



AP PHOTO/ANAT GIVON

Safety Net

The web is increasingly being used to exchange information about the latest outbreaks and even intervene in public health emergencies.

By Madeline Drexler

Catherine Strommen, an elementary school teacher in Fremont, California, padded to the kitchen computer and took one last look at her favorite chat room,

Teachers.Net. It was midnight, February 9, 2003. At that late hour, two or three stray chatters were scrolling down the screen—likely Asians or Australians, who usually logged on

when Americans were turning in.

One of the posts came from China—someone who called himself “Ben” (most adopted Anglo names). But his tone was distinctly different from the usual exchanges about pedagogy, food, and literature. In tenuous English, he described an illness that started like a cold, but killed its victims in days. A friend who worked in a hospital had died, as had the friend’s mother. In Guangdong Province, where Ben resided, hospital doors were locked.

Alarmed, Strommen emailed an old neighbor and friend, Stephen Cunnion, M.D., a retired Navy physician and epidemiologist who now lived in Maryland. A practical, no-nonsense man, Cunnion started searching the web. With no success, he tried a new tack—sending an email to ProMED-mail, a global electronic reporting system for outbreaks of emerging infections and toxins. After quoting Strommen’s missive, he asked: “Does anyone know anything about this problem?”

The tiny ProMED staff conducted its own web search. It, too, came up empty-handed. On February 10, it sent out to tens of thousands of subscribers a posting headed: “PNEUMONIA – CHINA (GUANGDONG): RFI,” or Request for Information.

Thus did the world first learn of SARS, the new and deadly infection that would kill 774 people and infect 8,000 in 27 countries. The next day, the World Health Organization issued a belated bulletin on the raging epidemic.

Welcome to modern disease surveillance. When a serendipitous exchange on a teacher’s chat room morphs into a global outbreak alert, public health practice will never be the same. Until a few years ago, we had to wait for bureaucrats to announce disease emergencies within their borders. Today, abetted by the Internet, outbreak news is highly contagious. Web crawlers, automated translation, GIS mapping, ISP tracking, and cell phone imagery have created a world where, for good or ill, rumors of outbreaks outpace confirmation.

And it’s not just fast-moving infections that are flushed out by high technology. Social epidemics, such as the next new fad in drug abuse, are also being monitored through canny—and perfectly legal—eavesdropping on public electronic forums. The Internet has even been used to intervene in public health emergencies—by emailing, for example, online daters exposed to sexually transmitted diseases.

If Hippocrates were alive today, he’d probably write a treatise on the Internet. But even in his time, he had a plugged-in perspective. In the classic *On Airs, Waters, and Places*, he described in vivid detail how disease was influenced by the seasons, winds, water, geography, and what today we would call “lifestyle.” Armed with those facts, aspiring healers, he wrote, “must proceed to investigate everything else.” In 2008, that’s just what’s happening online. The father of medicine would probably need three laptops to keep up with it all.

ProMED-mail, a program with the International Society for Infectious Diseases, is the iconic example of how the Internet is advancing public health. Launched in 1994, it arrived at a moment when CompuServe and AOL were fueling personal email, and when scientists were becoming aware of the intensifying emergence of new infectious diseases,

The Internet’s most salutary effect on public health is that governments can no longer hide outbreaks—though, as SARS proved, they can try.

such as Ebola hemorrhagic fever. It was also a time when government health officials still tightly guarded information on disease outbreaks. According to Larry Madoff, M.D., ProMED’s current editor, the thinking among its founders was: “Wouldn’t it be great if people who had access to the Internet in far-flung places, and were seeing something unusual, could send an email to this list? We wouldn’t have to wait for a public health laboratory to notify the Under Minister of Public Health, who would notify the Minister, who would notify the World Health Organization. We would all know at once.”

ProMED’s virtues are those of the Internet itself: It is fast, nimble, egalitarian, bottom-up, open, and transparent. These are also the hallmarks of an effective public health campaign: delivering the facts swiftly to those who need to know. China’s SARS epidemic actually surfaced in November 2002—three months before the fateful ProMED posting. If a ProMED subscriber in Guangdong had written directly to the listserv in, say, mid-December—by which time the epidemic had spread to three cities—

At the Telford Gardens shopping and apartment complex in Hong Kong, people wear protective masks Friday in this picture taken on April 11, 2003, about two months after the world was first alerted to severe acute respiratory syndrome, or SARS. SARS has killed 774 people and infected 8,000 in 27 countries.



