



Review of some effects of climate change on indoor environmental quality and health and associated no-regrets mitigation measures



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ABSTRACT

This paper reviews the potential health consequences of changes in climate that affect indoor environments, with an emphasis on residential environments in the U.S. and Europe. These changes in climate, include increases in the frequency and severity of heat waves, severe storms coupled with sea level rise, and wildfires, plus increases in urban airborne ozone. The potential for adverse health effects is substantial. Examples of projected effects include a doubling of heat-related deaths, increased hospitalizations for asthma, pneumonia, and cardiovascular effects during wildfires, and increased mortality and hospitalizations associated with ozone. The associated adverse exposures occur, to a significant extent, indoors. The adverse health effects will be substantially mediated by features of buildings, particularly of homes where people, particularly those most susceptible, spend the largest amount of time. Changes to buildings, or to building operations, are identified that could reduce the projected adverse health effects of climate change. Examples include improved roof insulation, roof coatings that reflect more solar energy, and more air conditioning to reduce indoor overheating. Improved particle filtration systems could reduce the health effects of particles from wildfires. Some of these measures will also reduce building energy use and the associated emissions of greenhouse gases. Most of these measures would improve health irrespective of climate change. Improvements in building energy efficiency in order to mitigate climate change, has to potential to either improve or worsen indoor environmental quality and health.

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1. Introduction

Fig. 1, adapted from Ref. [1], shows selected pathways through which climate change (CC) is likely to modify indoor environmental quality (IEQ). These pathways fit within three broad categories: 1) outdoor environmental changes that, in turn, influence IEQ; 2) CC adaptation measures, i.e., measures taken in response to changes in climate, that affect IEQ; and 3) changes in buildings to mitigate, i.e., reduce, the extent of climate change. The first category includes: increases in heat waves, severe storms coupled with sea level rise, and wildfires; increased outdoor ozone in urban areas; and increases in outdoor pollens. The second category includes increased use of air conditioning and the third category includes increased building energy efficiency. IEQ conditions, comfort conditions, and health may be affected positively or negatively, depending on the change in climate, and on the CC mitigation and adaptation

measures implemented. Ideally, in the selection of CC mitigation and adaptation measures, priority would be placed on measures that also improve IEQ and comfort or health.

The most comprehensive prior review of the linkages of CC with IEQ was performed by a committee of the Institute of Medicine (IOM) [1], and was also briefly summarized by Ref. [2]. The IOM report provides an excellent summary of the state of knowledge in the IEQ field and was the starting point for the organizational framework in Fig. 1. The IOM concluded that there was little information available that directly addresses the intersection of CC, IEQ, and health. Consequently, the IOM reviewed relevant information on each of the intersecting topics and developed findings based on a synthesis. Key findings included:

“There is inadequate evidence to determine whether an association exists between climate-change-induced alterations in the indoor environment and any specific adverse health outcomes. However available research indicates that CC may make existing indoor environmental problems [worse] and introduce new problems by:

