S&T REVIEWS

Disease Reporting & the BWC

James Revill, Kai Ilchmann, Caitríona McLeish & Paul Nightingale

In preparation for the forthcoming Seventh Review Conference of the Biological and Toxin Weapons Convention (BWC), the Harvard Sussex Program has produced a series of papers considering developments in science and technology of relevance to the Convention. This paper assesses developments in science and technology related to disease reporting and surveillance, primarily in human populations.

Electronic methods of reporting and monitoring disease have resulted in improvements in detection, reporting, surveillance and modelling

Maximizing exploitation of technological developments requires parallel capacity building, increased understanding of procedural processes and political support

Disease reporting and surveillance has implications for Articles II, IV, VI, VII and X

What are Disease Reporting and Disease Surveillance?

Disease surveillance has been defined as "the routine collection, collation, analysis and distribution of information relevant to the control of disease and its prevention".[1] Disease reporting concerns the communication of information about disease outbreaks to appropriate bodies in order to inform and activate appropriate responses at the national and international level. These two tasks are therefore an element of the broader process of epidemiological disease surveillance.

Overview of activity up to 2006

Over the course of the last two decades, there has been a sea change in disease reporting techniques with information and communications technology developments – particularly mobile phones, email and the internet – becoming more effectively integrated in the process of disease monitoring.[2] This has resulted in the emergence of a number of new regional and international infectious disease networks, as well as innovative projects designed to enhance the efficiency of reporting and monitoring outbreaks of disease. Notable examples of such projects include:

- ProMED-mail (1993/4): an e-based reporting system that rapidly disseminates information on outbreaks of infectious diseases and acute exposures to toxins that affect human health, including in animals and plants grown for food or animal feed;
- Global Outbreak Alert and Response Network (2000): a network of networks designed to identify and respond to outbreaks of international importance;
- Voxiva (2001): an integrated surveillance platform leveraging multiple technologies to provide data that supports integrated disease surveillance and co-ordinated response; and
- HealthMap (2004): an automated electronic information system for monitoring, organizing, and visualizing reports of global disease outbreaks according to geography, time, and infectious disease agent.

A number of related developments are noteworthy. Firstly, there has been continued progress and innovation in pathogen detection and diagnosis, in part as a result of progress in genome analysis capabilities.[3] Secondly, the period saw significant growth in recorded publications on 'syndromic surveillance'. Syndromic surveillance monitors disease indicators and symptoms to detect "outbreaks of diseases earlier and more completely than might

1 UN (2004) "Mechanisms being implemented for Disease Surveillance by Intergovernmental Organizations", BWC Meeting of Experts, 19th-30th July, Geneva, Switzerland BWC/MSP/2004/MX/INF.1/

2 Wildner, M & Weitkunat, R (1998) "Development of an epidemiologically based health reporting system", Gesundheitswesen, 60(1), 11-14.

3 Cleland, C & others (2004) "Development of rationally designed nucleic acid signatures for microbial pathogens" Expert Review of Molecular Diagnostics 4(3), 303-315.

otherwise be possible with traditional public health methods".[4] The syndromic approach to surveillance thus applies a complementary layer of monitoring to traditional approaches and has become increasingly common in health departments at least across western states. However, issues remain, including the development and harmonisation of procedures and definitions of symptoms.

The period also saw developments in the plotting of disease data onto digital maps, enabling graphical illustration of disease outbreaks. Although not new, the automation of disease reporting processes and data collation in, for example, online maps allows the collection of accessible, near real-time data on disease outbreaks. This may assist in the determination and targeting of more effective responses to disease outbreaks. A growing body of research on disease outbreak modelling and prediction is using a variety of approaches to assess disease spread such as internet search engine data, predictive markets thinking and geographic information systems (GIS).[5]

Work relating to disease surveillance is not limited to the academic or commercial sectors, thus patent and publication data will not reflect the full extent of developments in disease surveillance. However, a small number of disease surveillance related patents have been filed during the period, and include patents for a database system for inputting, storing and analysing disease outbreak data and a predictive tool for disease surveillance.[6]