CATHERINE STROMMEN

Early adopter: Catherine Strommen, an elementary school teacher in Fremont, California, was likely one of the first to sound the alarm about SARS when someone in her favorite chat room, Teachers.Net, warned about an illness that started like a cold, but killed its victims in days back in February 2003. She emailed a friend who sent word to a global electronic reporting system for outbreaks, which eventually alerted the world to the deadly illness.

who knows? Perhaps the scourge would never have vaulted beyond the country's borders.

Despite the explosion of web innovation, ProMED remains conspicuously low-tech and hands-on. Individuals feed outbreak information into the system through email, while ProMED's small staff gleans material from its own searches of media and official reports. The seven or eight daily postings, available through email or on the website, are thoughtfully moderated and commented upon by a panel of experts—a unique step that adds meaning and context to otherwise unmediated facts or assertions. Each posting is limited to 25 KB bandwidth—to ensure that it slips through an old-fashioned dial-up modem in the most remote areas of the world (where new infectious threats tend to smolder). “We use technology that was state-of-the-art in 1994. We use email—plain-text email at that. We don't use fancy fonts,” Madoff says. “The

power of the Internet is its ubiquity and speed; it's not necessarily in all the neat things you can do.”

More technologically awesome is GPHIN—the Global Public Health Intelligence Network, part of the Public Health Agency of Canada. GPHIN is a secure Internet-based early warning system that gathers preliminary reports of public health significance in nine languages, round the clock. Launched as a prototype in 1998, it relies on news aggregators to scour 20,000 media sources—from wires to websites to blogs. Every 15 minutes, its software pulls articles and assigns them a relevancy score based on keywords and syntax. Non-English articles are machine translated. Expert analysts further parse the material, which ranges from infectious diseases to natural disasters to product safety.

Each week, GPHIN sends hundreds of reports to its main client: the World Health Organization, as well as to government officials, NGOs, and other subscribers, who pay tens or hundreds of thousands of dollars annually. Unlike ProMED—which operates on a shoestring, is free of charge, and is open to the public—GPHIN is government-affiliated, pricey, and restricted to organizations with an established public health mandate: the loaded Lexus compared to the stripped-down Corolla.

Both services face the challenge of “noise.” Flooded by disease news—some vitally important, most not—what to publish? GPHIN actually snagged and sent out early Chinese-language news items about what later became SARS. In November 2002, it posted a report that an unusual number of people were showing up in an emergency room in Guangdong, appearing to suffer from atypical pneumonia. In January 2003, GPHIN's computers found an English-language financial report from a pharmaceutical company, describing a spike in sales for its antiviral drugs, which the firm conjectured was due to an unusual outbreak in the Chinese province.

At the time, these reports didn't stand out; only after SARS was front-page news did investigators comb the record and discover these unheeded warnings. In the massive daily GPHIN trawl, stories about respiratory symptoms during flu season in a country of 1 billion people were understandably overlooked.

Which is to say that the power of the Internet to amass ever-larger haystacks of information makes it more and more difficult to find the needles. According to Associate Editor Mar-

jorie Pollack, M.D., ProMED's lead moderator during the SARS outbreak, "Do you post every individual unknown case of everything? What's your threshold? What will your system tolerate? Is a single undiagnosed case of something unusual of global importance?"

Sometimes, it is. A strongly suspected case of smallpox would demand instant attention—because it would have to have been terrorist-sown. So would pneumonic plague, which is spread person-to-person through the air, outside areas where it is naturally endemic in wild rodents.

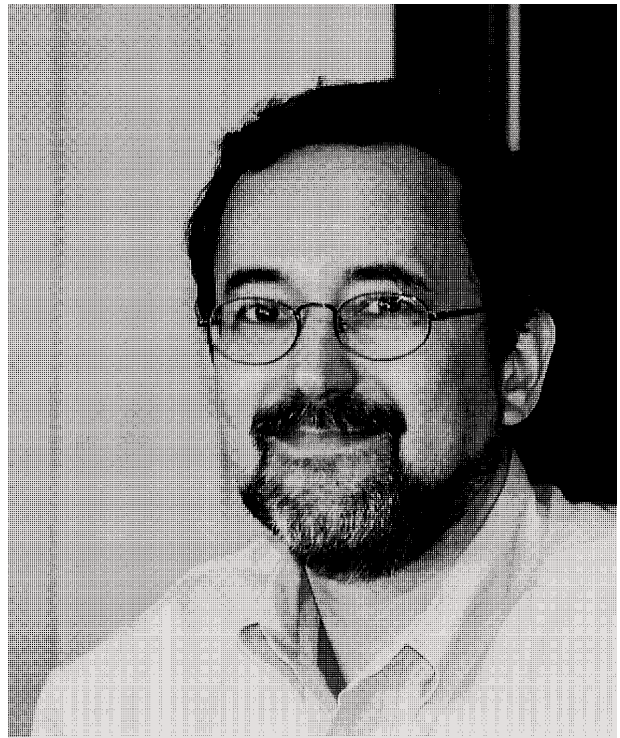
Yet a mass of data culled from news aggregators is riddled with false positives and false negatives. "We deal with a spectrum of electronic information. It's a constant tradeoff between sensitivity and specificity," says John Brownstein, Ph.D., an assistant professor of pediatrics at Harvard University Medical School.

