

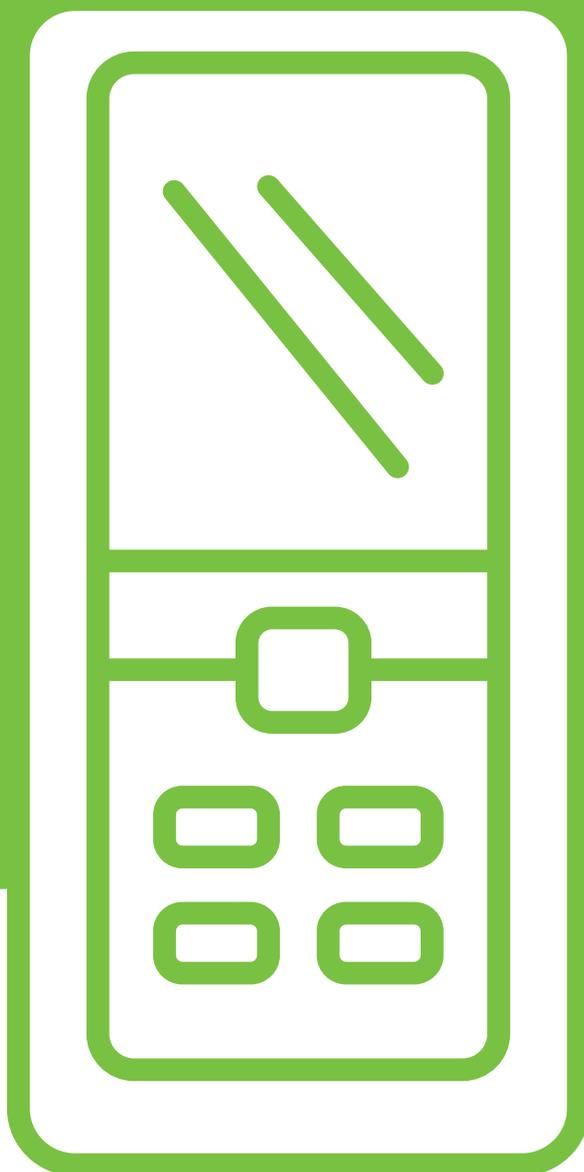


PUBLIC HEALTH
RESEARCH AGENDA
FOR INFLUENZA

One framework. Five streams. Sharing solutions.

STREAM 5

Background document



PROMOTING TOOLS

Promoting the development and application of modern public health tools

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1. Modern tools for early detection and disease monitoring/surveillance

1. Modern tools for early detection and disease monitoring/surveillance

Introduction

This background paper provides information on modern tools for early detection and disease monitoring/surveillance for pandemic, zoonotic and seasonal influenza infection.

Often, modern tools are well developed and more finely tuned adaptations of pre-existing tools and strategies for detection, monitoring and surveillance of existing or emerging diseases. This development and adaptation has often been possible because of trial and error and more readily available and applicable technology and communications practices and methodologies.

The goals of public health control of communicable diseases have remained the same over past decades but the operations, responses and expectations have changed. These changes are the results of advancement in technology and the heightened public perception of risks. The purpose of developing early detection tools is to provide support to a rapid global alert and response system for influenza epidemics and other public health emergencies, so that public health authorities can rapidly identify, assess and contain health threats. The longer term goal for early detection of influenza viruses with pandemic potentials is to reduce morbidity and mortality and avoid disruption of trade, travel and society in general.

Issues which require ongoing attention include:

- modern technologies for epidemic and pandemic influenza early warning and surveillance
- modern tools for policy implementation
- modern technologies for social mobilization

Surveillance consists of ongoing collection, interpretation and dissemination of data to enable the development of evidence-based interventions. In the case of surveillance for influenza, many types of data have been used to reflect increased activity of influenza-like illnesses in the community. Oftentimes, surrogate indicators of influenza activity in the community are used to facilitate early detection of possible outbreaks; examples include increased consumption of over-the-counter cold and flu remedies and increased visits to health care providers for respiratory infections. Confirmatory indicators of influenza outbreaks include an increase in the frequency of laboratory identification of influenza viruses. Effective prevention and control of influenza requires access to and further refinement of existing tools to monitor influenza activity.

Closely linked with the use and availability of technology must be an awareness of differing levels of access to modern tools in countries where economic realities and pressures are diverse. Technology will need to be introduced, adapted and utilized within an overall understanding of the limits of available resources and skill capacity of specific national and local contexts. Policy and practice of governments and communities will impact on priority setting. This is the challenge – to ensure rapid, effective and comprehensive data assimilation and analysis and to ensure that public health policies, practices and tools can maximize responses to that data, given the reality of resources and expectations.

Processes for effective use of technology will require reality checks about education levels, available personnel and supporting structures and skill levels – as well as basics such as security and infrastructure. Personnel may need training, there must be established processes for ensuring agreement and knowledge of where to send what data and information, and how to analyse and communicate observations, data and information. These processes must be established and supported if technology is to be effective.

1.1. Modern technologies for epidemic and pandemic influenza early warning and surveillance

Epidemiological data and operational information about emerging influenza pandemics are dynamic and change rapidly. However the cyclical natures of seasonal influenza outbreaks are predictable as long as continuous surveillance systems are in place. The maintenance of a continuous surveillance system relies on application of modern tools as described above and the development of specific analytical tools for virological characterization. International networks for rapid detection, risk assessment, response and technical cooperation are critical to informed response. The most notable informed response derived from seasonal influenza surveillance is the bi-annual recommendations for the specific viral strain components for the northern and southern hemispheres and their subsequent production and distribution.

In developing an effective surveillance system, managing information is a complex challenge. Data and current information flow are imperative. But, there are an ever increasing number of data access routes such as internet search engines that can lead to information overload. Some of the major challenges faced are the capacity to boost noise to signals. It is important to be able to translate information into knowledge by combining data streams and improving the positive predictive value of incoming information. This in turn can facilitate the shift from threat detection to systematic and scientific risk assessment.

The event management process consists of identifying events that may threaten international public health, assessing their risk, acting on that risk assessment to inform governments and public health institutions of events and assisting affected regional health authorities in their investigation and control. A number of systems had been built to identify events and to give warnings around the world (see below). An example of which is the WHO Event Management System (EMS). EMS is a comprehensive tool developed to manage vital information about outbreaks and to ensure accurate and timely communications between key international public health professionals. Such systems are capable of detecting serious communicable diseases such as unusual influenza activity that may indicate an emerging pandemic.

Modern technologies that aid in the detection and monitoring of influenza activity can be from both official and unofficial sources. Information is reported in various languages and often duplicated by different sources. There is a large variety of information sources including electronic media, organizations, groups and individuals that are constantly being screened for events that may alarm international public health authorities of unusual influenza activities. Prior analysis of such information flow demonstrated that over 60% of initial outbreak reports stem from unofficial informal sources such as electronic media. These need to be balanced against established sources.

The global spread of technologies such as mobile telephones can be a benefit in information sharing. Individuals may be able to communicate observations, data and localized situations. The use of mobile phone technology can be invaluable as rapid communication which may be easily available. However, the cautions expressed above regarding reality checks are reiterated. Access to signals, available credit, knowledge of where to send information and how to send it, how to frame it, how to know what is important – all these aspects must be considered. Processes for use of the technology are needed to maximize potential for sharing information and alerting agencies.

