Article

Pandemics of the future: Disease surveillance in real time

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Abstract

This paper explores disease surveillance systems in relation to preparedness, a security paradigm that strives to make future catastrophic events available for “real time” intervention in the present. I examine three different disease surveillance systems—the Global Influenza Surveillance and Response System, which is composed of physical laboratories and online information dissemination tools; Flu Trends, an algorithmic syndromic surveillance system; and EpiSimS and EpiCast, agent-based epidemiological modeling platforms—in relation to three different temporal logics of preparedness—tracking, anticipating, and projecting. These logical modulations all reflect different temporalities of preparedness, or different ways of making the future present, and there are two important implications of my attention to these logics. First, I argue these disease surveillance systems extend surveillance from the present into the future, constructing the very catastrophic threats for which they seek to prepare. Second, I argue the concept of “real time” on which preparedness depends arises from the technologies that construct this particular understanding of temporality. What’s more, the “real time” these systems construct is never the instantaneous erasure of the present; instead, I emphasize real time as multiple, as the proliferation of the present. At stake is an understanding of the ways in which preparedness establishes its own authority to make the future present by creating the very condition of unpreparedness it works to remedy.

Introduction

In 2013, the World Health Organization (WHO) published a document on the 2009 H1N1 influenza pandemic entitled *Evolution of a Pandemic*. This document traces the disease outbreak from April 2009 to August 2010 and documents how the WHO responded to the crisis. The document particularly emphasizes the importance of preparedness plans to mitigating the effects of the pandemic: it claims that investment “in developing national and regional pandemic preparedness plans” by WHO member nations had “paid major dividends” and that these plans “helped make the world better prepared to cope with public health emergencies” (WHO 2013a: 9, 43). Such plans involved the “active surveillance of diseases and public health events” and rapid response to “unexpected, internationally-spreading events” (WHO 2013c). Active surveillance and rapid response are important features of what’s known as global health security, which emphasizes preparing for pandemics before they occur through the adoption of international frameworks for pandemic response. These frameworks, or preparedness plans, allow public health officials to react quickly, in real time, to mitigate the effects of pandemics when they occur (Lakoff 2007).

Global health security can be seen as part of a larger program of preparedness, a security paradigm that emphasizes planning for future catastrophic events in the present. Preparedness, which moved to the center of United States national security policy after September 11, 2001, has also been adopted by international organizations like the WHO in order to secure against potentially catastrophic pandemics. It

is one among several modes of what Ben Anderson has called “anticipatory action”: these modes, which also include precaution and preemption, are all security paradigms that focus on making possible futures available in the present (Anderson 2010; also see Grusin 2010). Preparedness emphasizes institutional readiness and emergency management, treating a variety of potential catastrophic threats—terrorist attacks, hurricanes, pandemics—under the same rubric. Because the probability and severity of such catastrophes cannot be calculated, preparedness focuses not on trying to prevent such events but rather on preparing officials and experts for their eventual emergence. A variety of techniques and technologies make such preparation possible. For global health security, this has involved not only the creation of international preparedness plans, but also of international disease surveillance systems that monitor emerging infectious disease outbreaks. These systems allow public health officials to collect and manage huge amounts of data on disease outbreaks as they occur. Such systems attempt to harness the power of big data to get ahead of the catastrophic pandemic that is coming, not necessarily in order to prevent it from happening (because we can’t), but rather to better deal with its effects (de Goede and Randalls 2009; Lakoff and Collier 2010).

This paper analyzes some of these disease surveillance systems from the perspective of media studies. I focus on three influenza surveillance systems, the disease that has historically received the most attention from the global public health community and which has perhaps the most developed global surveillance systems in place today. FluNet, a data collection and mapping system developed by the World Health Organization’s Global Influenza Surveillance and Response System (GISRS); Flu Trends, a syndromic surveillance system developed by Google.org that uses data from social media to track the spread of influenza; and EpiCast, an epidemiological modeling platform developed by the National Infrastructure Simulation and Analysis Center that models possible epidemics. Official documents emphasize these systems as examples of real-time response, an important concept for global health security. Preparedness exercises define protocols for simultaneous or real-time response so that officials can react quickly to any number of catastrophic threats. The concept of real time on which preparedness depends, however, arises from and is specific to the computational technologies and logics that construct this particular understanding of temporality. As we will see, the real time official preparedness documents emphasize is technologically mediated time. And contrary to the desires expressed in these documents, technologically mediated time does not construct a singular and simultaneous present. Rather, its effect is to create a real time that is always multiple. Through the construction of multiple “present” moments, technologically mediated time proliferates the present.

