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Infectious disease surveillance in the US and the UK: from public goods to the challenges of new technologies

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Abstract

Infectious diseases are a long-standing and continuing threat to health and welfare, with their containment dependent on national disease surveillance and response capacities. This article discusses infectious disease surveillance in the US and the UK, examining historical national traditions for identifying and controlling infectious disease risks and how globalization and technical advances have influenced the evolution of their respective approaches. The two systems developed in different but parallel ways. In the US, surveillance remained quite localized at the state level until the early twentieth century and still retains many of those features. The UK approach became centralized from the latter part of the nineteenth century and has principally remained so. In both cases, disease surveillance was traditionally conceived as a public good, where national or local authorities held sovereign rights and power to protect public health. With the increasing globalized nature of infectious disease, such notions shifted toward surveillance as a global public good, with countries responding in turn through the creation of new global health governance arrangements and regulations. However, the limitations of current surveillance systems and the strong hold of national interests place into question the provision of surveillance as a global public good. These issues are further highlighted with the introduction of new surveillance technologies, which offer opportunities for improved disease detection and identification, but also potential tensions between individual rights, corporate profit, equitable access to technology, and national and global public goods.

Introduction

The HIV/AIDS pandemic and recent concerns about avian (H5N1) and swine (H1N1) influenza have drawn considerable public and political attention to the threat and potential deleterious consequences of infectious diseases. Infectious diseases can result in significant impacts on mortality and morbidity, but also on economic activity and population movement. Smith et al. (2009) recently estimated that the potential economic impact of pandemic influenza on the United Kingdom (UK) alone could range between £8.4 to £72.3 billion, or 0.5% to 4.3% of gross domestic product. On a global scale, health and economic losses in the region of 71 million deaths and \$3 trillion could be realized following a severe influenza pandemic (Burns et al. 2008). Such socio-economic implications emphasize the need for effective detection and control through robust and coordinated infectious disease surveillance and response activities.

Against this background, this article discusses infectious disease surveillance systems, how they are provided, and the future challenges they face. In particular, we draw upon a comparative history of surveillance systems in the United States (US) and the UK, in attempts to highlight different ways in which the provision of surveillance have transpired in two often divergent political environments and how such processes have been impacted by changes in global economic conditions and technological advances. The article begins with a brief overview of infectious diseases and their evolving global nature. We then review broad traditions of infectious disease surveillance in the two countries, followed by a discussion of how these approaches have evolved in relation to public goods theories. Finally, we consider the introduction of new surveillance technologies, identifying key issues and challenges that might arise with their expanded integration into national and global surveillance systems.

The globalization of infectious disease health risks

The shift of human affairs from the restricted frame of the nation-state to the vast global theatre is affecting not only trade, finance, science, the environment, and culture, but health as well. Increasingly, the distinctions between domestic and international health problems are losing their usefulness and are often misleading (IOM 1997). However, intense international contacts are not new phenomenon. The Black Death of 1347, which killed one-third of the European population shows that very clearly, as do the histories of infectious disease spread from the old to the new world – from malaria and yellow fever to syphilis. Indeed, infectious disease has a long cosmopolitan history.

We and our primate relatives and ancestors have co-evolved with a wide range of microscopic organisms, bacteria, viruses, prions, fungi and parasites; some of these cause pathology and death in humans. In addition, we have co-evolved with a variety of domestic and wild animals and shared disease organisms with them. It is through zoonoses that many of the so-called “new” diseases come into existence as pathogenic organisms, alter their ecological niches and infect humans. Zoonotic pathogens have caused the majority of the emerging infectious disease events in the past six decades (Jones et al. 2008) and have the potential to cause significant morbidity and mortality in humans and animals, with serious implications for international trade, travel, economies, and perhaps even civil and national security (Barnett and Whiteside 2006). They are also highly unpredictable, with variable effects on human and animal health. The potential deleterious and uncertain impact of infectious disease can wear on the public consciousness, causing fear, hyperbole, and identification of special social groups (e.g., women, “the immoral”, gay men, Jews) with the disease, and at times civil unrest and panic.