Developments since 2006

Since 2006, disease reporting and surveillance related technologies have broadened and deepened in their variety and use. Figure 1 (overleaf) illustrates the global distribution of research activity in this area, with many of the publications being trans-nationally co-authored. The shaded areas represent nations in which papers have been authored; the number of instances of authorship during the period 2006-2010 is represented by the size of nodes; and instances of international co-authorship are shown by the width of the connecting lines.[7]

Technological advances in disease surveillance since 2006 have been incremental refinements of already existing techniques and technologies rather than radical breakthroughs. Detection and identification technologies for example, have benefited from improved sensitivity of biosensors. Although handheld biosensors remain elusive,[8] peripheral advances in, for example, nanotechnology have resulted in patents, including those for portable devices which detect the presence of specific bacteria[9] and sensors with inbuilt reporting systems.[10]

Advances which have occurred in surveillance systems, such as the use of disease mapping software, easy-to-use mapping tools, as well as crowd-sourcing for local surveillance can provide an extra dimension to collected data.[11] A number of patent applications have been filed. These include systems and methods of disease mapping, data collection and collation, and visual presentation to facilitate data modelling to aid in monitoring infection spread and testing of control measures.[12]

Finally, there have been a number of developments in predictive forecasting or modelling of disease outbreaks. Electronic surveillance methods, including non-traditional surveillance sources, have also been refined and enhanced. For instance, during the H1N1 Influenza pandemic in 2009, non-traditional approaches helped to overcome some of the limitations of traditional surveillance systems, which include reporting delays, inconsistent population coverage, and a poor sensitivity to detect emerging diseases.[13]

---

4 Buehler. J & others (2004) "Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks – Recommendations from the CDC Working Group" Morbidity and Mortality Weekly Report (CDC), 7th May, 53(RRo5), 1-11.

5 See for example: Garner, M & others (2006) "An integrated modelling approach to assess the risk of wind-borne spread of foot-and-mouth disease virus from infected premises" Environmental Modelling & Assessment 11(3), 195-207.

6 Source: WIPO patent database (Patentscope®).

7 Data is sourced from ISI Web of Science, which covers over 10,000 high-impact journals in the sciences, social sciences, and arts and humanities, from 76 countries.

8 Caygill, R & others (2010) "A review on viral biosensors to detect human pathogens" Analytica Chimica Acta, 681(1-2), 8-15.

9 Sinha, S & Sapi, E (2009) "Bionanosensor Detection Device" (Patent PCT/US2009/059208)

10 Melker, R & others (2006) "Novel application of nanotechnology and sensor technologies for ex-vivo diagnostics" (Patent PCT/US2004/029131)

