**The Changing Geography of Ill Health.**
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This lecture will consider the wide variation in health which can occur even over quite short distances. This is not a transcript but notes of the key points in the lecture.

Health varies very considerably by geography. Sometimes this is a consequence of the environment itself; you do not get frostbite in a desert or heatstroke in a European winter. More often variation points to some other major driver of disease. It cannot be biologically inevitable if neighbouring areas with similar populations have very different experience of health and disease. Health varies over time in a particular area as well as over space. Identifying this variation is essential to understanding disease and to tackling it.

The shift from rural to urban living has brought distinct health challenges but it does reduce some of the impact of natural geography. Even within cities there is substantial variation; a short bike ride away from this part of London where life expectancy is around 86 years can get to places where it is in the 70s. Although there is a lot of additional variation, there are four major drivers of the geography of disease. The first is the geography itself, water, land, climate, especially for some major infectious diseases. Secondly there is deprivation and poverty which is usually concentrated geographically. The third major driver is the age structure which again can be highly concentrated geographically. Finally, there is cultural and behavioural elements in different geographies which this lecture considers less but remain important.

At a global level there has been massive change in the geography of ill health over the last 70 years. Life expectancy at birth in the 1950s was substantially lower in every continent, especially around what were then still referred to as the tropics. This was due to a combination of geography- diseases that occur principally in particular locations and warmer climates, and to poverty. Life expectancy at birth in 2020 has massively improved everywhere but particularly in those areas which were most disadvantaged a generation ago. A combination of improving medical science and reductions in poverty explain much of this change. In particular, under five mortality has fallen rapidly due to reduced poverty, better diet and housing, clean water, vaccines, bed nets, widely available treatment and antibiotics. I am confident that when people look back at these decades, this extraordinary improvement in health will dwarf most events we currently think important. There are even wider societal and economic implications. Where child mortality falls, fertility rates also fall. A much smaller part of the globe now has fertility at above replacement levels, and this is shrinking the whole time. We will pass the point where global fertility is above replacement levels for the first time in human history, in the lifetime of much of this audience. This remarkable change in child mortality occurred across the UK in the middle of the 19$^{th}$ century but then as now areas of relative deprivation had the highest mortality rates.

When considering infectious diseases, geographic differences in rates can be a direct consequence of the physical environment. Urban environments tend to favour diseases of crowding. Rural environments tend to favour vector-borne diseases. Which infections are most important change

over time; for example plague, both vector-borne and respiratory, was still a hazard at the stage when Gresham College was founded in 1597 but is not now. Some infectious diseases, and in particular the most important diseases of old age, are self-infections for example urinary tract infections. Geography is much less important for these.

Mapping disease has been essential to understanding it for centuries. Arguably, diseases associated with drinking water were the first to be examined scientifically. The classic study by John Snow demonstrated that cholera, then a major problem in London, mapped onto particular water companies with different sources. This helped establish the fact that contaminated water was the cause of the infection. Whilst cholera is a waterborne disease, some infections are more common where water is scarce and so washing is less frequent; a relatively old-fashioned but still useful term described these as water-washed diseases. They include diarrhoeal diseases, skin diseases such as scabies and eye diseases such as trachoma.

There are also examples of diseases due to infections from the soil. These include tetanus, a major cause of mortality pre-vaccine and generally from soil contaminated by faeces or animal dung, melioidosis a highly lethal infection associated with specific rice farming regions, and fungal infections which vary by geography based on the local fungus in the soil.

Much more common diseases are the vector-borne diseases transmitted by insects. Each has a geographical range depending on the local environment, in particular the climate and the water environment. These include dengue, Zika and Yellow Fever transmitted by Aedes mosquitoes, sleeping sickness transmitted by the Tsetse fly and Lyme disease transmitted by ticks. If the vector does not breed locally you will not catch the disease. Urbanisation, changes in land use, climate change and medical countermeasures have all changed the geography of these diseases. An example is malaria, passed on by Anopheles mosquitoes which has changed both his geography and its impact on humans over the last hundred years, including in the UK where it was eliminated in the 1920s. Some vector-borne diseases are much more geographically concentrated, such as river blindness. A recent example where the geography of vectors was important was Zika in 2015. It spread rapidly in some countries which had certain Aedes mosquitoes, especially Brazil, but was never going to make significant inroads in the UK because we currently do not have the mosquito vectors. Climate change does however mean that these mosquitoes are gradually spreading north in Europe.

Sexually transmitted infections, in contrast to vector-borne diseases, are more likely to spread in urban areas; this is because these tend to be where young adults are concentrated. Sexual infections are often seen as trivial but the last major pandemic before COVID was HIV which spread widely with 100% mortality, particularly in southern Africa.

