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# Challenges of global surveillance during an influenza pandemic

S. Briand*, A. Mounts, M. Chamberland

*Global Influenza Programme, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland*

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SUMMARY

Surveillance is an essential foundation for monitoring and evaluating any disease process, and is especially critical when new disease agents appear. The H1N1 influenza pandemic of 2009 tested the capacities of countries to detect, assess, notify and report events as required by the 2005 International Health Regulations (IHR). As detailed in the IHR, the World Health Organization drew on official reports from Member States as well as unofficial sources (e.g. media alerts) to quickly report and disseminate information about the appearance of the novel influenza virus. The pre-existing Global Influenza Surveillance Network for virological surveillance also provided crucial information for rapid development of a vaccine and for detection of changes in the virus. However, the pandemic also highlighted a number of shortcomings in global epidemiological surveillance for respiratory disease. These included the lack of standards for reporting illness, risk factor and mortality data, and a mechanism for systematic reporting of epidemiological data. Such measures would have facilitated direct comparison of data between countries and improved timely understanding of the characteristics and impact of the pandemic. This paper describes the surveillance strategies in place before the pandemic and the methods that were used at global level to monitor the pandemic. Enhancements of global surveillance are proposed to improve preparedness and response for similar events in the future.


## Introduction

Global surveillance is an essential foundation for monitoring and managing an influenza pandemic. Its goal is to develop a global picture of the event through sharing and analysis of information provided by individual countries. This, in turn, results in a better understanding of key epidemiological, virological and clinical features of the pandemic; guides global prevention and control activities, such as equitable access to antivirals and vaccines; allows healthcare providers and public health authorities to modify national strategies for case management, community mitigation and health resource allocation upon consideration of their own and other countries' information and experience; and reduces the impact of inaccurate and unconfirmed rumours.[1]

The global overview of past pandemics is very incomplete. Surveillance and epidemiological information about prior pandemics is available for some countries in varying levels of detail. This information was often determined decades later through painstaking retrospective research and analysis.[2–5] Much of this work was prompted by preparedness planning in advance of the influenza A (H1N1) pandemic in 2009.

Prior to the A (H1N1) 2009 pandemic, the World Health Organization (WHO) undertook a concerted effort with regions, Member States and other partners to plan for global surveillance during a pandemic,[6] and to improve seasonal surveillance at global and regional levels.[7,8] However, these efforts faced formidable challenges. Systems of surveillance for seasonal influenza are typically found in medium- and well-resourced countries but are rare in less-resourced areas. In March 2009,

* *Corresponding author*. Tel.: +41 22 791 23 72; fax: +41 22 791 48 78.
E-mail address: briands@who.int (S. Briand).
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a few weeks before the emergence of the H1N1 pandemic, 106 (54%) of 193 WHO Member States had no or very limited seasonal influenza surveillance capacity. A WHO review of 140 published national pandemic preparedness plans found that although many Member States had plans for the early detection and investigation of a pandemic, less than 20 countries had developed plans for ongoing monitoring throughout a pandemic.

This paper describes the global surveillance and monitoring systems that were in place prior to the pandemic; provides an overview of global surveillance during the first 9 months (April 2009–January 2010) of the pandemic; outlines some of the challenges that were identified as a result of the experience gained; and considers how global influenza surveillance can be strengthened in the future. It reflects the experience and perspective of WHO at the global level (i.e. WHO's headquarters in Geneva) during the 2009 pandemic.

## Global surveillance prior to the H1N1 pandemic

At the global level, there were three mechanisms in place for early detection and/or surveillance of influenza prior to the H1N1 pandemic: the 2005 International Health Regulations (IHR); the Global Influenza Surveillance Network (GISN); and systematic event detection.

### *The framework of the international health regulations*

The IHR provide a framework for the detection, notification, verification and early response to public health events that have the potential to cross borders and threaten people worldwide.[9] The earlier IHR (1969) focused primarily on reporting human cases and associated hosts/vectors for plague, yellow fever and cholera to WHO.[10] The 2005 revision of the IHR, which entered into force in June 2007, was influenced by the growth in international trade and travel, and by an increased appreciation of the risk of emerging pathogens, including pandemic influenza.[10]

The IHR mechanism specifies that WHO can receive information from unofficial sources, such as non-governmental organizations, in addition to official sources such as the ministries of health of its Member States. Under the IHR (2005), a number of reporting requirements oblige States Parties to promptly inform WHO of cases or events involving a wide range of diseases and public health risks including 'all cases of human influenza caused by a new virus subtype'. The official notification to WHO of cases or events likely to pose a serious international public health risk is done by a nationally appointed focal point (NFP) within 24 h of the country's assessment. WHO maintains a restricted-access website (event information system) to inform States about unusual events reported through the IHR and to convey WHO's assessment of their severity. The IHR also mandate WHO to perform public health surveillance, support States in their development of relevant capacities, and co-ordinate response activities to events that constitute an international public health risk. In extraordinary circumstances, the Director-General of WHO can determine that a 'public health emergency of international concern' is occurring. In this case, after taking advice from a committee of external experts (i.e. the Emergency Committee), the Director-General can issue 'temporary recommendations' to governments on the appropriate actions to prevent or reduce the international spread of the disease and minimize necessary interference with international traffic and trade.[10]

