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Is expert opinion enough? A critical assessment of the evidence for potential impacts of climate change on tick-borne diseases

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Abstract

Before attributing cause and consequence to climate change, the precise patterns of change must be known. Ground records across much of Europe show a 1–2°C rise in temperatures in 1989 with no significant rise since then. The timing and spatial uniformity of this pattern, relative to changes in the distribution and incidence of many vector-borne diseases, are sufficient to falsify most simple claims that climate change is the principal cause of disease emergence. Furthermore, age-specific increases in incidence indicate causes other than, or in addition to, climate change. Unfortunately, many public health professionals repeat the received wisdom that climate change is worsening the burden of indirectly transmitted infections; this 'expert opinion' soon becomes consensus dogma divorced from quantitative evidence. The pressing need is to gather appropriate data to test the simple concept that the composition and relative importance of disparate multifactorial factors, commonly integrated within a causal nexus, will inevitably vary with the geographical, cultural, socio-economical, wildlife, etc. context. The greatest impact of warming occurs at the geographical limits of current distributions, where low temperatures limit the hazard of infected vectors. Within core endemic regions, changing exposure of humans to this hazard, through changing socio-economic factors is evidently more important amongst both the poor and the wealthy.

Keywords: tick-borne disease, climate change, tick-borne encephalitis (TBE), infectious disease–climate change nexus.

Know your data

At more than one meeting on the health effects of climate change, I have encountered experts who have written extensively on the subject yet have never actually examined temperature records from ground instruments and do not know the precise pattern of temperature increases that we have experienced over the past 40 years. Their perception of climate trends is based on summary statements and graphs issued by the Intergovernmental Panel on Climate Change (IPCC), derived mostly from global averages and usually presented as 10-year running means (http://www.ipcc.ch/graphics/syr/fig1-1). The authority of the IPCC is taken at face value without any critical examination of the effects of averaging across such coarse spatial and temporal scales. One such effect is apparent from a much-reproduced graph (first compiled by Ross McKitrick) that shows a neat coincidence between a halving in the number of weather stations around the world and an increase of 1–2°C in the simple global mean temperature, both occurring abruptly in 1990 (Wishart, 2009). As most of the lost weather stations were in cold regions of Russia, this might bias global mean temperatures upwards if not taken into account. On the other hand, considerable 'global brightening' also occurred at the end of the 1980s due to reduced atmospheric pollution (Wild *et al.*, 2005), most probably as a result of environmental legislation and/or reduced industrial activity following the fall of Soviet communism.

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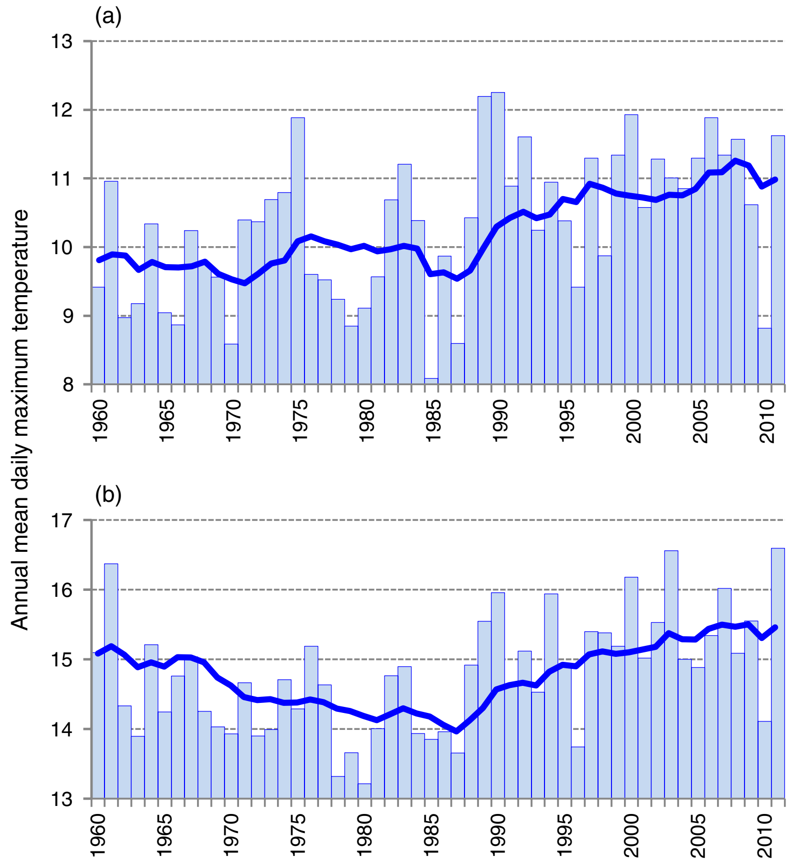