Some further examples of such sources include (but are not limited to):

- BioCaster is a research project that provides advanced search and analysis of Internet news and research literature for public health workers, clinicians and researchers interested in communicable diseases. The system has a web/database server and a backend cluster computer equipped with text mining technology which continuously scans hundreds of RSS newsfeeds from local and national news providers.

- The Emergency and Disaster Information Service (EDIS), managed by the Hungarian National Association of Radio Distress-Signalling, aims to monitor and document all global events which may cause disaster or emergency.
- GPHIN is a secure, internet-based "early warning" system that gathers preliminary reports of public health significance in seven languages on a real-time, 24 hour basis. This multilingual system gathers and disseminates relevant information on disease outbreaks and other public health events by monitoring global media sources. The information is filtered for relevancy by an automated process, and then analyzed by the Public Health Agency of Canada GPHIN officials. The output is categorized and made accessible to users. Notifications about public health events that may have serious public health consequences are immediately forwarded to users.
- The International Society for Infectious Diseases has developed ProMED-mail – a Program for Monitoring Emerging Diseases that is open to all sources. ProMED gathers information from a range of sources including media reports, official reports, online summaries, local observers, and others with the central purpose to 'promote communication amongst the international infectious disease community, including scientists, physicians, epidemiologists, public health professionals, and others interested in infectious diseases on a global scale.
- Veratect aims to provide early detection of emerging threats to human, animal and plant life while empowering corporations, government organizations, NGOs and global citizens with trusted, timely and actionable information through 24 hour tracking and actionable alert generation of emerging threats worldwide.

The next step in the event management process is to provide continued monitoring of a suspected event. The Event Management Group (EMG) – a multi-disciplinary team tailored to manage specific events – will seek to obtain further information about the event from the affected Member State and any other sources. Under the International Health Regulations (2005) each Member State is required to designate a National IHR Focal Point to promote and facilitate information sharing between WHO and its Member States. The Focal Point must be available on a 24 hour-a-day basis, seven days a week. The key tools available to assist with this are the experience and expertise of WHO technical staff in all offices in the 142 WHO Country Offices and 6 Regional Office hubs.

All information necessary for risk assessment is shared within the EMG and recorded in EMS, including confidential and sensitive information. Risk assessment is a systematic process of organising information to support decisions to be made for risk management. This goes hand in hand with threat detection. Risk analysis may be qualitative and/or quantitative and consists of the identification of hazards, exposures, vulnerabilities (contextual, technical, and operational) as well as the analysis and evaluation of risks associated with exposure to those hazards.

An allied, key tool is the WHO Field Investigation Management System (FIMS), a system developed for use when contact tracing is crucial. The FIMS can register epidemiological information, clinical information and case-contact, case-case relationships. The FIMS can be adapted to various outbreaks and support the follow up of contacts. An important feature of the FIMS is the ability to provide visualization of transmission trees.

Although technologies for early warning and surveillance of epidemic outbreak exist, not all of them are available in all areas in all countries. There is a great divergence in available tools across regions and from urban and rural areas. China, for example, has over 20,000 surveillance sites reporting every day. Other countries, especially developing countries have limited access to surveillance sites.

Early warning systems are, in most instances, timely surveillance systems that collect information on epidemic prone diseases in order to trigger prompt public health interventions. However, these

systems rarely apply statistical methods to detect changes in trends, or sentinel events that would require such intervention. In most cases they rely on an in-depth review done by epidemiologists of the data coming in, which is rarely done in a systematic way.

Accessing data is one aspect of information management. Data management in response operations is different for each event, evolves continuously over time, happens across all levels simultaneously, impacts all responders at different levels, includes all types of data and information and concerns data received in various formats from different and disparate sources. There is a diverse range of networks and resources available.

Raw intelligence gleaned from all formal and informal sources is converted into meaningful intelligence by WHO. Six main criteria are used to determine whether a reported disease event constitutes a cause for international concern:

- unknown disease
- potential for spread beyond national borders
- serious health impact or unexpectedly high rates of illness or death
- potential for interference with international travel or trade
- strength of national capacity to contain the outbreak
- suspected accidental or deliberate release.

As noted above, one of the most important tools in early detection and disease monitoring and surveillance is the availability and accessibility of disease experts, institutions, agencies, and laboratories. This network of experts is constantly informed of rumoured and confirmed epidemic intelligence, updates on verification and operations information to enhance operational readiness and communication.

HealthMap brings together disparate data sources to achieve a unified and comprehensive view of the current global state of infectious diseases and their effect on human and animal health and can contribute to influenza control. This freely available Web site integrates outbreak data of varying reliability, ranging from news sources (such as Google News) to validated official alerts from WHO. Through an automated text processing system, the data is aggregated by disease and displayed by location for user-friendly access to the original alert. HealthMap provides a starting point for real-time information on emerging infectious diseases. High-resolution, satellite imaging and GIS mapping on the ground - to locate water points, health care facilities, population grouping - and other tools facilitating estimations of population, nutrition status can support rapid assessment.

Currently GIS tools are used in conjunction with global event management, coordination and communications and early warning and forecasting by monitoring the spread of diseases across communities and across geo-political borders. GIS can assist analysing known or potential risk factors for effective control of influenza (e.g. poultry densities, flight routes of migratory birds for avian influenza, water bodies, tropical forests, elevation and land use).

Other currently available and utilized visualization tools are ESRI, GeoServer, OpenLayers, MS V/E, Google, InstantAtlas, GAV, among others including customized developments.

Currently, WHO and the Health Metrics Network (HMN) are coordinating efforts to build a broad-based collaboration with partners with a view to establishing an inter-operable and standards-based framework of health data and tools. This will be the Open Health platform and it can offer a suite of integrated and inter-operable tools for data collection, management, presentation, analysis, reporting and exchange. The platform leverages existing tools and data services and supports a wide range of applications: disease surveillance, district health management, programme management, and monitoring. All these are functions inherent in control of influenza. Open Health also operates in a range of technological environments (web -portal, enterprise, standalone).

1.2. Modern tools for policy implementation

On 15 June 2007, the International Health Regulations (IHR (2005)) entered into force and became binding international law on the 194 Member States of WHO. The IHR provide the architecture and global policy base for responding to and dealing with threats of and from diseases through a framework for coordination of the management of events that may constitute a public health emergency of international concern. As expressed in Article 2, the purpose and scope of the IHR (2005) are 'to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade'. The IHR (2005) are also designed to reduce the risk of disease spread at international airports, ports and ground crossings.

Global policy alone is insufficient. It is imperative that responses at all levels in the management of public health threats are timely, effective and coordinated. For this to happen, global policies and tools need to be implemented at the country level. Policy implementation that involves close collaboration and encourages links between all stakeholders, from the village community groups, county, state and central government organisations, implementing NGOs, United Nations' agencies and donors has proved to be effective in supporting implementation of global policies.

