities. At the same time, funders like the Rockefeller Foundation and the Wellcome Trust have become ever-more conscious of the need for systems thinking, which is inherent in the idea of planetary health. Research efforts like the new International Council for Science programmes on Systems Thinking for Urban Health[25] and Future Earth[26] are also embracing this paradigm, as are global research institutes like the United Nations University's International Institute for Global Health,[27] and scores of other academic institutions around the world. It is to be hoped that this collective effort will lead to a strong place for systems thinking about health and sustainability in the implementation of the New Urban Agenda that will emerge from Habitat III in late 2016.[28] In the meantime, we must take hold of the unique opportunity represented by the urban transition to push for a sustainable, healthy planet, full of sustainable, healthy cities.

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2.3 Addressing Planetary Health Challenges in Africa

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Keywords
Planetary health, human health, Africa, climate change, population growth, natural resource management, urbanization

Abstract
Drawing on the report of the Rockefeller Foundation-Lancet Commission on planetary health – Safeguarding human health in the Anthropocene epoch, this piece presents a discussion of the implications of the report's findings and conclusions for Africa. It explores the key planetary health challenges facing Africa and what Africa can do to address them. In addition to highlighting current and future trajectories of key environmental changes in Africa and their implications for health and well-being, this transcript from the 21st Conference of Parties (COP21) side event, "Healthy Lives on a Healthy Planet", identifies a set of priority action Africa needs to take in order to deal with these challenges. It ends with reflections and key recommendations from participants at the regional launch of the report in Nairobi, Kenya, in October 2015.

Background
Professor Haines, Chair of the Rockefeller Foundation-Lancet Commission on Planetary Health, has done an excellent job providing a high-level summary of the Commission's report on Safeguarding human health in the Anthropocene epoch [1]. My aim is to examine what this report really means for Africa. As it is commonly known, Africa contributes the least to global climate change but bears disproportionate burden of the adverse consequences of climate change [2]. Rather than a focus on the various ways Africa remains exposed to the consequences of climate change, I will focus on three key drivers of global environmental change where an African response could make a huge difference and limit the continent's exposure in the longer term.

One of the key drivers of environmental change globally is population growth. In 1950, Africa accounted for about 9% of the world population; by 2100 it is estimated to account for about 40% of the world population, with a projected total population of 4.4 billion people [3, 4]. Indeed, 83% of the projected increase in global population by 2100 will occur in Africa. When we think of a world with 4.4 billion Africans, it may give us a chill for many different reasons. The real question, though, is: what type of 4.4 billion people are we going to have in Africa by 2100? Is it going to be 4.4 billion poorly educated, hungry and sick people trying to leave the continent for greener pastures elsewhere or will it be 4.4 billion well-educated, healthy and productively engaged citizens contributing to the development of the region? I think these are critical questions that we should engage with now. The current and projected rates of population growth in Africa makes it difficult for many governments in the region to make the necessary investments in human capital development needed to transform the region.

While the projected population of 4.4 billion Africans by 2100 has some validity, it is not necessarily a predetermined and inevitable destiny for the continent. Recent examples from Ethiopia and Rwanda assure us that significant disruptions in fertility levels and population growth rates can occur within a very short time period under the right policy and programmatic contexts [5, 6]. Most countries in Africa are ready for such significant change in reproductive norms. One in four women in Africa still have an unmet need for family planning [7]. Responding to and meeting this potential demand can significantly reduce the region's population growth rate, especially unplanned pregnancies which account for nearly 40% of all pregnancies in Africa [8]. Another opportunity for Africa to change this demographic future is to increase age at first marriage and first childbearing. Over the last 60 years, female age at first marriage has not really changed in most of Africa, especially among rural populations where mean age at first marriage is still below age 18 [9]. Increasing age at first marriage can improve female education in the short term and reduce population growth in the medium and longer term by increasing the gap between generations. Finally, increasing access to female education will have immediate and longer-term effects on slowing population growth. Most of these are cost-effective, easily implementable policy options that can significantly change the course of population growth in Africa. Not addressing Africa's continuing rapid rate of population growth limits the capacity of governments to make necessary investments in human capital development which, in turn, forces increasingly large numbers of people in Africa to depend primarily on the provisioning services of already fragile and degraded ecosystems. Given the small carbon footprint of many African countries, any efforts to slow population growth rates in Africa must be matched by appropriate, complementary efforts to mitigate the environmental damage brought by countries with the heaviest carbon footprints, even if they are experiencing zero or negative population growth.

The second major aspect of the Planetary Health report that is critically relevant for Africa is the management of Africa's natural resources and ecosystems. The issue of degradation of the natural environment and ecosystems is a major challenge for Africa. Africa currently suffers from deforestation that is at least twice the rate of the world average [10]. In West Africa, the estimate is that about 90% of original forests have already been deforested. Africa lost the highest percentage of tropical forests of any continent during the last three decades. Similarly, land degradation in the past three decades has been very high due to expansion of agriculture and changing land use [11]. Changing land use, deforestation, desertification, and land degradation are already having, and are expected to continue to have impacts on environmental and health status in Africa. For example, malaria transmission is now evident in many areas where it was previously absent. Over the years, improvements in agriculture in Africa have largely been driven by expansion of land area being cultivated rather than by increasing yield per acre. Many countries have already run out of space in terms of increasing the land area that could be cultivated. About 95% of agriculture in Africa is still rain-fed and about 70% of arable land is degraded [12]. In 37 African countries, severe soil nutrient depletion over the past 30 years has led to substantial soil impoverishment and reduced agricultural output [13]. The growth of environmental refugees has been greatest in sub-Saharan Africa (e.g. in Ethiopia), but risk in other areas is likely to increase as multiple environmental stressors come into play. The constellation of these factors pose real challenges for Africa and raises a number of fundamental questions regarding the prospects of social cohesion and food security in the region. Forest and land conservation policies for greener and healthy Africa are urgently needed. Also needed are integrated strategies to address growing demands for food within environmental limits through food and agricultural policies such as sustainable intensification; efficient use of water and fertilizer; reduction of food wastage and spoilage; sustainable aquaculture and fisheries; support for subsistence farmers; innovative sources of nutrition; promotion of healthy, low environmental impact diets; and promotion of environmentally-friendly alternatives to wood-fuel.

The third key area of the report that Africa cannot afford to ignore is the role of urbanization. Although Africa is still the least urbanized region of the world, it is the most rapidly urbanizing region. Many cities are projected to continue to grow at rates of more than 7% over the coming decades. The share of Africans living in urban areas soared from 15% in 1960 to 40% in 2010 and is projected to grow to 60% by 2050 [14]. Currently, about 60% of urban populations in Africa live in slums or informal settlements [15]. As smaller towns grow into cities without proper planning and provision of basic amenities, especially with devolved systems of government creating new centers of attraction, slums will proliferate. Work by the African Population and Health Research Center (APHRC) has shown that morbidity, access to health services, and mortality rates are worse for slum residents than for any other sub-group [16].

Whether this rapid rate of urbanization can lead to economic growth, transformation, and poverty reduction or to increased inequality, growing urban poverty, and the proliferation of slums remains an unanswered question. It is however clear that Africa cannot effectively address its growth and poverty challenges nor deal with the environmental consequences of these without addressing and managing its rate of urbanization. Urbanization is not a sub-plot, but rather the main policy narrative for Africa, now and in the future.

Conclusions

There are many other issues raised in the report that are relevant for Africa but I will devote this last section to views from a regional dissemination of the report in Nairobi in October 2015. The participants at this event were drawn from academia, civil society, regional and national policy makers, youth groups, and experts in the health and climate change fields. The participants unanimously endorsed the recommendation that action is needed at all levels to address the issues of planetary health in Africa and globally. The magnitude of the challenge and the severity of the consequences demand individual responsibility and action at household, community, local authority, national government, and regional/continental bodies levels. The group underscored the need for a multi-layered action plan to implement a planetary health agenda in Africa. They identified a number of priority areas where action is needed, including research and training priorities and policy and governance priorities. They underscored the role of partnerships and regional cooperation in addressing these challenges. They also noted that global processes and agreements on climate change need to connect better with what people think and do in their households and local communities in order to achieve a healthy balance between our environment (planet) and our population (people).

Acknowledgements – AE acknowledges the support of Dr. Tilahun Haregu and Montira Pongsiri who co-facilitated the dissemination of the report in Nairobi. He also acknowledges the inputs of all the participants at the Nairobi dissemination event and fellow Commissioners who wrote the report.

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2.4 Adaptation and Resilience

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Keywords
Health adaptation, low- and middle-income countries, climate change, health outcomes, implementation, policy, risk management

Abstract
Lessons learned, opportunities, and barriers to scaling up health adaptation were identified from evaluation reports and other materials from three multinational health adaptation projects covering fourteen low- and middle-income countries and from qualitative data collected through a focus group consultation and interviews with key informants purposively selected for their expertise and role in health adaptation. The national projects aimed to increase resilience to climate-sensitive health outcomes by focusing on incremental improvements in policies and programs to address climate variability, and by beginning to establish enabling environments for further adaptation. At this early stage in implementing health adaptation, projects have made limited plans for scaling up specific health adaptation activities outside of normal ministry approaches. Scaling up is needed to prepare for the challenges ahead, including by improving integrated surveillance and other programs to manage the health risks of a changing climate.

Background
The 21st century will be very different from the last. More countries than today will face challenges of food and water security. Environmental degradation is a growing problem worldwide, with adverse consequences for human health and well-being. Extreme weather and climate events cause injuries, illnesses, and deaths today, with their frequency, intensity, and in some cases duration expected to increase with climate change. These global environmental changes affect children: 85% of the health impacts of climate change are in children. The international negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) recognize the importance of focusing on the risks to women and children, making sure the most vulnerable will be protected over coming decades as the climate continues to change.

Figure 1 from the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report summarizes the potential for health adaptation to reduce risks, based on expert judgement and an assessment of the literature [1].

