Meningococcal meningitis in western Africa shows recurrent seasonal patterns every year. Epidemics typically start at the beginning of February and last until May. We can try to explain the observed patterns on the basis of some seasonally varying environmental factor that favors disease transmission. Air dryness produced by strong dust winds is the most likely candidate.

But while there are qualitative “stories” of this kind in the literature for many seasonal phenomena, convincing quantitative evidence to support them remains largely elusive. Instead, we tend to see weak associations between environmental and transmission variables when measured by simple, linear correlations.

The study of meningococcal meningitis in Mali by Sultan and colleagues in this issue of *PLoS Medicine* is a remarkable exception [1]. The study reports a strong association between the yearly onset of epidemics and a large-scale regional index for atmospheric circulation related to the Harmattan winds in Sahelo-Sudanian Africa.

The Importance of Seasonality

Why is a focus on the seasonality of infectious diseases and its variation from year to year so important? Isn’t it more important for us to instead understand the effects of long-term climate change on human health?

At first sight, understanding seasonal patterns seems disconnected from understanding the impact of long-term climate change. However, seasonal patterns are one major pathway for the subtle but potentially drastic effects of climate change on disease dynamics. Long-term climate change affects seasonal patterns through the lengthening of the transmission season and the crossing of environmental and demographic thresholds that underlie seasonal outbreaks [2]. Thus, identifying the specific environmental factors underlying seasonal transmission is a critical step towards predicting and understanding how long-term environmental trends in mean climate and their variability will impact human health.

The Problem of Scale

One important difficulty in uncovering seasonal drivers of infectious diseases is to identify the appropriate scale of analysis. The relationship between disease and climate described by Sultan and colleagues only becomes apparent at large spatial scales. The authors argue that these large scales are necessary to eliminate “idiiosyncratic” variability in the relationship between cases and climate at the local level.

In other words, there are only weak correlations between seasonal variations and climate variables at small scales because of the multiple other factors that play a local role and act as noise.

But we should be cautious about the suggestion that appropriate larger scales will always resolve the problem of local variability and present strong linear associations between climate and disease. Public health measures might require predictions not only at national and regional scales, but also at a variety of smaller scales.

Moreover, one important source of variation in how infectious diseases...
understand the interaction between susceptibility levels and climate variation [3,4,5].

The problem of scale also arises when we need to identify the appropriate timing (the temporal window) to detect strong associations between disease outbreaks and environmental covariates. This is particularly important when strong couplings between environment and transmission occur only transiently. This seems to be the case for cholera in Bangladesh, where couplings are strong during El Niños, but considerably weaker the rest of the time [6]. Intermittent couplings provide insight into how the system might behave if pushed into specific dynamic regions by a change in climate. Intermittent couplings also suggest the existence of thresholds in the response to climate, an area of research that remains in need of quantitative approaches.

Seasonal Drivers May Be Elusive

Besides scale, specific seasonal drivers are often elusive because of the simpler reason that in nature seasonality is ubiquitous. Multiple and covarying drivers have been proposed for the seasonal nature of cholera, including temperature, rainfall, and plankton blooms [7]. Yet the specific roles of these drivers in the bimodal seasonal cycle of cholera, and particularly in the second peak in endemic regions in south Asia, have not been convincingly shown (Figure 1) [8]. We still don’t have predictive explanations of the geographic variation in seasonal patterns. We won’t find such explanations by considering the average seasonal pattern; instead, we must consider the anomalies in amplitude and onset of the peaks that occur in different years.

Ecologists have considered seasonality in mathematical models of the population dynamics of infectious diseases to oscillate and create epidemic outbreaks. The tendency of these intrinsic cycles to go up and down in synchrony at different locations in space will determine whether susceptibility levels act as noise at small scales or, alternatively, whether their effect must be considered in conjunction with climate at larger scales. Because the number of susceptible individuals is a hidden variable in most epidemiological analyses, recently proposed methods for its reconstruction from data on cases must be combined with studies on climate variation if we are to

Figure 1. The Role of Rainfall in Driving the Seasonal Nature of Cholera Is Unclear

This photograph was taken during a cholera and nutrition survey during flooding in Bangladesh in 1974. In Bangladesh, monsoon rains appear to have a seasonal “dilution” effect on transmission, producing a decrease in cholera cases during that season. We don’t know whether extreme rains also produce a lagged increase in cases later on in the cycle. In other parts of the world, cases typically peak during the rainy season. (Photo: Jack Weissman, Centers for Disease Control and Prevention)
progress in understanding long-term patterns in disease dynamics pale in comparison to the spatiotemporal coverage available for climate studies and modeling. The need to resolve these issues of scale and confounding variability only underscores the urgency and importance of maintaining and developing systematic surveillance programs for infectious diseases around the world.

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