Brownstein has fashioned a different form of electronic surveillance: real-time disease mapping. With computer scientist Clark Freifeld, he is scraping news aggregators such as Google News, as well as ProMED, WHO reports, and other sources, using software that matches a glossary of infectious disease terms with words related to geography. He then superimposes his results against a background of gorgeous Google satellite maps.

Brownstein's HealthMap is the first real-time disease alert that conveys facts graphically rather than verbally—a comprehensive and dynamic portrait of the world's well-being. Viewers can scan cities, countries, or continents for hourly updated reports. Teardrop-shaped "heat" markers indicate the level of urgency: red for, say, ongoing outbreaks of Ebola in Uganda or human "bird flu" cases in Egypt, yellow for older reports of food recalls, and the like. Viewers can click on news updates, and cut the data according to news feed, disease, country, or timeliness.

Brownstein's quest to deep-mine the Internet sprang from the realization that just about everything a disease cartographer needs is already on the web. "We use tools that are freely available and data sets that are open to the public," he says.

Who clicks on HealthMap? Not only web surfers, but also governments and public health officials. In a world where pathogens need no passports, bureaucrats often don't know what's fulminating just across the border—and could soon jump into their own backyard. Brownstein's next ambition is to track increases in



LARRY MADOFF

We can locate outbreaks within countries and provinces, but we can't locate them within a farm or village. In a blue sky future, I can envision being able to know where individual cases are.

Larry Madoff, M.D., Editor, ProMED

keyword searches by geographic region. With algorithms linking Google Trends—which displays the top cities, regions, and languages in which users type in a given search term—to Google Maps, he hopes to lexically locate nascent emergencies. Such an approach may have uncovered, for instance, a surge in searches for "pneumonia" and "flu" in Guangdong in late 2002.

The Internet's most salutary effect on public health is that governments can no longer hide outbreaks—though, as SARS proved, they can try. Ever since the WHO passed its revised International Health Regulations in 2005—an agreement to contain emergencies at the source, not only at national borders—the agency has relied more and more on "informal sector reports" from media and websites, and less on official candor. Before these new regulations, the WHO itself used to publish a weekly

Disease news traffic cop: Larry Madoff is editor of ProMED, which launched in 1994 and posts updates on disease outbreaks that are then commented upon by a panel of experts.

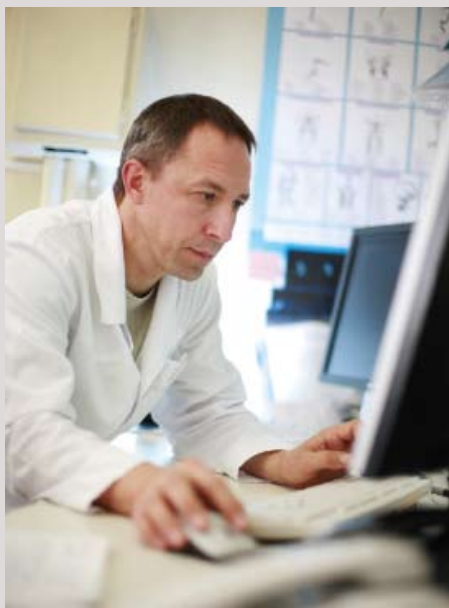
The 21st Century Messenger

Email is making it easier for health officials to collect vital disease information and warn patients about STD risk. But it also poses problems.

“Dear <<screenname>>,”

My name is John Doe, and I am from the Washington DC Department of Health, STD Control Program. I’m emailing you because someone you met online was recently diagnosed with a laboratory-confirmed sexually transmitted disease (STD).”