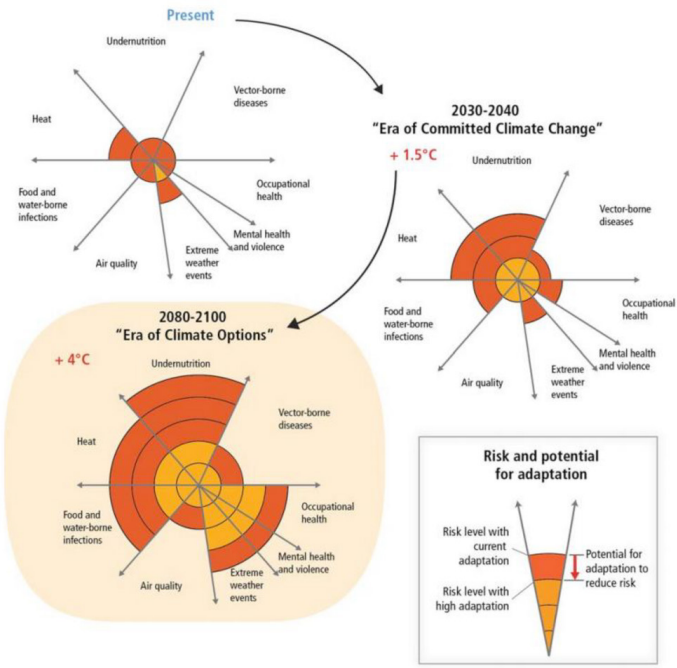

Figure 1: Conceptual presentation of the health impacts from climate change and the potential for impact reduction through adaptation
Source: Smith et al. 2014

This slide summarizes several key messages relevant for adaptation and resilience. The figure in the upper left-hand corner, labelled the present, summarizes current risks and the potential for adaptation to better manage those risks. As shown in the legend, the orange areas indicate the risk level with current adaptation (e.g. no additional efforts undertaken) and the gold areas indicate how much the risks could be reduced by effective, efficient, and proactive adaptation. The width of the wedges indicates the magnitude of the burden of major climate-sensitive health outcomes. Undernutrition and changes in the geographic range, seasonality, and intensity of transmission of vector-borne diseases are among the most important risks of climate variability and change today. As would be expected, risk levels are moderate today, with the potential to reduce risks for adverse health outcomes from extreme weather and climate events.

Looking across the periods 2030-2040, and 2080-2100, the figures show that risks are expected to increase dramatically over this century, with the opportunities for

adaptation also increasing. However, even with proactive adaptation, there will be significant residual risks that will need to be managed, particularly for undernutrition, heat-related morbidity and mortality, and food- and water-borne infections. Ministries of health will need to quickly and efficiently implement proactive adaptation option and to prepare for large increases in the magnitude of some climate-sensitive health risks. Limited adaptation efforts over the next few years will increase the risks that will need to be managed by mid-century.

Positive news from a public-health perspective is that the health concerns of a changing climate are known risks. Ministries of health already have programmes to address climate-sensitive health outcomes, such as malaria and diarrheal diseases; there are many tools, methods, and guidance documents for reducing and managing current and future health risks. Specific health adaptation projects are starting to be implemented, which will provide best practices and lessons learned to inform which interventions to scale up.

In addition to adaptation efforts within health systems, increasing resilience to climate change requires strong partnerships across sectors. The burdens of many health outcomes are not only a consequence of the effectiveness of policies and programmes within a ministry of health, such as for infectious diseases, but also are a consequence of policies and programmes in agriculture, water, and urban sectors. Collaborations across ministries are developing in many countries, with increasing numbers of effective examples. But much more progress is needed. Developing such collaborations will facilitate identifying and implementing innovative solutions to support transitions to more resilient and healthy societies.

The World Health Organization (WHO) published guidance on efforts needed to build climate-resilient health systems, summarizing the roles and responsibilities within a ministry of health [2]. Moving to climate-resilient health systems will require activities on many fronts, including enhancing leadership and governance to manage climate change; health workforce strengthening; conducting vulnerability, capacity, and adaptation assessments; developing integrated risk monitoring and early warning; conducting health and climate research; identifying and promoting climate resilient and sustainable technologies and infrastructure; improving management of the environmental determinants of health; developing climate-informed health programmes; increasing emergency preparedness and management; and increasing climate and health financing.

There is a long way to go for most health systems. Current policies and programmes for managing climate-sensitive health outcomes were established without considering climate variability and change, resulting in a significant gap for achieving resilience. For example, in certain regions, malaria control programmes will likely need to consider how climate change could alter the geographic range of the vector and disease,

seasonality, and the intensity of transmission, if they are to maintain their current level of effectiveness. Current and proposed surveillance and monitoring may need to be altered to include regions likely to be at risk in coming years, which implies that projections of malaria risks are available at the appropriate scale. Consideration also will be needed of whether sufficient human and natural resources are available to make necessary changes to policies and programmes, and whether partnerships with other ministries and organizations are needed to provide the required information (such as climate projections) to support informed decision-making.

WHO also published guidance on protecting health through adaptation planning to help these transitions to climate-sensitive policies and programmes [3]. The guidance on conducting the health component of a national adaptation plan promotes integration across sectors, and highlights the importance of integration from local to national scales. This guidance is being used by ministries of health to develop national health adaptation plans that integrate with plans developed by other sectors, to ensure protection of population health in a changing climate.

Several international projects were funded over the last 5 to 7 years on health adaptation. Lessons learned are highlighted from a 7-country WHO/United Nations Development Programme (UNDP) health adaptation project funded by the Special Climate Change Fund under the UNFCCC [4]. Examples of successful outcomes from some of these projects are highlighted below.

Bhutan is a mountainous country experiencing dengue and malaria moving into highland areas. Each village has a volunteer healthcare worker who undergoes training every year. Over the course of the WHO/UNDP project, healthcare workers from pilot communities were trained on the risks of climate change and on solutions to better manage changing burdens of disease. In a discussion two years ago, these workers, primarily farmers, talked about their lifetime experiences, what they had observed, and how it related to climate change. One farmer said when he was a child he could always tell when it was time for the fall festival because there was snow on the mountains. There no longer is snow on the mountains for the fall festival. He doesn't remember seeing mosquitos when he was a child. Whether or not there were mosquitos, mosquitos were not an important consideration as he was growing up. In April 2013, his community was sleeping under mosquito bed nets and the hospital said the closest known case of malaria was just 10 km away. So, in his lifetime, he has gone from not seeing diseases like dengue and malaria to being at risk of them.

The WHO/UNDP project in Bhutan was very impressive; it facilitated integration of data and information from the ministry of health with the meteorological services to develop early-warning systems. Through the project, collaborations were developed across the government to address challenges associated with a changing climate, and

partnerships strengthened with departments working directly with communities, to ensure information was communicated to those most at risk.

Another country in the project was Jordan, which is one of the ten most water-stressed countries in the world, with significant challenges of water-security. Starting several years ago, treated wastewater was used for agricultural irrigation. The neighbouring communities began experiencing higher than normal rates of diarrhoeal disease. The project facilitated coordination across the many departments and ministries with differing roles and responsibilities for water safety and security in Jordan. Achieving coordination across multiple mandates was challenging. In addition, the project supported underlying research that recently showed it was unlikely the treated wastewater was causing the increase in diarrhoeal disease; water handling and other issues were more important. The project aimed to ensure that Jordanians would have access to safe water while infrastructure is transitioning to a world where using treated wastewater will be commonplace.

Barbados, a third country in the WHO/UNDP health adaptation project, among other activities, trained schoolchildren about climate change and health. The children developed posters about what could be done in Barbados to reduce their carbon footprint.

An example of reducing greenhouse gas emission comes from Thailand. A medium-sized, 250-bed hospital outside of Bangkok (17th Somdejphrasangkharaj Hospital) implemented a CLEAN (Communication, Leader, Effectiveness, Activity, Networking) and GREEN (Garbage, Restroom, Energy, Environment, Nutrition) programme, with activities for each to promote resilience and sustainability. The hospital tracks its daily greenhouse gas emissions and has an extensive reuse program. The hospital staff designed and implemented a number of innovative activities. For example, a path was built around a wastewater treatment pond so that patients and staff could exercise. In addition, three bicycles were installed: riding the first aerates the pond, needed when treating wastewater; the second pumps pond water into a tub; and the third waters the lawn using a sprinkler system attached to the tub. In 2011 alone, the hospital reduced their greenhouse emissions by an impressive nearly 14% with a low-cost set of activities. The hospital has won many well-deserved awards, and shows what can be done locally with leadership and ingenuity. There are increasing examples of regional and local activities promoting more resilient societies using what they have at hand.

Conclusions

Climate change presents many risks to population health that, when addressed, could increase societal resilience and sustainability. In addition to adaptation and mitigation efforts, additional human and financial resources will be needed to prepare for and prevent the burdens of climate-sensitive health outcomes from increasing in future decades. Irrespective of resource constraints, low and middle-income countries

need to prepare for climate change through better understanding of potential risks, strengthening health systems, ensuring adequate policies and legislation, facilitating institutional support, and public education and awareness programs, including disaster preparedness measures.

Questions

Speaker from the floor

Madeleine Thomson from Columbia University. Thank you very much for the panel, I thought it was great and I was really interested to see a focus on the variability of the climate as well as a particular focus on Africa. I still think there is a gap that we have in the development of climate change and health where the benefits of a mitigation strategy for health are very clear in developed countries, in rapidly urbanizing environments, etc. and particularly in Asia, but less so, the discussion I think has been less developed for Africa and particularly the challenge we have around managing climate variability, which is now integrating with climate change. And I take for example the current El Niño, the biggest drought that we have in Ethiopia, which is really, meteorologically, the largest drought, bigger than the drought in 1984, and many of you in this room will remember the impact of that drought. We will see over the coming year, really, the capacity of the Ethiopian government to manage that drought and the donor response. But if we don't see that as part of climate change response, I think that we are really going to miss out, and particularly in the African context so I would really like to emphasize keeping an eye on that and also building that response in a more integrated way into the climate change discussion.

Thank you.

Speaker from the floor

Alex MacMillan from the New Zealand Climate and Health Council. It is great to see the development of systems thinking in planetary health and, as a systems-modelling environmental-health person myself, it is really reassuring to see. I wonder whether the ongoing calls for systems thinking and planetary health over time are about a complete lack of capacity among public health researchers, so my question really is about how we move public health research into systems thinking and capacity build in that way, and what's happening there.