This proliferation of time has important consequences for how we understand global health security and preparedness in relation to surveillance. Surveillance Studies scholar David Lyon has argued that computational surveillance systems have “contributed directly to the changing character of surveillance,” emphasizing that such technologies give surveillance “a decidedly future orientation” because they are pre-emptive (Lyon 2003: 81, 2007: 56). The disease surveillance systems I detail here, however, do not so much surveil the future as construct the present as catastrophic. They employ forms of algorithmic or calculative surveillance to collect data about possible catastrophic “futures,” but in so doing, they construct these “futures” as the inescapable here and now. The pandemics they surveil, in other words, cannot be prevented because these technologies construct them as if they are already happening (Genosko and Thompson 2006). In what follows, I analyze specific real-time disease surveillance technologies and systems—FluNet, Flu Trends, and EpiCast—to show how these technologies produce the catastrophic threats for which they seek to prepare by proliferating time, creating multiple presents and multiple real times. After a brief discussion of the relationship between computational technologies and global health security, I outline three different temporal logics that structure real time for the disease surveillance systems introduced above: FluNet (via the GISRS) *tracks* the movement of emergent diseases, Flu Trends *anticipates* the future trajectories of disease outbreaks, and EpiCast *projects* future pandemics. These unseen temporal logics construct the outbreaks about which technologies of disease surveillance collect data, preparing us for possible catastrophes. These “future” catastrophes, however, are constructed in the

here and now. In this way, these disease surveillance systems train us to accept “coming” disasters as part of our everyday lives in the present.

Global Health Security

Global health security as we know it today is the result of at least three major conceptual and programmatic developments in public health during and after World War Two. First, it is an outgrowth of the United States’ involvement during and after the war with malaria eradication programs in the United States and overseas (Ghosh 2014).¹ These programs, most notably the Communicable Diseases Center’s (CDC) Malaria Eradication Program, expanded the existing national framework for public health to a global scale. Second, it is the result of a fundamental shift in the definition of surveillance in a public health context that occurred around the same time. Prior to about 1950, the term “surveillance” in a public health context meant monitoring potentially infected individuals for signs of infection. However, CDC epidemiologist Alexander Langmuir changed this when he altered how doctors investigated and reported malaria cases to the CDC’s Malaria Eradication Program. These changes involved “the continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data,” as Langmuir later put it in his influential 1962 Cutter Lecture on Preventative Medicine (Langmuir 1963: 182). These changes drastically reduced the number of confirmed malaria cases and suggested the value of the large-scale surveillance of entire populations. The World Health Organization adopted many of these techniques when it launched its own Global Malaria Eradication Program in 1955, and it officially adopted this understanding of surveillance in 1968 at the 21st World Health Assembly, where the first explicitly global agenda for disease surveillance was formulated (WHO 1968). Third, global health security developed by broadening this understanding of surveillance to include “the regular dissemination of the basic data and interpretations to all who have contributed and to all others who need to know” (Langmuir 1963: 183). In this way, “surveillance” in a public health context came to encompass not just the monitoring of diseases at the level of the population, but also the communication of the data collected to specific experts and officials (French 2009). Public health surveillance became understood as fundamentally about collecting, managing, and communicating large amounts of data.

All three of these changes—the extension of public health activities beyond the nation, the shift from surveillance at the level of the individual to surveillance at the level of the population, and the expansion of surveillance to encompass the communication of data about disease outbreaks—were important to the early development of the WHO’s Global Influenza Surveillance Program following World War Two. This program was the first disease surveillance system, “a worldwide network of laboratories” connected by radio and telegraph and created in 1947 before the WHO Constitution was even in force (Payne 1953: 758). This network of electronic communications made it possible for the program’s Influenza Centers, according to a 1953 document, “to report with all speed the occurrence of influenza within a country” (Payne 1953: 760). Rapid information dissemination was important to this early system, as “the speed with which influenza spreads makes a delay of only a few days in collecting and distributing the information highly important” (Payne 1953: 760). The speed of microbial transmission must be matched—or even exceeded—by the speed of informatic transmission. Many public health documents from the time stress the need for the “timely” dissemination of data.

However, despite this need for speed, the dissemination of epidemiological information was not always smooth or problem-free. As Lorna Weir and Eric Mykhalovskiy have documented, up until the mid-1990s, “WHO’s system of official country notification was beset by problems of delay, incompleteness and

¹ Global health security today remains very focused on the United States and other wealthy countries of the Global North. As Andrew Lakoff has shown, one of the top priorities for global health security is the protection of wealthy countries from diseases that “originate” in poor countries (Lakoff 2007).

occasional concealment on the part of member states due to weak national public health surveillance systems and political consequences of revealing information about local outbreaks,” meaning “outbreaks were often reported months, even years, after an event had occurred or were included as part of annual statistics” (2006: 248-9). Such delays were not unusual in what has now come to be known as WHO’s “passive” system of international public health: the WHO depended on national health officials for information, information these officials were under no obligation to give and which they only received from regional officials who had in turn received it from local officials. The WHO, in other words, was not directly involved in gathering local, regional, or national data (Bashford 2007; Brown et al. 2007; Lakoff 2010).