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So, while zoonotic disease has long been a consequence of binding together people and animals from distant places through the forces of trade, migration, war, and travel, what has changed with greater global interconnectivity is the pace, range, and depth of integration, which has led to the rapid and dramatic increase of infectious pathogens in the last two hundred years, most notably in the past fifty years. We turn to a brief discussion of some of the key factors contributing to this heightened scale of “microbial unification”.

Frequency and speed of movement. New modes of transport and technological advances have brought a “virtual annihilation of time and space” (Hobsbawm 1994). The British epidemiologist DJ Bradley observed the lifetime travel tracks of four generations of his family. His great-grandfather spent his life within a square with sides only 40 kilometres in length, his grandfather’s square had sides 400 km long, his father’s square had sides 4,000 km long, and Bradley’s own travels spanned the entire world (Cliff and Hagget 2004). Today, more than 3 million people travel abroad every day, a three-fold increase since 1980, and are doing so with greater speed than ever before. A century and a half ago, it took as much as a year to circumnavigate the globe by ship; today it takes around a day (Cliff and Hagget 2004). The significance of this with regard to infectious diseases may seem intuitively obvious. With increased speed of travel, the incubation period of many infectious diseases is now longer than the time it takes the infected individual(s) to travel from one location to another, enabling the pathogens to silently and rapidly reach a large pool of as yet uninfected people (Anderson and May 1991). Human movement has thus become a process that involves much more than what transpires during the trip itself.

Urbanization of human populations. Rates of urbanization have increased markedly and rapidly, with a rising concentration of human beings now living in cities, often from diverse backgrounds and residing in poor conditions. In 1950, 30 percent of the world’s population resided in urban centres. In 2008, for the first time, the world’s population was evenly split between urban and rural areas. By 2050, approximately 60 percent of the world’s population (~6 billion) will reside in urban centres, with the majority of urban growth occurring in less developed countries (UNPD 2007). This has important implications for the range and magnitude of potential pathogens concentrated and transmitted in a relatively small area.

Evolving animal agriculture and trade. With increased urbanization, the frequency of urban and peri-urban farming is likely to increase. Contemporary China and India are good examples where demand for meat and milk and other animal products has increased in step with concentrations of relatively high income segments of the population. While there are several good economic reasons for livestock to live in close proximity to humans, the risk of zoonoses amplifies (Slingenbergh et al. 2004). The most dramatic recent example of this is the emergence of bovine spongiform encephalopathy (BSE) with resultant Creutzfeldt-Jakob Disease (CJD), better known as “mad cow disease”, in humans in the UK, US, and elsewhere. Simultaneously, the global food production system has become increasingly mobile. For example, Brazil is now the largest single exporter of poultry and beef, shifting product to more than 150 countries (FAO 2009). Such large scale production can result in animal crowding with unsanitary conditions; coupled with increased demand for meat and rising international trade of live animals, an increased risk of disease spread is consequent.

These are only but a few of the key underlying drivers of zoonotic diseases – their emergence and transmission result from an evolving complex of biological, genetic, ecological, political, economic, and social factors. Moreover, while we have discussed the potentially negative implications such changes can have on infectious disease risk, it is worth noting that discussion of these consequences needs to be balanced against the positive effects of improved population nutrition and health, urban sanitation, and enhanced safety in animal and food production and supply chains. The precise balance between the negative and positive effects of these changes is dynamic and varies from place to place,

resulting in different degrees of infectious disease risk and national and global approaches to their detection and control.