### *The global influenza surveillance network*

For more than 60 years, the GISN has monitored influenza activity and characterized circulating influenza virus strains. These efforts are the critical underpinning to formulate recommendations each year for seasonal influenza vaccines and to provide prototype viral strains for vaccine production. In addition, the GISN functions as a global early warning system to detect unusual influenza strains which could have the potential to become human pandemic viruses.

The GISN has grown into a global partnership of 131 national influenza centres (NICs) in 105 countries, five highly specialized collaborating centres (WHO CCs) for reference and research on influenza, and three national licensing agencies or essential regulatory laboratories (Fig. 1). The NICs collect, identify and analyse influenza strains isolated from clinical specimens, and forward representative or unusual virus isolates to a WHO CC for detailed characterization. Although individual-level epidemiological or clinical data are not collected, NICs provide weekly reports to WHO of geographically-based influenza-like activity using FluNet, a web-based electronic interactive data reporting, query and mapping system.[11]

In response to the challenges presented by the emergence and spread of highly pathogenic avian influenza A (H5N1) viruses in animals and humans, WHO established an ad-hoc network of H5 reference laboratories within the GISN in 2004. In addition, WHO worked with countries to expand the geographical coverage of the NICs. Both of these actions further enhanced the GISN's early detection capacity for novel viruses and reinforced the importance of co-ordinated animal and human health surveillance. However, despite the increase in the number of laboratories and expanded geographical coverage, influenza laboratory capacity in Africa was limited before the pandemic.

### *Systematic event detection*

In addition to official mechanisms of notification, WHO systematically monitors informal or unofficial sources of information to detect possible infectious disease outbreaks.[12] Much of this information is gathered using software such as the Global Public Health Information Network (GHPIN). GPHIN, developed by Canada's Public Health Agency in collaboration with WHO, is an internet-based system that continuously scans global media sources such as the web pages of major newspapers, biomedical journals and electronic-mail-based discussion groups (e.g. ProMed). Unusual disease events and rumours that are deemed to be of potential international importance are subsequently verified with countries.

## Preparation for pandemic surveillance

As part of global pandemic preparedness, WHO convened a technical consultation on surveillance for pandemic

