

Waving goodbye to measles

Peter M. Strebel and Stephen L. Cochi

An innovative way of analysing statistics on measles incidence in England and Wales since 1944 reveals recurring waves of infection originating in large cities. The information can guide strategies for preventing the disease.

Measles tends to occur in epidemics. It causes severe complications, such as pneumonia and blindness, and often kills. And it is highly communicable: in a population of susceptible individuals, a single primary case of the disease can result in 15–18 secondary cases¹.

The usual way of depicting the course of measles as it moves through a population is the epidemic curve — a graph of the number of cases occurring in a given population over time. Instead, as they describe on page 716 of this issue², Grenfell *et al.* have applied advanced methods of time-series analysis to weekly records of measles cases from England and Wales for the period 1944–1994. They show that recurring waves of measles infection begin in large cities and travel to peripheral towns. This fresh view of measles transmission in time and space provides the best documentation yet of what had previously been known largely anecdotally. It has implications for how we try to prevent, and eventually eradicate, the disease.

Uptake of measles vaccine in a population is the main factor affecting transmission of the disease; as uptake increases, epidemics become smaller and less frequent. In the 1990s, the Pan American Health Organization (PAHO) pioneered a highly effective approach to measles control. The approach combines high vaccination coverage for each group of newborns with periodic nationwide vaccination campaigns that target older children who either missed their first dose of vaccine or failed to develop an immune response³. When properly implemented, this strategy virtually halts measles transmission, as seen in various countries where it has been tried^{4,5}, and as is dramatically depicted in Fig. 1 for Romania. The few cases that are confirmed after such nationwide vaccination campaigns can be explained largely, if not exclusively, by import of the disease from countries where it remains prevalent.

In England and Wales, vaccination was initiated in 1968 and a nationwide, school-based campaign in 1994 has resulted in the sustained interruption of measles transmission since then⁶. Using data from the pre-vaccine period, Grenfell and colleagues² identify the cities of London, Manchester and Liverpool as the source of periodic waves of measles infection and the site of persistent reservoirs of the disease between epidemics. In the years 1945–1947 and 1962–1965 the

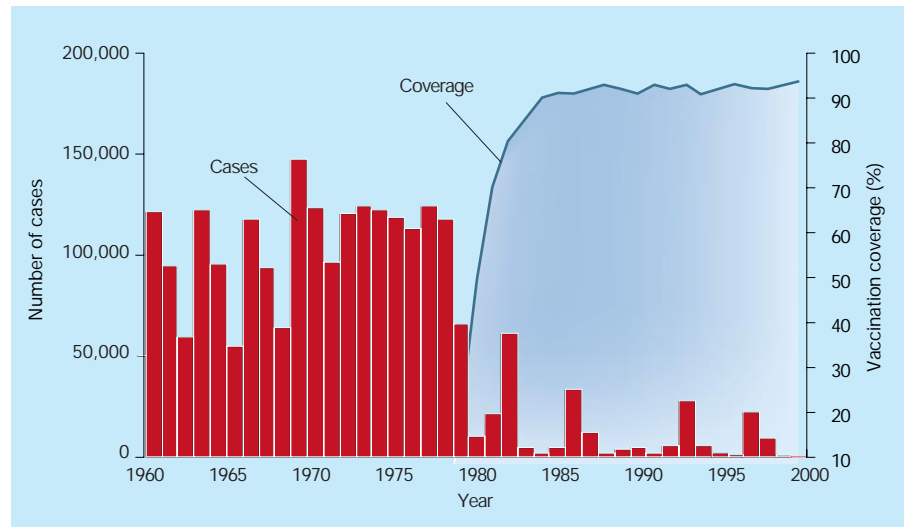


Figure 1 Beating measles with vaccination, as shown here for Romania. The red bars indicate the number of measles cases, and the blue line indicates vaccination coverage, among one-year-olds. In 1979, a single-dose measles vaccination strategy was introduced; a second dose was added in 1994; and in 1998 a nationwide mass-vaccination campaign was conducted among everyone between the ages of 7 and 18. In 1998, 1999 and 2000 the numbers of reported measles cases were, respectively, 9,547, 240 and 35. (Source: Ministry of Health, Romania, and ref. 10.)

inter-epidemic period was reduced to less than two years in London and the surrounding areas: this, the authors suggest, was due to increased birth rates (the 'baby boom' years) that fed susceptible people into the population at a higher rate.

Herein lies the main message of the paper. It supports the idea that preventing measles

in the world's most rapidly growing megacities, which are characterized by high birth and migration rates, is the greatest challenge to eradicating measles worldwide⁷. Although the PAHO strategy has been effective in stopping measles transmission in places such as Mexico City, São Paulo and Buenos Aires, none of these population centres will grow

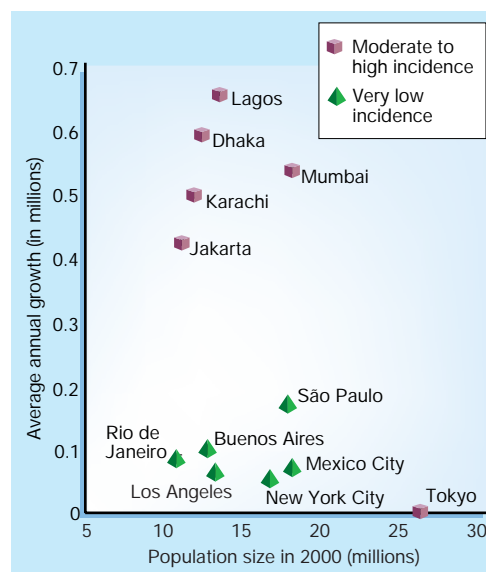


Figure 2 Measles and megacities. In 2000, the cities shown by green triangles had a low incidence of measles because of measles elimination strategies; these cities also have relatively low population growth. The other cities (purple squares) all had a moderate to high incidence of measles in 2000; in all of them, only the standard one-dose vaccination strategy was used, and all, except Tokyo, have an average annual population increase of at least 200,000 people. (Source: ref. 11.)

as rapidly as other cities including Mumbai (India), Dhaka (Bangladesh) and Lagos (Nigeria) (Fig. 2). Full implementation of the PAHO strategy is needed in the megacities and the surrounding regions to stop measles transmission. If this proves to be impossible, new approaches such as development of new vaccines for administration in early infancy may be needed.