This began to change with the widespread adoption of personal computers in public health practice in the 1980s. The introduction of personal computers was important not only because they made data collection, analysis and communication increasingly fast, but also because they made it easier to connect different disease surveillance systems to one another. As Stephen Thacker, former director of the CDC’s Office of Science, Epidemiology and Laboratory Services, and his colleagues wrote in 1989, “it is now technically feasible to collect nonduplicative detailed data in a timely fashion by using a single surveillance system based on a microcomputer” (Thacker et al. 1989: 197). The widespread adoption of personal computers as tools of disease surveillance coincides with the WHO’s transition from the passive system of disease surveillance of the Cold War to a more “active” one. This transition is marked by agency-wide developments like the creation of WHO’s Global Outbreak Alert and Response Network in 1997, and by partnerships with national agencies to create systems like Canada’s Global Public Health Intelligence Network. Such surveillance networks were driven by the ever more timely collection and dissemination of data about public health events, bypassing local and even national health officials.

The shift to active global health security around the turn of the 21st century, then, centered on the development of digital disease surveillance systems by both national and international institutions that track the spread of disease throughout the globe and disseminate the data they collect quickly to public health officials. Institutions like the WHO emphasize that the eventual goal for these systems is to be able to track disease outbreaks in real time, providing health care workers and public health officials with continuously updated information on the present movements of a disease. The phrase “real time” itself is important here. The turn to an active paradigm of global health security involved a shift from emphasizing the “timely” dissemination of information about diseases—which the WHO stressed throughout the latter half of the 20th century—to emphasizing the importance of the dissemination of this information in “real time.” This rhetorical shift coincided with the creation of the WHO’s first large, centralized disease surveillance network, the Global Outbreak Alert and Response Network (Weir and Mykhalovskiy 2010). Today, such surveillance systems provide “real-time feedback of patterns of influenza” and use “real time epidemiological evidence” to stop its spread (WHO 2000: 24, 2007b: 7).

This association of real-time surveillance capabilities with computational technologies emphasizes that these technologies are so fast that they make it possible to conduct surveillance of disease outbreaks as they occur, giving officials immediate access to important data. In contrast to surveillance under international public health, which involved the monitoring of diseases at the level of the population and the timely communication of this information to the appropriate officials, surveillance under global health security involves the monitoring of ever-larger “global” populations and the instantaneous dissemination of this information. The great dream for these disease surveillance systems is that they will be able to transmit information so quickly that their surveillance of disease outbreaks will occur simultaneously with these outbreaks themselves, in real time. But this understanding of real time ignores the formal structure and materiality of the technologies that make real time itself—which is always the *mediated effect* of real-time simultaneity—possible. The temporalities these systems construct are never quite so simple as the phrase real time implies. Instead of creating a singular, simultaneous present, these systems proliferate the present moment, constructing many different simultaneous presents.

Tracking: FluNet

FluNet is an information sharing and mapping tool associated with the WHO's Global Influenza Surveillance and Response System (GISRS), its oldest and most extensive disease surveillance network. The GISRS is composed of different kinds of hierarchically organized laboratories, and the main labs are located in Australia, China, Japan, the United Kingdom, and the United States. These centers analyze virus samples collected by ancillary labs around the world to determine whether influenza viruses currently in circulation differ significantly from viruses for which a vaccine already exists. Using this data, the WHO is able to make biannual recommendations for influenza vaccine formulations (WHO 2007a). In this way, the institutional network of the GISRS monitors the evolution of existing influenza viruses and attempts to detect the emergence of new strains, serving "as a global alert mechanism for the emergence of influenza viruses with pandemic potential" (WHO 2013d).

Serving "as a global alert mechanism" for influenza pandemics requires the systematic communication of information about the spread of the virus as well as the number and type of virus samples gathered and vaccines created. To this end, the WHO makes the information its labs gather and collate publicly available using FluNet, a web-based platform for sharing the virological data the GISRS labs collect. FluNet brings together data on the influenza virus, its movement through particular populations, and the kinds of resources—including health care facilities and transportation and information-infrastructures—available to these populations. Data entry is restricted to officials associated with official WHO laboratories but certain data is available to all public users in the form of charts, graphs, and maps. Users can search FluNet's interactive database to find and download the latest influenza surveillance information, including the number of specimens collected and the number of particular influenza subtypes identified in particular regions of the world over particular periods of time. This data can be used to generate maps and charts with customizable layers and filters and can also be exported to Excel for further analysis. FluNet, in other words, makes the data the GISRS collects visible for human users. The data it provides, the website assures us, "is real-time," meaning it is the latest, newest, most up-to-date data (WHO 2013b). And it looks the part. The maps FluNet allows users to create are seamless: they emphasize the easy, smooth transmission of microbes, goods, and people across various borders and through various scales, smoothing over local disconnection, friction, and delays to create easy-to-digest maps of infection. The presentation of data in FluNet, in other words, emphasizes in visual form the seamless speed with which real-time data travels through the GISRS.

