Employing mass collaboration information technologies to protect human lives and to reduce mass destruction of animals

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Summary
'A war against disease requires not only financial resources, sufficient technology, and political commitment, but also a strategy, operational lines of responsibility, and the capacity to learn along the way', according to J.D. Sachs. In our interdependent world, it is increasingly apparent that health is a global public good that requires collaboration across borders and generates transnational benefits. The same holds true for the information and knowledge necessary to uphold and defend it. It is only through collaboration that we can confront the complexity presented by host interactions and movement, genetic variability and environmental factors, ranging from chemical contamination to climate change. The Internet is an unprecedented tool for communication and collaboration which we need to use to best advantage for our purposes, be it to create value by combining data from various sources, harness mass reporting modalities, such as really simple syndication (RSS) feeds and blogs for surveillance and monitoring, participate in online ideas markets to spur research, use wikis to develop and share educational resources, or assemble virtual teams of experts as required. These are the skills for the 21st century which will facilitate disease prevention, early detection and rapid response to help protect human lives and livelihoods and to reduce the mass destruction of animals.

Keywords
Animal disposal, Collaboration, Disease prevention, Information technology, Public health.

L'utilizzo di tecnologie di massa per l'informazione e la collaborazione al fine di proteggere le vite umane e di ridurre la distruzione in massa degli animali

Riassunto
"La guerra contro la malattia richiede non solo risorse finanziarie, tecnologia sufficiente, ed impegno politico, ma anche strategie, linee opertive di responsabilità, e la capacità di apprendere lungo il percorso", in accordo con J.D. Sachs. Nel nostro mondo interdipendente, è sempre più evidente come la salute sia un bene pubblico la cui tutela richiede una collaborazione che superi i confini territoriali e come la stessa generi benefici che vanno al di là dei confini nazionali. Lo stesso concetto risulta vero anche per le informazioni e la conoscenza necessarie per mantenere e difendere la salute stessa. Ed è solamente attraverso la collaborazione che noi possiamo confrontare la complessità delle interazioni ed il movimento dell'ospite, la varibilità genetica ed i fattori ambientali che vanno dalla contaminazione chimica ed il cambiamento climatico. Internet è uno strumento per la comunicazione e la collaborazione senza precedenti

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che abbiamo necessità di usare ottenendo il migliore vantaggio possibile per i nostri propositi, permettendo di creare valore aggiunto integrando dati da diverse fonti, di codificare le modalità di report, come l'alimentazione in tempo reale via web di agenzie di stampa e blogs utilizzati per la sorveglianza ed il monitoraggio; di partecipare online a scambi di idee in grado di stimolare sviluppi di linee di ricerca; di utilizzare siti web interattivi in grado di promuovere lo sviluppo e la condivisione di risorse di carattere educativo o di assemblee virtuali di team di esperti, così come richiesto nella formazione di network di colloborazione internazionali. Queste sono le capacità che nel 21esimo secolo saranno in grado di facilitare la prevenzione della malattie, il riconoscimento precoce e la risposta rapida, al fine di proteggere le vite umane e il loro sostentamento e ridurre, al tempo stesso, la distruzione di massa degli animali.

Parole chiave
Collaborazione, Distruzione degli animali, Prevenzione della malattia, Salute pubblica, Tecnologia dell'informazione.

Rapid response to emergencies

Three synchronised bombs exploded in the underground rail system of London, England, at 8:50 am on 7 July 2005 (4). Eighteen minutes later, before the final explosion on a bus, the first entry was made in the editable online encyclopedia, Wikipedia. 'By the end of the day, over twenty-five hundred users had created a comprehensive fourteen-page account of the event that was much more detailed than the information provided by any single news outlet' (29).

A mere seven weeks later, while the world was still reeling from the London bombings, Hurricane Katrina hit the gulf coast of the United States, causing massive destruction and flooding that killed over 1 500 people (11) and displaced almost a million others (22). Families were torn apart and evacuees were scattered across the country. Desperate to find their loved ones, people began posting notices in online forums on the web. Many online services were set up to locate missing persons and critical data was hopelessly scattered among hundreds of different sites in various formats, much of it buried in simple narrative pleas for information.