Kristie Ebi

Thank you. Those are very good comments illustrating the challenges when a speaker has ten minutes to cover a broad field. Systems thinking is critical to addressing the health risks of climate and other global environmental changes. It's very positive that some funders are beginning to move this approach forward; further efforts are needed. The comment on soils: it's not so much a lack of recognition in the health sector of the important of soils. A major challenge is the disconnect between agriculture and

health systems. Agricultural models projecting the risks to food security typically focus on crop yields. There is a gap between these projections and health systems modelling of the risks of undernutrition with climate change. This goes back to the point about systems thinking; the importance of integrating across sectors to better understand risks and responses.

There have been efforts over the past twenty-some years to explicitly include climate variability in the UNFCCC and the IPCC. What I was hoping Dr. Thomson was going to say was that there are many researchers in this room; with the current El Niño, now is a perfect time for people to set up experiments to quantify the health risks of such events. If you have got long-term data sets, please think about how you can take advantage of this natural experiment, and come back next year to tell us what you found.

Acknowledgements - I thank Ms. Mariam Otmani del Barrio (WHO), Dr. Diarmid Campbell-Lendrum (WHO), the WHO regional offices, and the participants in the WHO/UNDP project.

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This commentary is available online:
Public Health Reviews 2016 37:17 | DOI: 10.1186/s40985-016-0032-5 | Published: 10 October 2016

3

Environmental change and nutrition: perspectives from young researchers

3.1 NUTRICLIM (NUTRition and CLIMate)

Investigating the relationship between climate variables, and childhood malnutrition through agriculture, an exploratory study in Burkina Faso

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Keywords
Malnutrition, low- and middle-income countries, climate change, stunting, remote sensing, weather

Abstract
Malnutrition remains a leading cause of death in children in low- and middle-income countries; this will be aggravated by climate change. Annually 6.9 million deaths of children under-five were attributable directly or indirectly to malnutrition. Although these figures have recently decreased, evidence shows that a world with a medium climate (local warming up to 3-4 °C) will create an additional 25.2 million malnourished children. This proof of concept study explores the relationships between childhood malnutrition (more specifically stunting), regional agricultural yields, and climate variables through the use of Remote Sensing (RS) satellite imaging along with algorithms to predict the effect of climate variability on agricultural yields and on malnutrition of children under five. The success of this proof of purpose study, NUTRICLIM (NUTRition and CLIMate), should encourage researchers to apply both concept and

tools to study of the link between weather variability, crop yield and malnutrition on a larger scale. It would also allow for linking such micro-level data to climate models and address the challenge of projecting the additional impact of childhood malnutrition from climate change to various policy relevant time horizons.

Malnutrition is globally recognized as having one of the largest adverse effects on the growth of nations, because it not only poses a challenge to the health, but also to the productivity of populations [1]. Unfortunately, climate change will have an additional negative impact on childhood nutrition, through a large number of factors [1,3]. Whilst malnutrition in children has globally decreased over the past few decades, climate change has the potential to reverse the recent gains in the global reduction of malnutrition [2]. A median climate (local warming up to 3-4 °C) is projected to create an additional 25.2 million malnourished children [3,5].

The 2015 Rockefeller Foundation and Lancet Commission on Planetary Health publication titled: Safeguarding human health in the Anthropocene epoch, states along with the IPCC that "… median crop yields would decrease by 0–2% per decade for the remainder of the century, as a result of climate change alone, with or without adaptation, whereas demands for crops are projected to increase by 14% per decade up to 2050" [4,6]. The publication continues by detailing that the projected decreases in crop yields result in increasing numbers of stunted children, especially in Asia and Africa. More than 90% of the world's stunted children live in Africa and Asia [7]. Currently, 36% of all children under five-years in sub-Saharan Africa suffer from stunting - a severe form of malnutrition [1,3]. Projections forecast that stunting will increase by approximately 23% in the region; this is why we selected a sub-Saharan African country as the site of this proof of concept exploratory study [3].

The relationship between changing climate, agriculture, and malnutrition is influenced by a multitude of factors. The complexity and interdisciplinary nature of these three issues converge into an elaborate web, which is represented in figure 1. The convolution of these links is precisely the reason these connections have been understudied.

Figure 1 illustrates an aspect of the complexity of the relationships investigated. Each of the three colored boxes represents one of three pillars: Climate, Agriculture and Malnutrition. Each arrow represents a relationship between two variables or factors. The three pillars converge on the subject of food crops and food yields.

This exploratory study, NUTRICLIM (NUTRition and CLIMate), in Burkina Faso aims to investigate the relationship between weather variability, crop yields, household socioeconomic variables and malnutrition. The study village of Bourasso, which has 12,548 inhabitants, in the rural Kossi Province is located 25km from the small town

of Nouna. The study involves 156 individuals, subdivided into 20 households with 29 children under the age of five. This first sample was randomly selected from the INDEPTH Human Demographic Surveillance System (HDSS) database of the Centre de Recherché en Santé de Nouna (CRSN) and the second sample from local Bourasso Health Post's database of malnourished children [9].

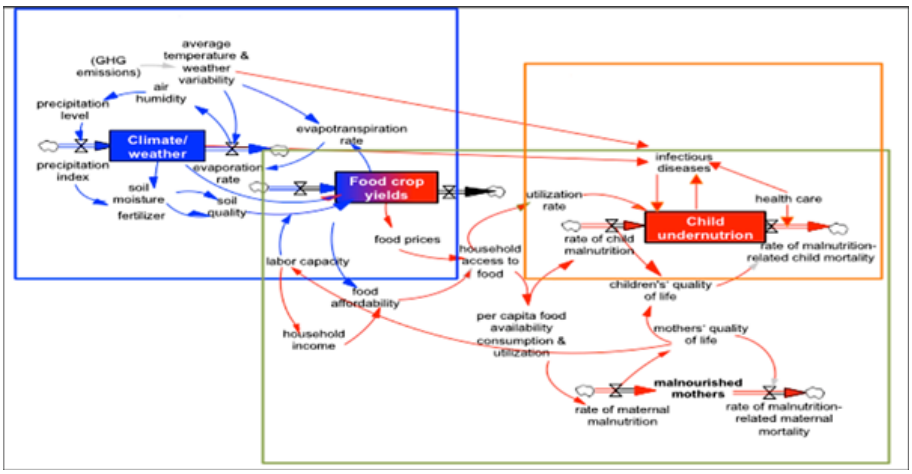

Figure1: Adapted from Dr. Revati K Phalkey "A systematic review of current efforts to quantify the impacts of climate change on under-nutrition" Proceeding of National Academy of Sciences, 2015 Aug 18; 112(33): E4522-9.

The 20 households can thus be subdivided into sample 1: 10 households that were randomly selected and coincidentally had no malnourished children under the age of five, and sample 2: 10 households that were purposefully selected for having children under the age of five who were undergoing treatment for malnutrition. The additional selection criteria were that all 20 households be subsistence farmers, living in the village of Bourasso, with at least one child under the age of five.

Data for the first pillar, climate, were acquired through the two nearest local weather stations of the HDSS. The weather stations provide information on median daily temperature, daily rainfall, as well as seasonal distribution and variability of rainfall.

Data for the second pillar, agriculture, was collected through two methods. The first method was harvest yields reported by farmers and converted from local measures into kilograms. The second was innovative in that it estimated plot level yields by household and crop using special algorithms from remotely sensed data of the village and its surroundings. This required the delineation of each field of all households with the farmers using a GPS to establish the polygons. These were overlaid with scenes from the Rapid Eye satellite, covering the agricultural fields of the 20 selected households. We carried out ground validation through verification and comparison of

the results from Remote Sensing (RS) satellite imaging; field agents physically verified that the satellite readings matched ground data. Post-harvest, the figures of the actual agricultural yields are used as input data to better calibrate the algorithms for modeling crop yields on a micro-level (household level).

The third pillar covered malnutrition and health. This data was collected using a socioeconomic and morbidity questionnaire for the selected households. The survey assessed (i) household assets, revenues and expenditure, (ii) a 24-hour nutritional recall journal of all children under five and (iii) all recent child illnesses within the household, both chronic and acute (episodes of diarrhea, malaria, etc…). Furthermore, we used standard anthropometry (weight, height and mid-upper-arm circumference) to assess the nutritional status of children under the age of five.

As data analysis was still in progress at the time of the presentation at the COP21, no definitive results could be stated. But preliminary findings indicate the possibility of disparities in the agricultural yield of households with and without malnourished children and between years with average and low rainfall. Differences were noticed not only in the types of crops sown, but also in the number of plots owned by the households: households with healthy children had on average a greater number of fields. When the subsistence farmers were questioned on their yields, only one-third classified their harvest as good, allowing the household to be fed in a satisfactory manner for the entire year until the next harvest. The remaining two-thirds of all households attributed insufficient yields to bad rains, changing rain patterns, or unpredictable rain patterns. This potentially highlights the significance of changing weather patterns and their consequences in terms of droughts [5,8].

Conclusions

We laid out a number of field methods in the fields of meteorology, agriculture, nutrition, and health that allow for the study of the web of causation of childhood malnutrition with a particular focus on the role of weather and climate in the future.

We propose that large-scale studies using these methods, amongst others, be considered. These could then be linked to downscaled climate models in cooperation with climate scientists in order to establish data-based projections of the future impact of climate change on malnutrition rather than relying on a set of assumptions and mono-disciplinary fragmented studies.

Declarations

Ethics approval and consent to participate – The study NUTRICLIM was approved by the Heidelberg University ethical committee "Ethik Kommission Medizinische Fakultät Heidelberg". Furthermore, in observation of ethically appropriate scientific research, NUTRICLIM followed the procedures of the ongoing Nouna Socioeconomic and

Health Panel Survey (SOHPS). This is the process, which has been utilized by the CRSN research center since 2000. For the anthropometric component of the study NUTRICLIM followed standard WHO procedures. The study team ensured that all malnutrition cases discovered during the course of the study would be presented to the CSPS and, if needed, be referred to Centre de Rehabilitation Nutritional (CREN) in the district capital Nouna. The project contributed 50% of all rehabilitation and care cost for such children. Lastly, the project had no environment impact.

All participants consented verbally and in written form to partake in the study. Participation in the research study was entirely voluntary; it had and will continue to have no effects or repercussions on the work or social life of participants. Participants were free to change their minds at any point, ceasing participation at will. There were no costs associated with participation nor were there financial incentives. The information collected in the framework of this research project was confidential. This information was stored in a file number anonymously. All consequent files were replaced with a unique identification number. No information was shared with anybody outside the research team. The knowledge gained from this research will be published so that other interested persons may learn from the research.