But the phrase "real time" implies more than speed; it also implies speed that is so speedy it is simultaneous. In its disease surveillance documents, the WHO defines real time as a continual, ever-present unfolding. Real time implies the speed of the instantaneous present: tracking an epidemic in real time means watching it live, as it unfolds, now, as if no processes of mediation separate you from it. Real time is so fast that there is no delay between the event itself and the information officials receive about the event.² The WHO's eventual goal for surveillance systems associated with the GISRS, in fact, is to perfect them to such a degree that they elide their own processes of mediation, so that mediation itself is erased in the pursuit of real time tracking. As Wendy Hui Kyong Chun writes, "What is real is what unfolds in real time" (Chun 2011a: 96); real time elides its own mediation and points to an elsewhere, to the "real world"

² This association of real time with simultaneity also occurs in scholarship on disease surveillance networks. As Eugene Thacker writes in his account of the disease surveillance networks that tracked the 2003 SARS outbreak, for example, disease surveillance is "a real-time battle between networks: one, a biological network operating through infection, but abetted by the modern technologies of transportation; the other, an information network operating through communication, and facilitated by the rapid exchange of medical data between institutions" (Thacker 2005). In Thacker's account, the activity of surveillance slips into and is indistinct from the movements of information and microbes themselves. Thacker, like the WHO, emphasizes the speed of biological and informatic exchange as evidence of "a real-time battle" between networks of control and emergence that is itself constitutive of the activity of disease surveillance.

and events as they unfold there. It is a measure of authenticity: influenza is *really* spreading, we are *really* trying to control it, this is all *really happening*, right in front of you, right now. The injunction within preparedness, and especially within global health security, to develop capabilities for real-time response is an expression of this desire to compress time and eliminate mediation itself in the name of transparent simultaneity. This is what FluNet's maps represent: the real-time display of data onto the totalizing perceptual field of the GIS system or map eliminates any sense of this mediation in the name of "naturalizing" data and making it easy to understand visually.

But it is, of course, mediation itself that actually constructs real time as simultaneous. To understand this, we need to think not about maps but instead about packets; not about the visual presentation of data but instead about how this data travels through networks. Real time is transparently real, the thinking goes, because of its speed. Information traveling at the speed of light arrives instantaneously, as if it, or you, were already there. However, as Adrian Mackenzie—via Derrida—makes clear, to understand speed as instantaneous, as that which is without delay, is to misunderstand the relationship between speed and delay:

It is no paradox to say that speed actually is coupled to delay, to whatever remains incompletely synchronized in a given context. Delay is a consequence of the relativity of speeds.... To be located entirely in the present, or to have access to complete instantaneity, if it were possible, would be to feel neither delay nor speed.

(Mackenzie 2002: 123).

Mackenzie argues that such "an absolute notion of speed as instantaneity and absence of delay" disregards not only the phenomenological or affective dimensions of delay, but also, and more importantly for our purposes, the discontinuous temporal scale of real time itself (Mackenzie 2002: 120). The "instantaneous" transmission of packets of information through disease surveillance networks like the GISRS is only experienced as such because of the differences between the speed of transmission and the delay of reception. Such a differential, in real-time systems, is known as lag, which connotes not only delay but also communication latency, or the time it takes for a packet of data to be sent through a communication channel and received at the other end. This also includes the time it takes to encode, transmit, and decode the data. In this way, lag is itself the process of slowness or delay—or, mediation—in real-time systems.

What's more, it is only through this lag—through processes of encoding, transmission, and decoding—that we experience real time as such. Despite the rapid speed of information transmission throughout the GISRS, this information lags inevitably behind the movements of the disease it is tracking. The speed of information transmission is never fast enough. Yet, the topology of a disease outbreak, or the rapid pace of viral transmission, can only be known to disease surveillance systems through the information that circulates about and behind it, which is visualized using a platform like FluNet. This lag is in fact constitutive of the speed with which we as users can map the spread of the disease. While some scholars have focused on real-time tracking as anticipatory—which I discuss next—my point here is that real-time tracking is also about lagging behind. In fact, lag constructs real time as such, as mediated time. The near-instantaneous speeds of infection/transmission pulse through disease surveillance systems as relations of difference, as lag or latency experienced as real-time movement (i.e., packet switching). The unfolding of these networks of transmission and infection in time—their ontogenesis—never happens entirely in *the* present, despite what we see on the screen when we use a feature like FluNet (Thacker and Galloway 2007). In fact, what disease surveillance systems and the diseases they track evidence is not one present, but many. Not a continual unfolding or the smooth, frictionless flow of infection and information, but rather surges of acceleration and deceleration, of speed and lag. The real-time tracking of infectious diseases and information through interconnected networks doesn't occur in some unitary, always unfolding now constituted by instantaneous speed: that's just how it looks on the screen. Rather, it happens in discontinuous bursts that are then, because of how FluNet is visually designed, presented as

simultaneous. Real time concerns not an imagined, simultaneous and singular present, but rather the proliferation of presents, as each movement through these networks, each burst or period of lag, produces yet another real time, yet another now. Technologies of preparedness like the GISRS, then, produce many different present moments—many different simultaneous instants—in the name of preparing for possible future pandemics.