Katrina hit on Monday, 29 August 2005. On the Friday of that week, some tech-savvy volunteers sought to create order out of the chaos. They deployed an automated process to scour the various websites for essential data and created a standardised format so all entries could be collated into a central database. Word of the PeopleFinder effort spread 'like wildfire across the blogosphere' (33). There were limitations to what could be captured automatically, so some high-profile bloggers called for volunteers to help sift through missing persons posts manually and code them for entry. Thousands responded. Others set up a wiki (a website that anyone can edit) to organise who was doing what. Four days after the onset, 50 000 entries had been processed, later reaching 650 000. Eventually over one million searches were conducted; people looking for friends and relatives could enter a name, zip code or address to find matching entries.

The responses to these two disasters demonstrated 'that thousands of dispersed volunteers can create fast, fluid and innovative projects that outperform those of the largest and best-financed enterprises' (29). Although these extraordinary examples of collaboration appeared to arise spontaneously, they were predicated on the open source movement in the software industry (whereby programmers share and build upon each other's code) with which the instigators were well versed. They simply applied their skills, using these powerful tools and practices, to a new situation.

Ideally, emergencies are anticipated and prevented whenever possible, proactive steps are taken to minimise damage and loss when prevention is not possible and emergency preparedness plans have been formulated for such events. It seems to be human nature, however folly, to ignore preparation for events of low probability, even when the consequences are known to be high. Financial constraints are also important, particularly in developing countries or disadvantaged neighbourhoods, which tend to be the most vulnerable.

Emergencies will still occur, whether they result from a natural, man-made or intentional disaster and whether the affected are rich or poor. For disasters of many kinds, time saves lives. In the case of infectious disease outbreaks, early detection and rapid response are critical to contain disease spread and limit the extent of losses. Lessons must be learned from past experience to ensure improved response in the future.

Time after time, coordination of communication and logistics are major limiting factors in the effectiveness of response. The Internet has provided unprecedented opportunities in terms of global communication. It is time to take full advantage of this potential. A few innovative examples have been set by people familiar with collaborative tools and practices who are not experts in emergency response, but who acted to fill an unmet need in a practical manner. Combining collaborative skills with scientific situational expertise will lead to a new arsenal of capacity in terms of emergency response. As described below, this combination applies equally well to prevention and detection and can also be used to make experts available 'virtually' when and where they are needed.

Early detection

Detection often arises from an astute observer noticing something untoward and reporting it to the appropriate authorities. With regard to disease, it is usually a secondary effect that is detected, such as a clinical sign, rather than the disease agent itself. For diseases of grave concern, surveillance and monitoring schemes may be in place (depending on available resources), as well as a legal obligation to report occurrence. An outbreak is considered to occur when there is a greater level of disease than would normally be expected. Thus, a single case can constitute an outbreak if it is a disease that is not normally present.

Early detection is the key to mounting an effective response, containing spread and minimising resultant damage and loss. Traditionally, disease reporting was initiated with a report to local authorities who would then channel it to regional or national governments. Other factors, such as concerns about lost trade or tourism, would at times weigh on reporting decisions. National governments have the responsibility to provide official reports to the relevant international organisations, such as the World Health Organization (WHO) or the World Organisation for Animal Health (OIE: Office International des Épizooties). Reports from other sources (e.g. laboratory testing, customs inspections) are verified with the national government prior to release. These reporting systems that were put in place in the early 20th century simply do not suffice today; they are far too slow in a world that is circumnavigated by people and goods in a matter of hours.

One of the first attempts to use mass communication technology to improve detection of infectious disease outbreaks was ProMED-mail. It was exceptional in that it captured reports from a wide range of constituents and because it was the first to combine human, animal and plant health. ProMED was established as a mailing list in 1994 with the support of the Federation of American Scientists and SatelLife (13). It is a moderated list (anyone can make a submission, but contributions are subject to expert review before being posted). In addition to official reports, sources of information include media reports and personal observations.

ProMED is primarily of interest to public health professionals and biomedical scientists, but anyone can subscribe to receive email postings, which are now also publicly available on the web. Since 1999, ProMED has operated as an official programme of the International Society for Infectious Diseases. It reaches over 30 000 subscribers in 150 countries. In addition to the English version of ProMED, there are also Spanish and Portuguese versions.