Evolution of infectious disease surveillance in the US and UK

Infectious disease surveillance aims to identify, detect and control health risks. Traditionally, nation states practised surveillance and movement control based on observation of symptoms, moral judgements and reports from neighbouring areas. These activities facilitated population quarantine prior to entry to cities or disembarkation at ports (Porter 1994) and were constructed to protect the public good. Following two epidemics of cholera across Europe, however, the notion that quarantine or other domestic protectionist policies provided effective defence against microbial forces came into question (Aginam 2003). Consequently, states began to respond to such threats in a diplomatic form. For example, in the nineteenth and twentieth centuries, British colonial administrations justified some of their actions in resettling “native” populations in Africa in relation to sleeping sickness control (Reining 1966; Barnett 1978; Hoppe 2003). In the same period, US actions in Central America and the Caribbean were justified on similar grounds, under the guise of “medical diplomacy”. Although use of isolation and exclusion to protect the public good remains a major element of infectious disease surveillance (e.g., Chinese government’s isolation of British school parties over concern over swine flu), much has changed since those early experiences. In this section, we explore the national traditions guiding the US and UK approach to disease surveillance and how such strategies have evolved or may change in step with the globalization of infectious disease risks and technological advances.

Historical national traditions

As might be predicted, the US approach to disease surveillance and control has been largely decentralized, with apparent resistance to state intervention and an emphasis on state rights and voluntary participation. This was in part related to the extraordinarily high death rates associated with the Civil War (Faust 2008) and the strong individualistic Puritan moral component underpinning much of US public health policy.

Throughout the latter decades of the nineteenth century, while city and state boards of health were established, there were no national entities. This situation began to change with the massive waves of immigration at the end of the century. Concurrently, the American Public Health Association (founded in 1872) grew in influence, as did the spirit of scientific management associated with the Progressive Movement, the leader of which, Henry Welch (founder of the Johns Hopkins Medical School and School of Public Health), argued that health reform made greater economic sense than meeting the cost of illness and premature mortality. Overseas military experience with disease in Cuba and Central America certainly produced pressure for more centralized responses in the southern states. However, it was the influence of Robert Koch and of bacteriology and germ theory that really provided the impetus toward a more centralized and coordinated approach to infectious disease control. As a consequence, the formation of two national bodies, the National Institutes for Health (NIH) in 1930 and the Centers for Disease Control (CDC) (originally named the Communicable Disease Center) in 1946 followed. While the NIH received significant support for rapid growth over the subsequent years, the survival of the CDC as a central institution was not certain during the following ten years. It was not until two major infectious diseases - poliomyelitis and influenza epidemics – appeared in the mid-1950s that the Centers’ future became more definite. In its response to these events, the CDC re-established its credibility and ensured its survival. It has since grown significantly through acquisition and involvement in several public health triumphs (e.g., eradication of smallpox), and assumes the principal role in federal communicable disease control efforts.

However, the existence and activities of the NIH and CDC more fundamentally grew from scientific advances and technical imperatives than from a substantive change in central-local responsibilities for

surveillance. Then and now, protection of the public's health remains within the purview of state and local public health departments. In particular, state officials decide which diseases should be monitored by state and local health departments and reported to relevant authorities, including the CDC. While most state programmes survey infections from the list of "nationally notifiable diseases", states are under no obligation to include such diseases in their surveillance programmes and state reporting to the CDC is voluntary (GAO 1999). While there is limited evidence on rates of state reporting to the CDC, most state officials are motivated to report, as funding and other training/infrastructure benefits provided by the CDC to states are often tied to reporting. Despite these incentives, surveillance activities vary across states, thereby leaving gaps in the surveillance network. Such variations have been attributed to state and local differences in surveillance resources and infrastructure, in terms of both financial, technological, and human capital (GAO 1999). This is also complicated by that fact that surveillance in the US can be characterized as passive, meaning that state officials often rely on providers to report or highlight potential risks, rather than actively seeking out or requiring particular surveillance information.

The US approach to infectious disease surveillance developed within a medical and public health culture that was paternalistic and authoritarian (Fairchild et al. 2007). Early public health advocates, such as Hermann Biggs, a general medical officer of New York City, promulgated that the dire health situations in the US and Europe required a heavy-handed approach (Bayer 2007). Such ideology was supported by the landmark case of *Jacobson versus the Commonwealth of Massachusetts* (1905), which established the right of the state to exercise its 'police powers' to control epidemic disease (Colgrove and Bayer 2005). Despite the existence of opposition to government interference, particularly around imposed quarantines and mandatory case reporting, such authority largely went unchallenged for most of the twentieth century. However, this began to change with developments in American law and culture and the emergence of HIV/AIDS in the mid- to late-1980s, as a diverse range of stakeholder groups pushed for greater protection of privacy and individual rights, particularly over health information (Bayer 2007; Fairchild et al. 2008). Such tensions between the interests of the individual and those of the collective still underlie much of surveillance today, which we discuss further below.

