PREDICT AND PREVENT

An initiative to help prevent local outbreaks of emerging disease from becoming pandemics

Summary
Several new lethal infectious diseases crop up every year. Examples include the well-known killers HIV/AIDS, avian influenza, and SARS, as well as drug-resistant strains of ancient scourges like malaria and tuberculosis. Three-quarters of new diseases are zoonoses, meaning they've jumped from animals to humans. Urbanization and deforestation increase human-animal contact, and with it, disease spread. Climate change is allowing insect populations to thrive in new areas, changing the face of mosquito-borne diseases. Through October 2008, Google.org's *Predict and Prevent* initiative has committed over $30 million in grants to support partners to identify hotspots where diseases may emerge, detect new pathogens and outbreaks earlier, and respond quickly to prevent local threats from becoming global crises.

These grants will increase our understanding of emerging infectious diseases and generate vast amounts of new data, samples, genetic sequences, and hopefully pathogen discoveries. One promising way to put this new knowledge to work to save lives is to invest in robust, affordable infectious disease diagnostics for use in Asia and Africa. There are also many ways in which Google's data management, data sharing and collaboration platforms can improve data access and sharing, support online bioinformatics, and advance the genomics of infectious diseases. Finally, as we get to know partners better, we expect that our grant making will shift to directly supporting partners at the frontline in high-burden countries to build sustainable local capacity to identify pathogens at their source.

Emerging Infectious Diseases
Despite advances in medical treatment and vaccine technology, emerging infectious diseases are on the rise worldwide. Over the last three decades, the World Health Organization (WHO) has reported more than 30 brand-new infectious diseases, including killers like HIV/AIDS, Ebola and SARS.[i]

In addition, known diseases are expanding in geographic distribution, even shifting to entirely new continents. For example, in the summer of 2007, health workers were shocked to diagnose chikungunya fever, a mosquito-borne disease normally confined to the tropics, in Ravenna, Italy.[ii] In 1999, another mosquito-borne infection, West Nile Virus, jumped continents to appear in New York, and became endemic throughout the United States within three years.[iii]

Other diseases have transformed into new threats as a result of drug resistance. For example, extensively drug-resistant tuberculosis (XDR-TB) is a new strain of an ancient disease that is resistant to a combination of standard and reserve treatment medications. [iv,v]

In the era of globalization, the risk of an isolated outbreak of disease becoming an epidemic or even pandemic is greater than ever. Vastly expanded international travel and trade allow disease-causing agents to move around the globe at accelerated speeds. Moreover, those areas of the

world most vulnerable to disease outbreaks are typically also those with the weakest systems for public health surveillance – putting all nations at risk.

One Health

A comprehensive understanding of emerging infectious diseases requires a 'One Health' approach, which recognizes the interdependence of humans, animals and the environment.

For example, environmental changes such as deforestation, global warming, pollution, and urbanization all disturb healthy ecosystems, which are regarded as an important safeguard against the emergence of disease.[vi] As humans increasingly infringe upon natural habitats with high biodiversity, they are exposed to larger numbers of potential pathogens. These biophysical stresses are compounded by the impact of rapidly changing social contexts – poverty, inequality and social unrest all contribute to the risk of epidemic outbreaks.[vii]

In addition, more than 70 percent of newly identified infectious threats are zoonoses, meaning they have jumped the species barrier from animals to humans.[viii] Animals such as non-human primates, bats and rodents have been recognized as important reservoirs and vectors of disease. Livestock can also be a key source of infection, as evidenced by the recent outbreaks of avian influenza in poultry. Wildlife and livestock often serve as sentinels of human disease.

The impact of disease is also mediated by the relationships between humans and animals. The lives and livelihoods of the rural poor are often tied to their animals, with more than 70 percent dependent on livestock for income.[ix] They are not only vulnerable to severe or fatal infection due to close contact with infected animals and animal products, but also bear the economic brunt of livestock losses due to animal disease or disease control programs.

Identifying and responding to emerging infectious diseases requires integration of livestock, wildlife, agricultural, environmental and human data. Despite these overlaps, government departments, academic institutions, and international agencies typically specialize in human, animal or environmental health and true interdisciplinary collaboration remains rare. An integrated approach necessitates breaking down historical divisions to allow sharing of knowledge and experience across and beyond disciplines.

From Reactive to Proactive Approaches – the Lessons of HIV

In practice, fragmented and crisis-driven disease management strategies have resulted in marked human and animal suffering and death, as well as extreme financial costs. Billions of dollars have gone into the emergency response to emerging diseases in general, and to one disease in particular – HIV/AIDS.

Recent estimates state that just over 33 million people are now living with HIV/AIDS.[x] As the standard HIV/AIDS epicurve shows (depicted in orange in Figure 1), this emerging disease first gained global attention when it was detected in California in 1981. However, retrospective studies of stored samples have found a case that dates back to as early as 1959 in Kinshasa, Democratic Republic of Congo. Accounting for this new information dramatically changes the graphic depiction of the HIV/AIDS epidemic (the grey dashed line in Figure 1). In fact, it is likely that the virus was circulating for 60-80 years before the first reported case, but because the disease was not detected, any opportunity for early containment was missed. [xi]

In addition, research has revealed that HIV began as a primate disease that later crossed the species barrier to infect humans. We can only speculate about the period when HIV was circulating in animals and evolving into a human pathogen. If we had had a better understanding

of the complex factors that cause diseases to emerge, could we have been watching and waiting when HIV made its earliest jump to humans?