Another example of an internet-based early warning system is the Global Public Health

Intelligence Network (GPHIN). This network was initiated as a joint project between the public health authorities of Canada and the WHO to automatically scan international news feeds in English and French, such as Reuters, the Associated Press and Agence France Presse, for information about disease outbreaks. Software development began in 1997 and GPHIN went live in 1999 (45). A second version, introduced in 2002, expanded language capacity to include Arabic, Chinese, Farsi, Russian and Spanish. In addition to scanning news feeds, GPHIN II has been extended to search health and science websites for preliminary reports of public health significance, including information on human and animal disease outbreaks, contaminated food and water, bioterrorism, chemical or radiological exposure and natural disasters, as well as the safety of products, drugs and medical devices (24).

Like other examples, such as PeopleFinder (Hurricane Katrina) and ProMED-mail, GPHIN consists of a combination of automated and manual components. Thousands of reports are processed each day. They are automatically scanned and filtered for relevance, 'gisted' into English by machine translation and then checked by humans. Public health experts in Canada relay the resulting information to the WHO headquarters in Geneva, as well as to regional WHO offices. This is verified by WHO country offices that contact host governments. GPHIN is credited with early detection of the newly emerging respiratory disease, severe acute respiratory syndrome (SARS), is currently being used to track avian flu and has led to changes in the way countries report disease outbreaks. These changes are reflected in modifications made to the International Health Regulations in 2005 which come into force in June 2007, making it legally binding to report public health emergencies of international concern (45).

Further development of GPHIN is partially funded by subscriptions which range from US$250 000 for governments to US$30 000 for universities and non-governmental organisations (41). Although this is beyond the reach of most individuals, there are other options available enabling receipt of specified information at no cost, such as subscribing to really simple syndication (RSS) feeds or Google News Alerts. RSS is a convenient way to keep up-to-date on digital sources of information that change frequently, such as news websites or blogs (a weblog or 'blog' is the publishing site of an individual with entries made in the style of a journal or diary).

Google News Alerts channel the power of Google's search capabilities to operate in an automated manner. Rather than conducting the same search at regular intervals to check for updates, terms of interest are entered just once and Google will send an alert by email whenever there is a new article that includes those terms. In addition, the nature of resources to search can be identified (news, blogs, web, groups, etc.), as can the search intervals (immediate, daily or weekly).

There are also various options in terms of multilingual capability. Terms of interest in other languages can be searched on the web (there are various websites that provide free samples of machine translation services). These foreign terms can be added to the search, then, like GPHIN, machine translation can be used to obtain the gist of the resulting articles received. Video news clips from around the world are available at nuvu.tv (19). They play in their original language to ensure integrity of content, but include English subtitles (20).

Another mode for the delivery of personalised information which could be used to track disease events will soon be available. Researchers at Northwestern University have created a completely automated news service called 'News at Seven' (18). Web resources are scanned for relevant content (news from RSS feeds, opinions from blogs, photos and videos from online collections such as Flikr and YouTube) which is processed, then presented by an avatar (a digital representation of a person). The starting point is a set of preferences for what the report should cover (27). While customised options are not yet available, a daily sample can be viewed at NewsAtSeven.com (17).

The next iteration of GPHIN could be a search engine (8). The philanthropic arm of Google is led by a medical doctor/epidemiologist who has proposed expanding GPHIN to dozens of languages, extending its search capabilities to include RSS feeds, blogs and the like, and to making it freely available.

Companies like Google have learned to exploit the synergies between their products and outside innovators. For example, chicagocrime.com combines crime statistics with Google maps so that an address can be entered to obtain a mapped display of the latest crimes in the area or, by specifying a crime, a map will be given, showing where those crimes occurred recently (34, 38). The visual display of disease data from the field and a statistical analysis for clusters will eventually become commonplace.

Spatial and temporal analyses provide additional dimensions to the investigation of disease outbreaks and spread. There have been parallel advances in the physical display and exploration of spatiotemporal data, such as a 'touch table' that displays maps that can be controlled by hand movements. One can zoom in from a global view to street-level detail, change perspective to a three-dimensional image or compare current and previous data for the same location. Another example is a terrain table with a rubberised top that can physically simulate heights and contours (40).