As a tool, therefore, of global policy formulation and management, the IHR are important – but they must be adapted and adopted at national levels. Information flow and effective communications between global and national level preparedness and responses must accompany policy formulation. The WHO Global Influenza Surveillance Network (the Network) provides an important mechanism for such information flow and policy collaboration. It enables WHO to recommend twice annually the content of the influenza vaccine for the subsequent influenza season. Established in 1952, to advise WHO Member States as to 'what influenza control measures are useful, useless or harmful', the Network serves as a global alert mechanism for the emergence of influenza viruses and provides regular updates on the necessary content of influenza vaccines to protect recipients efficiently from influenza disease and death.

The WHO Global Influenza Surveillance Network comprises five WHO Collaborating Centres (WHO CCs), four Essential Regulatory Laboratories and 128 institutions in 99 countries that are recognized by the Network as National Influenza Centres (NICs). The NICs collect specimens in their country and perform primary virus isolation and preliminary analysis. Newly isolated viruses are then sent to WHO CCs for advanced antigenic and genetic analysis, the result of which forms the basis for WHO recommendations on the composition of influenza vaccine for the northern and southern hemispheres each year, as well as relevant risk assessment activities of WHO.

Taken together the IHR (2005) and the Global Influenza Surveillance Network provide policy bases and practical tools for concerted responses. A framework for global policy is formulated. Information is shared between states. National policy can be formulated and implemented. Global support and monitoring can be informed and better targeted. Interaction between policy and responses at global and national levels is informed and more likely to be coordinated, maximizing resources and support strategies.

1.3. Modern technologies for social mobilization

Traditionally, social mobilization is perceived as a community-based call to action for political and social commitment by strengthening human and institutional resources development at local level. As social mobilization develops, it takes advantage of constantly evolving communications tools and technologies. Different communities choose locally relevant activities and messages.

Social mobilization seeks to facilitate change through a range of facilitators engaged in interrelated and complementary efforts. Social mobilization for and with public health promotion in the event of influenza outbreaks helps reduce excess mortality, address the leading risk factors associated with spread, helps strengthen sustainable health systems and places available health resources for control at the centre. It is a key element in the control of influenza.

Although biomedical and behaviour solutions are essential to combat influenza, it is important to undertake continued assessment of policy and practices relating to detection, prevention and treatment of all socioeconomic levels of societies. For an influenza control program to succeed, the health sector needs not just a helping hand from others, but a genuine partnership, whereby ownership of the program is shared and the stakes of other sectors are clearly recognized. The societal mobilization strategy relating to influenza control calls for partnership with all stake holders.

A multi-sectoral approach means the involvement of many levels of government, and of people with various specialties, including policy development, legislative review and drafting, animal health, public health, patient care, laboratory diagnosis, laboratory test development, communication expertise and disaster management. Community involvement means making optimal use of local knowledge, expertise, resources and networks. It is a powerful way to engage people and to build the commitment needed for policy decisions.

No single institution has all the capacity to respond to an outbreak of influenza or any other disease. The Global Outbreak Alert and Response Network (GOARN) brings partners together to rapidly focus global technical resources on an event. Established in April 2000, GOARN is a technical collaboration of existing institutions and networks which pool human and technical resources for the rapid identification, confirmation and response to outbreaks of international importance. Investigative teams from GOARN and partners are prepared to arrive at an outbreak site within 24 hours. GOARN is demonstrably effective in social mobilization. It links with and maximises the impact of available technology and builds on cooperation and collaboration in information sharing and knowledge building. It is a valuable tool for use in control of influenza.

Conclusion

There has been progress in the prevention and control of influenza due in part to new and more effective tools. The task, however, is to continue monitoring, evaluating and developing ever more effective tools. Influenza and other diseases continue to decimate communities and to threaten global development, trade, travel and social exchange across national borders. However many questions remain unanswered and more developmental effort is needed. Examples of such questions include:

- Is current global policy sufficiently broad and appropriate to meet globalised exchanges of goods, people and services?
- Is global policy sufficiently adaptable to meet the diverse realities of states which need national and local policy?
- Are states sufficiently supported in adapting and implementing global policies relevant to influenza control?
- Are existing networks and tools for data gathering, information analyses and application sufficient and appropriate for widespread use?
- Do they deliver data and information as and when needed in ways which ensure appropriate use and application?
- What gaps have emerged in tools and network application?
- What more is needed?

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2. Role of modelling in public health decision making

2. Role of modelling in public health decision making

Introduction

This document provides a general introduction to the modelling of influenza infection in the population. We begin with a brief review of the uses of models and how models can inform policy. We then dissect the main components that are required in a comprehensive model of influenza before reviewing some of the most highly cited work in this field. Finally, we consider the role that modelling has played in pandemic (H1N1) 2009 influenza and suggest the lessons that can be learned. Models are not a substitute for good epidemiological data and are only as reliable as the data and assumptions that are used to underpin them. Therefore, in any practical role it is impossible to separate modelling from statistics.

2.1. Uses of modelling in influenza control

Models are not a panacea. While models have a multitude of uses, they cannot compensate for either a lack of epidemiological data or a lack of epidemiological understanding. Modelled results are only as reliable as the data used for their parameterization and the assumptions used in their formulation. Therefore, while good models can play an important role in public health planning, ill-conceived or ill-parameterized models can be highly misleading. Here five fundamental uses of models are outlined, illustrating the benefits that can be accrued.

2.1.1. Models as planning tools

One of the most influential uses of epidemiological models is as a planning tool against a relatively unknown threat. This particularly resonates with the study of respiratory viruses such as Severe Acute Respiratory Syndrome (SARS) and influenza as plans to either control or mitigate their severest effects must be in place beforehand (Mills et al, 2006). In this context, very detailed models based upon a reasonable set of assumptions and parameters can be used to generate a range of scenarios. Undoubtedly, the most successful of such models were those of Ferguson et al, 2005 and Longini et al, 2004, which considered the spread and control of a relatively transmissible pandemic virus arising in South East Asia in response to concerns over highly pathogenic avian influenza A (H5N1). However, such planning scenarios and the levels of intervention needed to control the epidemics are computer-generated examples based on reasonable guesses. The reality of an influenza pandemic (or seasonal epidemic) is likely to differ from the preparedness plans as demonstrated by pandemic (H1N1) 2009 influenza. Therefore strategies must be flexible enough to adapt.

2.1.2. Models as tools for understanding

Mathematical models can also be used retrospectively to examine the behaviour of previous pandemics to identify patterns of infection and risk factors. A primary example is the use of case-report and death data from the 1918 influenza pandemic to generate a wealth of statistical analyses and dynamic modelling. Key questions that have been examined include: identification of socio-economic or other indicators for risk of infection and subsequent mortality (Chowell et al, 2008; Richard et al, 2009); evidence that social-distancing during the epidemic peak led to a decrease in transmission (Mills et al, 2004; Bootsma and Ferguson, 2007), and, using more recent outbreak information, identification of the likely impacts of school closures on transmission (Cauchemez et al, 2008; Cauchemez et al, 2009).

2.1.3. Models as statistical inference tools

Attempts to parameterize basic mathematical models can be highly informative statistical methods in their own right during an ongoing outbreak. For example, the most fundamental element of any mathematical disease model is the value of R_0 -- the basic reproductive ratio. R_0 is the average number

of secondary cases produced by an average infectious individual in a totally susceptible population. As such, the estimation of R_0 (and how it changes through time) is both fundamental to model parameterization and a vital component for quantifying the epidemiology of the infection (Fraser, 2007). Estimation of such parameters is achievable only through mathematical models that can account for the underlying disease behavior (Mills et al, 2004; Boelle et al, 2009; Fraser et al, 2009; Nishiura et al, 2009).