Fig. 1. Annual mean daily maximum temperature 1970–2011 (columns) recorded at ground meteorological stations at (a) Linkoeping, Sweden, 58′24′N, 15′32′E and (b) Basel, Switzerland, 47′33″N, 7′35″E. Lines show misleading impressions of smooth trends given by the 10-year running means as presented on many climate change websites, following the IPCC. Data are taken from the European Climate Assessment Dataset available at http://eca.knmi.nl (Klein Tank *et al*., 2002).

This could account for the real abrupt increase of about 1–2°C in annual mean daily maximum temperatures in 1989, with no significant increase since then, shown consistently by ground records from individual sites throughout Europe over latitudes of about 40–60°N (Fig. 1). Displaying these patterns rather than hiding them behind unrealistically smoothed averages raises a number of questions about the causes and effects of climate change.

As all practicing scientists know, the devil lies in the detail, and it is the devil that typically falsifies comfortable pre-conceptions such as, in the present argument, the increase in many vector-borne infectious diseases being the result of climate change. Thus, for example, any time delay, however short, between a prior effect (e.g. increased incidence of infection) and a later supposed cause (e.g. temperature increase) is sufficient to falsify any claim of causality. Likewise, variation in trends of infection incidence at local spatial scales undermines climate change as the sole explanation that might appear convincing if mean national data are considered without disaggregation. This is one of several reasons why, despite repeated assertions (Daniel *et al*., 2010; Kriz *et al*., 2012), climate change alone cannot explain the increased incidence in tick-borne encephalitis (TBE) two decades ago either in the Czech Republic (Zeman *et al*., 2010) or anywhere else where appropriate analyses have been conducted (e.g. the Baltic States (Šumilo *et al*., 2007) and southern Germany (Godfrey, 2012)). Furthermore, temporal changes in age-specific incidence in TBE in the Czech Republic (Kriz *et al*., 2012) show that from 1991 onwards people over middle age suffered a greater increase in incidence than younger adults, with the over-60 age group particularly badly affected (incidence increased 3–4.5 times between 1982–90 and 1991–99, compared with a doubling among younger adults) (Fig. 2b). This is surely another reason to seek causes other than, or in addition to, climate change. Only the identification of correct causes can elicit appropriate counter-measures.

Opinion, but not expert

If opinion is uninformed by accurate full analysis of the relevant data or critical examination of published evidence, it is worthless at best and dangerous at worst. Once opinion is published, it is citable and takes on an authority of its own, even if only the title and abstract