Anticipating: Flu Trends

The early detection and real-time tracking of potential pandemics is only one goal of global health security systems, however. The WHO's Global Influenza Surveillance and Response System is also interested in anticipating future pandemics. Such a goal is “the Holy Grail of public health,” as prominent infectious disease expert Nathan Wolfe puts it, and while it has been important to the GISRS since its beginning, it is today within reach of current syndromic surveillance systems (Wolfe 2011: 16). These systems focus on “identifying unanticipated clusters of data” that suggest early signs of an outbreak: such data may include work and school absenteeism; sales of over-the-counter medication and particular groceries like orange juice and facial tissues; and calls and visits to doctors, primary care facilities, and emergency rooms (Weir and Mykhalovskiy 2006: 254). One recent example of such a system is Google's Flu Trends, developed in 2009 by Google.org, which uses aggregated Google search data to track incidences of influenza infection across the United States. These statistics mirror those collected by the CDC. In fact, Flu Trends is often able to provide accurate data on influenza trends before the CDC, since search data is available immediately and the uptake of this data is fully automated.³ In this way, syndromic surveillance systems, driven by “the demand for ‘timeliness’... *push detection* [of diseases] *prior to diagnosis*” (Weir and Mykhalovskiy 2006: 254). Using automatically harvested data, these systems attempt to anticipate where a disease outbreak will travel by identifying early indicators of infection. This “unanticipated” data allows syndromic surveillance systems to survey large populations of people “indirectly” to increase the speed of detection.

Syndromic surveillance tools like Flu Trends strive to track the spread of a disease in real time by moving ahead of the flow of infection, anticipating where the next outbreak will occur by analyzing specific data points that precede its arrival. Such anticipation allows Flu Trends to “beat” the lag inherent in these systems discussed above and to approach real time “itself.” Real-time tracking, then, is only possible through anticipating the disease's future trajectory. It is not about observing something as it “really” happens; it's about anticipating where something will happen next so that it can be observed as it happens (Crandall 2010). It means, in effect, making the soon-to-be future available for intervention in the present not just by proliferating this present—like WHO's FluNet—but also by extending this present into the near future, by making the future literally present and vice versa. Additionally, real-time tracking means reaching back into the past. Flu Trends is only able to track diseases in real time, of course, because it uses past data to extrapolate the possible future movements of that which it tracks. To create the system, for example, the Google.org team aggregated historical logs of search queries from 2003 to 2008, generating weekly counts for 50 million of the most common search queries during that time in nine different regions of the United States. The team then used these logs to generate an automated method of selecting influenza-related search queries in each region, which they tested against CDC data for that region from that time period. The Flu Trends system used past data to produce 45 different search queries that correlate strongly with influenza and which can be used to anticipate an outbreak of the disease in a particular region (Ginsberg et al. 2009). Flu Trends programs the future movements of the disease through such extrapolations, paving the way for the eventual arrival of the pandemic, which is certain to come, as

³ Although this is not always the case, and recent “controversy” about the accuracy of Flu Trends data has worked, in some senses, to expose this kind of naturalization. For example, in mid-January of 2013, Google Flu Trends calculated that 11 per cent of the population of the US had influenza, while official CDC data put that number at around only 6 per cent. As *The New York Times* reported, Google's algorithms can be thrown off by “false positives” generated by widespread media coverage—including on social media sites—of influenza (Bilton 2013; Butler 2013).

it has in the past (Chun 2011b). The future is anticipated and surveilled using past data.

Real-time surveillance in relation to Flu Trends, then, concerns collecting data on possible future phenomena and events, on things that haven't yet happened but that we can anticipate algorithmically using past data. Such calculative operations position these anticipated events as empirical observations. They are empirical not only because they use historical data, but also because the data Flu Trends collects on possible future disease outbreaks is itself empirical—meaning observationally-derived—data. It's just that humans aren't doing the observing. Instead, Flu Trend's algorithms "observe" the outbreak event before it happens. In fact, there is no operative difference here between possible future events and real present events. For Flu Trends, the probable or possible is (usually) always just about to become the real. After all, the data Flu Trends collects sometimes almost exactly matches the data collected by the CDC using disease surveillance methods involving data collected by people, even though Flu Trend's data is collected by the Flu Trends program before the "actual" disease outbreak it tracks. The calculations Flu Trends makes, by the time we catch up to them, produce the sensation of real time. We seem to be able to follow the disease outbreak as it occurs by allowing Flu Trends to anticipate where it will go next. Of course, what we are following is not the "real" disease outbreak; it is Flu Trend's calculation of it. We should not mistake speed for simultaneity. Yet, the data Flu Trends collects is as real, empirically speaking, as the CDC's data, and the real time of Flu Trends is as real as any other time. This does not mean, however, that it exactly mirrors real time as it "really" happens for us. Once again, as with the GISRS, real time proliferates. It involves not *the* one-and-only simultaneous, instantaneous present but rather the calculation of *a* present time that brings past data into relation with possible futures. The goal is for this present to mirror what we observe to be "actually" happening, but there will always be a gap between Flu Trend's calculation of the near future and its unfolding. In this way, Flu Trends produces not *the* future, but *a possible* future that will necessarily be distinct from the "actual" future as it happens. Again, real time is not the obliteration of mediation, but rather is evidence of the effects of mediation. Its calculations create multiple real times, multiple present moments, multiple mediated times.