Acknowledgements – We would like to thank the people of Bourasso for the time they accorded to the collection of this pilot study data.

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This commentary is available online:
Public Health Reviews 2016 37:16 | DOI: 10.1186/s40985-016-0031-6 | Published: 6 October 2016

3.2 Integrated mixed-methods policy analysis for sustainable food systems

Trends, challenges and future research

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Keywords
Food policy, food systems, land use change, palm oil, mixed methods, sustainability, greenhouse gas emissions, economics, nutrition transition

Abstract
Agriculture is a major contributor to greenhouse gas emissions, an important part of which are associated to deforestation and indirect land use change. Appropriate and coherent food policies can play an important role in aligning health, economic and environmental goals. From the point of view of policy analysis, however, this requires multi-sectoral, interdisciplinary approaches which can be highly complex. Important methodological advances in the area are not exempt from limitations and criticism.
We argue that there is scope for further developments in integrated quantitative and qualitative policy analysis combining existing methods, including mathematical modelling and stakeholder analysis. We outline methodological trends in the field, briefly characterize integrated mixed methods policy analysis and identify contributions, challenges and opportunities for future research. In particular, this type of approach can help address issues of uncertainty, context-specific validity, incorporate multiple perspectives and help advance meaningful interdisciplinary collaboration in the field. Substantial challenges remain, however, such as the integration of key issues related to non-communicable disease, or the incorporation of a broader range of qualitative approaches that can address important cultural and ethical dimensions of food.

Introduction

Recent definitions of food sustainability have highlighted the existence of multiple inter-related dimensions including environmental, health, socioeconomic and cultural aspects(1). Related to this shift towards a multi-dimensional concept of food sustainability there has been increased emphasis on the understanding of food as a complex, integrated system (2). This implies that environmental, health and other dimensions of sustainability need to be considered jointly, and the relevant interactions between them need to be accounted for.

In particular, certain topics such as the «food versus fuel» debate or the debate around the allocation of resources for animal feed versus plant-based food for direct human consumption have drawn attention to the importance of such interactions across sectors within the broader food system (3). The most prominent examples are probably livestock or global flex-crops (4) which have several food, energy and other industrial uses, such as palm oil and corn. In these sectors, complex environmental impacts, largely related to indirect land use change, interact with changes in global dietary patterns. For example, global increases in meat consumption as part of a wider process of "nutrition transition" have been associated to increases in non-communicable disease in high income countries. At the same time, the use of land, water and other resources for animal feed has environmental impacts, and can also push up prices of cereals and other non-animal food products, aggravating malnutrition, especially in low and middle-income countries.

Methodological trends and developments

On the one hand, the need to incorporate this complexity has led to significant methodological developments. These include the design and application of integrated conceptual frameworks, (1) , as well as complex multi-sector models (5), (6), (7). A related trend has been the shift from traditional, attributional Life Cycle Analysis (LCA) towards a consequential, policy focused LCA (3). Consequential LCA attempts to include all of the relevant impacts of a certain policy across different sectors within the system, taking into account potential interactions (8).

Concerns have been raised, however, about the limitations of these increasingly complex models. In particular, researchers have pointed out the excessive uncertainty in the results as well as the lack of comparability in terms of both results, assumptions and methodologies (3). In addition, important differences in language and approach can hamper interdisciplinary work in the area (ibid.). Finally, there has been increasing acknowledgement that realistic policy analysis requires an assessment not only of multiple objectives but also of the different and potentially conflictive perspectives of relevant actors (9).Nevertheless, these issues are still comparatively neglected and

analysis often focuses on policy options that are unrealistic given the specific context for which they are recommended.

On the other hand, approaches based on stakeholder analysis have frequently been applied to the fields of natural resource management, alongside land use planning and social forestry (10), (11) and, more rarely, sustainable diets and foods systems (12). Environmental Impact Assessments (EIA) also routinely incorporate stakeholder analysis, albeit generally from a very site-specific and geographically constrained perspective (13).

Stakeholder analysis is inherently context-specific although not necessarily bound by specific geographical or sectoral constraints. Moreover, the theoretical frameworks underlying these research methods, unlike most quantitative analysis in this field, tend to highlight the socially constructed nature of reality and focus explicitly on perspective and the existence of potentially conflicting objectives. Although this type of approach has its own set of limitations (14), it has been identified as being complementary to commonly used quantitative methods for research on sustainable food and therefore recommended for its use as part of mixed-methods approaches.

What we mean by "integrated mixed-methods policy analysis for sustainable food systems" is a combination of quantitative economic and biophysical modelling and stakeholder analysis (or other qualitative methodologies) which aims to include different dimensions of sustainability across several sectors and their interactions, adopting a systems perspective and a policy focus, rather than addressing a specific site or technology. Similar methodological approaches have been recommended and applied in areas related to sustainable food systems over the last decade. In particular, variants of this type of approach have been recommended in fields such as sustainable nutrition at the household level (15), sustainable cropping (9), biofuels and food security (16) or biomass energy (13). These methodologies are often used together with decision making or "decision aiding" tools such as Environmental Impact Assessment (EIA), Multi-Criteria Decision Analysis (MCDA) or Back-casting.

The main contribution of this kind of approach is probably the explicit acknowledgement of different perspectives and possibly conflicting interests alongside the analysis of intersectoral impacts and linkages, increasing transparency and diversity in policy processesAlthough this methodology can also itself be captured and manipulated by specific interests, it has frequently been applied to empower fringe, marginal or vulnerable stakeholders, and methods have been developed for this purpose, such as radical-transactiveness (14). In the case of food, these stakeholders can include smallholder farmers, workers in various segments of the industry or street food vendors, vulnerable or low-income consumer groups, as well as more abstract entities, such as biodiversity. However, there are other relevant advantages which have been identified or suggested in the literature. Firstly, the use of methodologies that can combine quantitative and

qualitative information can help to realistically manage uncertainty, dealing with different types of knowledge and uncertainty that are incorporated in food sustainability models, although often not explicitly recognised (3). In addition, integrated methodologies can highlight the trade-off between context-specific validity and comparability, achieving a realistic balance and focusing the analysis on context-sensitive policy options (13). Finally, mixed-methods approaches can improve interdisciplinary collaboration, not by attempting to homogenise assumptions, but rather by increasing the transparency and understanding of the differences in underlying theoretical frameworks across disciplines.

Despite the many opportunities offered by integrated mixed-methods policy analysis there remain significant challenges for its application to the field of sustainable food systems. Firstly, further work is needed in order to incorporatecomplex health and nutrition impacts. In particular, there is a need for further integration of emerging issues of non-communicable disease, where changing food environments and food processing mediate between health outcomes and environmental or socioeconomic impacts. Furthermore, the cultural and ethical aspects of diets are also frequently neglected in food policy analysis, despite being increasingly recognised as an integral dimension of sustainability. The adequate assessment of cultural and ethical implications of food policy might require broadening the range of qualitative methodologies within multi-sectoral policy analysis, including anthropological approaches at the household, industry and food environment levels (17). To conclude, we argue that there is a need for further development of integrated mixed-methods policy analysis to assess food sustainability, particularly on topics such as food biofuels, flex-crops or livestock, which involve both indirect land use change and complex transformations in food environments and dietary patterns.

Acknowledgements – I would like to thank Professor Bhavani Shankar for his helpful comments

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3.3 How do sustainable diets fit into the climate agenda?

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Keywords
Food consumption, greenhouse gas emissions, water and land use, non-communicable diseases, diet

Abstract
Food production is a major driver of greenhouse gas (GHG) emission and other environmental footprints, and dietary risk factors are contributors to non-communicable diseases. A growing body of evidence has shown that changes in what and how much we eat can offer benefits for both the environment and health. However, several data gaps and complexities remain in this research area. A better understanding and increased uptake of sustainable diets will require further research, investment, and interdisciplinary collaboration.

Background
When the public thinks of major sources of greenhouse gas (GHG) emissions, agriculture does not seem to be at the forefront of their minds [1]. However, agriculture contributes about one quarter of all emissions, a magnitude comparable with other major sectors, including energy production (35% of global emissions), industry (21%), and transport (14%) [2]. Efforts to reduce GHG emissions require action across all sectors, and therefore agriculture will have to implement its own mitigation solutions. Beyond GHG emissions, food production is also responsible for about 70% of global water use, and takes up one-third of potentially cultivatable land [3].

Mitigation of GHG emissions is possible in various areas of food production and consumption, and approaches are broadly classified as supply side (the technical innovations producers can achieve) and demand side (how much and which foods consumers choose to eat) efforts. Action will be needed in both spheres, though evidence suggests that opportunities may be larger on the consumer side [4].

This raises the question of what food choices consumers can make to limit GHG emissions. The literature has shown that different foods can have markedly varied levels of emissions, with ruminant meat generally showing the highest emissions per calorie, followed by other meats and dairy, and plant-based foods having the least emissions [5]. Studies from high-income countries, where average diets tend to be high in animal-based foods and overall calories, show that health and climate benefits can be achieved by replacing meat and dairy intake with plant-based foods [6]. Additional benefits from these shifts can also be realized in land and water use. Many of these benefits can be achieved by following national dietary guidelines.

However, studies also point to complexities in these relationships. Some foods that should be restricted in our diets may have relatively low emissions, such as sugar. Foods that have good GHG profiles may have relatively more detrimental effects on other environmental indicators such as water use [7]. The opportunities for win-win strategies on environment and health are also unclear in low-income countries, where data on environmental impacts of food production are scarce, and where many individuals may need to consume more, rather than fewer, calories, and increase their diversity of food intake.

Conclusions

Ultimately, more needs to be done to comprehensively evaluate the impacts of shifting to low GHG diets. Further work should focus on strengthening the many gaps in region- and item-specific GHG data of food production and value chains. A broader assessment of sustainability will also require measurement of dietary shifts against a wider set of environmental, health, economic, and socio-ethical indicators. These efforts will require sustained investment in this emerging research area, and interdisciplinary collaboration.

However, despite these gaps, there is evidence that diets can play an important role in mitigation of GHG emissions. Climate and health benefits can be currently achieved in many regions by at least partial replacement of high intake of animal-based foods (particularly ruminant meat), with intake of plant-based foods (including an appropriate mix of pulses, cereals, and fruit and vegetables).