Some infectious diseases, especially respiratory, are likely in crowded and therefore urban environments. COVID is an example of this, with much greater mortality in the UK in urban areas than rural ones. Respiratory infections can spread very fast and the initial spread of COVID in China, and subsequently globally, took a small number of months. In the UK, as elsewhere, areas of deprivation were the places where the disease concentrated, and mortality is heavily influenced by deprivation.

Whilst infectious diseases have historically dominated everywhere, and still do in the lowest income areas, in high income countries noncommunicable diseases are usually far more important. In rural areas, on occasion, the land itself can cause noncommunicable diseases; an example is Podoconiosis, a disease caused by a red clay. Minerals and water can also affect health including fluoride for tooth health and arsenic in water which can cause cancers.

Most geographical effects are however caused by humans. One example is air pollution which is concentrated in the UK in urban areas, particularly around London. Another of a very different sort is homelessness concentrated in areas of high accommodation costs.

Deprivation is a risk for many noncommunicable diseases, including in high income countries. Risks accumulate from pregnancy all the way through to old age. These include diet, housing, work, often education and smoking. There is also the inverse care law that those who need healthcare most tend to receive it least relative to their need.

For diseases communicated person-to-person, if I increase my risk, I increase the risk for everybody around me. Very localised risks are therefore less common. For noncommunicable diseases, if I increase my risk it usually makes no difference to your risk if you are outside my household. They can therefore be very short distances where the risk of a particular disease varies widely. London has also been an example of this, and the maps of Charles Booth demonstrate how extreme poverty and extreme wealth often coexisted, and also these areas change over time.

Much of the rest of this talk consists of maps of different diseases and is not easily captured in lecture notes. A few key points however can be identified. There is a very strong correlation in the UK between under 75 mortality and relative deprivation. The more granular the data, the more concentrated deprivation can be seen to be, and avoidable ill-health follows. Smoking in particular follows deprivation as the cigarette industry goes to the most deprived areas to take their extraordinary profits from the least wealthy. Lung cancer deaths due to respiratory disease and cardiovascular deaths in younger people all follow the cigarette industry.

Deaths due to liver disease under the age of 75 are more complicated. They are highly geographically concentrated in England in more deprived areas but proportionally drink in fact increases by income band.

Obesity follows a slightly different pattern, and Type II diabetes goes along with that. Childhood obesity in particular is highly concentrated and correlates with fast food outlets.

Smoking in pregnancy, one of the most avoidable causes of stillbirth, prematurity and birth defects overlaps but is not identical in its geographical distribution. This shows where we need to go to tackle this preventable lifelong health issue.

Although the maps of deprivation look to be concentrated in areas of post-industrial urban centres, the more granular data we look at the clearer it is that this is more complex. Deprivation is not all post-industrial and includes coastal and rural areas. Beautiful towns such as Skegness, Margate, Hastings, Weston-Super-Mare and Blackpool had a major change in their economy and this led to localised deprivation. Blackpool, which has the lowest life expectancy at birth in England and Wales, although improving, is an example. Even within the city the lowest life expectancy is highly concentrated. Factors such as houses of multiple occupation (HMOs) in old guesthouses attracted transient population which frequently has multiple health needs. Blackpool is also an example where the ill-health effects of deprivation start early; obesity aged 10 to 11 correlates closely with male life expectancy geographically.

Mental as well as physical health varies at a large and small scale. Although there are often concentrations of serious mental illness in urban centres rural areas also have risks. Some of the areas for example with the highest self-harm in young people are rural.

Within any country, populations are not fixed. In the UK people tend to move to cities, either for University, College or your first job which means late teens or early 20s. They then tend to move

out after children, especially their second child. The result is that cities remain ever young, and the ageing of the rest of the country is therefore faster. This has significant implications for the future geography of disease. If you compare Wandsworth and the city of London, which have large numbers of people in their 20s and 30s relative to the rest of the population, for example with Rother Valley or Chichester the age profile is very different. Many areas of the country have increasingly large concentrations of people aged over 65 or aged over 85. They are likely to move again and this is where the diseases of old age will be concentrated. Some diseases are essentially almost exclusively of old age including dementia. Others including cardiovascular disease and many cancers are a combination of deprivation and old age so concentrate in either of those areas. The age support ratio is steadily shifting, and it is not clear yet where the younger people to care for this order population in peripheral areas will come from.

The challenge of the areas, often semi-rural, where we need to provide services for older people with frailty, dementia and multiple health problems, is one we need to tackle head on. It is predictable and will only easily be avoided if we act now in advance of need. It is however important to remember that across the whole of the UK health is improving if we take a multi-year view.

This lecture has considered how wide variations in ill-health go over even quite short distances. Sometimes these are the consequence of the environment itself especially for infectious diseases. More often the variations point towards some of the major drivers of disease. This varies over time as well as space. For public health to work we need to identify this variation, understand the disease and tackle it in the geographical areas it is most common.