Projecting: EpiCast

In addition to tracking and anticipating disease outbreaks, governmental agencies and institutions are also increasingly turning to projecting them using epidemiological modeling to simulate disease outbreaks among certain populations. In 2008, the National Infrastructure and Simulation Analysis Center (NISAC) publicly released a report entitled *National Population, Economic, and Infrastructure Impacts of Pandemic Influenza with Strategic Recommendations*, publishing the results of their two-year study on the potential impacts of pandemic influenza on the United States. To assess the impact of a pandemic on the U.S. population, scientists at NISAC, which was incorporated into the Department of Homeland Security in 2003, simulated the spread of the disease on national and global scales using the epidemiological modeling platform EpiCast. EpiCast utilizes person-to-person transmission dynamics and population and transportation data to model the spread of disease across national and global scales. The program calculates the transmission of influenza between individuals probabilistically, based on the contact times between two agents, the respective ages of the agents involved, and whether or not the agents are infectious or susceptible to disease. Infected agents can pass through fourteen possible disease states, remaining in each of these states for varying amounts of time, moving to various locations and infecting other agents with whom they come in contact within the appropriate time, and either dying and removing themselves from the population or recovering and becoming immune (Mniszewski et al. 2008; Dombroski et al. 2008).⁴ EpiCast models the daily movements and interactions of synthetic individuals within a nation and creates social networks representing these interactions, which it maps over a specific space in order to deliver models of the demographic and geographic distributions of a particular disease.

⁴ Mniszewski's article is actually about EpiSimS, another program used by NISAC with a very similar design that models the spread of disease on much smaller, local scales.

In this way, EpiCast can model how a disease like influenza might spread nationally or even globally. EpiCast suggests how to control the topology of futures-to-come, guiding policies about how to intervene in disease outbreaks. Some of the information NISAC's study produced about successful methods of intervention in the event of a pandemic, in fact, was utilized to control the spread of the 2009 H1N1 pandemic (NISAC 2007; LANL 2011). Like Flu Trends, EpiCast relies on historical data—in this case, data describing the known behavior of H5N1 influenza (transmission rates, infectivity period, susceptibility rates) as well as demographic data—to provide the parameters of its simulated outbreaks. In other words, this historical data provides the conditions from which certain phenomena emerge, phenomena that cannot be programmed in advance. It is not accurate, then, to think of the models EpiCast produces as representations of possible disease outbreaks. In fact, EpiCast actually produces these possible future outbreaks by simulating them, allowing for “unanticipated” phenomena to occur. What's more, EpiCast also “collects” the data on how disease spreads that is produced through the simulated interactions of its agents, data that can be used the next time a pandemic occurs. This data, although not collected about “actual” disease outbreaks, is nevertheless understood to be empirical, or observationally-derived. As historian of science Paul N. Edwards writes of climate models, “the idea that climate models are fantasies untethered from atmospheric reality [is] utterly, completely wrong. *Everything we know about the world's climate—past, present, and future—we know through models*” (Edwards 2010: xiv). This is the important point: although epidemiological modeling operates quite differently, computationally speaking, than climate modeling, models are important for both fields as tools of knowledge production.

Such an understanding of empiricism—of the idea that “observable” or sensory knowledge is produced through the simulation of the events about which data is being collected—is important for understanding EpiCast as a technology of disease surveillance. EpiCast produces the empirical data it also “observes” and “collects.” Just like the WHO's GISRS, it surveils actual, empirical data on the spread of diseases across certain populations. But unlike the GISRS, it produces the data on future pandemics that it also monitors. One way to understand its temporal logic, then, is that it produces the futures it also seeks to surveil (Bogard 1996).

However, this understanding of EpiCast's temporality gets more complicated if we consider the abstract material form of this modeling platform. At the time NISAC's study was published, EpiCast required large, high performance computers able to perform trillions and even quadrillions of calculations per second in order to model disease outbreaks at national and global scales. Many such machines exist, and one example at Los Alamos National Laboratory (LANL), which developed EpiCast during the time of NISAC's two-year study, was Roadrunner. Roadrunner was a supercomputer used for both classified and unclassified projects that was recently retired in April of 2013 (Feldman 2013). It was a massively parallel system, which means that individual processors or groups of interconnected processors were only responsible for a fraction of the entire computation involved in a simulation and that many calculations could be performed simultaneously. Roadrunner is important for our purposes here not because it was a computer often involved in epidemiological modeling or because it was the fastest computer at LANL, but rather because Roadrunner represents a number of firsts in the high-performance computing (HPC) world. In 2008, for example, it became the first HPC system to attain a sustained petaflop/second, a milestone in high-performance computing.⁵ Roadrunner was also the first hybrid supercomputer, meaning it used both central processing units and graphics-processing units for computation (graphics-processing units are generally better than central processing units at performing many small calculations simultaneously). This hybrid design allowed Roadrunner to compute at fast speeds while consuming less energy (Pakin, Lang