If we reflect back on the existing HIV/AIDS pandemic and begin to imagine how we might have predicted and prevented the global spread of this devastating disease, three important areas of action become apparent. First, we have the period after 1981 (on the *far right* of the HIV/AIDS epicurve) when the disease had been recognized as a threat that was circulating in the human population. At this stage, *responding quickly* to find new cases and prevent disease transmission is key. This relies on a robust system of public health surveillance.

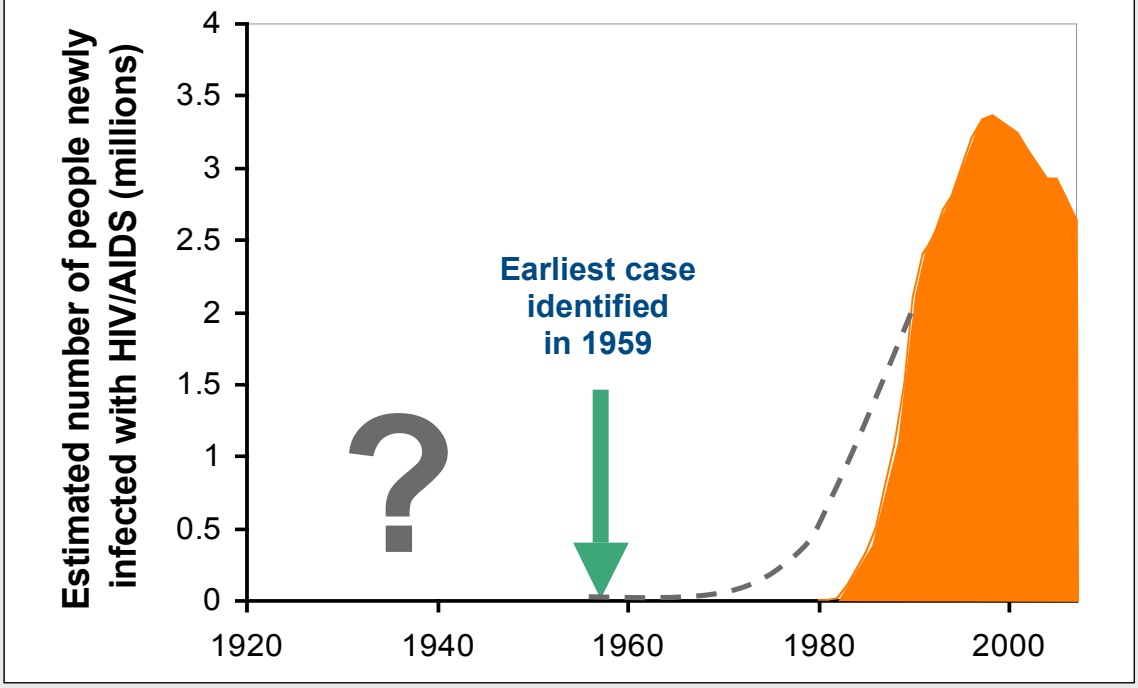

Figure 1: HIV/AIDS epidemiological curve

Source: based on data of UNAIDS/WHO (2007)

However, we know that millions of lives could have been saved if we had found cases of HIV in the 1950s or before. Instead of beginning our response once the number of human cases was already climbing (on the far right of the epicurve), we could have intervened several decades earlier – shifting the point of response *one step to the left* of the standard HIV epicurve. To do this, we would have needed fast and accurate methods to *find threats earlier*.

However, to have contained the HIV epidemic altogether, we would have needed to shift our response *a second step to the left* of the standard HIV epicurve by catching the virus right at its origin - at the point when it made the very first jump from chimpanzees into the human population. This may seem like an impossible feat, but if we really understood *why* and *how* diseases emerge when they do, we would have a much better idea of where and when to expect

them. *Knowing where to look* for disease emergence allows us to target our surveillance accordingly.

Initiative Goals

Predict and Prevent aims to work in three areas: *responding quickly* to improve where we are today, *finding threats earlier* to take us one step to the left, and *knowing where to look* to take us two steps to the left. We will work in partnership with others to strengthen traditional disease surveillance and response, and establish better systems for early warning. We will also strive to find threats faster by improving technologies for better detection and validation. At the same time, we will support efforts to build the science, technology and capacity in the developing world to map regions vulnerable to future outbreaks. The result of this will be to change the nature of disease response from reactive to proactive, moving us two steps ahead of where we are today.

Initiative Strategy

Responding quickly

Currently a lack of accurate and timely information exchange between local, provincial, national and regional levels hampers surveillance systems in the developing world. Human and animal health services are typically strictly segregated, precluding opportunities to detect disease in sentinel animal populations. There is inadequate human resource and laboratory capacity for data collection and analysis, and accurate diagnosis.