Acknowledgements - I would like to thank Andy Haines and Rosemary Green for their helpful comments.

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4

Linking health and environment change

4.1 Future Earth Health Knowledge Action Network

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Keywords
Future Earth, human health, planetary health, sustainability research, climate change, Knowledge-Action Networks

Abstract

Future Earth is an international research platform providing the knowledge and support to accelerate our transformations to a sustainable world. Future Earth 2025 Vision identified 8 key focal challenges, and Challenge #6 is to "Improve human health by elucidating, and finding responses to, the complex interactions amongst environmental change, pollution, pathogens, disease vectors, ecosystem services, and people's livelihoods, nutrition and well-being". Several studies, including the Rockefeller Foundation/Lancet Planetary Health Commission Report of 2015, the World Health Organization/Convention on Biological Diversity report and those by oneHEALTH (former ecoHEALTH) have been conducted over the last 30 years.

Knowledge Action Networks (KANs) are the frameworks to apply Future Earth principles of research to related activities that respond to societal challenges. Future Earth Health Knowledge-Action Network will connect health researchers with other natural and social scientists, health and environmental policy professionals, and leaders in government, the private sector and civil society to provide research-based solutions based on better, integrated understanding of the complex interactions between

a changing global environment and human health. It will build regional capacity to enhance resilience, protect the environment and avert serious threats to health, and will also contribute to achieving Sustainable Development Goals. In addition to the initial partners, Future Earth Health Knowledge-Action Network will further nourish collaboration with other on-going, leading research programmes outside Future Earth, by encouraging them in active participation.

Future Earth is an international research platform providing the knowledge and support to accelerate transformations to a sustainable world. Future Earth brings together existing programmes on global environmental change, as well as experts from all disciplines, including natural and social sciences, engineering, the humanities, health, law, and business, with a range of stakeholders including policymakers, to develop transdisciplinary solutions to sustainability challenges.Our Vision 2025 identifies 8 key focal challenges as:

1. Deliver water, energy, and food for all, and manage the synergies and trade-offs among them, by understanding how these interactions are shaped by environmental, economic, social and political changes.

2. Decarbonise socio-economic systems to stabilise the climate by promoting the technological, economic, social, political and behavioural changes enabling transformations, while building knowledge about the impacts of climate change, and adaptation responses for people and ecosystems.

3. Safeguard the terrestrial, freshwater and marine natural assets underpinning human well-being by understanding relationships between biodiversity, ecosystem functioning and services, and developing effective valuation and governance approaches.

4. Build healthy, resilient and productive cities by identifying and shaping innovations that combine better urban environments and lives with declining resource footprints, and provide efficient services and infrastructures that are robust to disasters.

5. Promote sustainable rural futures to feed rising and more affluent populations amidst changes in biodiversity, resources and climate by analysing alternative land uses, food systems and ecosystem options, and identifying institutional and governance needs.

6. Improve human health by elucidating, and finding responses to, the complex interactions amongst environmental change, pollution, pathogens, disease vectors, ecosystem services, and people's livelihoods, nutrition and well-being.

7. Encourage sustainable consumption and production patterns by understanding the social and environmental impacts of consumption of all resources, opportunities

for decoupling resource use from growth in well-being, and options for sustainable development pathways and related changes in human behaviour.

8. Increase social resilience to future threats by building adaptive governance systems, developing early warning of global and connected thresholds and risks, and testing effective, accountable and transparent institutions that promote transformations to sustainability.

To coordinate development of knowledge and action on these challenges Future Earth is developing new inter- and trans-disciplinary approaches on three themes of Dynamic Planet, Global Sustainable Development and Transformations towards Sustainability. The platforms for collaboration developed are called Knowledge-Action Networks (KANs).

Knowledge-Action Networks (KANs)

Knowledge-Action Networks constitute the framework for applying Future Earth approaches to research and related activities that respond to societal challenges. The main method of the Knowledge-Action Networks is facilitating high quality actionable scientific knowledge through the integration of research and the involvement of societal partners, following the engagement guidelines of Future Earth. Knowledge-Action Networks build on the broad range and diverse specialist expertise represented in the large community of researchers and practitioners within the Future Earth structure, as well as endorsed and associated organisations, projects, and individuals that want to join the Future Earth Open Network.

The objectives of the Knowledge-Action Networks are to:

- identify and respond to society's needs for scientific knowledge to successfully undertake the transformation to sustainability;
- generate integrated knowledge that is relevant to decision-makers;
- develop and cultivate research that is solution-driven, inter- and trans-disciplinary, and
- add value to research that is or has been carried out already.

Participation in KANs is on a voluntary basis through members, projects or groups with the appropriate expertise and an interest in putting their expertise into the broader context of sustainability research addressed by Future Earth.

Future Earth Health Knowledge-Action Network

In 2015, the Rockefeller Foundation-Lancet Commission on Planetary Health published its report: Safeguarding human health in the Anthropocene epoch [1]. It showed how the health of people is tightly linked to the health of the planet we inhabit and thus

how adverse changes in the Earth's natural ecosystems are a threat to human health. Advancing this concept requires wider understanding of the eco-social dimensions of health.

The Commission argued for urgent development of a new avenue of research inquiry - on planetary health. Attention to the human systems (economic, social and political) and Earth's natural systems can improve health and wellbeing of all. The Future Earth Health KAN responds to this call, bringing health researchers together with other natural and social scientists, health and environmental policy experts, and leaders in government, the private sector and civil society. The goal is to promote research-based solutions for better, integrated understanding of the complex interactions between a changing global environment (such as climate change, pollution, biodiversity loss, fishery declines and land use change) , the loss of ecosystem services and the health of human beings (including livelihoods, nutrition and well-being). Long-term integrated observation systems to collect rigorous health, socioeconomic, and environmental data will be encouraged.

Another major focus will be to build regional capacity to integrate and act on planetary health knowledge to enhance resilience, protect the environment and avert serious threats to health. This work takes place in the context of the 17 Sustainable Development Goals approved by the United Nations Member States in 2015 [2], many of which deal directly or indirectly with health. Together with potential initial partners, including Future Earth's oneHEALTH (former ecoHEALTH) project, the International Council for Science (ICSU) programme on Urban Health and Wellbeing, the World Health Organization and the United Nations University's International Institute for Global Health, Future Earth Health KAN will further nourish collaboration with other on-going, leading research programmes.

Conclusions

We anticipate that the development of this network will be a bottom up exercise lead by scientists, policy makers and stakeholders. We will be issuing a call for interest in late 2016, ealt 2017 to identify voluntary participants. We encourage active participation from interested parties both in the scientific communities and in broader society.

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4.2 Addressing Challenges to Human Health in the Anthropocene Epoch

An overview of the findings of the Rockefeller/ Lancet Commission on Planetary Health

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4

Keywords
Planetary health, climate change, environmental change, human health, policy

Abstract

The report of the Rockefeller Foundation/Lancet Commission on Planetary Health described how human health directly depends upon the environment. It takes a broad perspective acknowledging climate change as the most important factor, but also recognizes other impacts, including dramatic loss of tropical forests, land degradation, loss of biodiversity, declining freshwater resources, ocean acidification, and over-exploitation of fisheries. All pose challenges to human health gains, leading to the concept of planetary health - that the human condition is tied to natural systems. The Planetary Health Commission report highlights several major concerns arising from environmental change including impacts on food availability and quality, increases in natural disasters and population displacement, and newly emerging diseases e.g. from zoonotic infections.

Three challenges emerge from the report: the first is imagination, or conceptual challenges - better metrics are needed to assess human progress within the context of environmental change; the second is a lack of relevant knowledge, requiring more research on the inter-linkages between environmental change and health and on the effectiveness of potential solutions; the third is implementation of solutions, ensuring that the science is translated into policy and practice. There are many opportunities to promote planetary health including development of sustainable and healthy cities, encouraging more resilient health systems and disaster preparedness, reducing food waste, preservation of ecosystems, and redirection of subsidies in food, agriculture, fishery and energy sectors. Many current trends are driven by inequitable, inefficient,

and unsustainable patterns of resource consumption and technological development, coupled with population growth, but solutions lie within reach. Prosperity must be redefined as an enhancement of the quality of life and the delivery of improved health for all, together with respect for natural systems.

The report of the Rockefeller Foundation/Lancet Commission on Planetary Health [1] described how human health ultimately depends on the state of the natural systems. It is complementary to the work of the Lancet Commission on Climate Change [2] and takes a broader perspective on global environmental change, acknowledging that climate change is probably the single most important environmental change, but there are many others that can separately and in combination have wide ranging impacts on human health.

Human health has advanced tremendously in recent decades, for example there has been an increase in life expectancy of over 20 years since the middle of the last century and a dramatic decline in childhood death rates, of over 70%. But this has all come at a considerable environmental cost. Global average temperature has increased by 1° C since pre-industrial times and based on the commitments that were made in the run up to the COP21 Paris, the increase could amount to around 2.7° C or more by the end of the century in absence of further actions. There are many other changes as well, including dramatic loss of tropical forests, one of the factors that is driving the loss of biodiversity that is occurring at rates 100-fold greater than pre-human times. Freshwater resources are in decline in many parts of the world and about 3 billion people live in locations that are subject to varying degrees of water stress, partly because of depletion of aquifers, which cannot be replenished in human lifetimes. Carbon dioxide is dissolving in the ocean leading to increasing acidification with probable major impacts on marine ecosystems.

A single species, Homo sapiens, is now dominating the global environment, and that has led an increasing number of scientists to call our epoch the Anthropocene, in recognition of the dominant role played by humanity. There are likely to be very major consequences for human health due to these changes, which are still incompletely understood. In particular there are very few studies of the interactions between different environmental changes. One of the major concerns arising from the Planetary Health Commission report was the effect of multiple environmental changes on food availability and quality. Climate change itself will likely reduce crop yields, particularly in tropical and subtropical regions in the next few decades, and probably in temperate regions in the second half of the century. Carbon dioxide fertilization is making some types of crops (C3 crops) grow a little faster but it is also changing their nutrient quality, so it is reducing micronutrient levels. Declines in pollinators are occurring in many

parts of the world, probably as a result of a number of environmental changes, with important implications for the yield of crops that depend on pollinators. A paper that appeared together with the Commission report suggested there could be an extra 1.4 million deaths a year if all the pollinators (such as bees etc.) were lost, largely because of declines of fruit and vegetable availability, increasing the risk of non-communicable diseases and increases in infectious diseases because of reductions in vitamin A intake in some populations [3].