⁵ Roadrunner had a peak calculating capability of 1.45 petaflops, or 1.45 quadrillion floating-point calculations, per second. Flops, or floating-point calculations, refer to how the computer handles numbers. It divides a word—or number of bits, fixed at the computer's hardware level—into two parts, the mantissa and the exponent (for example, 1,245,000 is expressed as 1.245×10^6 and 0.00016475 is expressed as 1.6475×10^{-4}), allowing for a more efficient format than standard notation, where the decimal point is “fixed” (Mackenzie 2002: 166-8; Edwards 2010: 175-6).

and Kerbyson 2009). Systems like Roadrunner, because they can make quadrillions of calculations per second, can run highly complex simulations—can use millions of processor hours—in relatively short periods of human wall-clock time (wall-clock time refers to elapsed time, on a human scale, as measured by a chronometer like a wristwatch or a clock on the wall, while processor time refers to the time a processor is working on a task). Indeed, the speed of calculation is important to the accuracy of any simulation, as shorter wall-clock times mean the simulation can incorporate ever more complex variables because formerly time-consuming calculations take up less time and computational resources. As the first hybrid supercomputer, Roadrunner is often positioned in industry literature as marking a turning point in HPC architecture because its hybrid design allowed for faster computations that used less power (Feldmen 2009; *HPCWire* 2012). I have chosen to highlight Roadrunner here as one example among many of these massively parallel systems, then, because of the importance of its hybrid design to its overall speed.

Although they are speedy, high performance systems that can make quadrillions of calculations instantaneously—in real time—are anything but simultaneous. Like real time tracking in disease surveillance systems, which is composed of multiple temporalities, real time in high performance computing is also multiple. This proliferation of time happens a bit differently for systems like Roadrunner, however. For Roadrunner, techniques of parallel programming that move information within the system from processor to processor in particular ways proliferate time. For example, in EpiCast, many different calculations can be carried out at once because these calculations are organized according to simulated location, with each processor involved in the simulation taking care of the computations for a subset of possible locations. Each processor's event-handler maintains a time-ordered event queue, and arrival events (the arrival of an agent) in a particular location spawn departure events (the departure of an agent from that location), which in turn spawn arrival events, all while the processor simultaneously handles the transmission of disease between agents. These events, in turn, affect the future behavior of the agents involved in the simulation because some of this behavior changes according to circumstance. Agents move between locations assigned to different processors via asynchronous messaging, meaning a processor assigned to one location can move an agent to another location on another processor without waiting for the receiving processor to finish its current calculations (Stroud et al. 2007; Mniszewski et al. 2008). Parallel programming, then, increases the speed of the application—it takes fewer wall-clock hours—because many different calculations concerning many different agents occur at the same time—it allows millions of processor hours to happen simultaneously. Or, more accurately, these many different calculations create many *different* “simultaneous” times, because each processor creates its own timescale as it completes its calculations. The parallel design of systems like Roadrunner, in other words, constructs multiple “real times” or “nows” of calculation.

Real-time surveillance for a program like EpiCast, then, involves the interaction of many different, seemingly incompatible temporal scales: calculations done in quadrillionths of a second constitute simulations that run for millions of processor hours; two or three simulated years are modeled overnight. The instantaneous “now” of computation—the quadrillionth of a second that it takes to perform a calculation—grows long, stretching into hours and days of human time as programs complete their computations. What's more, even the fastest supercomputers are never fully synchronous because some processors always finish their tasks before others. In fact, as leading computer architect Peter Kogge reminds us:

Realistic applications running on today's supercomputers typically use only 5 to 10 percent of the machine's peak processing power at any given moment. Most of the other processor cores are just treading water.... It has proved impossible for programmers to keep a larger fraction of the processors working on calculations that are directly relevant to the application.

(Kogge 2011: 53)

No matter how many processors there are—no matter how quickly a particular system can compute—time lags. Real time is never quite speedy enough in supercomputing systems. Rather, the real time of computation is composed of many layered times, all moving at different speeds. Here, again, real time is the proliferation, not the annihilation, of time. Time does not “pass” for these systems; it accumulates. Different layers and scales of present time exist within the same space as data travels through the system “instantaneously.” This proliferation of the present encompasses any possible future, producing instead a “future” pandemic that looks remarkably like our present(s) (because it is).

