PUBLIC HEALTH

Infant deaths from air pollution estimated

A carefully considered observational study estimates that up to 22% of infant deaths in sub-Saharan Africa could be prevented by improving air quality — a value much higher than previous estimates. SEE LETTER P.254

LANCE A. WALLER

Big data can help to address many pervasive problems in the field of public health. For instance, large-scale data analyses are helping researchers to understand global patterns of disease, the range of factors that contribute to global health and the policies that provide the greatest potential for improvement[1,2]. On page 254, Heft-Neal *et al.*[3] propose, implement and (importantly) scrutinize such an approach, exploring the impact of air quality on infant mortality in sub-Saharan Africa.

The authors' study joins a growing body of work that explores international patterns of health outcomes through creative analyses of big data — a set of approaches pioneered by many on local geographical scales, but brought to the global-health stage by a project called the Global Burden of Disease Study (GBDS). In these types of study, multiple sources of health, administrative and research data are pooled and subjected to mathematical modelling and complex statistical analysis. But this exciting branch of public-health research is still finding its place amid conventional epidemiological techniques that involve gathering data from direct observations in cases and controls, or in longitudinal studies.

GBDS data have previously been used to estimate links between local air quality and mortality on a global scale (for example, in the project's 2016 report[4]). But these analyses were dominated by data obtained from air-pollution monitoring stations, which are predominantly found in developed countries. In these areas, air pollution is typically lower than in sub-Saharan Africa.

By contrast, Heft-Neal *et al.* used satellite-based measurements of air pollution. They combined these measurements with data from 65 household health surveys, which they used to determine mortality for almost 1 million births in 30 countries across sub-Saharan Africa between 2001 and 2015. The authors also focused on infant mortality from all causes, whereas the GBDS emphasized mortality due to respiratory illness.

The results are surprising. Heft-Neal *et al.* estimate that 22% of infant deaths in sub-Saharan Africa — a total of 449,000 — could be avoided by decreasing average levels of air pollution to the lowest levels observed in the region (a concentration of 2 micrograms per cubic metre). This level of comparative improvement is higher than the estimates reached by two previous analyses using the publicly available GBDS data[5,6] (Fig. 1). The authors place their results in the context of the previous work, putting forward several reasons for the different values. These include differing assumptions about what level of improvement in air quality is attainable (improvement from a median of 25 to 2 $\mu g\,m^{-3}$ in the present paper, compared with improvement to 5.8 $\mu g\,m^{-3}$ in the earlier analyses) and different sets of mortality data.

Rather than being satisfied with the headline association alone, Heft-Neal and colleagues carefully review the uncertainty in their estimation. For instance, they detail how the results might be affected by analytical assumptions, such as a linear relationship between air pollution and mortality within the range of observed values, and potential biases associated with using satellite-based measurements as a proxy for air pollution at ground level. They also consider potential confounders such as socio-economic status — it has previously been predicted that wealthier households would be less affected by air pollution than poorer households, but the authors show that this is not the case in their analysis. Such self-reflection is refreshing and essential, and places the results in an appropriate context for consideration by researchers and policy experts.

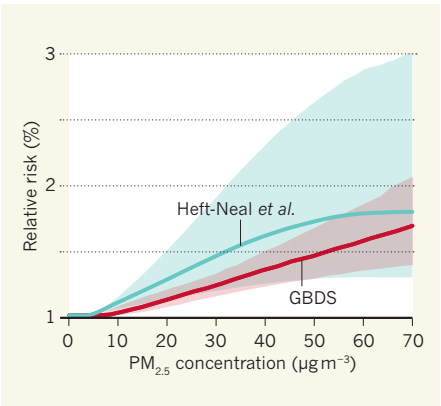

Figure 1 | Two estimates of the risk of infant death linked to air pollution. Air pollution can be measured as a concentration of breathable particulate matter ($PM_{2.5}$) in micrograms per cubic metre ($\mu g\,m^{-3}$). The Global Burden of Disease Study (GBDS)[6] estimated the relationship between increasing $PM_{2.5}$ and relative risk of infant mortality due to respiratory infections globally. By contrast, Heft-Neal *et al.*[3] used different data-analysis approaches to estimate the relative risk of all-cause infant mortality related to air pollution only in sub-Saharan Africa, where pollution rates are generally higher than in wealthier regions of the world. The general message is the same (a clear benefit from reducing levels of air pollution), but Heft-Neal *et al.* find a greater increase in mortality with increasing air pollution. The levels of uncertainty (shaded areas) provide essential context for understanding the results. (Adapted from Fig. 3 of ref. 3.)

Heft-Neal *et al.* outline their data sources in their supplementary information, but future work can go further by filling in the details necessary to replicate and reproduce results from big-data studies. For example, detailed, peer-reviewed descriptions of data curation should be published, and the final data set should itself be deposited in citable repositories such as datadryad.org. By sharing citable analysis details and data, the value of studies such as Heft-Neal and colleagues' could be even greater.

Is this the final word on associations between air quality and infant mortality? Certainly not, because any observational study runs the risk of confusing correlation with causation. But I would suggest that proof of causation should not be the only motivation for such studies. Rather, the goal of any scientific exploration should be to know more afterwards than we did before. Proving causation might help researchers to pinpoint the direct effects of particular policies on particular aspects of health. But carefully vetted broad-scale associations can point to ways in which small policy changes can yield large improvements (even if indirectly) in addressing challenging public-health goals. This is especially useful for aspects of public health, such as air-pollution analyses, in which tightly controlled experimental studies would be difficult and ethically challenging — it would not be possible, for instance, to randomize levels of air pollution to individuals, nor to easily assign specific exposures to specific locations.