In spite of the new technologies that are becoming available, early detection of disease is an elusive goal, particularly in light of the rapidity of our global mobility. In truth, diseases will never be detected early enough unless their occurrence can be preceded. Preventing outbreaks from occurring is the ultimate aim.

Prevention

Prevention is the first line of defence, be it on an individual or population level. Since every outbreak begins with an initial or index case, in some respects the challenge is one and the same. If prevention fails, the next best action is to try to detect disease early in its course and respond rapidly. To achieve this, knowledge on how to prevent a disease or intentional misdeed must be obtainable, the means to detect it early must be available and expertise on how to treat it must be accessible.

In regard to prevention, the more that is known about a disease, the better equipped we are to deal with it. If the causal agent has been identified, such as the virus or bacterium, a vaccine may be developed to prevent or even totally eradicate the disease, as was the case with smallpox (46). However, the availability of a vaccine alone is not sufficient; there must also be a strategy for effective deployment and coordination among all affected nations or there will be a risk of disease being reintroduced at a later date. As illustrated by foot and mouth disease outbreaks, for example, vigorous efforts in one country can be thwarted by lapses of control in a neighbouring country, by a trading partner or by a traveller transporting food treats.

Although knowledge of the causal agent is an important factor in disease prevention, it is not always necessary, as John Snow famously demonstrated in 1854 when he stopped a cholera epidemic by removing the handle of the Broad Street pump (44). In so doing, he also demonstrated that cholera was transmitted through the water supply. Mad cow disease provides a more recent example of a disease of uncertain origin that was dealt with by interrupting the means of transmission. In spite of the remaining uncertainty about the nature of the causal agent, measures were implemented to drastically reduce the incidence of disease in both cattle and humans. It did, however, entail the mass destruction of animals and resulted in loss of human livelihoods and lives.

Avian influenza is the epitome of an emerging disease that has caused mass destruction of birds and threatens a massive loss of human lives and livelihoods. It vividly demonstrates our global interdependency and the need for multidisciplinary, as well as international collaboration to mount an adequate response. A diverse combination of experts is needed to identify and resolve the complex relationships among migratory birds, the waterfowl reservoir, backyard flocks, commercial poultry, humans and other potential hosts or carriers, as well as the intricacies of viral mutations. It is necessary to decipher the patterns of movement and contact among the different entitites and to understand the production systems and marketing chains, all within very different cultural contexts and in a variety of languages. Evidence is clouded by the contentious politics and economics that accompany a high-stakes industry and a high-risk disease.

The notion of health as a global public good is now accepted more widely. Diseases do not recognise borders and efforts to contain them are best expended at the source.This frequently means working with developing countries where much of the population does not have access to clean water or safe food, and people and animals mingle under circumstances that are less than ideal for themselves, but are perfect for harbouring or concealing disease.

Unfortunately, knowledge sharing has not been effective to date with those at greatest risk, most of whom do not speak English and are not literate. Furthermore, diseases of the poor (HIV/AIDS, malaria, tuberculosis, Rift Valley fever, trypanosomiasis, screwworm, ticks and tick-borne diseases, etc.) receive the most attention when they threaten those with the most resources.

In the avian influenza example, much controversy remains in regard to the roles of backyard flocks versus commercial poultry operations in relation to the relative risks for exposure to and propagation of the virus (9). The poor, whether they work in the poultry industry or tend their own backyard flocks, are most vulnerable. A study in Vietnam found that the highest risk factors for transmission of avian influenza to humans were handling dead or diseased poultry, having dead or diseased poultry in the household and not having running water in the household, which increased the likelihood of contracting disease by a factor of 31, 7 and 5, respectively (6). On some occasions, simple preventive measures have been overlooked and the root causes never confronted.

Options for prevention depend on knowledge of the causal agent(s), means of transmission and predisposing factors or conditions. Infectious diseases transmitted by food or water can often be eliminated by processing or treatment. Vector-borne diseases can be prevented by disarming, evading or eliminating the vector. Judicious use of antimicrobials will reduce the development of resistance. Quarantine is employed to avoid the mixing of sick and susceptible populations. Then, of course, there is the blunt instrument of mass destruction.

