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Climate variability and infectious diseases nexus: Evidence from Sweden

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ABSTRACT

Many studies on the link between climate variability and infectious diseases are based on biophysical experiments, do not account for socio-economic factors and with little focus on developed countries. This study examines the effect of climate variability and socio-economic variables on infectious diseases using data from all 21 Swedish counties. Employing static and dynamic modelling frameworks, we observe that temperature has a linear negative effect on the number of patients. The relationship between winter temperature and the number of patients is non-linear and "U" shaped in the static model. Conversely, a positive effect of precipitation on the number of patients is found, with modest heterogeneity in the effect of climate variables on the number of patients across disease classifications observed. The effect of education and number of health personnel explain the number of patients in a similar direction (negative), while population density and immigration drive up reported cases. Income explains this phenomenon non-linearly. In the dynamic setting, we found significant persistence in the number of infectious and parasitic-diseased patients, with temperature and income observed as the only significant drivers.

1. Introduction

Climate change has become a topical issue globally, as the physical and biological systems on all continents are already being affected by recent changes in climatic conditions (Asante & Amuakwa-Mensah, 2014). Climate change, including climate variability, has multiple influences on human health and these are expected to be either direct or indirect (Costello et al., 2009; IPCC, 2014, 2007). The impacts of climate change on human health include intensity of transmission of vector-borne, tick-borne and rodent-borne diseases, food- and water-borne diseases, and changes in the prevalence of diseases associated with air pollutants and aeroallergen. Climate change could alter or disrupt natural systems, making it possible for diseases to spread or emerge in areas where they had been limited or had not existed, or for diseases to disappear by making areas less hospitable to the vector or the pathogen (National Research Council, 2001). The direct and immediate effects such

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as deaths due to heat waves and floods which are mostly dramatic provoke immediate policy responses. However, long-term effects act through changes in natural ecosystems and in most cases impact on disease vectors, waterborne pathogens, and contaminants (National Research Council, 2001).

Until recently, the climate-health nexus did not feature prominently in the climate change discourse. In the past, discussions on climate change focused on the effects of the phenomenon on the global economic outlook and eco-systems sustainability (McMichael, Neira, Bertollini, Campbell-Lendrum, & Hales, 2009). Increasingly, scientists have become interested in the potential effects of global climate change on health (Campbell-Lendrum, Corvalán, & Prüss–Ustün, 2003; Carson, Hajat, Armstrong, & Wilkinson, 2006; Costello et al., 2009; IPCC, 2014; McMichael, Woodruff, & Hales, 2006; Nerlander, 2009; Woodward, Lindsay, & Singh, 2011; Wu, Lu, Zhou, Chen, & Xu, 2016). According to McMichael et al. (2006), climate change already has and will continue to have a negative impact on the health of human populations. Evidence already exists that climate change affects the rates of malnutrition, diarrhoeal diseases, malaria and deaths as a result of changing precipitation and high temperatures (McMichael & Woodruff, 2005). This is because there is ample evidence that links most of the world's emerging and re-emerging infectious diseases to climatic variations. Climate change according to Costello et al. (2009) was responsible for 5.5 million disability adjusted life years (DALYs) lost in 2000. These initial assessments and figures of the disease burden attributable to climate change were conservative and relate only to deaths caused by cardiovascular diseases, diarrhoea diseases, malaria, accidental injuries during coastal and inland floods, landslides and malnutrition. Not all of the effects of climate change will be harmful to human health but the damages are projected to outweigh the benefits (Confalonieri et al., 2007). A warmer climate is expected to bring benefits to some populations, including reduced mortality and morbidity in winter and increase local food production, particularly in northern high latitudes. Against this background, the negative effects of climate change on health are likely to be greater and are more strongly supported by evidence than are the possible benefits.

Developed countries are also not immune to the health impact of climate change. As presented in Table 1, climate-dependent infectious diseases are likely to impact on most developed countries (Panic & Ford, 2013). For example, water-borne and food-borne diseases which are caused by environmental or climatic factors are likely to affect almost all developed countries. Also, Northern European countries (particularly Sweden) are expected to be affected by tick-borne diseases which are predominantly caused by increased daily precipitation, humidity, changing patterns of seasonal precipitation, increased average temperatures and extreme heat.

Although the impact of climate change on health is anticipated, few studies have really used data to empirically estimate the effect on health outcomes, specifically infectious diseases. Most of the few studies which exist are based on biophysical experiments and do not control for socioeconomic covariates. In Sweden for example, Lindgren (1998), Lindgren, Tälleklint, and Polfeldt (2000) and Lindgren and Gustafson (2001) examined the link between climate change and infectious diseases. These studies ignored socioeconomic factors in their analysis and also focused on only one infectious disease (i.e. tick-borne encephalitis). We therefore contribute to the literature by analyzing the effect of climate variability and socioeconomic factors on infectious disease patients in Sweden. Our study utilizes panel data from in-patient care diagnoses records on infectious and parasitic diseases, climate indicators (e.g. temperature and precipitation) and socio-economic variables for twenty one counties in Sweden. The study employed both static and dynamic analysis, and also accounts for county and year fixed effects. We considered a pooled estimation where all the infectious and parasitic diseases are lumped together, and also a disaggregated estimation where dominant infectious and parasitic diseases (such as intestinal infectious diseases and other

Table 1
Climate-Dependent infectious diseases and sample countries likely to experience health hazards linked to changes in disease exposure.

Disease Type	Disease	Environmental factors impacting disease dynamics	Countries likely to be affected
Mosquito-borne diseases	Malaria	Increased average temperatures, precipitation	Australia, New Zealand, Chile, Southern Europe
	West Nile Virus	Increased average temperatures, drought	USA, Southern Europe, Canada, Australia, New Zealand, Chile
	Dengue, Chikungunya fever, Yellow fever	Increased average temperatures	New Zealand, Mediterranean region (coastal areas in Spain, Portugal and France), Chile
Tick-borne diseases	Lyme borreliosis, tick-borne encephalitis,	Increased daily precipitation, humidity, changed patterns of seasonal precipitation, Increased average temperatures, extreme heat	Northern Europe, Canada, USA
Waterborne diseases	Sewage and sanitation: Vibrio vulnificus and Vibrio cholera, E.Coli, Campylobacter, Salmonella, Cryptosporidium, Giardia, Yersinia, Legionella	Increased rainfall and storm frequency, flooding, landslides, increased average temperatures, extreme heat episodes	All countries
Food borne diseases	Salmonellosis, campylobacteriosis	Extreme rainfall, flooding, increased average temperatures, increased frequency of extreme heat, changed seasonal patterns	All countries

Source: Adapted from Panic and Ford (2013) with modifications.