The report also outlined the potential effects of multiple environmental changes on disasters and displacement of populations. It gave the example of Pakistan, which is facing a combination of challenges: population growth, which is the highest outside Sub-Saharan Africa; recent exposure to very large-scale floods and droughts affecting over 10 million people, displacing many people from their homes. And as the Commission report went to press, there was a major heatwave with temperatures over 42° C in parts of southern Pakistan. There is already evidence that labourers in parts of Pakistan, are beginning to move from rural to urban areas because they cannot work in the very intense summer heat that will only get worse [4].

Many emerging diseases are zoonotic infections that are often related to changes in agricultural practices, land use, increasing mixing of human populations with animal populations. In the Commission report there was a case study of Ebola, which provides a dramatic example of how such outbreaks can disrupt fragmented and weak health systems. These challenges are likely to get worse in the future.

The report identifies three types of challenges that need to be addressed. One is imagination, or conceptual challenges, for example the tendency to focus on indicators such as GDP growth as the main indicator of human progress. However economic growth may be profoundly inequitable and associated with unsustainable environmental damage. Better metrics are needed for assessing human progress against the background of environmental change. The second challenge is that of a lack of knowledge and relevant information, which requires more research on the inter-linkages between environmental change and health and on the effectiveness of potential solutions. It is encouraging to see that two major research funders, the Rockefeller Foundation and the Wellcome Trust, have risen to the challenge of investing in research to address these planetary health issues. Forging better links between environmental data and human health data is essential to advance understanding, and Future Earth (see accompanying paper) provides an opportunity to do so. The third set of challenges are implementation challenges, which need to be addressed to make sure that the science gets into policy and practice. These require surmounting barriers such as those related to poor governance and vested interests as well as implementing policies to reform damaging subsidies and taxes.

There are a number of opportunities to promote planetary health, for example by developing sustainable and healthy cities, including reducing greenhouse gas emissions from fossil fuel combustion with resulting improvements in fine particulate air pollution, and making cities more resilient against climate change. Green spaces, can reduce the urban heat island effect, they may also help to protect biodiversity and to promote mental health. Also, sustainable transport systems which promote public transportation and active travel – walking and cycling- can reduce air pollution and increase physical activity. Watershed conservation can help provide a clean water supply for cities, whilst reducing biodiversity loss, soil erosion and flooding. Programmes to improve slums and informal housing can reduce vulnerability to disasters and temperature extremes, increase access to clean household energy and help to address poverty.

More resilient health systems that can rebound from shocks stronger than before are essential to deliver a diverse range of services, which promote universal health coverage, and prepare for and respond to disasters. They will require much better disease surveillance systems that detect and control emerging diseases rapidly. Another example of a policy that contributes to improving planetary health is the reduction of food waste. About 30% of the world's total agricultural land is used to produce food that is never eaten and strategies to reduce food waste will need to address poor practices in harvesting, storage, transportation, marketing, and consumption. Many crops are not fed directly to humans but are used to feed animals because of the increasing demands for animal products. There are conversion inefficiencies which vary according to the type of animal product (being particularly high for beef) and also many animal products are associated with higher greenhouse gas emissions compared with vegetables, particularly from ruminants because they produce methane in their intestines. Increasing fruit and vegetable consumption and reducing animal product consumption in high consuming populations hold the potential to reduce environmental impacts and improve health. This will be a crucial area for research and the disciplinary silos between health, agricultural and environmental scientists must be overcome so they can work together.

Ecosystem strategies can help to increase disaster resilience, for example preserving wetlands and mangroves can help protect coastal populations against tidal waves and sea-level rise, and coral reefs can provide a safe haven for many fish on which human populations depend. Around 90% of the world's fisheries are currently fully or overexploited, and over 2 billion people depend on fisheries for a significant proportion of their protein intake. Around 70% of aquaculture depends on supplemental feeds and there is widespread use of antibiotics and pesticides. More sustainable aquaculture is needed in order to take the pressure off natural fisheries.

There is also increasing evidence that forest conservation can protect biodiversity and health as well as reducing greenhouse gas emissions. For example, 300,000 people a year

die from air pollution caused by landscape fires, in part to clear forests and peatlands for commercial use. This is particularly striking in parts of Southeast Asia.

The Commission also showed that there are many subsidies in the food, agriculture, fisheries and energy sectors that are driving humanity in the wrong direction. They are allowing us to exploit resources, which are in turn causing serious damage to the environment and human health. A recent International Monetary Fund report has shown for example there are annual energy subsidies of around $5 trillion. Some of them are direct but most of of them are caused by the fact that we do not pay the full economic costs of air pollution, and of climate change. Policies should be enacted to reverse damaging subsidies and also to reform tax systems to ensure that taxes reflect the damaging externalities of economic activities, for example by implementing carbon taxes to reduce greenhouse gas emissions.

The Sustainable Development Goals (SDGs) will be a major driver of policies worldwide over the next 15 years. Planetary health can act as an integrating framework across the SDGs. Health is only reflected directly in Goal 3 but many other goals address key determinants of health, for example goal 1 on poverty, goal 2 on sustainable agriculture and nutrition, goal 6 on water and sanitation, goal 7 on access to clean energy, goal 11 on sustainable clean cities, and others on preserving biodiversity in terrestrial and marine ecosystems. The goals, targets and indicators for the SDGs reflect many of the key dimensions of planetary health.

In conclusion, despite the many challenges, solutions lie within reach. They should be based on the redefinition of prosperity to focus away solely from the growth of GDP towards the enhancement of the quality of life and the delivery of improved health for all, together with respect for the integrity of natural systems.

Acknowledgement - The author would like to acknowledge the work of the Rockefeller Foundation – Lancet Commission on Planetary Health, which included contributions from Sarah Whitmee, Chris Beyrer, Frederick Boltz, Anthony G. Capon, Braulio Ferreira de Souza Dias, Alex Ezeh, Howarrd Frumkin, Peng Gong, Peter Head, Richard Horton, Georgina M. Mace, Robert Marten, Samuel S. Myers, Sonia Nishtar, Steven A. Osofsky, Subhrendu K. Pattanayak, Montira J. Pongsiri, Cristina Romanelli, Agnes Soucat, Jeanette Vega, and Derek Yach. The author thanks the Rockefeller Foundation for their financial support.

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This commentary is available online:

Public Health Reviews 2016 37:14 | DOI: 10.1186/s40985-016-0029-0 | Published: 4 October 2016

4.3 Linking Health and Environmental Change: perspective from WHO

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Keywords
World Health Organization, climate, health

Abstract:
The Paris Agreement on Climate Change represents not just an environmental treaty, but potentially the most important public health agreement of the 21st Century. The health community has contributed to the evolution of the international climate change negotiations since their beginnings in the late 1980s, although our engagement has not been as close or as effective as it could have been. It is therefore critical for health, environmental and sustainable development that the health community adopts the Paris Agreement as its own, and supports its full implementation, through advocacy, evidence, public health action, and a broad and active mobilization of the health voice to address climate change.

We are clearly at an historic moment in terms of addressing climate change. It is important to understand a little bit about the history of how we got to where we are, in terms of the relationship between work on climate change and on health. We began to become aware of climate change in the late 1980s and early 1990s. The scientific community mobilized behind the Intergovernmental Panel on Climate Change (IPCC), the United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992(1), we had the Kyoto Protocol in 1992 (2) and now we are moving forward to, hopefully, a strong agreement in Paris in 2015 (3).

Sometimes we think that health has not been there, has not been actively engaged, but in fact health has been involved in these discussions right from the beginning. As early as 1989-1990, the World Health Organization (WHO) published its first report on the links between health and climate change(4). There were programmes established in the WHO European office and headquarters a few years later, and in 2000 we produced

the first quantitative estimates of the burden of disease attributable to climate change. Then in 2007-2008, Dr. Margaret Chan, Director-General of WHO, highlighted climate change as potentially the greatest public health threat of the 21st century and we had a World Health Assembly resolution(5) at that time. So maybe we have not been strong enough, but we have been part of this story from the beginning. As we come out of the Paris agreement, it is important to learn one of the lessons of history: there was perhaps some disappointment in some of the early discussions on this, that health had been somehow omitted from the climate change discussions, and that led to a lack of engagement from the health community. It is very important that whatever comes out of the Paris agreement, that the health community supports it, sees it as its own agreement and implements it. I think we now have the evidence, we have the consistent messages, and we have the numbers.

WHO has been accompanying the negotiations of the Paris Agreement climate change treaty. We have been pushing for a greater recognition of health within the Agreement since the beginning, and, at the same time, we have been very clear that the most important result for health is just to have a strong climate change agreement. Irrespective of where and how health appears in the final text, we would not want to do anything to undermine the strength of the agreement. Our Director-General and all of us have been very consistent with the message that a strong climate change agreement is a strong health agreement. If we sign this, it is probably going to be the most important public health agreement of the 21st century. It is always hard to negotiate an agreement amongst over 190 parties, but there are references to health which seem to be effectively agreed within the treaty. We have health within the draft decision, we have health within the draft agreement and we have references to health care benefits within the urgent actions up until 2020. And there are many other implicit references to health within the treaty in reference to earlier documents. There is enough to say that this is our treaty as well. The delegations we have talked to want to present this as a public health treaty, amongst other things, as they come out of Paris. Just briefly, apart from praising the organization of the COP21 from France, I have to praise the diplomacy of France in getting this close and hopefully to the final stages of the negotiations. So once again, bravo, and as an Englishman, stop making me say it, it's making me feel bad.

Finally on this subject, on what we need to do as a health community - we obviously have a role in responding to the threats that climate change presents to health, but also to the Paris Agreement that we hope will be signed within the next 24 hours. The tasks described below are structured around our own WHO work plan, which is approved by our Executive Board, and effectively approved by all ministries of health in the world. It is quite a comprehensive set of tasks that we have to do and that we have to work on within the health community.

The first item is advocacy. WHO has a mandate to go out and speak about this. The first WHO climate and health conference was held last year and we are already talking about the second one to mobilize the health community around this issue.