Turning to the other side of the Atlantic, as with so much in British social policy, the origins of the UK approach were influenced by the Elizabethan Poor Law of 1597, where local control of and responsibility for aspects of population welfare were paramount. While the subsequent Poor Law Act of 1834 shifted focus, enshrining the principle of central control, it had little real policy influence until much later as it was roundly resisted by local authorities. In the interim, however, the impetus toward a centralized approach was becoming deeply rooted, as a result of a number of events, including the 1839 investigation of the state of public health under the great reformer Sir Edwin Chadwick and the permissive Public Health Act of 1848. Chadwick was a convinced Benthamite who saw public health as something governed by the principle of utility: "reforms were good only if they increased the sum of human happiness" (Holland and Stewart 1998). However, the most powerful interventionist policies were created at the end of that century, again consequent upon the 'bacteriological revolution' and Koch's work. Key among these policies was conditions for notification by medical practitioners and action by local authorities in relation to certain infectious diseases, such as typhoid, smallpox, and measles. These provisions came into force as early as the 1870s, and did so against the background of a broader development of a public health bureaucracy, as part of the growth of the bureaucratic British state (Porter 1994).

Since the early twentieth century, the UK has firmly pursued a statist tradition. The influence of David Lloyd George's Liberal government, the Fabians, the trade unions movement, and the nascent Labour Party during the early years of the century all coalesced into a substantive shift toward a major role for central government in health care provision. This movement was bolstered by vast popular support from the population at the end of World War II, enabling the Beveridge reforms to be enshrined in

government policy and more importantly in the national consciousness. Since those heady post-war days, the centralized health service has extended to cover infectious disease surveillance in the form of the Public Health Laboratory Service (PHLS), which was created in 1938 (Williams 1986) prior to the establishment of the National Health Service (NHS). Since that time, the PHLS has been reorganised and constituted as a “non-departmental public body”, the Health Protection Agency (HPA), charged with providing “an integrated approach to protecting UK public health through the provision of support and advice to the NHS, local authorities, emergency services, other Arms Length Bodies, the Department of Health and the Devolved Administrations”.

The past twenty years have been characterized by a countervailing pull of regional political devolution in the NHS and calls for “local accountability”, as evidenced by the development of Primary Care Trusts (Greer 2004; Greer 2006). How this will or has impacted upon centralized control of public health and infectious disease surveillance is yet to be explored. For now, one can argue that control of infectious disease risk resides within central government and that protection over public health is perceived to be a state level responsibility. Indeed, the NHS occupies an important symbolic role in the British consciousness, where citizens place great trust and pride in the service to protect public health.

The US and UK traditions in infectious disease surveillance differ by degree of centralization and with respect to the reasons surveillance systems were established and have evolved. For example, domestic protectionist policies directed the initial development of disease surveillance and control in both countries, with US efforts largely decentralized in comparison to the UK, who adopted a statist approach. In the US, despite development of national structures involved in surveillance activities, this was driven more by technical imperatives than by any substantive movement toward centralized authority. Opposition to government intervention and support for individual rights by various population groups and physicians further supported the decentralized nature of disease control. In the UK, centralization of disease surveillance and containment became entrenched both in practice and normatively and this was influenced most significantly by political pressures from influential political leaders and stakeholder groups.

