Mini-symposium

"Current and Future Research trends on Climate Change and Health" Monday, the 6th of July 2015 (14:00-18.00)

Auditorium of Biopark - 11 rue Watt 75013 Paris

Major conclusions

The human health consequences of global environmental changes (GEC) are among the top priorities of citizens worldwide. There is strong evidence that climate change (CC) which is one of the many GEC (land-use changes, ocean acidification, biodiversity loss, transcontinental trade and transportation,…), has already had significant effects on population health and additional consequences are expected in coming decades. One of the critical issues is how and to what extent CC, together with other associated environmental and social stressors, leads to health consequences at the individual and population levels. Understanding such effects and possible interactions between different stressors will be critical for effective public health decisions. The mini-symposium hosted by the French Alliance for research in life sciences and health (Aviesan) in collaboration with the research alliances AllEnvi (the French national alliance for research on the environment) and Athena (the French national alliance for research on human and social sciences), aimed at exploring the current research trends and the new multidisciplinary approaches that will support future research. The present article will discuss some of the major conclusions and perspectives of the symposium and is by no means a comprehensive summary of the talks and discussions.

Lessons from research on the health effects of CC

Recent scientific evidence has confirmed that CC has both direct and indirect effects on human health. For example, increased temperatures, humidity and floods are directly involved in mortality and morbidity. Large scale studies have shown that extreme temperatures are now clearly associated with increased human mortality and morbidity. Indirect effects are also extremely important. As an example, increased exposure to allergens, air pollution and infectious diseases that are related to climate change, all significantly contribute to elevated frequency of respiratory diseases (developed below). There are several major lessons that can be drawn from this example. The first lesson is that the indirect effects of CC are numerous and diverse; think about air pollution, pollens, water quality, infectious diseases, increased UV exposure. The second is that each of these indirect effects can also be triggered by other activities; for example, air quality is altered by CC but also by industry, transportation, urbanization, etc. The third lesson is that the interactions between CC and the other activities and their associated stressors are very likely and it would be extremely useful to know whether they act in additive, synergistic or antagonistic manner. So a major conclusion at this stage is that a better assessment of the

effects of CC on health would be obtained if it is combined with that of other environmental stressors. In addition, the understanding of the underlying mechanisms in the human organism would be of utmost importance.

Knowledge in the area of CC and respiratory heath is based on limited information and substantial-but-informed speculation. CC, and its driver greenhouse gases (GHG) emissions, will affect respiratory health through multiple ways: 1) an increased number of deaths and acute morbidity due to heatwaves; 2) an increased frequency of cardiorespiratory events due to higher concentrations of ground-level ozone; 3) changes in the frequency of respiratory diseases due to transboundary long-range air pollution (*e.g.* related to fires and aerosols); and 4) altered spatial and temporal distribution of allergens and of some vector- or reservoir-borne infectious disease vectors. These impacts will not only affect those with existing respiratory disease but also may influence the incidence and the prevalence of respiratory conditions. There are many gaps in this knowledge, many of which will only truly become clear as climate change advances, which may be too late for some situations. Consequently, much research is needed into the improvement of predictive models supplemented by continuous prospective measurement and assessment of the key outcomes and exposures which determine the impact of CC on respiratory health. The complexity of the issues involved requires coordination and collaboration across medical and research disciplines and this is true for practically all the fields related to the effect of CC on health.

While studies on CC and health have mainly focused on a number of specific diseases such as respiratory, cardiovascular and climate sensitive infectious diseases, unexpected observations have been made recently that tend to enhance the complexity of CC related health effects. A very illustrative example comes from recent epidemiological studies showing that air pollution has a significant effect on child birthweight and cognitive and psychomotor development. Those observations indicate that reproductive health is altered by air pollution. Therefore, one can expect that CC, by altering air quality, could also display developmental and reproductive effects. This illustrates the relevance of studying CC effects in vulnerable individuals. In addition to early development described here, age (notably the children and the elderly) and socio economic status are also vulnerability states that should be considered. The second point is that the time of onset and the duration of exposure to CC is critical. Therefore, in addition to the simultaneous interactions of different stressors mentioned above, one should also take into consideration the cumulative effects over time.