The second is evidence. We are an evidence-based organization, and health is an evidence-based community. WHO is moving from the large-scale global estimates of health impacts of climate change and co-benefits, to take it down to the country level, to produce individual country profiles of climate and health in partnership with the UNFCCC Secretariat (6). These are products that we take to individual ministries of health or ministries of environment, to tell them, for example, about the risks that climate change presents to health in their own context, the actions they can take to get health co-benefits in climate change mitigation policies, and to track their own progress in implementing actions to address the health threat from climate change, and the health opportunities of mitigation action.

The third point is implementation, which WHO has drastically scaled up its work. We now provide a comprehensive package of support to planning health adaptation to climate change, and have now implemented pilot projects of US$500,000 or more in over 20 countries. We will be working with other UN and bilateral partners to further scale up this implementation in future years.

Finally, perhaps the most important element is the partnerships. There are for instance very important, technical partnerships amongst UN programmes, but really the most important partnership I would say for WHO is the engagement and backing and the interaction with the wider public health community represented in this room.

Thank you very much.

Acknowledgements – I would like to sincerely thank Antoine Flahault and Corinne Kowalski for the invitation to present in this event, and in editing the transcript of my presentation.

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5

The role of foundations

5.1 Wellcome Trust: The Role of Funders

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Keywords
Global Health, planetary health, environment, transdisciplinary research, foundations

Abstract

Wellcome exists to improve health for everyone by helping great ideas to thrive. We are a global charitable foundation, both politically and financially independent. We support scientists and researchers take on big problems, fuel imaginations, and spark debate. The health of the global population and the planet are inextricably linked but there is a poor ecological fit between what we are asking of the planet and its resilience. If the complex natural systems we rely on for clean air, fresh water, fertile soil, biodiversity and a stable climate are threatened, so too is our health. The challenge is to secure the health and well-being of present and future generations whilst responsibly stewarding the planet. As research continues to unravel our understanding of the vital links between health and the environment, we become better equipped to develop robust, coherent and coordinated solutions that jointly reduce threats to human health and to the surrounding environment that sustains it. There are already clear opportunities for change but more research is needed.

Our Planet, Our Health was identified as new priority area for Wellcome in 2015. We support work that embraces and stimulates creative partnerships, collaborating across disciplines and sectors, because we believe that we need a diversity of competencies to tackle these complex problems. Our aim is to gain deeper insights into these issues, to inform the global response through transdisciplinary research and develop policies that will help mitigate the risks to human health.

The Wellcome Trust is an independent global charitable foundation dedicated to improving health. Since 1936, our funding has helped to save millions of lives worldwide, through science, research and engagement with society. This support includes transformative work like the sequencing of the human genome, and research that established the front-line drugs for malaria.

As a funder of health research we need to understand how health and the environment interact. Just as The Lancet as a leading health journal is addressing the connections between health and the environment with the Planetary Health Commission, we as a funder need to consider these links carefully. Increasing population growth, combined with changes in consumption, is testing the resilience of the planet on which we live. This ecological overreach is threatening prosperity, health and wellbeing for current and for future generations.

For three and a half years a team at Wellcome have been striving to build our understanding of these global challenges, and work out what role Wellcome can play in developing the field of planetary health and safeguarding the health of our planet and its inhabitants.

In 2013 we were allocated a small amount of research funding, and used this to fund a range of pilot projects. When we put out a call for proposals we had around 840 expressions of interest from researchers around the world, from ecologists and epidemiologists to engineers, all of them thinking in a transdisciplinary way about research questions that bridge environment and health. It is clear there is an appetite for new research opportunities, both from the academic community and from policy makers who need evidence, and Wellcome can play a part in creating and funding these opportunities.

The next step in Wellcome's investment in this area is Our Planet, Our Health, an initiative, announced in September 2015, which includes a commitment to invest £75 million in the area of planetary health over the next five years. Through Our Planet, Our Health we will provide funding for international research programmes, develop strategic partnerships, and, importantly, engage with society.

From working with partners and talking to others in the field, we are convinced of the importance of evidence, education and engagement in furthering the development of planetary health and ensuring it has an impact on human health worldwide.

Wellcome's philosophy is that good health makes life better. We work to improve health for everyone by helping great ideas to thrive; the planetary health community is full of people with great ideas and the passion to bring about meaningful change, and Wellcome is committed to working with them.

This letter to the editor is available online:
Public Health Reviews 2016 37:8 | DOI: 10.1186/s40985-016-0022-7 | Published: 24 August 2016

5.2 Rockefeller Foundation

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Keywords
Climate change, public health, planetary health, foundations, future health

Abstract
The consequences of climate change and the impacts of human activity on the environment have made it clearer than ever before that we must evolve our current model of public health to better account for the inextricable link between human health and the natural systems on which it depends – creating a "public health 2.0" that builds on the innovations of the 20th century to account for a world where humans have bypassed planetary boundaries to achieve well-being. First coined at the Rockefeller Foundation's Centennial gathering in Beijing in 2013, "Planetary Health" will factor in future health and environmental harms over present day gains, particularly those that disproportionately affect the poor and those in developing nations. To build this new field, foundations must address the challenge of information, increasing support for research to bridge knowledge gaps on the links between economic development, natural systems, and human health.

Thank you Jose, Stefanie and of course Sarah. And thanks to Antoine and his team for organizing this event during a very packed two weeks, to say the least.

By now we have heard the compelling case, eloquently made, for evolving our current model of public health to better account for the inextricable link between human health and the natural ecosystems, the natural systems on which life depends.

This was the seminal idea that emerged from the Rockefeller Foundation's Centennial gathering in Beijing in 2013. We met there at a critical time. The consequences of climate change were already making themselves apparent in vulnerable places around the world. The impacts of human activity were equally evident, nowhere more than in the exploitation and acidification of our most precious resource, our oceans. A pet resource of mine. Meanwhile, 7 million deaths were being attributed to air pollution; new diseases were emerging; and patterns of known diseases were changing. And this

was before Ebola confirmed to us growing anxieties about the dangers of disease transmission from animal to human and the quickness by which it spreads in a globalized world.

And so it was no far-flung conclusion that we needed a new frame for public health in the 21st century - a "public health 2.0," if you will.

Don't misunderstand me. As the great-grandson of the man whose foundation pioneered in many ways the modern field of public health, I am quite fond of the original version, Public Health 1.0. And I am proud, as we all are, of the progress it has helped us achieve, from wiping out diseases like hookworm and yellow fever. Humanity has never been in greater health. But we have also never been in greater peril. So we need a health framing that accounts for both, which is what planetary health offers.

But two big challenges are standing in our way.

The first, as has been said before, is one of imagination. For the last 85 years, the world has relied on gross domestic product as the chief indicator of human progress. But we have failed to account for future health and environmental harms over present-day gains, with the disproportionate effect of those harms on the poor and those in developing nations. Foundations can lead the way in helping to establish new indicators that measure human progress by balancing economic development with advancing human health and protecting the environment.

Second is a challenge of research and information. There is still so much we don't know when it comes to understanding the social and environmental drivers of human health. Foundations must increase our support for the inter- and trans-disciplinary research necessary to bridge these gaps and recognize the links between economic development, natural systems and human health. Which is why I am delighted today to announce the official launch of the Rockefeller Foundation funded Planetary Health Alliance – a network of researchers who will develop curricula to train the world's first planetary health scientists, convene scholars around the world and conduct advocacy work to ensure an enabling policy environment for planetary health. The alliance will have a base at Harvard University but will welcome minds and scholars from around the globe.

We are excited at the promise here. Planetary health offers an unprecedented opportunity for advocacy of global and national reforms, and foundations like ours and Wellcome will play a key role in launching a new approach to health for the next century. We look forward to working with everyone in this room and other rooms to make that a reality, and I look forward to discussing exactly how we might begin alongside the esteemed Sarah Molton.

Thank you very much.

6

The challenge of communication about environment change and health

6.1 Why should health be a central argument in climate negotiations?

Can a MOOC help to bring the message across?

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Keywords
Climate change, human health, policy, messaging, decision-making

Abstract
There are four key messages from health for climate negotiations. Two positive ones include (i) health as a motivator for action and policy, (ii) huge health co-benefits to be included in the cost-benefit trade-offs of climate negotiations. Two warning messages: (iii) there are health based absolute limits of adaptations and (iv) hotter average temperatures will cut work productivity of farmers and other outdoor workers as well as workers in non-air conditioned factories in poor countries. This paper will examine how a Massive Open Online Courses (MOOCs) has been used in the run-up to this COP to disseminate these 4 messages to the audience of high level policy-makers. This required a departure from the classic MOOC format in several ways: duration, focus on decision- making rationale, policy-relevant messages presented in big brush, leaving "traceable accounts" to evidence in two layers of resources provided: essential and "deep dive".

Background

This presentation is predicated on the argument that health is more than just one of many other sectors, like agriculture, forestry and so forth. Rather, health is an argument, a leverage in otherwise conflict, conflictual and interest-guided debates to promote and motivate climate policy and climate-conscious behaviours [1].

This paper has two parts: First, we consider the four key messages from health for climate policy makers. Second, we identify challenges in the scientific evidence from health for climate policy. In which areas can we improve to strengthen the evidence-base for these health messages for climate policy?

There are four such key messages, two of them positive and two negative or warnings.

The first positive message is that health is a motivator for citizens' behavior change and climate policy-makers. In fact, it is the driving force, why most people care about climate change. So it is an argument that drives change, that generates energy to do something about climate change.

The second positive message lies in the huge health co-benefits that accrue from climate policies [2,3]. The somewhat simplifying motto is "what's good for the climate is good for health" – is true for many policies, such as enhancing personal mobility or eating less red meat. A huge co-benefit has only recently been identified [4]: black carbon is a climate-active pollutant, which is produced mainly by indoor cooking with biomass, a practice, which is wide-spread particularly in low income-countries. Indoor air-pollution kills about 4 million people each year, most of them women and children [5]. So, by doing something for the climate (reducing black carbon), we also do something for our health. Cognitive psychology tells us that positive arguments are much more powerful in inducing change in behaviour and for that matter in policies, than the quite negative scenarios that are often put forward. The message is, a climate-friendly planet is a healthier planet.

This said, there are also two negative messages from public health which we see as warning signs or guard-rails for climate policy-makers.

The first of them states that there are absolute health-based limits of adaptation to a world with unfettered climate change, beyond 2-degree warming. This is based on physiological evidence, i.e. from the way our body works. This is true certainly for our limits of adapting to a warmer world, to higher temperatures, but it also applies to ability to cope with other diseases that will be increased due to climate change, such as infectious diseases, heart and lung diseases as well as mental diseases [3,4].