Current disease prevention methods really amount to managing disease that is already present rather than preventing the occurrence of disease. Historically, progress has been made from treatment, to early detection, to prevention. The least headway has been made on prevention, but a change of focus is being seen in relation to the maintenance of health.

While it is not necessary to have perfect information to be able to act, the more knowledge available, the more refined the approach. Mass collaboration is an important force throughout the cycle of information generation and its application for health, namely:

- to spur research and speed the development of new tools for prevention
- to open participation in the development and dissemination of educational resources, international standards and best practices, and
- to bring diverse expertise to act on problems in the field as required.

These aspects, as illustrated in Figure 1, will be developed further in the next section.

Complexity requires collaboration from start to finish

Many of the current new disease challenges result from changing global circumstances. Expanding human populations are impinging on wildlife habitats. Mass migration from rural to urban areas is accompanied by an increasing demand for education, greater wealth and demand for animal protein. With intensified

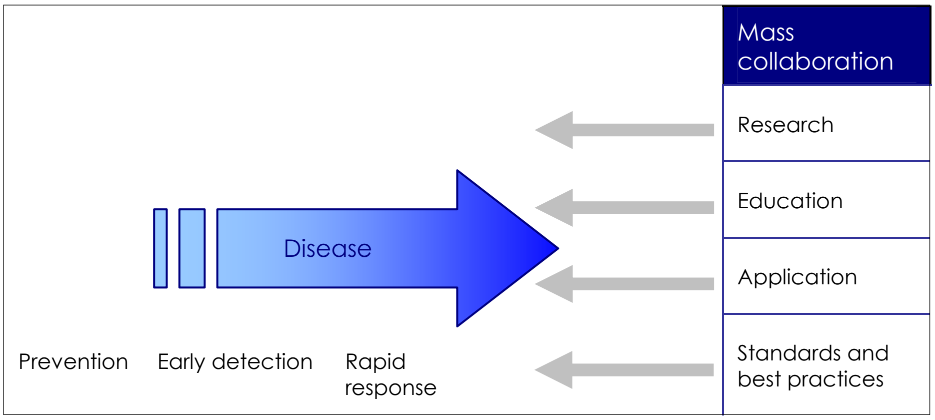

Figure 1
Mass collaboration at all stages to halt disease progression

food production systems and the majority of people increasingly removed from the place of production and preparation of food, greater concerns have arisen about food safety, conditions of origin and treatment of animals and people involved in the process (2). The potential for disease transmission increases with greater mobility of people, animals and food.

In the 20th century, significant progress was made in identifying causal agents and modes of transmission for many diseases. With the advent of computers, epidemiologists were able to analyse the determinants of disease using statistical calculations that would previously have taken a lifetime. The host, agent and environment triad were studied. Since then, it is obvious that a triumvirate of human, animal and wildlife hosts need to be considered and that environmental effects are not limited to immediate surroundings, but encompass a wider range of considerations, from chemical contaminants to climate change and its effects on the distribution of vectors. Advances in genomics have revealed that each causal agent (whether a virus, bacterium, parasite, etc.) is actually an entire family of genetic variants, as are the hosts. Thus, more individualised treatment will have to be considered.

Complexity requires collaboration. Science is 'perhaps the largest cooperative enterprise in human history. The global Internet enabled many-to-many communications, and with it, peer-to-peer economies and collective action on an unprecedented global scale' (12). Workforce skills for success in the 21st century include technological literacy and the ability to work in teams, across language, geographic and cultural barriers (3, 42). Such teams will assemble and disband with unprecedented flexibility and speed, beyond what can be accomplished through traditional partnerships and alliances, with representation as required from the public, private, academic and societal sectors. It is through adoption of collaborative tools and practices that sufficient breakthroughs will occur to provide better health alternatives.

Research: a marketplace of ideas

What leader would not be intrigued by the prospect of increasing research capacity by a factor of 200, without incurring the costs of additional employees? Proctor and Gamble, with a research battalion 7 500 strong (28), estimates that 'for every top notch scientist inside its labs there are another 200 outside who are just as good' (37). It is taking advantage of this external pool of talent through participation in InnoCentive, a company name that elegantly expresses the essence of its business: an online market for trade in innovation.