—Sample email, from “Guidelines for Internet-based Partner Notification,” National Coalition of STD Directors, October 2007



Public health experts are using the Internet not only to track epidemics, but also to find people newly exposed to sexually transmitted diseases. Contact notification for STDs is a cornerstone of public health practice. A patient diagnosed with an infection is asked the names of any individuals he or she may have gotten it from or given it to (though the patient isn't legally compelled to say). Health officials then contact the people on the list—while never disclosing the identity of the source—in hopes of persuading them to be tested and treated before the infection spreads further.

The Internet not only promotes potentially risky sex (because strangers can negotiate in advance the forms of their intimacy), it can also

help public health investigators do their job. As a 2000 study in the *Journal of the American Medical Association*, titled “Tracking a Syphilis Outbreak Through Cyberspace,” stated: “the Internet is a technology that may facilitate transmission of syphilis but may also provide targeted awareness and enhance control of STDs.”

In 2002 and 2003, faced with a syphilis outbreak afflicting hundreds of gay men, the Los Angeles County Department of Health Services used the Internet to try to stem the epidemic. One index patient reported 134 sex partners, all of whom he had met on the Internet during a six-month period. He supplied health officials with 111 email addresses. Of those contacted, about a quarter responded.

In emailing people who may have an STD (or any other disease), officials tread a fine line between enlightened government intervention and Big Brother intrusion. Where does public health end and the right to privacy begin? What if notification emails are read by the wrong person, breaching confidentiality? What if the emails are hacked—or blocked as spam? On the other hand, are health authorities abdicating their responsibility if they know who has been exposed and fail to act?

In a recent online survey of gay men who frequent a popular dating website, researchers at Boston's Fenway Institute found that 81 percent said it would be important to them to receive a partner notification email if they had been exposed to a sexually transmitted infection. Seventy percent said that, if infected, they would use a public health specialist to inform partners of possible exposure through the Internet. “It makes sense that if they met a partner online, they'd also want to find out the same way that the partner may have exposed them to something they should get care for,” says Kenneth Mayer, M.D., professor of medicine and community health at the Brown University School of Medicine, and a collaborator on the study.

Email notifications aren't just for STDs. A 2004 Finnish study described a community where nearly half of the households had free Internet access through a common provider. When a norovirus—the highly contagious bug that has triggered wretched outbreaks on cruise ships—swept through the area, health officials conducted an online survey through the Internet provider. Users logging onto the network filled out a questionnaire. The results confirmed officials' sinking suspicion: the nasty virus had spread through tap water.

—M.D.

Images and text from cell phones—far more available than computers—could also tip off the world to disease. In a crisis, digitized pictures of strange rashes, suspect parasite eggs, or even shuttered hospitals may carry more weight than words.

Outbreak Verification List, known in the trade as the Wednesday “rumor list,” a tally of unconfirmed disease reports from all over the world that only a select group was permitted to read. Now the Internet generates its own rumor lists—24/7, for anyone to peruse.

A GPHIN or ProMED posting is a wedge for the WHO to convince reticent nations to come clean with the truth—or for outside authorities to investigate. As GPHIN chief Abba Mawudeku puts it, “WHO can knock on a country’s door and say, ‘We have some information about an event occurring in your backyard. It’s from the media. Could you help verify this?’”

or even shuttered hospitals may carry more weight than words. Telemedicine images—from body probes, x-rays, or monitors—could also be instantly dispatched and analyzed by experts. Together, these add up to a multidimensional portrait of a moving epidemic—showing, in real time, how an epidemic is playing out on the ground and in the body.

Speech recognition technology could translate local health dispatches in remote places. “NGOs or grassroots organizations on the ground usually communicate by AM radio to the community about any type of health concern,” says Mawudeku. “If there was a



As communications technology gains definition, so will disease surveillance. “We can locate outbreaks within countries and provinces, but we can’t locate them within a farm or village,” says Madoff. “In a blue sky future, I can envision being able to know where individual cases are.”

Images and text from cell phones—far more available than computers—could also tip off the world to disease. In a crisis, digitized pictures of strange rashes, suspect parasite eggs,

way to tap into that information and transmit it electronically—from voice to text—that would help us gather more information from the local levels.”

The ultimate vision is a network of networks—all the ProMEDs and GPHINs and HealthMaps of the world electronically synchronized. “There’s no reason why there shouldn’t be one global system that integrates all this information and this technology into early detection—all languages, all sources,

Mapping disease:
HealthMap is
the first real-time
disease alert that
conveys facts
about outbreaks
geographically.