2.1.4. Models as indicators of unexpected behavior

One often-ignored benefit of attempting to capture epidemic behaviour with a detailed mathematical model is the insights that can be gained from situations in which the model does not perform well. Such situations may indicate one of two things. Firstly, poor performance of the model could indicate inadequate understanding of an important feature of the epidemiology of infection; further studies may increase our knowledge in this area and may even suggest improved methods of targeting control. Secondly, failure to predict the dynamics of particular segments of the population may indicate that they are not conforming to the expected (normal) behaviour; again this would be a strong signal for further studies, which may identify previously unknown risk factors that could improve methods of targeting control.

2.1.5. Real-time modelling

Finally, the ultimate goal may be seen as real-time modelling of an epidemic as it unfolds (Hall et al, 2007; Coburn et al, 2009; Epstein, 2009). This requires models that can take epidemiological data from a variety of sources to parameter the model from the reporting institutions as they emerge; iterate the resultant model so as to predict the likely dynamics over the short- and long-term; and incorporate a range of potential control measures to assess which are likely to have the greatest impact. Ideally this calls for an integrated parameter inference and a modeling framework, possibly based around Bayesian statistics such that priors (i.e. beliefs about parameter distributions) can be set by expert opinion and previous experience; this type of integrated methodology is currently under development. In principle, such real-time modeling could be used in a variety of contexts, from predicting demand on public-health and hospital resources, to efficient targeting of pharmaceutical and non-pharmaceutical control measures, to advising businesses on potential absenteeism levels. However, while such models could potentially be extremely powerful, their results must be used with caution as the real-world is far more complex than any simulation model and unforeseen factors will inevitably emerge. For this reason it is essential that the short-term predictions of real-time models are continually validated against the ongoing epidemic.

Real-time analysis (sometimes assisted by modelling) has played a significant role in the public health planning and decision-making during the pandemic (H1N1) 2009. However, this has been hampered by our inability to ascertain the true level of infection from the complex biases in reporting influenza-like-infections (Lipsitch et al, 2009a,b).

2.2. Structure in influenza modelling

Although different diseases, data resources, populations and public health questions call for different types of model formulation, there are several aspects that are desirable in most models. Here, after a very simple and brief overview of the simplest of disease models that is applicable for influenza, we focus on a range of complexities, their implications for a simulated influenza outbreak and the necessary data requirements that are needed.

2.2.1 Simple SIR-type models

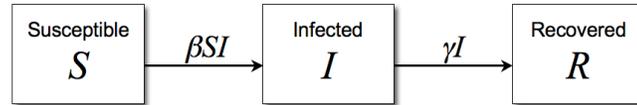
Almost all models of influenza operate by dividing the population into a series of compartments (Anderson and May, 1992; Keeling and Rohani, 2008). In the most simple model three compartments are used: susceptible (individuals in this compartment are naïve to the strain of influenza and therefore

able to become infected); infected (individuals in this compartment are infected with influenza and are assumed to be infectious and able to transmit the virus to susceptible individuals); and recovered (individuals in this compartment acquired the infection and are now assumed immune to this strain). The SIR model captures our basic assumptions about how the numbers of individuals flow between these compartments, noted as rates of change of the three basic parameters:

$$\frac{dS}{dt} = -\beta SI/N$$

$$\frac{dI}{dt} = \beta SI/N - \gamma I$$

$$\frac{dR}{dt} = \gamma I$$



In this most simple of models, β measures the transmission rate of influenza and γ measures the rate at which infected individuals recover; other complexities such as births, deaths, vaccination or other treatments are ignored. Such a model is a reasonable description of a single epidemic wave and allows a wide variety of epidemiologically important parameters (such as the basic reproductive ratio, the early growth rate of the epidemic, the peak of the epidemic and the final epidemic size or case attack ratio) to be calculated analytically. Intuitions based on the behaviors of such models are fundamental in our understanding of the results from more complex formulations.

Major improvements to the predictive ability of this model can be realized by introducing multiple infected classes, thereby better mimicking the natural history of infection. The simplest such change is to introduce an exposed or latent compartment that contains individuals who have been infected but are not yet infectious. Additional improvements are achieved by further dividing the latent and infectious classes into multiple compartments (Wearing et al, 2005); this allows for more accurate characterization of the distribution of times spent in each class and a more accurate relationship between early growth rate and the basic reproductive ratio (Wallinga and Lipsitch, 2007; Chowell et al, 2007).

2.2.2 Strain structure

One way in which models for influenza differ from those traditionally used to predict disease dynamics is the impact of strain structure and the cross-protection offered between strains (Ferguson et al, 2003). Often the implicit assumption is that having been infected and recovered from one strain of influenza provides some protection against other strains with the degree of protection greatest for strains that are most closely related. However, parameterising this dependence and assessing the historical challenge associated with the population may be difficult. In addition, if models are required to predict over relatively long time scales of greater than one year they need to take into account antigenic variation and evolution of the virus (Smith et al, 2004). We are still a long way from being able to predict this with great certainty.

Finally, the issues of strain-structure and cross-immunity are likely to be less critical when dealing with a novel pandemic strain of influenza as it is generally assumed that the entire population is naïve. However, pandemic (H1N1) 2009 influenza is calling into question the prior assumption of complete immunological naivety as older adults appear to have substantial protection from disease (if not infection).

2.2.3 Parameterization

Parameterization is a vital aspect of any modelling. Any model should be consistent with the available data – although how the data are interpreted and what biases are represented in the collection of these data may be open to some debate (Lipsitch, 2009b). To this end, it is generally impossible to simply add new structures to an existing model; adding new structures and new processes (such as those detailed below) will generally require a complete reparameterization of the model.

For an ideal mathematical model, we would like two features to hold for all of the necessary parameters. Firstly, there should be firm estimates of their ranges before the onset of an epidemic; secondly, it should be possible to estimate their value (together with appropriate confidence intervals) from data available during the epidemic. For simple models (such as the SIR model above) where there are analytic relationships between parameters and observables this is relatively simple. However, for more complex simulation models inference of parameter values is often difficult and great uncertainty will exist in the early stages when limited data are available.

Secondly, any method of determining parameters must take into account biases and temporal delays in the reporting of cases and deaths (Fraser et al, 2009, Lipsitch et al, 2009a, Garske et al, 2009). For example, it is anticipated that not all cases of influenza will seek medical help, and not all those seeking medical help with influenza-like symptoms will actually have influenza. Understanding such under- and over-reporting (and its temporal variability) is key to model parameterization. This clearly calls for close interaction between those who are responsible for collecting and collating the data and those responsible for using such data in a modelling context.

2.2.4 Stochasticity

One facet that is relatively trivial to include in mathematical models is the element of chance; epidemics do not progress as a clock-work deterministic process, but instead transmission is stochastic. Introducing stochasticity is important for two reasons (Keeling and Rohani, 2008). Firstly, the impact of random transmission can be relatively strong when the infection is rare, especially if transmission is relatively weak. Hence, it may be impossible to interpret the early dynamics of infection without such random processes which can even lead to the localized extinction of the infection. Secondly, the inclusion of chance behaviour – and therefore variability between epidemic simulations – may in principle make it easier to fit to epidemic data.