Some infectious diseases, notably those that have an indirect life-cycle with a vector or a reservoir host, are known to be strongly affected CC. Both short term and long term environmental processes interact to lead to disease epidemics and this has clearly been shown in the case of vector-borne and water-borne infections. Studies in this area have clearly shown that a good knowledge of climate trends and ecological characteristics of the disease system are required for a better understanding of human epidemics. Statistical and dynamical modeling approaches allow a better prediction of epidemics outbreaks. For example, in the case of vector-borne diseases, predictions can be based on various physical determinants such as ocean surface temperature, rainfall, air temperature and land characteristics. Different CC and demographic scenarios need to be employed in combination with different disease models to estimate the spread of infectious diseases in various continents. This field perfectly illustrates the relevance of integrating ecological health and human health and more generally is in line with both the One Health and EcoHealth concepts.

The exposome as a useful framework

Remarkably enough, current research on the health effects of CC indicates that this field fits perfectly with the exposome concept. Indeed, the exposome concept consists in integrating all exposures over the lifetime of an individual. Therefore, the interaction between different exposures and the cumulative profile of exposures over time is an integral part of the exposome research. In addition, the exposome encompasses not only the different exposures but also the effects of exposures. The internal exposome and the biological changes it induces can be measured with high-throughput methods such as metabolomics, proteomics, transcriptomics, adductomics and epigenomics and may be of relevance to understand CC effects. Furthermore, the eco-exposome promoted by the NRC report on exposure sciences of the 21st century combines studies on exposure sources with human health outcomes. The examples given above clearly show that the exposome concept is well suited to integrate CC effects on health with other environmental and socio-economic stressors and this is a major outcome of this mini-symposium.

There are practical consequences to the exposome concept in relation to CC. Indeed, a combination of several environmental stressors can yield a specific health outcome. Therefore it is useful to study the combined effects of several stressors and underlying mechanisms and to elicit public action on all major stressors in a sustained manner and not to focus on only one stressor depending on the news of the day. It is also important to also try to disentangle the effects of CC on health with respect to other stressors and to study the various interactions among stressors and this remains a very challenging task. The second important conclusion is that a single source of exposure can yield different outcomes at different time scales. For example, fuel use and transport increase greenhouse gases emission and contribute to long term climate warming and at the same time increase air pollution by particulate matters and organic gases which have rapid direct effects on health. Therefore, mitigation of these environmental stressors leads to long-term and short-term health benefits (or co-benefits). Thus the exposome appears to be a useful conceptual framework for public health action.

Future research and research for a better future

A multidisciplinary research effort will certainly contribute to a better assessment of the effect of CC on human well-being and health. The symposium reflected the possibly huge contributions of large scale and long term studies and registries particularly in developing countries with an open assessment of different environmental stressors. It also highlighted the development of new technologies such as the different sensors that can measure physical, chemical and physiological features and provide more quantitative data to this field. Obviously having so many data requires appropriate statistical and mathematical approaches to make sense out of such a large amount of observations and figures. This field, like many others, will benefit from the development of adequate mathematical and modeling tools allowing an adequate interpretation of scientific findings. Finally, current concepts of health effects of CC integrate direct and indirect effects, but also highlight the many interaction of those effects with social dynamics such as the socio-economical and health system status and those related to increased migrations and conflicts. Multidisciplinary integrated approaches are obviously seriously needed.