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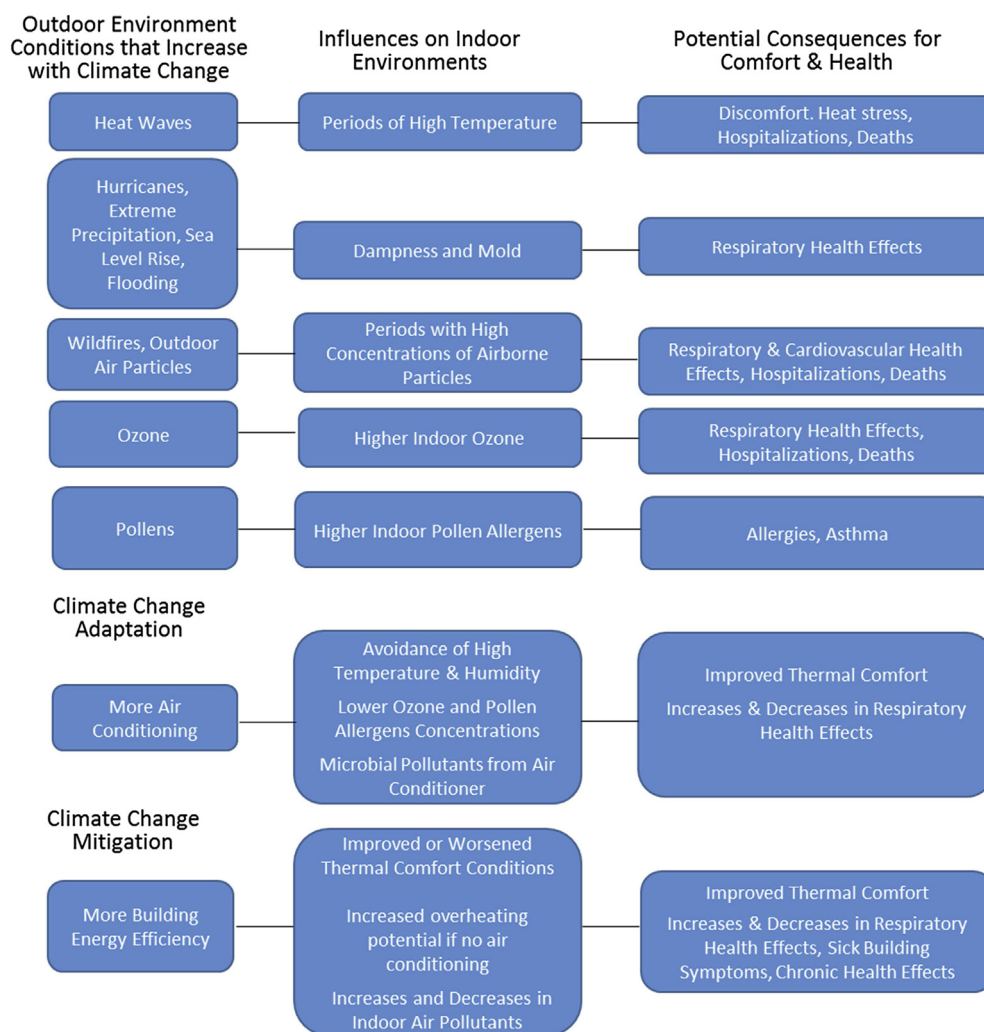


Fig. 1. Examples of how CC may affect indoor environments and health (adapted from [1]).

- Altering the frequency or severity of adverse outdoor conditions that affect the indoor environment.
- Creating outdoor conditions that are more hospitable to pests, infectious agents, and disease vectors that can penetrate the indoor environment.
- Leading to mitigation and adaptation measures and changes in occupant behavior that cause or exacerbate harmful indoor environmental conditions”.

The IOM report then summarized related literature pertaining to: air quality; dampness, moisture, and flooding; infectious agents and pests; thermal stress; building ventilation, weatherization, and energy use. The IOM report relied on literature available before or during 2010 and placed little emphasis on the identification of mitigation measures for reducing adverse indoor-environmental health effects anticipated to result from CC.

A subsequent paper by one of members of the IOM committee provided a general review of the potential consequences of CC for indoor exposures to volatile and semi-volatile organic and inorganic gaseous pollutants as well as particles [3]. The paper focuses on the “factors that influence the indoor concentrations of health relevant pollutants and how concentrations might shift as a consequence of CC”. Accordingly, this paper summarizes basic knowledge needed to develop an understanding of how CC may affect exposures to gaseous and particulate pollutants.

Since the IOM report [1] was published, substantial new relevant literature has been published and the Intergovernmental Panel on Climate Change (IPCC) has also released a new report on how CC is expected to affect climate and human health [4]. The purpose of the current paper is to provide an updated and more in-depth assessment pertaining to how CC may affect IEQ-related health risks related to heat waves, wild fires, ozone, severe storms and flooding, and building energy efficiency. In addition, the purpose included assessment of linkages between changes in outdoor environmental conditions and associated indoor environmental conditions and identification of related mitigation measures.

The effects of CC on IEQ and health are expected to vary regionally and among segments of the population. The elderly, people with poor health, and the economically disadvantaged may be most affected. While many of the issues addressed in this review are relevant throughout the world, most current literature pertains to the effects of CC in the more developed sections of the world, especially North America and Western Europe; thus, this review has the same overall bias.

The review only considers potential IEQ-related health effects associated with heat waves, wild fires, severe storms and flooding, and ozone, plus an assessment of some of the key effects of improved building energy efficiency in homes as a means of CC mitigation. Not addressed are: effects of climate-related changes in indoor exposures of pollens, outdoor particles (except from

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