Influence of globalized infectious disease risks – reframing surveillance systems as global public goods and the national response

In both countries, national institutions, and in the case of the US state and local bodies as well, came into existence to collect and disseminate infectious disease information with which to inform public health policy, albeit with different histories. With this backdrop, disease surveillance systems in the US and UK met the definition of a public good, they are: *...[goods] which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtractions from any other individual's consumption of that good...* – to a degree (Samuelson 1954). At the time, surveillance was not being provided for by the private sector and access to its information by planning bodies was non-excludable (even less so with the coming of the Internet) and non-rivalrous in the sense that access to the information by one interested party did not reduce the amount available to others.

However, the impact of globalization on infectious diseases changed the way that the surveillance and, more broadly, governance of such risks were conceptualized and addressed. Due to the emergence of HIV/AIDS, SARS, and avian flu in the mid- to late-1990s and 2000s, many countries, including the US and UK, increasingly deemed emerging zoonotic disease surveillance and response capacities a global concern. Related discourse began to frame infectious disease risks and the policies around their control as not only a matter for the public health community, but as issues for foreign and security policy. In this rise to greater political prominence, the paradigm of surveillance as a public good to be attained within sovereign states underwent transformation. Framing infectious diseases as a global issue shifted emphasis to surveillance as a global public good (GPG).

As defined by the United Nations Development Program (Kaul et al. 2003), GPGs are public goods with benefits or costs that extend across countries, population groups, and generations. Smith et al. (2003) suggest that this definition is problematic. In particular, it does not clearly distinguish between cross-border and within-country externalities; assumes a strong sense of “universality” in terms of affected population groups (i.e., risks affecting predominately women, children, urban dwellers, or the poor would be excluded); and, requires that current and future generations must be affected equally. Because of these limitations, Smith et al. (2007) argue that some risks conceived as GPGs (and thus their surveillance) would be better defined as regional public goods. For example, following this line of argument, the control of malaria would be considered a regional public good, as it is typically restricted to a number of world regions. However, this distinction or categorization is not always clear. In the case of malaria, there are questions as to how far it is a “tropical” disease or a disease of poverty given that until the middle of the last century it was found in southern Italy and earlier in the UK. Conversely, the revealingly named “tropical disease” West Nile Fever is now found in many other parts of the world and is widespread in the US. While not often discussed, the framing of infectious disease surveillance as global, regional (or national) public goods has important implications, which we discuss further below.

As the GPG concept became accepted and promulgated within the UN community, emphasizing the need for collective action, the world saw an unprecedented growth in international collaboration and new global health institutions (Dodgson et al. 2002; Sridhar 2009), including the Global Fund for AIDS, TB, and Malaria, the Gates Foundation, the Global Alliance for Vaccines and Immunisation, among others. McColl (2008) suggests that this mix of efforts equates to more than 40 bilateral donors, 26 UN agencies, 20 global and regional funds, and 90 global health initiatives. Such initiatives have been accompanied by significant resource mobilization. Ruger (2007) estimated that global financial investments in health doubled from US\$6 billion in 2000 to nearly US\$14 billion in 2005. This figure may have reached near US\$20 billion in 2008. Another analysis suggests that more than US\$40 billion have been pledged, committed or spent by nine leading initiatives launched between 1998-2005 (Cohen 2008).

The framing of infectious disease risks and their surveillance as a GPG and movement toward collective governance was conveyed in the national global health strategies of the US and UK and in seminal policy documents. In the late 1990s and early 2000s, several influential reports produced by the Institute of Medicine (1997), National Intelligence Council (2000), and other governmental bodies in the US outlined the national and global health and economic threats posed by infectious diseases and called for greater US leadership (and from all countries) in global health to address these issues. The UK government followed suit, outlining its role in and commitments to the governance of infectious diseases (DFID 2004). The driving forces underpinning the call for enhanced involvement in infectious diseases differed across countries, however. In the US, the policy community’s discussion of the threat of infectious disease and inadequate control related to the potential implications for national security rather than global health and human security. In comparison, the UK government’s position was more heavily guided by a humanitarian and health development agenda, and was closely linked to the Millennium Development Goals (MDGs), most notably in relation to HIV/AIDS.