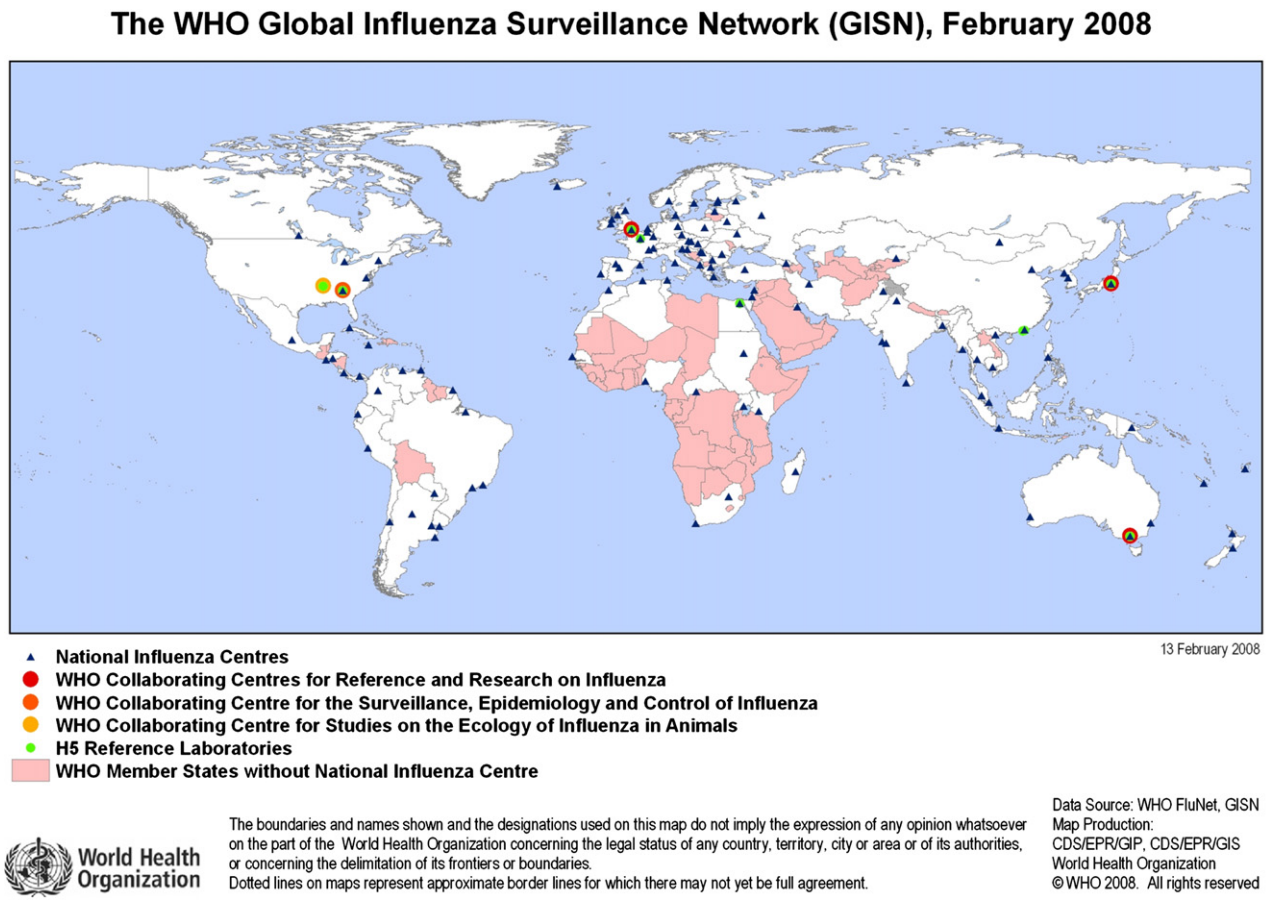


**Fig. 1 – The WHO Global Influenza Surveillance Network (GISN), February 2008.**

influenza in December 2007, attended by nearly 100 experts and key stakeholders from 25 countries.

The consultation reinforced that the availability, quality and timeliness of global information about a pandemic was inextricably linked to systems at the national level; however, there was tremendous diversity in the capacity of countries for surveillance. In view of this, it was recommended: (1) to identify a minimum core set of indicators that were feasible for all countries to collect, yet would be useful in managing the pandemic at global and national levels; (2) to place a limited emphasis on reporting individual case counts at the global level; (3) to implement different surveillance activities during the course of a pandemic to match evolving information needs at country level (Fig. 2); and (4) to build pandemic monitoring systems on existing tools and surveillance systems whenever possible.[6]

Subsequent to the consultation, WHO published guidance on global surveillance during a pandemic in April 2009 at the start of the (H1N1) 2009 pandemic.[1] As part of national pandemic preparedness planning, countries were advised to plan for enhanced surveillance comprised of three components: (1) early detection and investigation; (2) comprehensive assessment of the first 100 or so cases; and (3) pandemic monitoring.

The objective of the first component (i.e. to detect and investigate the first evidence of sustained human-to-human transmission of an influenza virus with pandemic potential) was closely aligned to the notification, reporting and verification requirements under the IHR. The guidance acknowledged that collection of detailed epidemiological, clinical and virological data during the second component (i.e. comprehensive assessment) would require an intensive effort on the part of countries. However, this information was critical for WHO to provide an initial assessment of the severity of the event and for countries to refine their pandemic response plans and prioritize interventions. Comprehensive assessments were not to be limited to the first affected countries, but rather were to be carried out by all countries to improve understanding of the pandemic and refine interventions during its course. Reports from Member States to monitor the pandemic (i.e. third component) tracked qualitative indicators of the geographical spread of the virus, national disease trends, the intensity of transmission, the impact on healthcare infrastructure, and any changes in the antigencity and antiviral sensitivity of the virus.

## Surveillance during the H1N1 pandemic

### *Early detection and investigation*

In mid-March 2009, the Mexican Ministry of Health began to identify an unusual increase in the number of cases of influenza-like illness at a time when seasonal outbreaks were typically declining.[13] By early-to-mid April 2009, increases in severe pneumonia requiring hospitalization were occurring