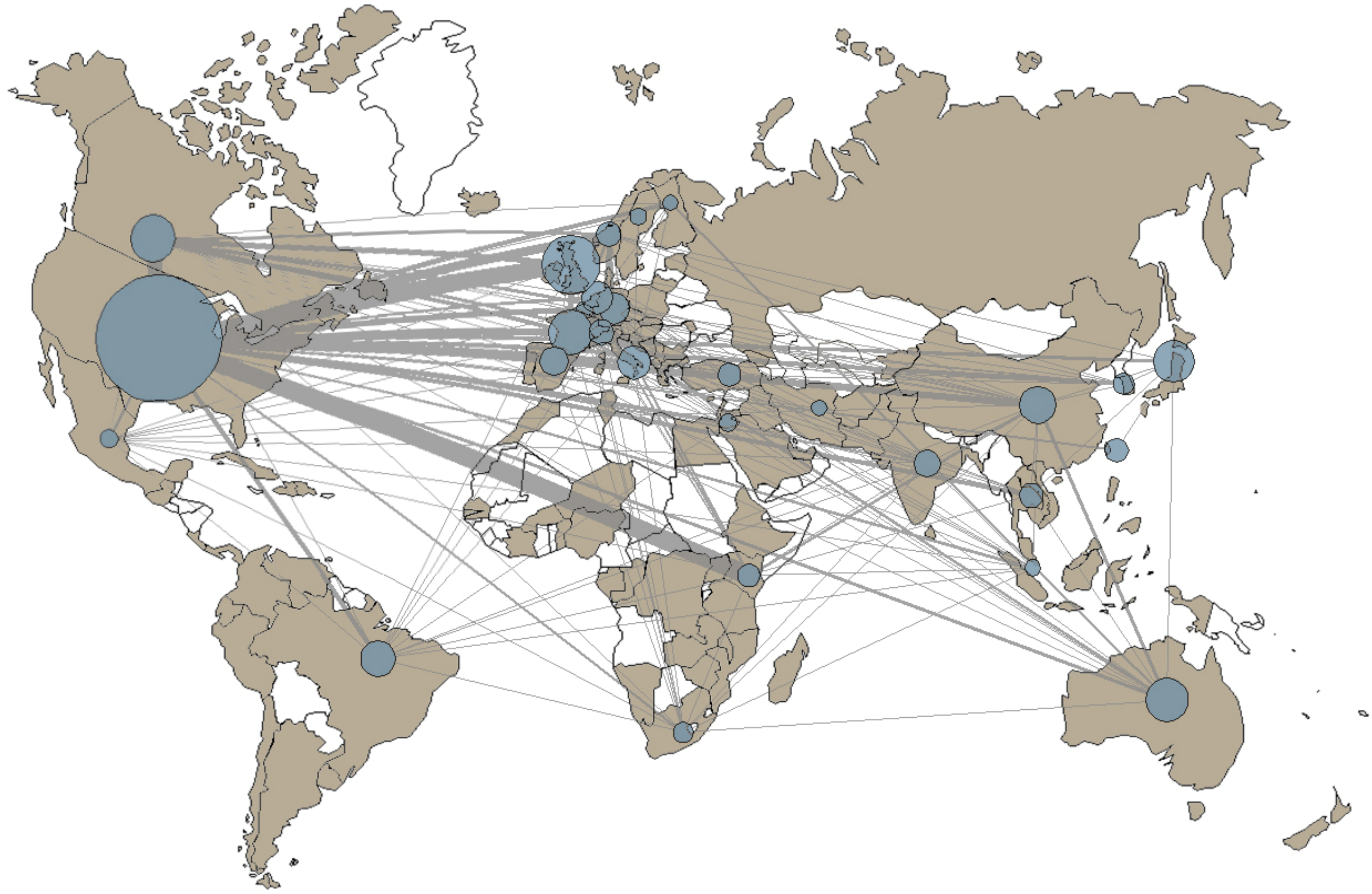
11 McKenna, M (2008) "More efforts look outside the box for outbreak signals", CIDRAP News, 21st July.

12 See for example: Wallace, N & others (2010) "Disease mapping and infection control system and method"(Patent PCT/CA2009/001776)

13 Brownstein, J & others (2010) "Information Technology and Global Surveillance of Cases of 2009 H1N1 Influenza", The New England Journal of Medicine, 3(18), 1731-1735.

Technical advances have been augmented by political, structural, procedural and capacity related developments. Although the bulk of developments in disease reporting and surveillance have taken place in three research clusters located in the US, Europe and South East Asia, it is notable that there is considerable research activity located in the global south (see Figure 1).

Figure 1: Global distribution and patterns of collaborations of publications on disease surveillance and reporting. (Source: ISI Web of Science)



The development of non-traditional surveillance sources is particularly relevant for geographical areas that have limited or no public health reporting infrastructure but where the highest risk for emerging diseases resides.[14] The increasing importance of non-traditional approaches indicates disease reporting and surveillance is perhaps limited less by technology, but rather by the capacity to maintain and use technologies, and awareness of procedural requirements for disease reporting. States Parties have been seeking to address this through international co-operation over the course of the second intersessional process.