2.2.5 Age-structure

Age structure is of fundamental importance in a range of disease models. This is for three main reasons. Firstly, older individuals, by virtue of their age, are more likely to have encountered a comparable strain and are therefore more likely to have some level of partial immunity. This has been observed during the pandemic (H1N1) 2009; individuals born prior to 1930 have some level of cross-reactive antibodies to the H1N1 pandemic virus (Hancock et al, 2009). Secondly, there tends to be considerable age-dependent variation in the number of contacts that are pertinent for influenza transmission (Mossong et al, 2008); with strong assortativity individuals tend to interact primarily with others of a similar age group (Mossong et al, 2008). Finally, mortality and morbidity associated with seasonal and pandemic influenza strains are often age-dependent; the very young and the very old are most severely affected by seasonal influenza strains, while pandemic strains most often affect children and young adults. The incorporation of age-structure into models obviously adds an additional dimension. This in turn necessitates the collection of age-structured case-report data and an examination of whether other structural elements are age-dependent.

2.2.6 Risk-structure

Risk structure in a disease modelling context generally refers to the fact that some individuals will have more (often many more) transmission-relevant contacts compared to the average (Anderson and May, 1992, Riley et al, 2003, Lloyd-Smith et al, 2005). Such individuals will naturally have both a greater risk of infection but also a greater risk of transmitting influenza once infected. If such high-risk individuals tend to interact with each other, then their presence can greatly inflate the early growth rate (Diekmann et al, 1990). If the model has been parameterized to match the early growth rate the presence of such high-risk individuals will lead to a far smaller predicted epidemic than if their presence is ignored. In general, risk-structure has been considered as a part of age-structured models (with some ages having more transmission-relevant contacts), as well as in terms of heterogeneity in household and workplace size. Heterogeneity in contacts, and therefore risk-structure,

can often be represented in terms of networks of contacts between individuals. This is a growing field of study (Eubank et al, 2004; Longini et al, 2006; Halloran et al, 2008) and it is still unclear how transmission should scale with the number of links or the context within which the link occurs.

2.2.7 Spatial-structure

Spatial-structure is an important element in model formulation and statistical analysis of case-report data. It is intuitively obvious that the vast majority of people do not frequently move great distances (especially when ill). Therefore, they are likely to generate most of their secondary infections close to where they live (Ferguson et al, 2005; Ferguson et al, 2006; Viboud et al, 2006). In addition, there may be parameter variation between different regions; understanding this variation at a relatively fine scale may provide important indicators of risk. On a larger spatial scale, the rapid global spread of the 2009 H1N1 pandemic (Fraser et al, 2009) and before that, the SARS epidemic (Hufnagel et al, 2004) reinforce the importance of 'translating' the experience of one country to other countries. It is necessary to understand how parameters and reporting and treatment schemes vary by country. For instance, the pan-European survey POLYMOD highlighted differences in social interaction between European countries (Mossong et al, 2008).

2.2.8 Temporal fluctuations

One often overlooked element of modelling influenza is the temporal forcing that may impact the transmission dynamics (Truscott et al, 2009). This results from two principal sources: climatic seasonality and mixing of children in schools. Climatic seasonality helps to explain the outbreaks of seasonal influenza that occur every winter in the temperate regions of the world; while many different reasons for this seasonality have been proposed (such as temperature, UV levels or closer social contacts) recent work suggests that vapor pressure or humidity have by far the greatest impact (Lipsitch and Viboud, 2009). Closely linked to ideas of age-structured mixing is the concept that school terms lead to a general increase in transmission compared to school holidays, and that enforced school closures may be a potential means of reducing the scale of an epidemic (Cauchemez et al, 2008; Cauchemez et al, 2009).

2.2.9 Behavior and responses

Many of the above characteristics are parameterized from surveys and other data collected on healthy individuals outside of a pandemic (or even a severe epidemic) of influenza. Using these data during an epidemic is flawed for two reasons. Firstly, sick individuals tend to behave very differently from healthy ones; in particular they are likely to be far less ambulatory which increases the risk of spread within the household but decreases it in other settings. Secondly, even healthy individuals may modify their behaviour and reduce the frequency of contact with others if there is extreme concern about mortality from an ongoing epidemic. Examination of mortality records from several cities in the United States suggests that this latter effect, often known as social distancing, may have occurred spontaneously during the 1918 pandemic (Mills et al, 2004; Bootsma and Ferguson, 2007). Finally, it is likely that case reporting is strongly influenced by the public perception of the viral strain, with heightened levels of concern or awareness leading in turn to greater reporting of illness.

2.3. Review of recent influenza modelling publications

In this section we provide a brief overview of the most frequently cited (i.e. greater than 100 citations) influenza-related modelling papers (Table).

These papers detail studies that actively model plausible influenza epidemic scenarios and investigate the impacts of control (Rvachev and Longini, 1985; Longini et al, 2004; Germann et al, 2006; Longini et al, 2005; Ferguson et al, 2005); undertake extensive statistical analyses of previous epidemics and pandemics (Longini et al, 1982; Mills, Robins and Lipsitch, 2004); and consider evolutionary changes in influenza viruses (Ferguson et al, 2003; Smith et al, 2004).

Reference	Number of citations	Paper description
Ferguson et al (2005) Strategies for containing an emerging influenza pandemic in Southeast Asia	301	The population of S.E. Asia is modelled at an individual-level taking into account spatial and social structure; people are ascribed a home and workplace or school as appropriate with other transmission occurring randomly within the local vicinity. Impacts of social distancing and prophylactic treatment are modeled.
Longini et al (2005) Containing pandemic influenza at the source	236	The population of S.E. Asia is modelled at an individual-level, based on a hierarchy of regional localities, villages and households which are interconnected through clustered networks of contacts. A mixture of geographically targeted antiviral prophylaxis, quarantine within the household and vaccination are examined.
Ferguson et al (2006) Strategies for mitigating an influenza pandemic	216	The large-scale model used in the Ferguson 2005 article on pandemic containment is adapted to examine pandemic mitigation in whole-country simulations of the US and UK populations. The impact of antiviral treatment, prophylaxis, vaccination and social distancing measures (school closure, household quarantine and case isolation) is examined. The authors conclude that antiviral prophylaxis could reduce clinical attack rates for a 1918-style pandemic by one-third, that school closure could reduce peak attack rates by 40% but have little effect on cumulative attack rates, and that even a 20% stockpile of pre-pandemic vaccine could also reduce attack rates by one-third.
Mills et al (2004) Transmissibility of the 1918 pandemic influenza	161	Uses data from deaths during the 1918 pandemic in 45 US cities to determine the basic reproductive ratio of the pandemic virus. Given that the data are mortality- and not case-based and typically weekly in nature, there is considerable uncertainty in the estimates. The authors estimate that the reproductive ratio for the 1918 pandemic virus was less than 4, with a median of approximately 2.9.
Longini et al (2004) Containing pandemic influenza with antiviral agents	157	Examines the potential control of pandemic influenza in the USA, using spatially stratified models that include household, workplace, community and age structure, with demographics parameterized from US census data. The authors conclude that intensively targeted antiviral prophylaxis on a large scale could effectively contain a pandemic influenza outbreak.
Germann et al (2006) Mitigation strategies for pandemic influenza in the United States	152	Using a comparable model to Longini et al, 2004, this paper considers a wider range of control options including antiviral agents, vaccination and travel restrictions to contain a novel influenza virus outbreak in the United States. The authors conclude that vaccination or antivirals alone could substantially reduce a weakly transmitting influenza virus strain, but multiple containment strategies may be needed for strains with a higher reproductive ratio.
Smith et al (2004) Mapping the antigenic and genetic evolution of the influenza virus	153	This paper analyses the evolution of influenza A (H3N2) from 1968 to 2003, examining both antigenic and genetic evolution. The authors conclude that antigenic evolution was more punctuated than genetic evolution and that small genetic changes could result in a relatively large antigenic change.