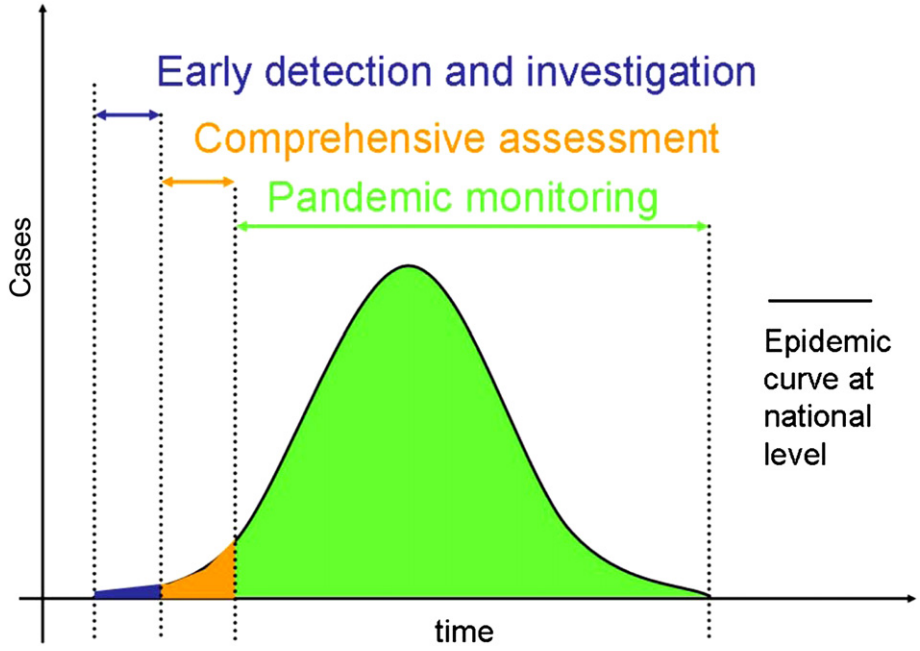


**Fig. 2 – Overview of the three surveillance components at national level.**

principally among young, previously healthy adults in different areas of Mexico.[14] The Government of Mexico reported these events to WHO through the IHR reporting system in April 2009. In April 2009, the US Government notified WHO through the IHR system about a novel swine-origin influenza A (H1N1) virus that had been identified in specimens obtained in late March from two epidemiologically unlinked children living in southern California who had developed an acute febrile respiratory illness.[13,15] On 23 April 2009, the National Microbiology Laboratory of the Public Health Agency of Canada determined that the influenza virus isolated from patients in Mexico was identical to the influenza A (H1N1) viruses from the two Californian patients.[13] The Mexican Ministry of Health immediately reported these findings to WHO. WHO, in turn, shared this critical information globally with IHR NFPs through the IHR information mechanism (i.e. event information system). Two days later, the WHO Director-General, after having convened the Emergency Committee under the IHR (2005), declared that the events constituted a public health emergency of international concern. Countries were advised to intensify their surveillance efforts and remain alert for unusual outbreaks of influenza-like illness.

On 27 April 2009, WHO raised the pandemic alert level from Phase 3 to Phase 4 based primarily on epidemiological data demonstrating human-to-human transmission of the virus and sustained community-level outbreaks. Disease had already been reported from three different locations in Mexico. Given the widespread presence of the virus, and on the advice of the IHR Emergency Committee, the WHO Director-General considered that rapid containment planned in Phase 4[16,17] to halt transmission of the virus at its source was not possible. Sustained human-to-human transmission was soon documented in at least two countries (the USA and Mexico) in the same region, prompting WHO to raise the alert level to Phase 5 on 29 April 2009. WHO did not advise border closures or restrictions on international travel.[13] The first outbreak investigations found that a significant proportion of cases had no or minimal symptoms, reducing the likelihood that screening at border crossings would be effective. For the next several weeks, spread of the virus globally was documented through reporting of laboratory-confirmed cases and deaths through IHR focal points in each newly affected country. Daily updates on the situation were issued on the WHO website during the first weeks of the pandemic. There was a continued need to detect and report the virus as it appeared in each subsequent country, to inform decisions about pandemic phases and to alert countries that had not yet been affected.

The GISN facilitated the rapid sharing and analysis of virological specimens from early cases of H1N1 pandemic influenza. Within days of the announcement that a new influenza A virus had been detected in patients in Mexico and the USA, the WHO CC at the Centers for Disease Control and Prevention in Atlanta developed a diagnostic protocol using a real-time reverse transcriptase-polymerase chain reaction for the pandemic influenza A (H1N1) 2009 virus that was electronically shared on the GISN website.[18] Shortly thereafter, the WHO CC in Atlanta made polymerase chain reaction kits available to laboratories worldwide.

### *Comprehensive assessment, including pandemic severity*

The first affected countries undertook comprehensive assessments of their early cases to characterize the clinical illness and spectrum of disease more fully, to describe the risk factors for severe outcomes, and to track any changes in the pandemic virus and its associated disease as it began to spread globally. These initial assessments were based in large

part on reports from clinicians, public health officials and other experts during teleconferences organized by WHO with affected countries during the first weeks of the pandemic.[19–21]

This information was critical for WHO to make a preliminary determination about the severity of the pandemic. The assessment of severity proved to be complex upon consideration of the multiple factors that influence the health effects of a pandemic: (1) the virological, epidemiological and clinical characteristics of the pandemic virus; (2) the vulnerability of the population, related in part to the level of pre-existing immunity to the virus in the population and the proportion of people who have medical or other conditions that may increase the risk for serious or fatal illness; and (3) the capacity of the population for response including access to care, risk communication, social mobilization, and advance planning and preparation.[22]