What the Doctor Ordered: Eavesdropping

Public health consultants are monitoring online chatter for clues to the next drug epidemics.

Q: “Hi Everyone. I’m new to this forum and wanted to know if anyone has had experience with both Hydromorphone (tablets) and Oxycodone. If so, please share your opinion regarding the differences—both positive and negative—between them.”

— Urban Radio, age 31

A: “I prefer Roxicontin to Oxycontin (personally for recreational usage) because it’s immediate release like a Percocet but without the liver damaging Tylenol. You can also chew or crush an OC to sorta eliminate the time release properties of the pill.”

— G0dm4ch1n3, age 22

Hip Forums hosts “more than 400 individual Free Speech forums,” as its home page boasts. Such sites are a gold mine not only for gregarious devotees of mind-alteration, but also for those who surreptitiously monitor the site’s repartee to predict the next trend in drug abuse.

One such listening post is Newton, Massachusetts-based Inflexxion. Specializing in research, education, and product development in substance abuse and other areas, the company deploys some of today’s most sophisticated technology to listen in on electronic small talk. As Senior Vice President Stephen F. Butler, Ph.D., explains, “For any kind of antisocial activity, the Internet is ideal. It’s fast, it’s easy, it’s cheap, it’s anonymous, it’s unsupervised, it’s unregulated.”

And it’s therefore perfect for tracking the next community epidemic. Inflexxion’s approach was a response to the 1999-2000 spike in prescription opioid abuse, including such popular medications as OxyContin and Vicodin. Companies marketed the drugs as time-release formulations—ostensibly, less likely to be abused. But users and addicts soon discovered that chewing, dissolving, or injecting the pills unleashed all of the psychoactive potential at once. To satisfy new government regulations, pharmaceutical firms needed a systematic and timely way to find out what drugs were being abused, where, and how.

One way is to simply quiz users who end up in emergency rooms, treatment centers, or jails. But those are stilted interactions. “The Internet provides an avenue for tapping into unadulterated



AP PHOTO/TOBY TALBOT

conversations,” Butler says. “We’re eavesdropping on conversations between people who are not in trouble at the moment. They do not see themselves as having a problem. And they are in many cases quite proud of what they do.”

Inflexxion monitors dozens of such sites. Each day, two staffers read about 500 posts apiece, noting not only the substance of substance abuse, but also its ever-changing lingo—which forms the basis for new search terms. Supported by a grant from the National Institute on Drug Abuse, Inflexxion’s natural language processing also analyzes the between-the-lines tenor of Internet posts. Unfortunately, the more unstructured the text—drug forum texts are ecstatically loose-jointed—the more difficult to decipher.

“What we’re looking for is the level of chatter,” says Butler, sounding more like a government terrorism scout than a behavioral scientist. Inflexxion also embraces writer Malcolm Gladwell’s model of social epidemics spread by “mavens,” “opinion leaders,” and “early adopters”—the very type of sophisticated enthusiasts who both post and “lurk” on drug forums. In the 1970s, chemical recipes to freebase cocaine spread by word of mouth. Today, chemical recipes to defeat the “abuse-resistant” prescription opiates currently being developed would instantly radiate across the web. Inflexxion’s goal: to mount an early warning system that ensures that public health officials and drug companies are not the last to get the message.

—M.D.

everything, round the clock,” says Brownstein. Such a network could adopt the wiki model: gathering information, but letting anyone curate. “You combine open-source technology, freely available information, and the willingness of people to donate some of their time,” he adds, “and it doesn’t have to cost an arm and a leg.”

Admittedly, such a system would need safeguards to ensure accuracy. Wikipedia itself operates under guidelines that call for citing sources of information and for maintaining a neutral point of view, among other things. One idea for guaranteeing rigor in an open network of disease tracking is a reputation-based arrangement, in which the validity of a surveillance report is based on the reputation of the contributor, reflecting the number of valid reports he or she has contributed—similar to the system by which eBay rates its PowerSellers, based on sales volume, positive feedback, and marketplace policy compliance.