Large-scale data-science studies can offer insight into factors that predict trends in health outcomes, but may have limited use for defining causation, particularly at continental scales. For example, consider Google Flu, which aimed to estimate the numbers of influenza cases in the United States by analysing search-term trends relating to flu symptoms. For many weeks, the system's data-science-based predictive approach provided more-accurate results than did conventional epidemiological tracking based on physician reports and laboratory confirmation. However, following an adjustment to the prediction algorithm in

early 2013, the system vastly overestimated flu cases for two weeks[7]. By relying wholly on associations rather than also incorporating epidemiological risk factors, the algorithm had few checks and balances against over- or underestimation, and offered few insights into the factors driving short-term patterns in flu incidence.

In summary, although big-data analyses cannot replace careful epidemiological studies, they can give broad insight into the potential benefits of public-health policies. In this case, Heft-Neal and colleagues' work highlights the benefits of aspiring to reduce air pollution to the lowest levels observed in their data set, and provides assessments of the effects of more-modest changes in pollution levels. This type of analysis certainly has a place in the modern public-health toolbox. As noted by Kofi Annan[2]: "Without good data, we're flying blind. If you can't see it, you can't solve it." ■

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CONDENSED-MATTER PHYSICS

The heat is on for Majorana fermions

Exotic particles called Majorana fermions have potential applications in quantum computing, but their existence has yet to be definitively confirmed. Two groups have now glimpsed these particles. SEE ARTICLE P.205 & LETTER P.227

KIRILL SHTENGEL

The building-blocks of matter — protons, neutrons and electrons — are examples of particles called fermions. Eight decades ago, the Italian physicist Ettore Majorana predicted the existence of fermions that are their own antiparticles[1]. These particles, now known as Majorana fermions, would be of great fundamental interest, and could revolutionize quantum computing. Evidence for Majorana fermions among elementary particles remains elusive; however, in the past few years, there has been striking progress in this hunt in the realm of condensed-matter physics[2]. On pages 205 and 227, respectively, Banerjee *et al.*[3] and Kasahara *et al.*[4] report signatures of Majorana fermions in heat-transport experiments in two very different condensed-matter settings.

Condensed-matter systems contain excitations that behave like ordinary particles, but that need not resemble the actual elementary particles that the systems are made of. For example, the phenomenon of superconductivity (more specifically, topological superconductivity) provides a setting in which an electron can effectively 'forget' its electric charge. As a result, the electron becomes indistinguishable from its antiparticle, which in this context is an electron vacancy called a hole. Whether topological superconductivity is an intrinsic feature of solid-state materials remains an open question. However, the key aspects of the phenomenon can be mimicked in certain condensed-matter systems, providing the right conditions for the emergence of Majorana fermions. The two systems investigated in the current papers seem to be of just this kind.

Banerjee and colleagues looked for evidence of Majorana fermions on the edge of a condensed-matter system that exhibits the quantum Hall effect — whereby, at low temperature and in the presence of a strong magnetic field, the material's transverse electrical conductance becomes quantized (it can have only specific values). The authors focused on a particular state for which this conductance is 5/2 times the fundamental unit. The exact nature of this state has been a subject of debate, but all of the strong contenders can be thought of as superconducting states of composite fermions[5].

By contrast, Kasahara and colleagues investigated a form of ruthenium chloride known as α-$RuCl_3$. This material is thought to be in a phase known as the Kitaev spin liquid — a peculiar state of matter that lacks long-range magnetic order all the way down to zero kelvin[6,7]. Although α-$RuCl_3$ is an electrical insulator, the description of the magnetic properties of a Kitaev spin liquid is mathematically equivalent to that of a topological

50 Years Ago

Motorists in south and central England who cleaned their cars during the last weekend of June regretted their diligence when they rose on Monday, July 1, to find deposits of orange coloured dust over every exposed surface. The explanation was an early morning shower of rain, laden with dust swept up probably from somewhere in North Africa … this was an unusual event, even for a country which prides itself on the peculiarities of its climate … it turned out that the last time a dust fall like this happened was in 1903 … On the same day as the widespread dust fall, Minehead … Dulverton … and Burnley … were bombarded by hailstones the size of golf balls … The Meteorological Office is keeping an open mind on whether this is a coincidence or whether there was a causal relationship between the dust and the hail.
From *Nature* 13 July 1968

100 Years Ago

During the last twenty years there has been an extraordinary increase in the … output of books and papers on scientific subjects. In the olden time many a quiet student would be content to spend his life upon one piece of work … in the hope that it might remain a permanent addition to human knowledge … [A]nyone wishing to learn the present state of our knowledge … might well despair of ever discovering all that has recently been written … A complete catalogue of all scientific publications throughout the world would be, unfortunately, very bulky … An alternative method is to draw up a list of journals … and to confine the catalogue to papers published in these journals. When this plan is adopted it is hoped that authors … will gradually acquire the habit of sending any original paper they wish to publish to one of these periodicals.
From *Nature* 11 July 1918