Further complicating determination of the pandemic's severity was the limited availability of high-quality information at the time. For example, the case fatality ratio, although an important indicator of severity, proved particularly problematic because of incomplete information for both the number of deaths and the number of persons who had been infected, including those with mild disease. Severity-related parameters that were useful early in the pandemic included the proportion of cases that required hospitalization for treatment or required intensive care and mechanical ventilation, and the proportion of severe cases that occurred in previously healthy individuals without underlying risk factors. The impact on the healthcare system was reflected in hospital occupancy rates, the proportion of intensive care beds occupied by influenza cases, and the busyness of emergency rooms and outpatient treatment centres. However, few of these indicators of impact had historical data to place them in context, and the interpretation of the data depended somewhat on anecdotal reports. Most of this information was not available through routine information systems but was obtained through *ad-hoc* data collection.

On 11 June 2009, WHO raised the pandemic alert level to Phase 6 as there were cases in more than two WHO regions. At that time, 74 countries had officially reported 28,774 laboratory-confirmed cases of influenza A (H1N1) infection, including 144 deaths; however, these numbers likely underestimated the actual situation in countries. At this time, WHO provided an initial assessment that, overall, the H1N1 pandemic was of moderate severity. This assessment reflected that: (1) most people appeared to recover from infection without the need for hospitalization or medical care; (2) overall, national levels of severe illness from influenza A (H1N1) appeared similar to levels seen during local seasonal influenza periods, although high levels of disease had occurred in some local areas and institutions; and (3) overall, hospitals and healthcare systems in most countries had been able to cope with the numbers of people seeking care, although facilities and systems had been stressed in some localities.[23]

This information was used by countries to activate and update their pandemic preparedness and response plans, make decisions about the use and allocation of vaccines and antivirals, implement proportional mitigation measures, and deploy supplies and human resources.

### *Monitoring*

As the pandemic evolved, the focus of the global surveillance activity transitioned to one of monitoring its progress and detecting any changes in the virological, clinical or epidemiological patterns associated with disease. Relevant data were derived from a variety of approaches, including monitoring the media and rumour surveillance, both of which were in place before the pandemic. In addition, systematic monitoring of national websites that reported on the pandemic's progress as well as regular review of the published literature were initiated. Networks of experts (i.e. clinicians, epidemiologists, modellers and virologists) were created to provide a platform for information sharing via regularly scheduled teleconferences. In these fora, the early results of investigations could be shared with colleagues in countries that had not yet experienced their first cases, and regular updates on the course of the pandemic could be communicated. WHO regional offices also communicated directly with national governments and reported summary information to WHO headquarters.

The view that emerged was that the pandemic placed a moderate burden on most healthcare systems but was particularly problematic for intensive care units because of the disproportionate number of cases requiring prolonged ventilatory support. Mortality rates were not excessive overall, but disproportionately affected the young and spared the elderly. Overall, the risk factors associated with severe disease and death were similar to those seen with seasonal influenza. However, the pandemic differed from seasonal influenza in that there were fewer cases in older age groups and 40–50% of severe cases occurred in young healthy adults with no underlying risk factors. In addition, some groups reported that obesity possibly increased the risk of severe disease.[24,25]

As the global number of reported laboratory-confirmed cases approached 100,000 by the beginning of July 2009 (Fig. 3), it became clear that case-based surveillance was placing an unnecessary burden on national surveillance systems, including laboratory testing capacity. Also, case counting had become less useful to public health decision makers.

In July 2009, WHO issued new guidelines for surveillance requesting countries to continue to report laboratory-confirmed fatal cases and to focus testing activities on severe cases.[26] Member States were still requested to report unusual events suspected to represent a change in the pattern of transmission or the epidemiological and clinical characteristics of the pandemic virus. In addition, countries were requested to report through their NFPs by e-mail on the national status of the pandemic using the following qualitative indicators: the geographic spread of the pandemic virus in the country; the intensity with which disease was occurring; whether the number of cases was trending upwards or downwards; and what impact the pandemic was having on the healthcare infrastructure.

The GISN's monitoring of circulating pandemic and seasonal influenza viruses, including their antigenic and genetic characterization and resistance to antivirals, continued to be a key component of the global response.[27] Under the co-ordination of the GISN, WHO CCs, essential regulatory laboratories and other institutions worked to develop candidate vaccine