This process also captures the past as well, bringing it under the purview of the instantaneous present. For example, the layering of time I have described is not exactly a metaphor; in fact, it relates to how the processors that systems like Roadrunner use are designed. How data moves to and through computation, or how a machine accesses its memory, is an increasingly important issue for high performance computing. Machines with hybrid architectures, like Roadrunner, are important for improving the speed and efficiency of HPC systems not only because they incorporate graphics processing units, but also because hybrid architectures address the problem of memory access. Today’s traditionally architected supercomputers, although faster than ever, are actually taking longer and longer to access their memory. According to Kogge, “every thousandfold increase in flops has brought with it a tenfold decrease in the memory accessible to each processor in each clock cycle” (Anderson 2011: 13). The speed of computation, then, depends not only on graphics processing units and parallel processing, but also on how these processors are constructed. One potential graphics processor design from Nvidia, for example, involves directly attaching dynamic RAM chips to processors in order to bring computation to the data instead of dragging copies of the data all around the system to the processors (Kogge 2011; *TechEYE.net* 2012). This would literally layer memory on top of computational process, suturing past (data) to present (computation) and future (results). The design of the machines on which EpiCast runs actually works to dissolve distinctions between the past, present, and future, treating them all as *the (already occurring) present*.

Real-time surveillance for EpiCast doesn’t just involve bringing possible futures into the present. It also involves, at the same time, expanding the present ever outward to encompass both the past and the future. An examination of the structure of the massively parallel systems on which models like EpiCast run, in fact, shows us how this happens through parallel programming and processor design. For EpiCast, the future and the past are quite literally made present through the formal and material structures of a system like Roadrunner. Like FluNet and Flu Trends, EpiCast makes “real-time” calculation possible because it constructs it, insisting on its simultaneous relationship to the present even as it constructs this present through its own processes of mediation. Real time, therefore, is only possible because of these processes of mediation itself. Real time is always mediated time.

Conclusion: Expect the Unexpected, Again

The proliferation of time these systems make possible changes how surveillance works for global health security. These systems never simply represent or collect data about the present; instead, they construct multiple present times (which also engulf the past and the future). Nor do these technologies, as Lyon suggests, necessarily orient surveillance away from the present and toward the future. Rather, the systems I have documented here conduct surveillance by creating different present moments. They lag behind or jump ahead or capture both the past and the future. These odd temporal maneuverings are constructed for and by us as “real time surveillance,” but they are also about the production of other, “alternative” present moments *as* surveillance of the (one-and-only) “actual” present. For the system of passive international health out of which today’s active global health security grew, surveillance in a public health context meant collecting and disseminating information about the incidences of disease across an entire population. For global health security and for the computational technologies of disease surveillance on which it depends, however, surveillance means something different: it means constructing the possible

future phenomena these systems surveil in and as the present. It means, for FluNet, creating a vision of “real-time” data and information exchange through its interface, smoothing over or erasing the lag and proliferation of time that constitutes all communications networks. For Flu Trends, it means anticipating future disease trajectories and producing entirely new “real times” from these calculations. For EpiCast, it means producing the data it also collects, creating multiple present or “real times” from possible futures and past data. These disease surveillance systems construct many different possible future global disease outbreaks, but these outbreaks are then positioned as if they were occurring now, in the simultaneous present.

This is the temporal logic of preparedness itself. In harnessing big data about future pandemics, these technologies actually produce these pandemics in the present. To stay ahead of the catastrophe that is coming, we must build it, proliferating the present moment in the attempt to capture, and thereby forestall, a future that is always just about to arrive. Yet this capture is always incomplete. The production of these futures must be repeated to cover different possible scenarios and updated as new information or technologies become available. The futures produced by EpiCast, for example, change as the model parameters change, or as new data is introduced, or as the platform is ported to new, ever faster machines. What’s more, the futures that emerge from these productions, by definition, will never “actually” come to pass. They are simulations, models, projections, even fictions.

Such perpetual preparation for future catastrophes that will never arrive affects not only how we envision the future, but also how we understand our present moment. Although these technologies may seem to focus on the future, their continual construction of soon-to-arrive pandemics normalizes catastrophe. They build “future” catastrophes all around us, teaching us to accept them and, by extension, the measures we all must take to prepare for them, as given. They train us to expect catastrophe as part of our everyday lives, managing our sense of possibility for the present. The disease surveillance technologies I have described here teach us, in other words, that the coming catastrophes they envision are in some sense already here, that there is nothing we can do to stop them, that change is impossible.

If we want to imagine other possibilities for our present and future, perhaps turning back on the odd temporalities constructed by the technologies of disease surveillance I have discussed here is a start. Although all of these technologies are valued for their potential to make real-time disease surveillance possible, they also all unsettle this very notion. They disrupt the idea, so important to global health security in particular and to preparedness overall, that the transmission of information can ever be simultaneous with the event such information describes. These technologies produce other kinds of time—not simultaneous “real time,” but rather discontinuous, proliferating present moments. Perhaps we should consider the possibilities opened by understanding these alternative present moments as such. Perhaps we can see them as indicative of something other than the soon-to-arrive future. Perhaps we can then construct other possibilities for our present.

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