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Ferguson et al (2003) Ecological and immunological determinants of influenza evolution	136	This paper develops a model to account for the evolutionary dynamics of influenza A and B, bringing together a relatively simple immunological model (incorporating between-strain cross-protection) and an epidemiological model that accounts for individual-level dynamics and spatial segregation.
Rvachev and Longini (1985) A mathematical model for the global spread of influenza	118	This is one of the earliest papers to consider a global model for the spread of influenza and compares results to those seen for the 1968-69 pandemic. The model consists of a 52 cities each of which can support a localized epidemic; individuals move between the cities, as parameterized from airline transportation data and can transfer infection.
Longini et al (1982) Estimating household and community transmission parameters for influenza	112	Serological data from the Tecumseh Respiratory Illness Study and the Seattle Flu Study from 1975-1979 were analyzed using likelihood-based methods based on simple transmission models. Children were the most likely source to introduce infection into the household, and the probability of transmission within the household was approximately 15%.

2.4. Lessons from the pandemic (H1N1) 2009

Finally, we turn to the questions of what lessons can be learned from the pandemic (H1N1) 2009 and where did modelling succeed and where did it fail. Concern about the pandemic potential of highly pathogenic avian influenza H5N1 led many countries to plan for a severe pandemic, assisted in some instances by modelling (Longini et al, 2005; Ferguson et al, 2005; Ferguson et al, 2006). Consequently, countries and health organizations were far better prepared than was the case five years ago. However, our expectations surrounding an H5N1 pandemic, preliminary data from Mexico (Fraser et al, 2009; Lipsitch et al, 2009c) and the difficulties associated with quantifying severity lead to early assessments about the H1N1 pandemic that were considerably more pessimistic than what has since unfolded. In a policy sense, the legacy of these early expectations has sometimes been difficult to overcome, as predicted numbers of cases and deaths have monotonically decreased as more data have become available. In terms of saving lives, it is far better for early predictions to be pessimistic; but if early assessments deviate too far from the eventual reality then there may be a lack of confidence in the methods used to make such assessments, including mathematical models.

In view of the wealth of detailed influenza models developed before the H1N1 pandemic it was expected that real-time modelling (providing accurate short-term forecasts of the epidemic) would be rapidly achievable. However this has not been the case as limitations in data availability (in particular poor estimates of the 'true' number of cases compared to the number of reported cases) made detailed predictions near impossible (Lipsitch et al, 2009a,b). For example, the number of people diagnosed with influenza-like illness over time can provide some idea of the relative changes. However, without detailed population-based serosurveys, it is difficult (if not impossible) to predict both the true number of cases and the course of the pandemic until after it has peaked. Similarly, age-dependent patterns in reported influenza-like illness could represent true patterns of infection or could represent age-dependent concerns and reporting biases. In the future it is vital that modellers and health officials work together to ensure that the necessary data are available as soon as possible.

Nonetheless, mathematical models have played an important role in the 2009 pandemic. Shortly after WHO declared that the emergence of a novel influenza A (H1N1) strain in Mexico and the US represented a 'public health emergency of international concern,' WHO convened an informal network of mathematical modelers with the following goals: (a) to describe and predict the behavior and impact of the pandemic and demonstrate the potential outcome of proposed pharmaceutical and non-pharmaceutical interventions in different settings; (b) to present these analyses in formats suitable for various audiences, including technical experts, policy-makers and the general public; and (c) to adapt models and interpret experiences from developed countries so they can be applied in low-resource countries (WHO, 2009a).

Mathematical models have provided an understanding of the early dynamics of the H1N1 pandemic virus and have organized statistical analyses of trends in reported cases into a usable and epidemiological framework (Fraser et al, 2009; Nishiura et al, 2009 a,b; McBryde et al, 2009; White et al, 2009; Lipsitch et al, 2009c; WHO 2009a,b). Models helped to more rigorously define the move from WHO global pandemic level 5 to level 6 on 11 June 2009. They have been used to extrapolate from the early epidemic behaviour to generate reasonable worst-case scenarios for

planning purposes (e.g., UK Department of Health¹; ECDC²), although these scenarios have large confidence intervals and the meaning of “reasonable worst-case” is subject to individual interpretation.

In addition, models have been useful in evaluating the impacts of pharmaceutical interventions (i.e. vaccines, antivirals) and non-pharmaceutical interventions (i.e. school closures, mask wearing) on transmission and the severity of the pandemic in different settings. Historical data from past influenza pandemics and seasonal epidemics as well as modelling studies and preliminary analyses of the 2009 H1N1 pandemic suggest that the main health benefit of school closure is slowing the spread of an outbreak (Cauchemez et al., 2008; Cauchemez et al, 2009). School closure can lower and flatten the peak incidence of infections and substantially reduce health care demand by 30-50% at the peak of a pandemic. However, when considering the total number of people infected during the duration of a pandemic, school closure is thought to have a relatively small impact (10-20% reduction), and significant economic and social costs (Cauchemez et al, 2009; Lempel et al, 2009). Models also have been used to examine targeted vaccination, in particular the benefits to be gained by vaccinating individuals at increased risk for severe illness infection and the merits of extending vaccination to the most epidemiologically important groups in the population (Miller et al, 2006; Basta et al, 2009; Medlock and Galvani, 2009).

Finally, mathematical models provide one of the few methods of obtaining relatively unbiased assessments of the current situation, recent trends and the likely impact of various control measures. Surprisingly, mathematical models have not radically changed our response to the 2009 pandemic, which has focused on contact-tracing, antivirals, good hygiene practices and rapid development of a pandemic vaccine. Mathematical models may have had a greater impact if the pandemic virus had been more severe and complex resource tradeoffs were needed. Key questions that have been examined include: identification of socio-economic or other indicators for risk of infection and subsequent mortality (Chowell et al, 2008; Richard et al, 2009); evidence that social-distancing during the epidemic peak led to a decrease in transmission (Mills et al, 2004; Bootsma and Ferguson 2007) and, using more recent outbreak information, identification of the likely impacts of school closures on transmission (Cauchemez et al, 2008; Cauchemez et al 2009).

1

http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/@sta/@perf/documents/digitalasset/dh_107428.pdf

2

[http://ecdc.europa.eu/en/healthtopics/Documents/091111_Pandemic_\(H1N1\)_2009_Planning_Assumptions_for_EU_EEA_countries.pdf](http://ecdc.europa.eu/en/healthtopics/Documents/091111_Pandemic_(H1N1)_2009_Planning_Assumptions_for_EU_EEA_countries.pdf).