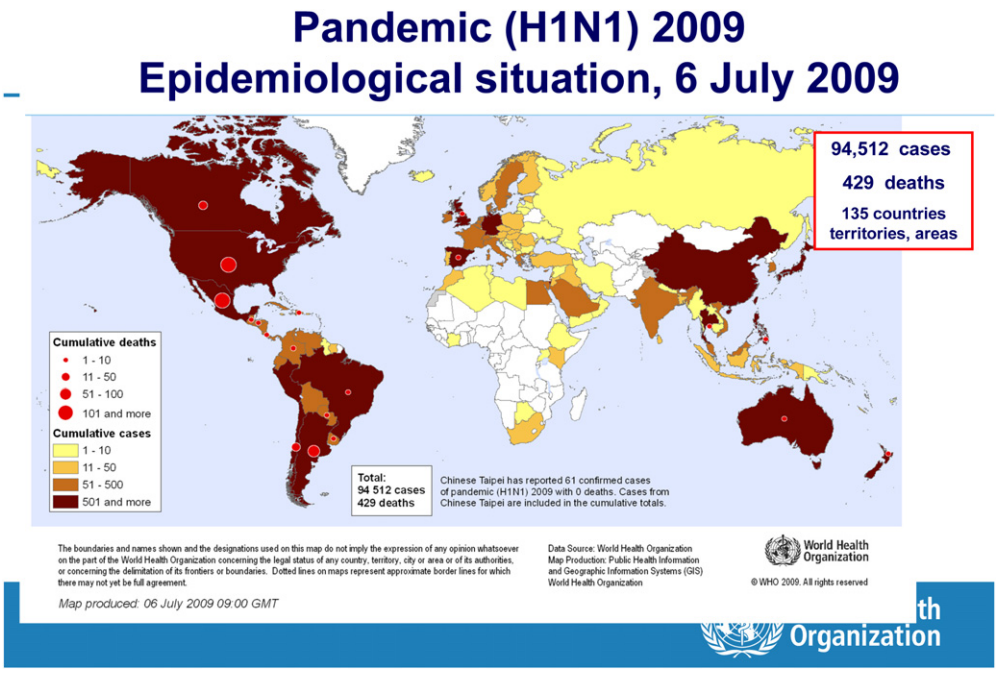


**Fig. 3 – Pandemic (H1N1) 2009 – epidemiological situation on 6 July 2009.**

viruses using a variety of techniques. Within 1 month of identification of the H1N1 2009 virus, WHO recommended the A/California/7/2009-like virus for pandemic vaccine development. Serological studies undertaken by WHO CCs determined that while some older adults had evidence of cross-reactive neutralizing antibodies to the pandemic H1N1 2009 virus, children and young adults had little or no antibody protection.[27]

After the initial detections of pandemic H1N1 viruses with resistance to the antiviral drug oseltamivir were reported through the IHR mechanism in early July 2009,[28] WHO continued to collate and analyse additional reports of resistance at the global level. This, in turn, helped to inform national and global recommendations on the optimal use of antiviral drugs for the H1N1 pandemic virus, in particular the recommendation not to use antivirals as a prophylactic measure in contacts.[29] Similarly, following the emergence and reporting of pandemic viruses with the D222 G and other amino acid substitutions,[30] the GISN was activated to closely monitor and assess any risks associated with such viruses.

## Challenges to global surveillance during the pandemic

The detection, reporting and monitoring of the influenza A (H1N1) 2009 pandemic highlighted both the successes and limitations of global surveillance.

### *Timeliness of information*

The IHR structure served as a key channel for early reporting of the initial cases of pandemic influenza and other unusual events such as antiviral resistance. Timely information about the number and early, widespread geographic distribution of cases led WHO to conclude that any opportunity to implement a rapid containment strategy (i.e. widespread, population-based use of antivirals for treatment and prophylaxis coupled with non-pharmaceutical interventions in a defined geographic area to prevent spread of a pandemic virus beyond a small cluster of initial cases)[17] had passed. Instead, WHO's earliest recommendations focused on the use of public health and mitigation measures (e.g. social distancing, respiratory etiquette and hand hygiene). In addition, WHO advised against closing borders or restricting international travel to minimize disruptions to the global economy, as had occurred during the outbreak of severe acute respiratory syndrome.

Importantly, the requirements of the IHR do not include continued reporting of detailed epidemiological and clinical information which is important for planning and response efforts. Instead, these data were collected from a variety of public sources and through the expert's networks organized by WHO during the early stages of the pandemic. WHO developed similar networks during the severe acute respiratory syndrome outbreak and found them to be helpful. Although reporting to these networks was voluntary, it proved to be an effective tool for information sharing that supplemented established routine surveillance mechanisms; such networks should be considered during unusual events.

