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My colleagues basically said that we need investment, research, good governance and education, and that will help us move forward in organising the health of human beings. I will make their and your lives more miserable by arguing that the situation is a little more complex.

Health is linked to the way we function as a planet. Pathogens have always been there; they are part of the evolution of life, and we could even argue that we have needed them to become what we are today. Pathogens will always emerge and will always continue. There is a continuous competition between pathogens and humans, as parts of the planetary ecosystem. Therefore, I will argue that unless we link pathogens, or health more generally, to the ecosystem, we will not really get a grip on these issues.

Indeed, Ebola was a wakeup call, but most people do not know that the source of Ebola was actually the wild population of bats, at least in Liberia. The pressure of the disease continued to exist in ecosystems, since we will not eradicate all bats.

Tropical ecosystems in particular, hot climates where most poor people live, are far more at risk of disease and a continuous disease burden than temperate climates and affluent countries, so health and disease are very much linked to the ecosystem and to inequality.

Looking beyond Ebola, there was an earlier wakeup call of a different nature but again completely linked to the ecosystem. Do you remember Mad Cow Disease, BSE, and the Creutzfeldt-Jakob human variant of the disease? Do you remember how that came about? It was through the consumption of meat. The infectious agent in the neural cords of cows came, again, from the ecosystem, possibly transferred through the lands where the animals were grazing or, in the case of the more advanced, integrated food chain systems, it was because animals were fed infected bone meal. Both cases draw our attention not just to the infection itself but also to the complexities of modern food chains. This is a new dimension; how we feed ourselves is as important as isolating the pathogens.

We feed ourselves today through international trade. That leads to two other public health dimensions, the heavy use of chemicals and the risk of infections moving from one continent to another. A case in point is avian influenza. Influenza exists permanently in wild birds, but it does not usually cause any symptoms in wild birds; until recently nobody was worried about finding a few dead birds on a lakeside somewhere in Siberia. Interestingly enough, the influenza virus is very resistant to cold, which makes it even more complex, because it can move with the seasonal bird migration.

Avian influenza does cause problems in poultry, in domestic animals, but that again may be quite unnoticeable because the symptoms are not always clear to the untrained eye. It becomes a problem when this low pathogenic influenza then turns into highly pathogenic influenza that may also cross the boundary between animals and humans. Influenza viruses are probably one of the most complicated pathogens we have to deal with, because they are so ingrained in the ecosystem, but they are also so closely linked to another phenomenon which is very much part of our modern times, which is the growth of cities and the intricate connection of poultry and pigs in particular with human life.

A city like Shanghai might harbor ten times more poultry than humans, and they are close geographically. Avian influenza it is impossible to eradicate, as there will always be sources in wild birds. When the highly pathogenic form emerges, we have an enormous problem that we have seen, for example, in Hong Kong in 1997. Avian influenza has migrated towards Europe, possibly through the pathogens carried by wild birds that had been re-infected in Asia.



This leads us to the fact that the ecosystem as a whole needs to be understood in order to get a sense of pathogens and infection routes. It also leads us to the awareness that we need to understand the whole food chain. Moreover, it leads to the fact that we need to deal with public health both at the local level and an intergovernmental level.

The food chain often involves international trade. Take for example the case of the outbreak of an especially highly pathogenic variant – producing a Shiga toxin – of *E. coli*, one of the most common bacteria around, in what were initially thought to be cucumbers in Germany. This was in 2011. Hundreds of people died quite suddenly because of *E. coli* infections. What happened there? It was, again, the entire food chain. Many research institutes were involved in this, and it took us about a month to understand what exactly the pathogen was in its genetic details and to trace it back – most probably, because we are not entirely sure – to an organic farm in Egypt that had used cow dung as an organic fertiliser. Think about how intricate this whole linkage was, and if we had not understood these trade patterns, we would not have understood this disease at all.

However, disease burden is not just a matter of the most noted current infectious diseases. There are two other aspects to global health. One aspect are the endemic diseases that cause enormous damage which we have not tackled yet and which we must tackle soonest. A case in point is malaria, which still affects 200 million people a year. It is not only a disease that is crippling and causes about 500,000 deaths a year but is also a disease that is immediately linked to economic productivity. Sufferers from malaria cannot work as much as others and are not as productive. What is also important is that malaria is aggravated by low iron consumption; again the dietary link in food chain. Therefore, if we do not understand the consumption patterns, we cannot deal with the disease as effectively as we would like to.

Secondly, food safety related issues. I am not just talking about acute cases such as *E. coli* in Germany. There are toxins or contaminants in the food chain on a very regular basis, sometimes as a result of fraud, such as the ill famous melamine in milk case in China. They often have to do with problems with hygiene in the food chain. This becomes more serious when we have lack information on the origin of the food and the processing steps. A major complication is the anonymity in the way trade is currently carried through the Internet driving prices down at the expense of quality.

There is the so called double burden of malnutrition and obesity, very severe in developing countries and also linked with the likelihood of getting other complex diseases. Global health is the result of many complex processes, with pathogens that will always exist in our ecosystem, their transmission which is often, but not always, through animals to humans, and a number of other diseases that are endemic or chronic and non-contagious in human beings, all of them linked through the food chain. This complex set of disease burdens is unfortunately aggravated by climate change.

Climate change, especially through high night temperatures and high humidity in some cases, will lead to greater growth of the vector or the pathogen itself, making control even more difficult. But the most important thing is our lack of ability to deal with this. First of all, understanding the linkages between animals, humans and ecosystems requires an interdisciplinary approach, scientifically but also administratively, at government level and internationally.

There are very few if any countries with a close connection between the ministry of health, the ministry of education, the ministry of trade and the ministry of agriculture. There are very few international mechanisms, certainly not in the UN where as a matter of course this discussion is going on, yet it is absolutely essential to have an integrated approach. We are doing it a little better in research, because we do not adhere to disciplinary boundaries, but unless we have a mechanism to at least let ministries of agriculture, health and trade talk to each other, we will not solve the issues.

Secondly, we need a multi-scale approach. This is something where the local, the regional, the national, the inter-regional and the international all need to be linked and organised together. Unfortunately, very few countries have the surveillance power to even monitor, let alone act quickly, when it comes to pandemics or when it comes to some of the chronic non-communicable diseases. Monitoring will be made easier by technology, but you still need the people to analyse the meta-data and set up early warning systems. We need to get that organised digitally, and we are not all there. The disruptions of a pandemic and the disruptions of chronic disease in large sections of the populations are tremendous.



We are making great progress in terms of finding new ways to treat animal and plant diseases, with genes coding for resistance. Some of this breeding uses forms of genetic modification. This is an issue particularly in Europe, because the potential of genetic modification may actually not be applied due to political hesitations. However, genetic modification may help to reduce pesticide use and hence disease risks to humans.

There is also an educational aspect. A lot of the problems of food safety actually occur at consumers' level, in the kitchen, on the sink, in the fridge. Few people actually keep their fridges at the right temperature, and few people hygienically separate the animal and plant products they consume at home. The problem is not so much in supermarkets or factories; it is very much at home. That requires education and awareness. We need more research in an integrated fashion to get the global one health concept working. We need investment in modern digital, chemical and genetic technology to understand the complexities of food chain, toxicity, and the ecosystem together, and above all we need the political will to integrate that and to get ministries and sectors to work together, not to impose more barriers but to reach an integrated approach. We need education as well at a primary and secondary school level so people understand that pathogens are a danger but can be managed if we have a good monitoring system and awareness in the public at large.