The following ten years brought new zoonotic diseases (e.g., SARS, avian flu) and critical assessment of the triumphs and failures of both national and global governance arrangements to control infectious disease risks. While considerable resources and attention were now being directed toward infectious diseases, the US and UK (along with other major donors) were criticized for focusing their investments and activities in infectious disease control, and global health more broadly, on specific diseases or through vertical programs, rather than on the complex myriad of health system, economic, social, political, and cultural factors underlying disease risks (England 2007; McCoy 2009). The US government, in particular, was perceived as only supporting activities that aligned with national interests or “American values”. Moreover, there were issues around the coordination, transparency, and

accountability of governance activities (Gostin and Mok 2009). Within both the US and UK, there were various turf battles within the government and between the vast constellation of interested actors (e.g., private sector, civil society), and these power and ideological struggles were extended to collaboration with and between other countries. In the case of SARS and avian flu, the Chinese and Indonesian governments, respectively, delayed or refused to share disease risk information with the rest of the world out of national protection. In the case of the latter, the government claimed “viral sovereignty” over the viruses isolated in its territory until the WHO and leading developed governments ensured it and other developing countries would gain benefits in terms of response capabilities from sharing information for global surveillance purposes (Fidler 2004). As a result, the International Health Regulations were revised in 2005 and 2007, which place requirements on all national governments for communicable disease reporting and national core capacities for surveillance and control. Finally, the emergence and re-emergence of infectious disease risks, particularly pandemic flu, highlighted the gaps and inefficiencies in the public health system in both the US and UK. In the US, for example, this was amplified by 9/11, bioterrorism threats, and Hurricane Katrina, where the concept of and necessity for disease preparedness pushed national and state governments into action to develop stronger surveillance systems. Still, these efforts have largely been highly decentralized with variation between state capacities and a heavy burden of response placed on local communities and individuals (Garrett 2009). Such deficiencies also relate to animal health. Despite some of the issues discussed earlier in terms of human-animal interaction and the impact of zoonotic pathogens, responsibility for disease surveillance and reporting in animals (i.e., livestock, game) has not been placed under the purview of any department in either country (IOM 2009), and there is minimal interaction between human health and agricultural departments.

Some of these lessons appear to be reflected in recent US and UK national global health strategies (IOM 2008a; Department of Health 2008a). However, perhaps unsurprisingly given their different traditions, the new visions for a national response to global health risks converge and diverge between the two countries. Given the global recession and internationally contested Iraq war, the economy, international reputation, and global peace are common threads, although these issues, particularly international credibility, are more central to the US agenda. Here, it focuses on the need to act as a ‘global citizen’ and in the ‘global interest’. In addition, both countries suggest an expanded focus on some of the broader factors influencing infectious disease risk, namely climate change, water sanitation, health system strengthening, and food security. Strengthened inter-governmental and global collaboration is emphasized in both national plans, but with some differences. Considering the centralized nature of the UK response to infectious disease risks, there is greater emphasis in its strategy for central government departments to more effectively ‘join-up’. The US plan, in contrast, reiterates the dispersed responsibilities for disease control (and health) and places greater responsibility on the WHO as a beacon for supplying and coordinating GPGs, including disease surveillance and the International Health Regulations. Further differences emerge in relation to the national values underpinning the strategies. The US strategy outlines “generosity”, “compassion”, “optimism”, and a desire to “share the fruits of US technological advances with others” (IOM 2008: 7), while the UK plan emphasises “liberty”, “security”, and “justice” (Department of Health 2008: 3). These differences are subtle yet important. They reflect and reiterate deeply rooted divergent orientations in their respective public health and health policy traditions. Indeed, the values outlined in the US strategy focus on individual actions and the technological imperative, whereas the UK values are more orientated towards the system and public goods. Both strategies discuss the importance of security. However, in the UK context, one could argue that the term denotes a human security orientation - security from health and economic inequality, fairness of opportunity, and poverty relief. In contrast, in the US strategy, security predominately refers to national security – a defensive stance to protect the population from within national boundaries (Barnett 2005). The fact that there are proposed plans to place a new Interagency Committee on Global Health within the National Security Council endorses this position.