We will work with key partners to develop mechanisms for community-based and cross-sector reporting, building on the success of mobile phone technologies in the developing world. Support to our partners may extend beyond funding where there are opportunities to leverage existing Google tools and resources.

Successful early warning and response will depend on having basic epidemiology and laboratory capacity throughout the world and the willingness to openly share important data for disease control and prevention. We will support improved field investigation by partnering to build laboratory capacity and epidemiology training programs that take an integrated 'One Health' approach.

As diseases do not respect national boundaries, these activities are best situated within regional disease surveillance networks, which provide a mechanism for cross-border sharing of data, expertise and best practices.

In short, Predict and Prevent will focus on:

- Using innovative methods to enable timely information transfer to and from the field
- Strengthening regional networks that are using integrated 'One Health' approaches to disease surveillance and response
- Engaging key stakeholders, from villagers to global health authorities

Finding threats earlier

To prevent pandemics, we need to identify emerging infections wherever they occur. Our work to support better detection of disease threats includes activities in *digital detection* and *genetic detection*.

We can capitalize on faster, stronger and more ubiquitous Internet and mobile technology to enhance our traditional surveillance activities. This can be done by building upon data-mining efforts that monitor news feeds and other online resources to identify early signals of potential disease threats, and improving the speed of reporting to the appropriate responders. Automated alerts require validation by on-the-ground personnel. We will strengthen a global network of 'threat detectives' by enhancing collaboration between outbreak investigators around the world.

We can also take advantage of new molecular technologies to advance understanding of the genomics of infectious diseases. This includes work to map out the range of pathogen diversity and study how viruses circulate and evolve before they jump species. We will support targeted sample collection at the human-animal interface in hotspot countries. Key activities can range from monitoring cohorts of vulnerable populations, to 'One Health' surveillance of key emerging infections through screening of arthropods, wildlife, livestock and humans to identify vectors, hosts and reservoirs of disease. We will also invest in robust and affordable infectious disease diagnostic technologies, ranging from point-of-care tools right up to more sophisticated systems for pathogen discovery.

Google.org also will strive to leverage Google's knowledge, technology and products to enhance open access, open source bioinformatics data platforms and tools that will support virtual communities and enhance innovation and discovery.

Predict and Prevent will support projects that:

- Enhance the use of automated systems for effective disease surveillance
- Improve pathogen discovery and understanding of which classes of viruses pose the greatest threat
- Strengthen efforts to bring molecular sequencing capacity closer to hotspots countries

Knowing where to look

One of the keys to finding a new disease at its source is *knowing where to look*. Although no model can predict precisely when or where a new infectious disease will emerge or how it will spread, an understanding of the complex drivers – such as climate change or deforestation – that lead to disease emergence and transmission can help communities to anticipate potential outbreaks and target scarce resources.

By integrating high quality, local level data on land use, ecosystem dynamics, climate, and demographics we might be able to identify areas of the world at greatest risk, allowing for focused surveillance and preparation. Predicting hotspots of disease emergence requires an integrated understanding of the multiple factors that create vulnerabilities. Building this understanding necessitates sharing knowledge and experience across and beyond disciplines.

Predict and Prevent is focused on:

- Sharing knowledge of key drivers of disease emergence, such as climate change and deforestation, across human, animal, and environmental health sectors

- Improving data collection, sharing, visualization and analysis for enhanced vulnerability mapping and predictive modeling of, for example, long-term weather and climate patterns that affect disease emergence and could provide early warning of disease outbreaks
- Applying risk-based approaches to target surveillance and management programs

Regions of Focus

Predict and Prevent will initially focus on Southeast Asia and sub-Saharan Africa as these two regions have been recent hot spots of emerging disease and together bear the biggest infectious disease burden.[xii] In Southeast Asia, which has been the center of the emergence of both avian flu (H5N1) and SARS, infectious diseases cause about 40 percent of annual deaths.[xiii] The disease threat is heightened in this region as it has the most intense animal-human coexistence in the world, which hastens the exchange and spread of new and re-emerging infections.[xiv] Sub-Saharan Africa bears the greatest infectious disease burden and has the weakest public health infrastructure in the world.[xv] More than half of the African population lacks access to health facilities and 40 percent lacks access to safe drinking water and sanitation, leaving them even more vulnerable to the emergence and outbreaks of new and re-emerging infectious diseases.[xvi] Poverty and poor infrastructure in both regions heighten vulnerability.

Conclusion

Current disease surveillance and response approaches often lead to action after the peak of the outbreak has passed – or worse, after outbreaks have developed into epidemics or even pandemics. The Predict and Prevent initiative aims to save lives by contributing to changing this reactive approach towards a proactive, one-health approach. Our vision is a future in which proactive surveillance systems are targeted to known disease hotspots, where outbreaks are reported within days not weeks, where known diseases are routinely diagnosed at the point of care, and where the response to outbreaks is rapid and effective.

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