The second negative argument is a health-based economic argument. We know that as temperature rises, our capacity to work is decreasing, so is our work output [6]. This is very bad news for high-temperature tropical and subtropical countries, for which economic growth is a key precondition for development. Not only outdoor workers, such as construction workers, farmers or traffic policemen are concerned, but also the increasing number of factory workers. To date, only a tiny fraction of factories in low- and middle-income countries are air-conditioned. Hence, temperatures inside the factory are likely to be even higher than outside. This argument from heat physiology has a bearing on health effects, but also on work productivity.

In the second part of this presentation, we present data indicating research needs to further corroborate these health messages for climate policy. Does the world produce enough health-research for policy-makers in the right areas?

There is good and bad news. The good news is the upward trend of scientific publications, in which health aspects of climate change are studied from 1990 till

today. Simultaneously, but with a delay of several years, the Intergovernmental Panel on Climate Change (IPCC) increasingly deals with health aspects in its assessment reports. For example, the term "health" is mentioned 10 times in the first IPCC report in 1990 but more than 2,500 times in the last report in 2014 [7]. Interestingly, only 26% of these references of the world "health" originated from the health chapter. In the majority of instances, "health" was mentioned in the chapters of other sectors, such as agriculture, tourism, or forestry. One could arguably say that health has become a mainstream concern.

However, when looking at the absolute numbers of publications dealing with health aspects of climate change and comparing them to climate related publications from other sectors, health research is still significantly behind [7].

The second not so good news is the mismatch between on the one hand the topics of published studies and on the other hand the topics and evidence which policy-makers want. The latter include studies on the costs and effectiveness of adaptation measures for example. Furthermore, the topics that interest researchers are often not in sync with the imputed size of climate-related health problems. For example, research on the effect of heat waves abound, from Göteborg to Italy, but research on climate impact on malnutrition is very scanty (9), although malnutrition is considered to be one of the main health impacts [3,4,8]. It is very telling to compare the research output on different risk factors: the scientific output was about 40,000 papers in between 2002 and 2012. In the same time span, only 300 articles or less than 1% were published on climate change as a risk factor for health [10].

Beyond the mismatch of health topics studied and those most relevant, there is an huge North-South gap in publications. Both as far as authors and as far as the socio-economic study context are concerned, the North dominates the scientific production. This too, needs to see rigorous funding policies to fill the gap [7].

Looking at the policy relationship between a health topic and climate change, we classified research into the following categories (i) impact, (ii) co-benefits, (iii) adaptations (iv) cost estimates of policies and (v) long term projections linking health data to climate models. We observed that most health-related research on climate change is on impacts and only recently on co-benefits. Very little research is dedicated to adaptation policies, their costs and effectiveness. Long-term model projections of health impacts are the least frequent subjects of research.

Conclusions

To sum up: there are four important messages from health for climate policy. These should be undergirded with more research, which focuses better on the evidence needs of policy makers: projection of health impacts in understudied areas, such as malnutrition and health adaptation strategies and their costs are the two major areas that need further research.

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This commentary is available online:
Public Health Reviews 2016 37:18 | DOI: 10.1186/s40985-016-0030-7 | Published: 19 October 2016

6.2 Communicating Climate Change and Health in the Media

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Keywords
Public Health, climate change, communications, media, information sharing, social media

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Abstract

The translation of science from research to real-world change is a central goal of public health. Communication has an essential role to play in provoking a response to climate change. It must first raise awareness, make people feel involved, and ultimately motivate them to take action. The goal of this research is to understand how information related to this issue is being addressed and disseminated to different audiences: public citizens, politicians and key climate change stakeholders. Initial results show that the scientific voice struggles to globally highlight this issue to a general audience and that messages that address the topic do not meet the challenges, going from dramatic framing to a basic adaptation framing. Communication experts can help inform scientists and policy makers on how best to share information about climate change in an engaging and motivating way. This study gives an insight about the key role of the media and communications in addressing themes relating climate change and transmitting information to the public in order to take action.

Background

It has been proven that human activity has an important impact on climate change [1,2]. Targeted communication is necessary to engage people to adapt towards a more climate friendly behaviour. Previous literature suggests that a lack of basic knowledge on climate change is one of the largest perceived barriers to taking action [3]. Thus, the framing of the issue by the media has a critical influence on the perception of urgency and willingness to respond [4]. Subsequent studies allow to better understand what communication methods are most effective in inducing behaviour change [3-8]. In particular, two media-impact studies [4,6] have shown that framing climate change as a public health concern rather than as an environmental issue is one of the elements that would help increase the involvement of the public in engaging with climate change. The goal of this 4CHealth's contribution is to understand how information on climate change and health is communicated in two different forms of media, the French newspaper Le Monde, and the social media platform, Twitter.

A review of articles in Le Monde referring to climate change and health was conducted covering the time period from the release of the first Intergovernmental Panel on Climate Change (IPCC) report in 1990 to the end of the COP21 climate negotiations held in Paris in December 2015. Moreover, during the 6 months prior to the conference, tweets referring to the COP21 were collated and the frequency and manner in which the issue was addressed was analysed.

The analysis of Le Monde's articles demonstrated an evolution in the communication surrounding climate change and in its framing. Between 1990-2015, 4465 articles mentioned "climate change", however only 599 of those articles also mentioned "health" (13,4%) and merely 189 of these linking climate change to its health outcomes (4.2 %). Despite the low number of published newspaper articles displaying health outcomes of climate change, the issue has been gaining prominence in Le Monde since 2000, which leads us to believe that the public health frame is becoming more pertinent in climate change reporting. However, the sections in which they appear demonstrate the media's tendency to frame climate change as an environmental issue [4]. 59.4% of the articles are published in the "Planet" section followed by "Ideas", "Economy" and "International".

A 2015 study by Maibach et al highlights the "clear need to better inform on the health threats associated with climate change" [7]. The frequency of studies relating to the health impacts due to climate change in peer-reviewed scientific publications has also increased over the past 25 years [9]. The growing research in this area may indicate the transmission of scientific knowledge to the general public through media channels.

This is particularly true of the French media potentially arising from reporting both before and during the COP 21 climate negotiations held in Paris in December 2015. Most articles linking climate change and health in Le Monde mentioned extreme climate change events (31%) followed by infectious diseases (23%) and environmental migration related impacts (18%). Malnutrition (10%) and Respiratory diseases (8%) and others (10%) remain less represented. However, highlighting the health risks associated with climate change is an ineffective communication method according to

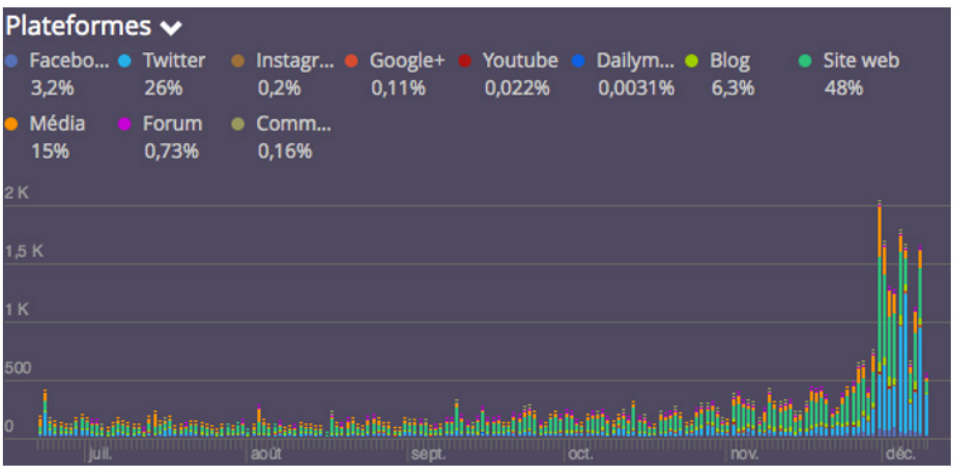

Figure 1: Evolution of the occurrence of the #COP21 related to health from June 15 to December 11, 2015 in the social media: Successful mobilization of the health sector on Twitter (Data collected by Linkfluence)

Maibach et al. (2008) [5], if it is not acompanied by relevant information regarding potential solutions. Furthermore, "information about the potential health benefits of specific mitigation-related policy actions appears to be particularly compelling" [6]. Even though an increase of the reference to health cobenefits since 2000 is noticable, we observed that only very few of the analyzed articles (16%) provide information about health benefits which relate to regulation policies in favour of climate change.

On social media, the number of tweets indicating the link between climate change and health, in terms of impacts or co-benefits has increased during the COP21. A study based on data extracted using Radarly, an extraction tool of social media content (Linkfluence), was conducted to analyze posts including the hashtag #COP21 from June 15th 2015 (date of the publication of the Lancet Commission on Climate change and health [10]) to the end of the COP21. In the run up to the conference, an increased number of health-related posts were monitored. While during the first months institutional actors expressed a growing interest in the health related issues of climate change, this topic became endorsed by a diverse range of actors, from the

health field (such as Doctors for Climate or the Ordre des Médecins in France) to the industrial sector and the civil society. The climate health campaign initiated by the Global Climate Health Alliance, which was very often referenced, as well as the World Health Organization's call for urgent action to protect health from environmental changes, played an important role in the increase of attention paid to the topic in social media.

Acknowledgments - I would like to thank Stefanie Schütte, Niamh Herlihy and Corinne Kowalski for their helpful comments.

Conclusions

In conclusion, "the lack of constant attention paid to climate change" [3], as well as the lack of efficiency of the message prevent the analysed media from fullfilling its role of provoking a collective response and a change in behavior. Moreover, information regarding health risks associated to climate change should be framed as a public health threat and supplemented with recommendations and action items provided by experts.

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Centre Virchow-Villermé de Santé Publique Paris-Berlin
Conception: Julien Ricca avec le soutien de Sophie Puig-Malet
Achevé d'imprimer au service de reprographie de l'Université Paris Descartes

IMPRIME EN FRANCE

Climate Change and Health

Proceedings from the COP21 "Healthy Lives on a Healthy Planet" 2015 Conference in Paris

Edition Editors:
Anneliese Depoux, PhD
Corinne Kowalski, MA
Antoine Flahault, MD, PhD

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