If and how such policy rhetoric will play out in ‘on-the-ground’ national responses to infectious disease risks now and in the future remains to be seen.

A new horizon of surveillance capabilities and challenges for governance

As in other areas of health care, evolving technology has led to a number of breakthroughs and new ways to collect and transmit epidemiological, clinical, demographical, and other information. Examples of new technologies include the use of handheld computers, cell phones, remote sensing, and Internet programs. These sophisticated technologies bring the laboratory into a single technology (e.g., dipstick) and the analysis of raw data into the realm of computer programs. Consequently, they offer new opportunities to detect pathogens prior to the appearance of illness and because of their ease and efficiency, could be used in various levels of surveillance - in hospitals and communities to mass screening locations (e.g., airports), or as part of a broader national and global surveillance system in genomic research, and environmental and biological terrorism monitoring.

Some of these technologies, namely automated web-crawling programs, are already being used in practice in the US and UK. These online surveillance programs scan the Internet in quest for signs and signals from mass media that might indicate outbreaks of infectious diseases well before they percolate to the attention of the formal public health reporting infrastructure. Among these systems are the Global Early Warning and Response System (GLEWS), the Global Disease Alert Map, and the HealthMap. The latter, for example, is a freely accessible, automated, real-time system that monitors, organizes, filters, visualizes, and disseminates online information about emerging diseases (Freifeld et al. 2008). Impressively, the site pulls data from more than 20,000 sources every hour. Similar efforts from Google (e.g., Google Flu Trends) and Yahoo were used during the 2009 swine flu pandemic and their experience demonstrate that proxy data gathered from web sources could provide quite accurate and sound accounts of disease outbreaks (Ginsberg et al. 2009; Polgreen et al. 2008). Used in conjunction with traditional approaches during the swine flu outbreak, these technologies helped overcome reporting delays, inconsistent population coverage, and poor sensitivity to detect emerging cases (Brownstein et al. 2010).

It is possible to foresee that these approaches to disease detection and identification could come into regular use within the next five to ten years. Like many other technological advances, they portend potential advantages and threats to the surveillance of infectious disease, depending on how they are deployed and the cultural narratives of which they become part. Such facilities mean that a substantial range of information about infectious disease events is readily available and accessible to the masses, including in world regions where governments may have very limited resources for disease surveillance. Information technology also has the potential to enable the collection and sharing of information outside of traditional approaches and to increase the effectiveness of early-warning and disease surveillance activities.

However, these types of surveillance technologies also raise some important challenges. In particular, these new approaches potentially serve to decenter information and thus may shift action away from governments and global public good agencies (e.g., WHO) towards individuals or private corporations. This, of course, raises a number of concerns. Individuals may detect and identify their own infections and then decide what to do with that information, while large private corporations, who are not necessarily under public control and have responsibilities to their shareholders or private owners, may or may not act in the public good. For instance, Google’s acceptance of censorship by the Chinese government has demonstrated just how far a corporation that is protective of its image may go in certain political-commercial circumstances. This is also true of individuals, who often have a limited or poor understanding of risk and thus may make potentially detrimental decisions, in terms of protecting the public good. Moreover, differential access to these technologies could introduce significant inequities in surveillance capacities and disease risk information between rich and poor

countries, which could potentially undermine national and global infectious disease control efforts. Accordingly, new technologies raise fundamental questions concerning infectious disease surveillance and whether such systems would still be considered a GPG. Although, disease surveillance would remain a GPG in principal, would it no longer be *provided* as a public good? Do these approaches fundamentally enhance the detection and control of disease, or do they introduce the possibility for stigmatization of population subgroups, human rights abuses, and restricted human movement and freedom? Will individuals' recognise and act upon their wider societal responsibilities to act in the public good and how will or can individual behaviour be regulated?