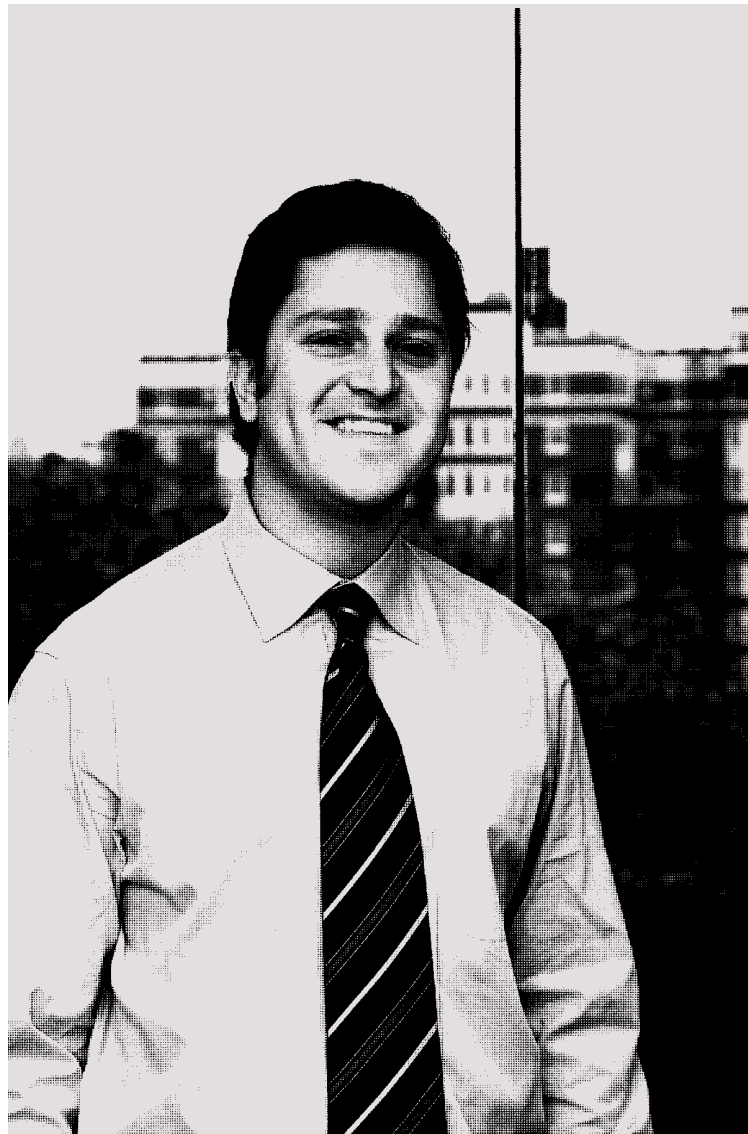
But even if a web of webs were politically and financially feasible, would it catch everything out there? In a hyper-connected world, could a new disease still elude detection?

Very possibly—if the affliction were insidious, took a long time to develop, and didn’t kill quickly. In other words, if the disease was something like AIDS—which hid in plain sight for decades in the mid-20th century.

If AIDS emerged in today’s communications-rich era, would we realize it sooner? Not necessarily. The digital divide still leaves Africa comparatively uncovered. (ProMED’s subscription list, for example, has no Nigerian ISPs.) “We would hear news reports if there was some disease eating away at Rwandans and western Ugandans, which caused weight loss and gradual deterioration. But where do you put that down with the burden of malaria and everything else?” asks Jack Woodall, Ph.D., one of ProMED’s founders. “I’m not sure what kinds of bells would ring.”

In other words, extending the reach of the web to every square meter of the earth’s surface means nothing unless the right person in the right place—someone who is curious, who senses that things are awry, who is connected both socially and virtually (a doctor or nurse, perhaps, but then again, maybe a schoolteacher)—cares enough to dash off a few words and press “Send.”

When Catherine Strommen looks back on her unwitting role in alerting the world



CHILDREN’S HOSPITAL BOSTON

to SARS, she marvels at the sheer improbability of it all. “It’s very chaos theory or butterfly effect to me,” she says.

And she regrets that she couldn’t tangibly help the stranger named Ben, who never returned to the Teachers.Net site. Strommen is a people person, but the disease-tracking power of the Internet comes from thickly impersonal networks. “I was never able to tell him anything,” she still laments, five years later. “I didn’t get to complete the circuit.” **TOOLS**

Madeline Drexler is a Boston-based science journalist, and author of Secret Agents: The Menace of Emerging Infections.

John Brownstein, an assistant professor of pediatrics at Harvard University Medical School, created HealthMap with computer scientist Clark Freifeld. Says Brownstein: “There’s no reason why there shouldn’t be one global system that integrates all this information and this technology into early detection—all languages, all sources, everything, round the clock.”