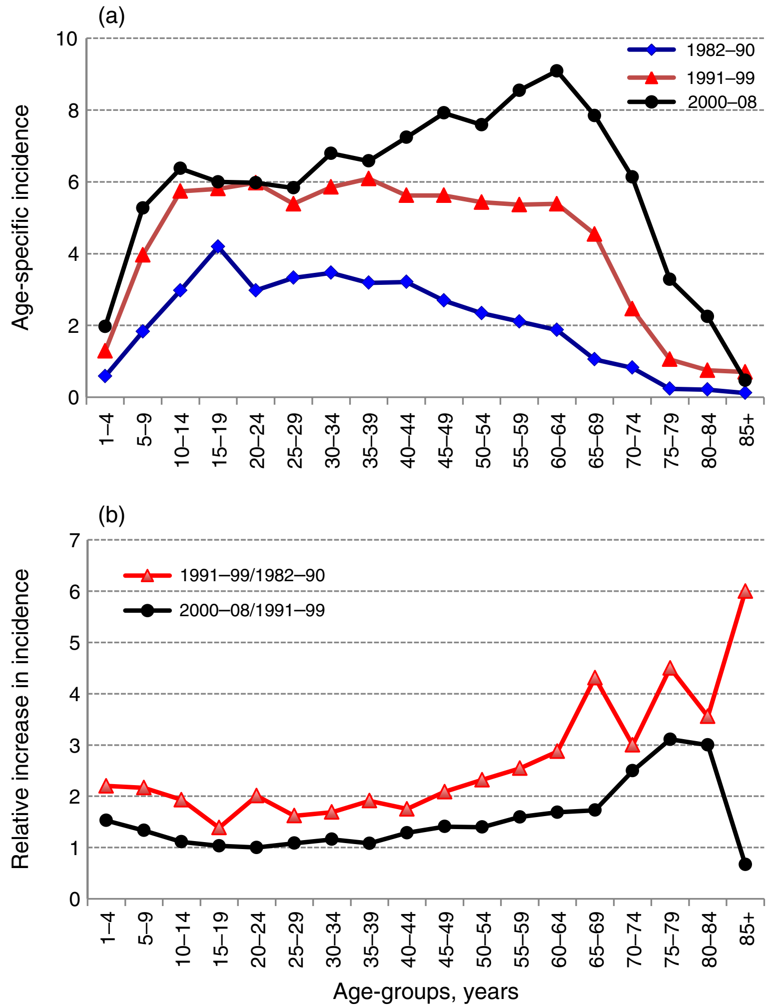

Fig. 2. (a) Age-specific incidence (cases per 100,000) of tick-borne encephalitis in the Czech Republic at three time periods, redrawn from Kriz *et al*. (2012), who incorrectly stated 'the pattern in the second period was similar'. (b) Relative increase in incidence between consecutive periods shows markedly greater increased incidence in the over-60 age groups over both time intervals.

have been read. As an example, a survey of national infectious disease experts from 30 European Economic Area countries revealed that 68–86% agreed that climate change would affect vector-borne, food-borne, water-borne and rodent-borne diseases, and that institutional capacity to manage this vulnerability should be strengthened (Semenza *et al*., 2012b). This body of experts comprised representatives of governmental health protection agencies, ministries of health, and infectious diseases surveillance centers, whose opinions were more likely to be secondhand than based on their own primary research. The majority probably did not have first-hand experience of analysis of the subtleties of past and potential future impacts of climate change on this wide range of 30 different indirectly transmitted infections. In science, opinion is a poor substitute for quantitative evidence. However, their opinions, based on unspecified evidence, became 'expert opinion' that was fed into the literature, from where it can be, and indeed already has been, cited (Lindgren *et al*., 2012; Semenza *et al*., 2012a) and gradually transformed into consensus dogma. A meta-analysis of the evidence would be far more credible than the received wisdom of busy, multi-tasking health administrators.

Integration not confrontation

We need to replace the current polarized argument – 'climate change is or is not responsible for past increases in tick-borne diseases; it will or will not cause future increases in tick-borne diseases' – with a much more balanced position, recognizing the disparate multifactorial and integrated causes for the observed emergence of tick-borne diseases over the past several decades. The task is to gather appropriate data, while maintaining an open mind over which data may prove to be appropriate, to test the simple concept that the composition and relative

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importance of factors within such a causal nexus will inevitably vary with the geographical, cultural, socio-economical, wildlife, etc. context. The distinction between expanding distribution, due to one set of causes, and increasing incidence, potentially due to a different set, becomes apparent even within a single country if analysis is applied at the right spatial scale.

There are many instances of expanding global distributions of vector-borne infections due to introductions across wide geographical distances, commonly facilitated by human travel and/or trade (reviewed by Randolph, Rogers, 2010). From patterns of the subsequent epidemics it is clear that the pathogen arrived in an environment that was already hospitable, with no need to invoke environmental change as a cause. West Nile virus in the USA, Chikingunya in the Indian Ocean islands and blue-tongue virus in Northern Europe are well-documented examples. Interestingly, the short-lived (during the mid-20th Century) and highly focal circulation of Far-Eastern subtypes of TBE virus in the European region of the former Soviet Union, thousands of kilometers west of their recognized endemic region but no further west than the Soviet borders, appears to be a case of repeated introductions into areas where the environment did not permit persistence or spread. The most likely vehicle, matching the spatial and temporal patterns of viral introductions deduced from phylogeographic analysis, is the large-scale predominantly westward redistribution of hundreds of thousands of game animals for economic purposes (Kovalev *et al.*, 2010).