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3. Risk and Crisis Communication in the Context of Public Health

3. Risk and Crisis Communication in the Context of Public Health

Research in the field of risk and crisis communication is at a crossroads: it can either enhance its current tools, or it can look for alternatives to its current ways of working and develop new thinking. Indeed, the emergent crises of our times call on public health authorities for communications tools and preparedness as well as for a capacity to deal with unpredictable outcomes and uncertainties. The general guidelines for risk and crisis communication are simple and straightforward: planning in advance, announcing early, being transparent, respecting public concerns, and building trust (Abraham, 2009).

3.1. Background

The field of risk and crisis communication has been in existence for more than three decades. It is often associated with technological disasters such as Chernobyl (1986) or Bhopal (1987), natural disasters such as hurricanes (Katrina in 2003), floods, or, more recently, bioterrorism, such as the anthrax attacks of September 2001. It is concerned with outbreaks and epidemics, including Severe Acute Respiratory Syndrome (SARS), H5N1, and the present H1N1 influenza pandemic. Risk and crisis communication is also associated with other public health priorities and concerns, such as the hazards of cigarette smoking.

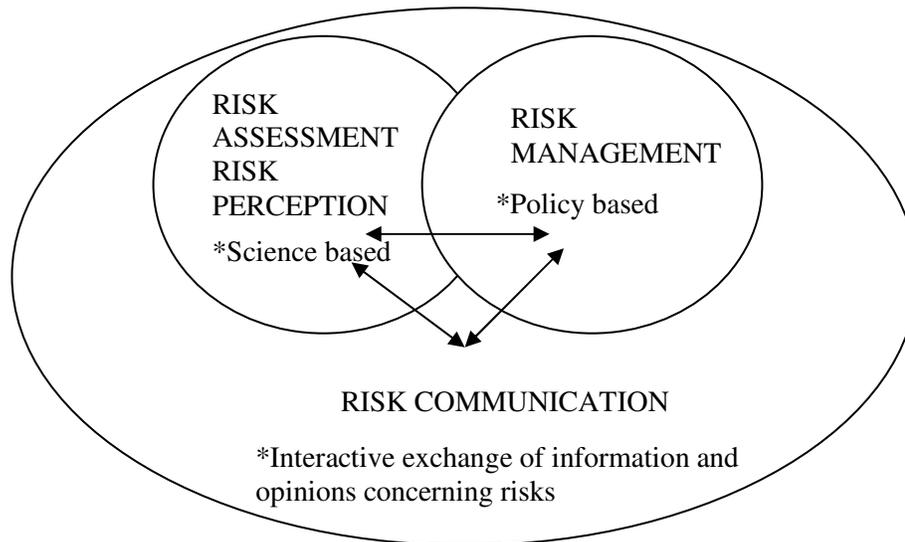
Fields such as psychology, social psychology, sociology, media studies, and political science have clarified much of what can be expected from risk and crisis communication, but also what is beyond the reach of its tools and approaches. In this brief overview we stress that “good” risk or crisis communication can do little in the face of governance problems, where the controversies and conflicts that naturally arise within institutions dealing with complex crises will inevitably be revealed to the outside world. Attempting to suppress disagreements over uncertainties is an untenable strategy. Therefore, crisis management is increasingly becoming a question of governance, with a significant political component, rather than being confined to a question of communication.

The literature of risk and crisis communication is roughly divided into two categories: 1) information on how to prepare, design, and run a “good” communications strategy and develop messages; many books and manuals summarize case histories and give advice on how to achieve an adequate communications strategy; and 2) literature dealing with failures and less than adequate strategies that explores reasons why, in the light of specific events, crises, and catastrophes, communication to the public was so difficult, counterproductive, and sometimes even lethal.

Experts make a distinction between risk communication and crisis communication (Reynolds & Seeger, 2005). In practice, risk communication most often involves the production of public messages regarding health risks and environmental hazards. Risk communication provides information about the expected type (good or bad) and magnitude (weak or strong) of an outcome from a behavior or exposure. Typically, it consists of a discussion about an adverse outcome and the probability that the outcome will occur. Risk communication targets behavior by providing knowledge and tools to individuals and groups so that they can reduce their risk of an exposure, or modify or abandon the risk behavior and thereby diminish the likelihood of a negative health outcome. Effective communications campaigns have middle-term horizons and key messages that are based on building credibility and trust as well as empowering decision making and crafting calls to action.

Risk communication is only a part of an overall risk analysis framework, which also includes risk assessment and risk management (Figure 1).

Figure 1: Risk Analysis Framework



Crisis communication is associated with unexpected events or crises that an organization or government is facing, and to which it must respond (e.g. toxic spill, transportation accident, plant explosion, hurricanes). Its purpose is to disseminate messages that explain the crisis, support affected communities and stakeholders, and give information about evacuation, shelters, drinking water, and the like. These types of messages essentially inform and persuade.

These events and the way they were publicly managed have led to various critiques, most often stressing flaws in communicating risks to the public during rapidly evolving situations. For instance, Hurricane Katrina is emblematic of a complete institutional failure. As a result of internal communication and coordination failures at the state and federal levels, it is thought that people died in greater numbers than would have been predicted (Gheytanchi, Joseph, Gierlach, Kimpara, Housley, Franco and Beutler, 2007). Counterexamples also exist; for example, the effectiveness of Singapore’s response to the SARS crisis (Menon, 2006).

Risk and crisis communication have important relationships with both the public and the media. Professional collaborations in these fields have improved, owing to an increased need for joint work with health authorities to obtain knowledge needed to adequately address the public.

There is now consensus on the intrinsic qualities of a professional campaign: i) audiences tend to simplify messages and reduce their complexity; therefore, it is important to communicate with this principle in mind; ii) credibility and believability go hand in hand; therefore, experts really need to be independent; iii) risk messages should include some efficacious action that individuals can take to alleviate risk; iv) messages should be matched to audience needs and values, and their

particular economic, political, and sociological backgrounds; and v) candor, openness, and transparency are the cornerstones of risk and crisis communication.³

New social media and electronic networks (e.g. blogs, Facebook, Twitter, podcasts, e-cards, etc.) pose new challenges to public health communicators. Public health campaigns must now be tailored to a variety of audiences that do not read the same news media outlets, nor inform themselves in the same ways. Campaigns must be devised in many more sub-categories and must reach out to many more different communities and stakeholders. This is true both for routine risk communication and ad hoc crisis communication.

3.2. Research gaps, research needs, and questions

3.2.1. Risk communication and crisis communication: new tools or new philosophy?

The critical issue for risk and crisis communication is the need to move away from standard public-relations campaigns toward strong anticipatory and elaborate strategies. Some experts believe that current crises are very different from older ones: “The accidental, compartmentalized crises of the 20th century have mutated into systemic dislocations calling for new intelligence” (Granatt, Young and Lagadec, 2009). Further, some experts call for much more elaborate strategic thinking that deliberately moves away from a “plan” culture; plans can give false comfort to managers and leaders and may be counterproductive in the face of rapidly evolving crises (Lagadec, 2009). Moving away from a ‘plan culture’ allows for the development of ad-hoc strategies, according to local situations and needs. Pre-determined scenarios are important tools to develop and rehearse; yet they should be supplemented with ‘out-of-the box’ capabilities.