Although WHO developed a framework for assessing the severity of the pandemic's health effects,[22] detailed information about the severity of the disease was not available at the early stages of the pandemic. Much of our subsequent under-standing about the severity of the pandemic and the spectrum of associated illness required intensive, detailed investigations of cases supplemented with mathematical modelling[31] studies and other formal research. The time required to develop even preliminary estimates of severity

parameters, such as the case fatality ratio, lagged behind key decision making and response planning that WHO and countries needed to initiate regarding pharmaceutical and non-pharmaceutical interventions.[32]

There were inevitable instances in which sharing of data was delayed until after its publication in a peer-reviewed journal. WHO's networks of investigators ameliorated this to some extent by allowing investigators to informally share preliminary results of ongoing investigations with colleagues from other countries by teleconferences. Weekly public health reports with rapid turnaround times, such as WHO's *Weekly Epidemiological Record*, the European Centre for Disease Prevention and Control's *Eurosurveillance* and the Centers for Disease Control and Prevention's *Morbidity and Mortality Weekly Report*, which are freely available online and widely distributed, served as effective vehicles for the early dissemination of surveillance data and investigation results. In addition, many journals aided the rapid dissemination of critical information through expedited review of H1N1-related papers and making then freely available online to non-subscribers. This published information was still relevant many months into the pandemic for countries that had not yet been affected.

### *Gaps in surveillance information*

The pandemic demonstrated that although many countries are able to detect unusual events, they lack surveillance capacity to monitor an outbreak over an extended period of time. The absence of pre-existing routine surveillance for respiratory disease in much of Africa and parts of Asia resulted in substantial information gaps about the progress of the pandemic in large areas of the world. It is still unclear at the time of writing if all of West Africa has yet experienced sustained community transmission of pandemic influenza. Some countries were also reluctant to report on the progress of the pandemic for fear of discouraging tourism and trade.

Influenza monitoring systems have historically focused on mild outpatient-managed disease (i.e. influenza-like illness) rather than severe respiratory disease. Even countries with longstanding influenza surveillance systems often do not have systems for monitoring severe acute respiratory infections (SARIs) or the means to relate the numbers of severe cases to the population affected. This resulted in difficulty describing the severity of the pandemic in terms of mortality rates or rates of severe infection.

The GISN virological data reporting system was useful to track the appearance and, to a limited extent, the rise and fall of cases in participating countries. However, the GISN has notable gaps, principally in Africa where laboratory capacity for influenza is limited. Despite the early distribution of reagents by the WHO CC in the USA, many countries lacked capacity to detect the virus. Other challenges encountered as part of laboratory surveillance and response included inadequate surge capacity to meet the high demand for laboratory testing and difficulties in prioritizing specimens for testing. In some instances, this led to the exhaustion of reagents before the peak of the pandemic. WHO was able to support the shipment of specimens from countries with no influenza laboratories to reference laboratories through its Shipment Fund Project.

Finally, the absence of a global mechanism for direct reporting of epidemiological data, analogous to the FluNet system for virological data reporting, contributed to the sporadic and labour-intensive manner in which data were finally collected at the global level. WHO is working to implement a web-based electronic platform for reporting of epidemiological data. However, its success will require improvements in national surveillance and reporting capacities, along with open and transparent data sharing.

### *Lack of standardization at the global level*

The lack of standardization across national surveillance schemes often made comparisons between countries impossible. As an example, countries use different criteria for influenza-like illness, and collect and summarize age-related data using different break points in their age groupings. Thus, while general patterns can be observed, it is impossible to aggregate or directly compare data from countries using different groupings. Similarly, countries collected information on different risk factors for severe disease and death and used varied definitions for factors such as obesity and chronic cardiovascular disease. Even the reporting of fatal cases was complicated by the use of different definitions for 'influenza-associated' death. Consequently, at a global level, there was considerable imprecision in reporting such key parameters as the proportion of previously healthy young adults with influenza-related severe respiratory disease (e.g. range of 20–50%). As the genetic markers for severity of disease and transmissibility are not completely understood, tracking epidemiological markers as the virus moves from country to country is critical for detecting changes that might reflect an important mutation.

### *The problem of 'acute numberitis'*

It became evident very quickly, despite the demand for actual case counts by the media and the general public, that it would not be possible to maintain a global count of laboratory-confirmed cases of pandemic influenza. Some viewed this as evidence that surveillance was 'ineffective' or that WHO was hiding key information. However, case counts were never accurate, even from the beginning of the pandemic, due to limitations in detecting and testing all persons with an influenza-like illness, nor would it have been a good use of resources to attempt to do so. Further, such efforts do not take into account the potentially large number of persons who were asymptomatic or experienced a mild, non-specific illness. Different surveillance approaches and testing policies by different countries resulted in wide disparities in the reported numbers of both mild and severe cases of pandemic influenza between countries. Such technical constraints are challenging concepts to convey to the media and the public, especially in the setting of uncertainty associated with an emerging public health threat. At the same time, public health authorities need to review their communication strategies in an effort to better understand and meet the needs and expectations of the media and the public.

Modelling and population-based serological surveys can help to form a more complete picture of infection with the

pandemic virus. The first studies of this nature began to appear some 8–9 months after the initial appearance of the pandemic virus.[33,34] However, comprehensive estimates of the total number of infections and related morbidity and mortality will likely not be available until months after the peak of the pandemic, and perhaps not at all for some countries.