The answers to these questions perhaps lie at the tenuous intersection between who might lay claim to the information from these technologies, how the information would be subsequently used, and individual and collective rights. As past experiences have highlighted, the state can claim exclusive use, if not ownership, of surveillance data on the basis that it alone has the capacity to use the data for the public good. However, these technologies open up the potential for individuals and corporations to do the same, albeit for the purposes of individual and commercial good. For example, suppose that aggregate health information derived from cell phones, which collect data from individual users, is held by a commercial company, but under what terms is uncertain. The company might choose to sell the aggregate data to other commercial users, to public authorities, or possibly to anybody who wanted to access it such as an academic researcher or individuals involved in a political movement. Who is granted ownership of the information may boil down to who has the loudest voice and the greatest financial and political capital.

In both the US and UK, there are explicit stipulations or rights to conduct surveillance, but almost all of these relate to state engagement, leaving individual or private remit over detection and control highly uncertain. How these issues will be resolved will in part depend upon national public health traditions, structures, and past experiences with infectious diseases. For example, with regards to the surveillance of HIV/AIDS, individual rights have been given priority over public health in both (and many) countries. Moreover, individual or commercial use of these technologies and ownership over their data may particularly resonate in the US context, as individualism and privacy are fundamental values to the "American way" and the sanctity of the doctor-patient relationship over governmental intervention is of great import (Fairchild et al. 2008). Furthermore, use of these technologies may be more widely supported or facilitated in the US, as part of a surveillance system that is already decentralized and underpinned by technical imperatives. However, despite these issues, disease surveillance has held special status in the US and various pieces of privacy-related legislation (e.g., Health Information Portability and Accountability Act) have either not affected state surveillance activities or resulted in public health 'carve outs' giving states the authority to obtain private information for surveillance and investigation purposes. Furthermore, as these technologies offer the potential for rapid and widely-accessible sharing of information, incentives regarding transparent national reporting about infectious disease risks may change. Nevertheless, this must be carefully considered against the potential imposition of harmful trade sanctions and broader adverse economic consequences that can result from earlier, broader, and more open information exchange, as occurred in the case of Mexico following the swine flu outbreak in early 2009. Similar impacts were also felt in the US, as closures of schools resulted in children being dropped off in libraries and parents threatened with dismissal from their jobs if they stayed home to care of their families. Arguably worse than economic concerns is the blame and inflamed sentiments that transpired against immigrants.

Clearly, technological advances offer the potential for improved detection and control of infectious disease risks. However, disease surveillance is a complex process and the possible information and power asymmetries (within and between countries) introduced by these technologies may threaten its provision as a GPG.

Conclusion

Infectious disease surveillance has been a long standing concern for both the US and UK, although their respective histories are marked by different traditions. The acceleration of globalization has significantly affected the risks associated with infectious diseases, demanding new governance approaches. Rather than a national public good, infectious disease surveillance and control, as a part of “health”, has been framed (in some quarters) as a GPG. The US and UK, along with other developed and developing countries, have responded via newly established global health institutions, networks, and increased financial investment. However, this new paradigm or approach has been met with some limited success to date, as tensions remain between national interests and the global good and between sectoral authority and agendas. The history and evolution of the US and UK response to infectious disease surveillance raises an important question: how far can global health institutions or inter-governmental partnerships provide public goods at the global level in the face of national interests to maintain ownership over such goods or to meet other policy objectives outside of health? The new frontier of disease surveillance – the use of novel technologies to detect, identify, and track infectious disease risks – introduces further complexity to this question by adding commercial and individual interests and rights that might be considered against the public good and the very public nature of infectious diseases. Although many of these new technologies have yet to be used in practice in the US and UK, the recent case of swine flu suggests some of the benefits and challenges such approaches may introduce in the future.

It goes without saying that there are no easy or straightforward answers to some of the issues raised herein, but indeed we face a future in which debate on these issues will be increasingly necessary, so as to ensure effective, efficient, and fair national and global infectious disease surveillance in the face of new risks. The US and UK have rich national traditions of infectious disease surveillance that have continued to evolve with the changing nature of zoonotic disease. As major actors in global surveillance efforts, they will undoubtedly assume a key role in shaping the debate.

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