Grenfell and colleagues² show that, in the pre-vaccine era, waves of measles infection moved away from London at a speed of around 5 km per week and were evident up to 30 km away from the city. There was a time lag between the peak in the originating urban centre and its arrival in the periphery — the lag was greater for smaller and more distant towns. Given this pattern, it is tempting to think that the extent of measles outbreaks can be controlled by vaccination ahead of the epidemic. But attempts to control outbreaks show that once a wave of infection has been established, it is difficult to stop it through selective vaccination. Often the intervention comes too late or, if it is in time, the ‘wave’ of measles infection still sweeps over and around the ‘breakwater’. Current recommendations are that measles outbreaks should be prevented rather than controlled after they have started⁸. But vaccination in areas next to districts in which an outbreak occurs may be effective if high coverage of all susceptible age groups is achieved.

From Grenfell and colleagues’ results, it might seem that concentrating on cities would be an effective vaccination strategy (although this is not something they themselves propose). This approach — based on the idea that cities are the key disease reservoirs — has been tried in Africa, and has not worked. In the late 1990s, Burkina Faso and Mozambique conducted mass vaccination campaigns, targeting children of preschool age in the largest cities with the aim of preventing spread to more remote rural towns and villages that health services found hard to reach. In both countries, the urban campaigns were associated with some reduction in the size of the expected epidemic in the city but were unsuccessful in preventing disease spread to rural areas⁹. The urban campaigns still left enough susceptible city dwellers to result in an epidemic, and then human migration seeded the periphery, leading to large outbreaks elsewhere.

These examples reinforce the need for universal vaccination against measles for all children regardless of where they live. The sheer number of people moving around for business or pleasure, in addition to forced migrations, make importation of measles a common occurrence: achieving and maintaining high population immunity by vaccination throughout an entire country is the only proven way of preventing large outbreaks.

The results in Grenfell *et al.*’s paper should stimulate activity in at least two areas. First, it is likely that the city-to-village dynamics that they document for measles also apply to other common human diseases. Among them are some that can be prevented by vaccines (rubella, mumps, varicella and hepatitis A) and some that, as yet, can’t (those caused by respiratory syncytial virus, rotaviruses and adenoviruses), and influenza, which has pandemic potential but is vaccine-preventable. Better characterization of the patterns of disease transmission in space and time could offer unique opportunities for prevention: in particular, more research is needed on the effect of long-range jumps of infection that occur, for example, with air travel.

Second, the new work highlights the value of careful collection, analysis, dissemination and storage of disease-surveillance information. Accurate records of measles cases were kept in England and Wales long before vaccination against the disease was introduced, and Grenfell and colleagues’ sophisticated time-series analyses were possible only because of the geographically detailed and complete nature of the data sets. We would be wise to strengthen the disease-

surveillance systems in both developed and developing countries, and to include collection and storage of clinical specimens as part of that endeavour. Not only is such information essential for immediate disease control, but it will also make possible future research with analytical or laboratory methods yet to be devised. ■

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High-temperature superconductivity

Charged with smuggling heat

Kamran Behnia

Good conductors of heat are usually good at conducting electricity. So the discovery that electrons in a superconductor can carry an unauthorized amount of heat at low temperatures raises many questions.

Copper oxide compounds are noteworthy for the relatively high temperatures (up to 160 K) at which they lose their resistance to electrical currents and become superconducting. This was discovered by Bednorz and Müller¹ in 1986, and gave birth to the field of ‘high-temperature’ superconductivity. High temperatures aside, the unconventional nature of the superconducting mechanism in these materials has puzzled researchers ever since.

In 1986, few would have guessed that a shock wave produced by that scientific earthquake would reach an old realm of solid-state physics 15 years later and shake one of its most fundamental concepts. But on page 711 of this issue, Hill *et al.*² report that, at low temperatures (close to absolute zero, or $-273\text{ }^{\circ}\text{C}$), a copper oxide material in which the superconducting state has been suppressed violates the Wiedemann–Franz law. This universal law relates two basic properties: the ease with which a solid conducts heat and charge. As this is the first time a material has been found that deviates from this law, it reveals, yet again, that high-temperature superconductors are far from being understood.

Almost 150 years ago, Wiedemann and Franz discovered a remarkable correlation between the thermal and electrical conductivities of various metals — good conductors of electricity are also efficient conductors of heat. At room temperature the ratio of the two conductivities was found to be very similar for a broad range of metals. Several decades and a scientific revolution later, this ratio was linked to two fundamental constants: the quantum of electrical charge, e , and the ‘quantum’ of entropy, k_B (better known as the Boltzmann constant). Roughly speaking, entropy measures the disorder of electrons and is the microscopic origin of ‘heat’.

The fundamental mechanism behind the Wiedemann–Franz correlation is easily grasped. The propagation of electrons in a crystal is impeded by the presence of any imperfection (impurities or defects). So there is always a maximum finite distance that an electron can travel before being scattered. Because the electron carries both heat and charge, scattering will affect thermal and electrical conductivities in the same way. This is strictly true only if the scattering is