Alternatively, local expansions may be due to spill-over from neighboring endemic regions driven by environmental change. There is evidence of the new presence of ticks at high latitudes in Sweden (Jaenson *et al.*, 2012b) and cases of TBE at high altitudes in Slovakia (Lukan *et al.*, 2010), the Czech Republic (Danielova *et al.*, 2008) and Austria (Holzmann *et al.*, 2009) where this virus was previously unrecorded (i.e. incidence increased from undetected to measurable). This is reasonably presumed to be the result of the climate recently having become permissive where thermal conditions are limiting along the distributional boundaries of this system. The biological mechanism for this 'edge effect' is very straightforward: the effect of warming is more marked at lower temperatures due simply to the non-linear positive relationship between temperature and tick development rates. Furthermore, in places newly colonized by infectious agents, not only will humans have little pre-existing immunity, but also the pathogen basic reproductive number (R_0) must have recently crossed the critical threshold value of 1, allowing large increases in case burden. Subsequent increases in R_0 have diminishing impacts, especially for pathogens with sterilizing immunity, when the effective reproductive number, lower than R_0, comes into play.

At the same time, incidences within the core-endemic regions of the above countries (apart from Austria, where vaccination coverage is >85%) also increased markedly, pointing to alternative or additional driving forces. In Central and Eastern Europe, an abundance of quantitative evidence supports the role of changing socio-economic conditions, as a consequence of the transition from communist to free-market economies at the start of the 1990s (reviewed by Randolph, 2008). This is not to deny an impact of climate change, but rather to conclude that its effects on the abundance of infected ticks, the zoonotic hazard, were considerably smaller than the effects of socio-economic factors on increased human exposure to that hazard. The data support the concept that both increasing wealth, and thereby leisure and outdoor recreation in tick-infested forests, and increasing poverty, and thereby the greater need to gather mushrooms and berries from the forests, may exacerbate exposure, but with poverty having a greater effect due to the limited potential for adaptability, hazard avoidance and self-protection (see Figure 3 in Kilpatrick and Randolph, 2012). Irregular but sustained increases in TBE cases in Sweden, both within the previous range and further north, evidently provide a good example of interactive effects of environmental (abiotic and biotic) and human recreational factors (Jaenson *et al.*, 2012a).

Good analytical tools to handle good data

Fortunately these days, sophisticated analytical tools are available to match the complexity and abundance of co-varying factors operating within vector-borne disease systems. Off-the-shelf software offers statistical packages that take account of the messy realities of non-normal distributions, a mixture of discrete and continuous variables, time series to be de-trended to look for cycles or smoothed to look for trends, etc. Statistics, however, were never meant to provide the answers but rather to test conjectures. Any simply quantitative conclusions must be constrained by plausible and well-understood mechanisms. The same word, model, is used for the blind output of a statistical analysis and for the insightful framework for the input of data into a series of biologically realistic quantitative relationships. The latter is especially useful for estimating the quantitative impact of past climate change and then seeing how such predictions compare with the actual change in incidence. Nevertheless, the former is claimed by Jeremy Howard, president of the open access data-crunching web-site Kaggle (http://www.kaggle.com/), to free the analysis from the constraints of expert pre-conceptions, throwing up unexpected factors selected objectively by whichever algorithm proves to be most useful (currently it is one called 'random forest' that commonly wins) (interview by Aldous, 2012). Howard argues that understanding why the selected factors are important is less interesting than achieving a 'predictive model that works'. Once again, it seems to me to be less productive to argue for the relative merits of one over the other than to integrate the two approaches and make the practical solution more versatile by underpinning it with expert understanding.

There is nothing wrong with expertise, but it must be based on familiarity with and sound analysis of the data, not simply on opinion. Experts must have the courage to say: 'I do not know the answer because I have not studied that particular problem in detail'. In the words of a Russian proverb, 'There is no shame in not knowing; the shame lies in not finding out.'

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