Buyers post the problems they wish to solve and the price they are willing to pay for a solution. In turn, 90 000 scientists from 175 countries provide solutions for 35 Fortune 500 companies (30). Scientists can participate independently or configure their own businesses around these opportunities. There is also potential for university involvement. Graduate students at Duke University have formed InnoCentive Solvers clubs and InnoCentive has signed agreements with leading universities in India and China where student teams gain valuable experience, recognition and income (32).

InnoCentive is one of a number of companies that list research problems that require a solution. Conversely, there are companies offering solutions looking for a problem. Yet2.com provides its 500 clients with access to about 40% of the world's research and development (R&D) capacity, allowing them to squeeze additional utility and revenue out of underutilised intellectual property that is available to licence (31).

This open market approach might also be applied to hasten innovation in the provision of global public goods, including public health issues. Research areas identified as essential to provide alternatives to mass destruction of animals include the following: remote sensing, rapid field diagnostics, immune modulation and pathogen and host genomics (14). A government or a consortium of governments with an issue in common could offer incentives and rewards for a solution to a problem, leaving its resolution to the ingenuity of those that take up the challenge.

Education: by and for all

In spite of initial skepticism, even on the part of the initiators, evidence is now available that a major scholarly resource, such as an encyclopedia, can be composed by a group of volunteers largely left to their own devices (23). A study conducted by the journal *Nature* found little difference in the number of errors between Wikipedia and the online *Encyclopedia Britannica* (an average of four versus three in a blind comparison of matched articles) (7). What Wikipedia lacks in editorial polish, it makes up for in size (over 1 500 000 articles compared to 100 000 for *Encyclopedia Britannica*) and the speed with which it is updated (3, 23, 43).

The use of a wiki, or a wiki-like website is being expanded to education more generally with the advent of Wikiversity, Connexions and Curriki. The latter was initiated when the long-standing chairman of Sun Microsystems found an engaging and interactive explanation of electricity for his young son on the web and concluded that all information should be available in this format (42).

The Massachusetts Institute of Technology (MIT) caused a stir in 2001 when it announced that it would make all of its course materials freely available on the web for anyone to use (15). Since then, over 100 institutions of higher education from around the world have joined in to form the OpenCourseWare Consortium (21). As more institutions come on board and the instance of course duplication increases, it would seem obvious that much efficiency can be gained through collaboration (3).

The more recent wiki-based initiatives differ from OpenCourseWare in that the materials are not just freely available to use, they are freely available to construct and edit. Intellectual property rights to the content is covered by the Creative Commons attribution licence (5), which states that the material can be freely shared or used for derivative works as long as attribution is given in the manner specified by the original author.

The ramifications for public health are significant (particularly when one considers the need to involve the public in their health) across the spectrum from basic knowledge to the latest research. Facts for Life, co-published by a number of United Nations agencies, provides authoritative information in simple language about practical, effective and low-cost ways to protect children from the major causes of childhood illnesses and death. It is available online at Connexions, courtesy of Teachers Without Borders and UNICEF (16). Connexions is also forming a relationship with the AMD 50 × 15 Consortium which aims to provide 50% of the world's population with access to computers and the internet by 2015 (1).

The Johns Hopkins School of Public Health is making its most popular courses available online. There are numerous open-access electronic journals devoted to various aspects of public health that rapidly disseminate new research findings. It is only a matter of time before all information will be available on the web as a shared knowledge base that will help meet the increasing global demand for education.

Application: adding value

Public data is largely underutilised. Although governments are one of the largest sources of public data they are frequently hobbled by politics, regulations, legacy systems and cultural inertia. If such data were openly accessible, that information could be leveraged to provide additional public services. The best uses of public data are often made by the nonprofit sector (35).

One such example is Scorecard, which was launched by the Environmental Defense Fund in 1998 to aggregate data from hundreds of sources to create a powerful tool for assessing environmental risks. It grew out of concern that an environmental public disaster could occur in the United States after the tragic chemical explosion in Bhopal, India, in 1984 killed 3 500 people and injured tens of thousands of others. Heightened awareness of the dangers posed by toxic chemicals led to demands for access to information about nearby environmental hazards. One can now access Scorecard on the web and search for sources of pollution by zip code, make use of mapping applications, customise displays or send emails and faxes to transgressors (36).