So is there hope? One has to be aware that such major environmental changes can lead to social and health disasters as observed in the past for large civilizations. The relation between the stressor and the effects can be nonlinear and be highly sensitive to critical thresholds. One of the expected outcomes is the increase in inequalities across the globe and within countries and this is one of the major determinants of severe conflicts. On the other hand, if action is taken, it is possible to mitigate CC effects. A good example of successful international cooperation is the ozone action coordinated by the United Nations Program which led to a significant reduction in stratospheric ozone depletion. Increasing awareness on health effects and on the co-benefits expected from CC mitigation can lead to a more robust international action. Furthermore, on the research side, an interdisciplinary approach such as the one promoted by the Climate-Environment-Society Consortium (GIS Climat) in France is required to provide technological and societal tools for adaptation and mitigation.

There are currently many international efforts which attempt to foster stronger interactions between the environmental and human health sciences. The focus on the positive effects of biodiversity and the ecosystem services that it provides on human well-being and health and on CC mitigation and adaptation is a good example. Such a large scale vision has been named “One Health”, “EcoHealth”, “global health”, “planetary health” and so on, but it basically states that it is not possible anymore to ignore global and local environmental changes if one wants to assess current and predict future human well-being and health.

The European scale is also relevant to address critical research issues related to CC and health. For example, comparative studies on the effect of CC in different European cities, is particularly useful, as well as large scale studies on infectious diseases focusing on the alteration of ecological niches and microbiomes, the development of reservoir- and vector-borne diseases and on emerging diseases. Furthermore, current and future projects on the exposome and health which combine various exposures, including those related to CC are certainly relevant at the European scale. Obviously interdisciplinary research is to be supported at this scale.

French research has the capacity to address the most relevant issues related to CC and health. Indeed, France has developed tools such as cohorts, registries and experimental capacities. French research is coordinated by different alliances focusing on life sciences and health (Aviesan), environment (Allenvi), socio-economic studies (Athena), energy (Ancre) that are highly relevant for CC research. Furthermore, French research has traditionally strong ties with developing countries in which CC effects on health are expected to be dramatic. Finally, in the field of environment and health, there is a coordination between these alliances so that transdisciplinary research can be stimulated and supported.

Research can help. Some may think that it is time for action not research. In fact, there is no contradiction between research and action. The previous research efforts should now allow rational preventive and precautionary public health action. But current and future research will set the stage for future sensible public health action. Research is integral to the solution.

Program

14:00 **Pr Yves Lévy**, (Inserm/Aviesan): Opening

14:10 **R Barouki** (Inserm, UPD, Paris): Short introduction on applying the exposome concept in the context of climate and health

14:20 Session 1: critical health effects

14:20: **R Slama** (Inserm, Grenoble): « Influence of meteorological factors and atmospheric pollutants on human reproduction »

14:40: **I Annesi-Maesano** (Inserm, UPMC, Paris): « The burden of meteorological factors to allergic and respiratory health and risk factors »

15:00: **JF Guégan** (IRD, Montpellier): « Both short and long-term climatic patterns drive the epidemics of water-borne infections, disentangling the impact of climate change on epidemics »

15:20 Session 2A: new methodologies

15:20 **P Roy** (CNRS, Lyon): « On the importance of biostatistics in a big data world »

15:40 **M de Paula Corrêa** (Brasil): « Sensors in UV detection »

16:00: Coffee break

16:20 Session 2B: new methodologies

16:20: **R Sauerborn** (Heidelberg): « Using ongoing decade-long health cohorts from Africa and Asia to quantify health impacts of climate change »

16:40: **JP-Gaudillière** (CNRS, Villejuif): « Social sciences and climate change »

17:00: **C Caminade** (UK): « Modelling the impact of climate change on human and animal vector-borne diseases »

17:20 Round table: *chair by **P Kinney** (Columbia, USA).*
***C Flamand** (Institut Pasteur, Guyane), **S Joussaume** (IPSL, GIS Climat), **JP Moatti** (IRD, Marseille), **MA Stauffer** (HEAL, Brussels), **Shamila Nair-Bedouelle** 5Ozonaction branch, UNEP), all speakers and the audience*

18:00 **P Kinney** (Columbia, USA) and **JP Moatti** (IRD, Marseille)*:* Conclusion

Organizing committee

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