Issues related to case counting and presentation of surveillance data remain a complex communications challenge at global and national levels. For example, the number of deaths reported for pandemic (H1N1) 2009 influenza and annual estimates of seasonal influenza deaths are not directly comparable.[35] Seasonal influenza deaths are estimated using statistical models to derive 'excess mortality' due to all causes (not just influenza) during the period of time when influenza viruses commonly circulate. In contrast, global pandemic-related death counts have been restricted to persons with laboratory-confirmed infection; this results in undercounting pandemic deaths for a variety of reasons. Artificially low case and death counts may have contributed to the perception that WHO and countries 'over-reacted' or have dissuaded persons at increased risk of severe disease to delay seeking care or elect not be immunized.

## Improved global surveillance: the way forward

WHO is currently working to address some of the shortcomings of global influenza surveillance evident during the 2009 pandemic. WHO has defined standards for reporting of fatal influenza-related cases and risk factors, as well as data collection and reporting standards for SARIs and risk factors. Such efforts should improve comparability of data at the global level. An online system of epidemiological influenza data reporting is under development; when implemented, the system will allow countries to report data directly into a database that also contains virological and demographic data. The system will also allow countries without formal surveillance systems to report informal assessments of respiratory disease activity. Both epidemiological and virological data will be available on a WHO global influenza monitoring platform that will display influenza surveillance information provided by countries.

There continues to be a need to strengthen capacity for respiratory disease surveillance in much of the developing world. Respiratory disease is the second most common cause of death in low-income countries, and little is known about the role that influenza and other common respiratory pathogens play. Regular tracking and reporting of influenza and other respiratory pathogens globally is an important tool for creating baseline respiratory disease data and monitoring for signals of a future pandemic or other event of international importance.

Hospital-based sentinel surveillance focused on SARI has been proposed as an efficient and effective way to strengthen a country's capacity for monitoring influenza trends and impact, and to provide critical information about disease impact and risk groups at the severe end of the disease spectrum.[36] Such an approach includes the systematic collection of epidemiological and clinical information, as well as specimens for laboratory testing – ideally from all patients or, if this is not possible, from a representative sample. Sentinel-based surveillance for SARI has application for both seasonal and pandemic settings,[36,37] can serve as a flexible platform for monitoring other respiratory pathogens, provide useful baseline data on severe disease, identify those at highest risk for severe disease, and provide infrastructure needed for response to acute public health events. The utility of influenza surveillance is closely connected to the availability of adequate laboratory capacity. Although progress has been made in increasing the geographic reach of NICs and improving their capacity for diagnosing influenza,[38] there remain notable gaps in access to quality testing, especially in Africa. Further, the development of reliable, inexpensive, fast and easy-to-use point-of-care methods for laboratory testing to detect influenza and other common respiratory pathogens could reduce the burden on NICs and other reference laboratories, especially in the setting of a pandemic.

Finally, access to the Internet and advanced methods of information technology provided an unprecedented capacity to disseminate information as well as augment traditional methods of public health surveillance.[39,40] While this enhanced the collection and reporting of surveillance and other information about the pandemic in real-time, it also served as an efficient vehicle of rumours and misinformation through social virtual networks. For instance, the reporting in virtual social networks of one case of Guillain–Barre syndrome that occurred after vaccination may have helped to foster a belief among some persons that the pandemic vaccine was not safe.

## Conclusion

Preparedness planning followed by the response to the first influenza pandemic of the 21st Century provided a unique opportunity for building and implementing a global system of surveillance to meet both global and national needs. This system, while not perfect, alerted the world to the emergence of a novel, easily transmissible influenza virus capable of causing severe disease; provided early and updated information about the key epidemiological, clinical and virological characteristics of the pandemic virus; monitored and regularly disseminated qualitative summaries of pandemic activity; and facilitated the rapid development of diagnostic tests and a pandemic vaccine. Surveillance information from other countries helped to inform national decision making about the prioritization and scale of control measures, both at the beginning of the pandemic and over time. This was only possible through countries' unprecedented openness and willingness to exchange information and rapidly mobilize available resources.

A global influenza surveillance system should be able to provide an overall picture of seasonal or pandemic influenza at the global level based on contributions of qualitative and quantitative data from as many countries as possible. Data requirements, therefore, must be scaled to a minimum core set of indicators (as was done for the pandemic) and ideally should build on existing platforms and systems. The virological information about the pandemic virus collected through the GISN, for example, was easier to collect than the epidemiological information for which WHO had no pre-established system or standards in place. Clinical information was collected through an ad-hoc mechanism at the global level

and sometimes at the country level as well; such an approach was time and resource consuming. While progress has been made in the development of an electronic system for reporting of epidemiological influenza data, more reflection is needed to address the challenge of clinical surveillance. In many countries, integration of virological and epidemiological influenza data has improved. However, surveillance capacity building in under-resourced countries remains a daunting challenge.

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