It is difficult to predict the future potential impact of technological developments related to disease surveillance and reporting. What is clear is that the challenge of disease is neither contained by borders nor likely to disappear in the near future. Consequently, research into disease reporting and monitoring remains important. Equally important however, are those factors that are needed to enable and maximise exploitation of technological developments, such as capacity building, procedural processes and political support. Indeed, advanced biosensors, for example, are of little use without the requisite capacity to maintain and operate such technology; likewise improvements to the institutional mechanisms need to be complemented by improvements in the awareness of reporting requirements.

14 Keller, M & others (2009) "Use of Unstructured Event-based Reports for Global Infectious Disease Surveillance", Emerging Infectious Diseases, 15(5), 689-695.

Relevance to the BWC

Article II	Detection technologies could be useful if required to validate the destruction of weapons related material and facilities. Surveillance would be important to confirm the protection of populations and the environment during destruction or conversion to peaceful purposes.
Article IV	Equipping national disease reporting systems with indicators of unusual - and thus potentially suspicious - origins is relevant not only to defence against foreign attack but also to the implementation of Article IV. Measures to prevent acquisition of weapons by sub-state actors need to be able to detect and pinpoint unusual domestic outbreaks for example caused by accidental release during weapons production.
Article VI	Article VI explicitly states that allegations of breaches of the Convention "should include all possible evidence confirming its validity". Disease surveillance data provides a baseline from which to determine release or use (which has been accepted in a Review Conference reaffirmation as implicit in the language of Article I). Moreover, disease surveillance data has been used in the past, albeit partially, to resolve allegations of use, and could provide important indicators during investigation of any future suspicious outbreaks.
Article VII	Under this article each State Party undertakes to provide or support assistance on request to counter dangers resulting from a violation of the Convention. Disease reporting and surveillance data and infrastructure support could be important in an assistance package to help in containing a current disease outbreak and preventing a resurgence.
Article X	Figure 1 illustrates one type of international co-operation in research on disease reporting and surveillance. The development and application of scientific discoveries in this area is globally distributed. A global approach is important because increased international travel and transportation of goods now rapidly spreads infectious disease around the world. It is thus in the interests of all States that the infrastructure, communications and skills for monitoring and reporting infectious disease are in place and sustainable in every region and country.

Disease reporting and disease surveillance, although perhaps not always considered in efforts to develop material on background developments in S&T in the past, nonetheless remain relevant to the BWC, particularly Articles VI, VII and X. In addition, demonstrable advances in disease detection, diagnosis and surveillance could enhance the effectiveness of the Convention by dissuading actors from seeking biological methods of attack. Improvements in surveillance and reporting of disease, combined with emerging disciplines, such as bio-forensics which provides improved capacity for attributing suspicious outbreaks, reinforce the Convention. These positive reinforcements should not be overlooked when reviewing scientific and technological developments relevant to the Convention.

Recommendations

Technologies related to disease reporting and surveillance support the realization of the preamble and provisions of the BWC and should not be overlooked in the process of conducting science and technology reviews. Disease reporting and surveillance related technologies have the potential to minimize the impact of an attack, limit the effects from spreading and can contribute to the return to a state of normality, as well as facilitating investigations into the source of any attack. Moreover, the underlying public health value of these mechanisms in an interconnected and globalised world in which no country can be safe in isolation suggest that co-operative mechanisms may be a constructive focus for Article X related activities and initiatives in future meetings. Any such effort should not underestimate the importance of the human capacity building activities nor duplicate initiatives being undertaken by other organisations.

This note is part of a Harvard Sussex Program project examining the role of S&T reviews within the BWC and options for change. The project is funded by the UK's Economic and Social Research Council and is part of the RCUK Global Uncertainties Programme.

For more information about the project visit http://hsp.sussex.ac.uk/sandtreviews/

Correspondence about this note should be addressed to j.revill@sussex.ac.uk