The web has become increasingly important for accessing data, information and ultimately, people. Not just people's thoughts and opinions as expressed in their web pages and blogs, but the people themselves, as if they were in the room. Videoconferencing fulfils this purpose to some extent, but is limited by the need for specialised equipment, whereas anyone with a computer and an internet connection can participate in a live session using web collaboration software (also known as web meeting software). Participants can type in their questions and comments or respond to polls created by the presenter. If they have a microphone they can be heard and those with a webcam (which costs less than $100) can be seen.

In addition to transmitting voice and video (like videoconferencing), web collaboration software provides a workspace that can be configured for a variety of purposes, namely: to draw diagrams, view and annotate PowerPoint© presentations, visit websites and share documents or software on any of the participants' computers. Sessions can be archived for subsequent review. One can either buy a licence for a specified number of participants or, for occasional use, one can use a hosted solution (residing on a commercial server). Many software companies use 'webinars' to help users learn about and trouble-shoot their products, but the use of webinars is not yet mainstream.

Competence in the use of this type of software will become a valued skill. For example, in the event of an emergency, it could be used to assemble an ad hoc team of the best international experts tailored to the requirements of that particular situation. If needed, an interpreter could also participate to facilitate communication among the experts and those on site. Thus, contributing as a productive member of a distributed team will require not just scientific and technological ability, but intercultural competence as well.

Standards and best practices: incorporating lessons from the field

We have seen how collaboration can be used to extract additional value from data and research, then to share this new knowledge through education so it can be applied in the field. Very often, unexpected glitches and situational idiosyncrasies are encountered in the practical application of knowledge. Lessons learned from implementation in specific contexts in the field, often gained through trial and error with the input of expert practitioners, can be used to develop best practices.

An example within the health realm is the Cochrane Collaboration, whereby about 7 000 volunteers (researchers, healthcare professionals and consumers) have conducted systematic reviews of the literature to produce over 2 000 evidence-based guidelines for the practice of medicine (10, 26). Summaries of the effectiveness and appropriateness of treatments (medication, surgery, education) are made freely available to facilitate health care choices by all (3, 39). Combining best practices accumulated from application under the range of circumstances presented in different countries could form the basis for international standards.

Different organisations are responsible for the development of international standards related to health and the environment. Under the Agreement on the Application of Sanitary and Phytosanitary Measures of the World Trade Organization, the development of international standards for animal health, plant health and food safety are the responsibility of the OIE, the International Plant Protection Convention (IPPC) and Codex Alimentarius, respectively. In general, these organisations convene teams of highly qualified experts from across the globe to draft standards that are then reviewed and ratified by an international body, comprised of member countries.

Some of these organisations have a long and successful history of standards development, but by modern criteria there is room for improvement in speed and inclusivity. Expert teams could use a wiki-like tool to facilitate and document their process and eventually open it up to broader participation. Web collaboration technology could also be used for ongoing consultation and modifications. The networks of global experts who work with international organisations are a strategic asset that could be mobilised when necessary or deployed virtually when response time is critical or travel is curtailed due to a high-risk situation.

Just as distributed teams could work together to create and update standards and best practices, best practices could be developed for working in distributed teams. Standards for how best to collaborate at a distance, work through an interpreter, and be an effective member of an interdisciplinary and multicultural team would make it easier to prepare people to work globally.

In this age of modelling and simulation, computer models of disease emergence, spread and mitigation exist and tabletop exercises of multinational disease outbreaks are conducted. It is possible to practise applying different strategies in a low-stakes, non-threatening environment where mistakes are valued as input for improvement. 'A war against disease requires not only financial resources, sufficient technology and political commitment, but also a strategy, operational lines of responsibility and the capacity to learn along the way' (25).

Incorporation of lessons learned from applying strategies either historically or virtually will ensure better preparation for decision-making and taking appropriate action to protect human lives and livelihoods and reduce the mass destruction of animals. There is an obligation to master the skills, tools and practices, as well as exercise the behaviour that will improve our effectiveness in combating disease and promoting health. Let's collaborate to save lives and preserve livelihoods.

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