There is an urgent need for research that assesses the value of plans and predetermined mitigation strategies. Do plans work, or do those on the frontlines of a crisis struggle to modify and adjust them as crises unfold? If and when they do so, what is known about the implicit or explicit criteria they are using to adapt plans?

3.2.2. Risk perception

This new philosophy also implies a move away from dogma such as “educating the public” and “educating the media.” The idea is to use public perceptions, resources (cognitive, social, symbolic), rationales, beliefs, and assumptions to determine the real degree of risk perceived by the public, as well as to use the opinions of experts, stakeholders and political appointees for building a reasonable communication strategy capable of dealing with uncertainties. Of course, the first step is to understand if this approach can be understood and embraced by different countries, cultures, and social classes.

³ Adapted from Covello VT, Allen F. The Seven Cardinal Rules of Risk Communication (1988).

1. Accept and involve the public as a partner
2. Plan carefully and evaluate your effort
3. Listen to the public’s specific concerns
4. Be honest, frank and open
5. Work with other credible sources
6. Meet the needs of the media
7. Speak clearly and with compassion

For example, it is believed that one of the reasons why Europeans oppose genetically modified organisms more strongly than do Americans or Canadians is the impact that several previous health crises -- "mad cow" disease, transfusion of HIV-infected blood and blood products, and the development of Creutzfeldt-Jakob disease in persons treated with human growth hormone -- have had on beliefs, social practices and risk perception.

Understanding the perception of risk is vital to risk and crisis communication. Not all risks are created equal. Risk communication is an interactive process that requires constant feedback from the public. Risk perception surveys can help explain "why some risks cause more alarm than others" and give direction to improving communication methods. Risk communication that involves the public as an active participant in the process of understanding and controlling risk implies a different dialogic communication between experts and the public (Abrahams, 2009).

3.2.3. Rumors: Production, dissemination, influence

One of the goals of risk communication is to promote and maintain trust and confidence in the actions of government or other organizations through open and honest information, acknowledging uncertainties where they exist. Oftentimes during a public health emergency we also face an "epidemic of fear," mistrust, and widespread suspicion.

Rumors, tales, urban legends and false stories, which have always existed, especially during epidemics, now have the potential to spread to millions of people in an instant via the Internet and other electronic forums. Some studies show that rumors and conspiracy theories are now part of mainstream political opinion (Stempel, Hargrove and Stempel III, 2007). If this is the case, a much clearer understanding is needed for why rumors develop, spread, mutate, or die. For example, cultural, political, and economic factors are important considerations. It is believed that rumors develop and amplify where uncertainties and lack of leadership are apparent (Prasad, 1935; Allport and Postman, 1947). Rumors help to make sense of what is happening and reduce the level of anxiety. They provide narratives and attribute clear responsibilities. Some scholars also suggest that groups with less access to "legitimate" sources of information are more subject to rumors and more prone to disseminate them in their communities (Mirowsky and Ross, 1983; Knight, 2002).

Our understanding of the dissemination of rumors requires further research (Harris, 2006). Rumor research is not new, with the study of rumors by psychologists dating back more than seventy years (Prasad, 1935). Dunn and Allen (2005) have developed a working definition of a rumor: "A rumor is a hypothesis offered in the absence of verifiable information regarding uncertain circumstances that are important to those individuals who are subsequently anxious about their lack of control resulting from this uncertainty."

The International Health Regulations (2005) enable the WHO and other public health institutions to act upon circulating rumors, notably those on the Internet. Public health intelligence and surveillance schemes track rumors about possible disease outbreaks in real-time and seek follow-up information from local and national health authorities. This pro-active approach seeks to obtain information and confirmation more quickly than the older system of reactively waiting for a country to declare a public health problem or emergency. While rumour tracking is helpful to give advance warning of a possible public health emergency, it is also of interest to gain a better understanding of the contextual appearance of such rumors: where do rumors start within a network and how convincing are they and to whom. These questions are part of current research

agendas that use game and network theories (Kostka, Oswald, Wattenhofer, 2008). The use of the Internet is also stimulating interest in rumor research and studies, as fieldwork is relatively easy, i.e. one can review web archives and discussion groups on specific topics such as “rumors” and see how well they travelled over the Internet (Bordia and DiFonzo, 2004). One area for much needed research is understanding stigmatization (for instance, the stigma of “the Mexican flu”) and discrimination.

3.2.4. *Work with media*

Major public health emergencies and alerts will instantly engage the media, who should be seen as major stakeholders in all the processes of communication. The media are not an adjunct to public emergency response; they have their own obligations to the public. Public health emergency planners should acknowledge the media’s role in a crisis and plan to meet reasonable media requirements during the outbreak. This requires that health officials have adequate media training which in turn can help the media to deliver objective and correct information during public health emergencies. Media tracking and message analysis, especially to monitor whether the media are aligned with official data and actions, as well as to prevent the generation of rumors is important during an emergency. However, few tools exist for health authorities to do this and further investigation in this area is needed.

3.2.5. *Organization, sense-making, and communication*

Another key issue is to better understand the influence of internal organizational or institutional debates and controversies on external public messages. Communicating about uncertainties and potential hazards calls for a clearer understanding of the sense-making activities at work inside the organization, or, rather, inside the network of organizations concerned with the problem. Communication strategies and messages are the result, and in return, these strategies and messages shape organizational responses and decision-making processes.

Very little is known about how organizations (whether international, regional, local, public, or private) coordinate responses in conjunction with one another and ultimately influence the general process of sense-making in the public arena (Ansell, A. Keller, A. Reingold, M. Bourrier, 2009).

The pandemic (H1N1) 2009 has brought different organizations and different countries together in response development. The best example is the Risk Management and Communication Working Group,⁴ a part of the Global Health Security Initiative,⁵ which some years ago started

⁴ Main objectives of the group are to: 1. share emergency preparedness and response plans, including contact lists, and consider joint training and planning and agree on a process for international collaboration on risk assessment and management and a common language for risk communication.

⁵ The GHSI was formed in October 2001 and provides a global forum for high-level discussion around and the coordination of public-health emergency-preparedness and response policies. The overarching purpose of the GHSI is increasing preparedness among its members to address health-related threats to global security, such as nuclear, chemical, or radiological terrorist attacks, and outbreaks of infectious diseases. The GHSI members, who meet annually, are the Ministers of Health from Canada, France, Germany, Italy, and the United Kingdom; the Secretaries of Health from Japan, México, and the United States; the Health Commissioner of the European Union (EU); and the Director-General of the World Health Organization (WHO). (<http://www.globalhealth.gov/initiatives/ghsi.html#ghsi>)

developing and sharing key messages for a possible pandemic of avian influenza. This group has constantly communicated and exchanged information and messages since the beginning of the 2009 H1N1 pandemic. For some countries this has been a very valuable way to unify information based on scientific evidence and the experience of other communicators.

3.2.6. From routine risk communication to crisis communication

It is believed but remains to be scientifically proven that a rich, active field of routine risk communication (involving recurrent campaigns) is a key element in the success of crisis communication. Implementing a solid communication strategy from scratch is a daunting challenge, especially for under-resourced countries, where recurrent public health campaigns are rare, if they exist at all. Therefore, in the absence of routine risk communication, research is needed to develop a feasible strategy for crisis communication.

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