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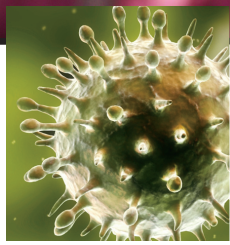

2009 Influenza A/H1N1 Mass Vaccination Strategy: A Multinational Comparison

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Key Points

- Many of the initial responses to the 2009 H1N1 pandemic went well but there are many lessons to be learned for future pandemic planning.
- Greater and timelier access to influenza vaccines worldwide remains an ongoing challenge.
- Initial target groups for vaccination should be well-defined and clearly understood by both the public and public health authorities.
- Local health authorities must play a role in determining when to begin offering vaccines to persons outside the initial target groups, a decision made based on local situations.
- Public health authorities should plan for a range of vaccine supply scenarios when supply is uncertain.
- Factors that influenced vaccine uptake include a history of seasonal influenza vaccination, perceived risk of pandemic influenza, attitudes toward the pandemic vaccine, including vaccine efficacy and potential adverse effects, and importantly in many countries, uptake and recommendation by healthcare workers, particularly general physicians.
- Vaccine should be administered by a combination of public and private providers.
- New ways of dealing with crowds at mass vaccination clinics must be devised (i.e. invitations and/or appointments).
- Vaccination strategies should continuously be revised as new information becomes available and situations change.
- An integrated surveillance system should be developed for immunizations to aid in vaccine monitoring and data collection.
- Our ability to communicate science to various audiences needs to be improved.

Introduction

In 2005 the World Health Organization (WHO) published *WHO global influenza preparedness plan, The role of WHO and recommendations for national measures before and during pandemics* (1) and asked its member states to construct or revise a similar plan specific for their countries. By 2008, 47 countries had a preparedness plan in place (2). In 2009 the WHO published an updated version of the preparedness plan (3) that highlighted the current reality of antiviral drug stockpiling and new approaches to influenza vaccine development.

Using the WHO documents as guidance, Canada developed its own pandemic preparedness plan, *The Canadian Pandemic Influenza Plan for the Health Sector*, first published in 2004 then updated in 2006 with new and revised annexes. The overall goals of the Canadian pandemic preparedness plan are first to minimize serious illness and overall deaths, and second, to minimize societal disruption due to the pandemic (4). The Canadian, American and

European pandemic preparedness plans, which include mass vaccination strategies, assert that actual implementation is the responsibility of local and provincial/territorial (state) governments and that vaccination strategies may need to be adapted as epidemiological, clinical and pharmaceutical evidence accumulates (4-6).

Vaccines are one of the seven pillars in the Canadian pandemic preparedness plan. Modeling studies have demonstrated that vaccination is an effective way of minimizing virus spread, hospitalizations, morbidity and mortality (7), thus making vaccination the cornerstone of most pandemic preparedness plans. The guiding principle of these studies is to vaccinate as many people as possible, as quickly as possible. Unfortunately, pandemic vaccine production can only commence once the pandemic virus has been identified, limiting vaccine availability in the first phase(s) of the pandemic (8). Thus during early stages of the pandemic, strategies must be in place to optimize distribution of the limited and increasingly available vaccine.

Although the mass vaccination strategies employed by various countries adhered to the WHO recommendations, there were slight differences in how each country handled the first pandemic of the 21st century, declared by the WHO on June 11th, 2009 (9). This report contains a multinational comparison of mass vaccination strategies, including the examination of vaccination priority groups, vaccine procurement and distribution methods, vaccine monitoring and data collection, and public heath communications. The goal of this report is to identify the strengths and weaknesses of the 2009 pandemic influenza A/H1N1 (pH1N1) mass vaccination campaign in order to identify potential solutions to better prepare for future public health emergencies.

Vaccination priority groups

The vaccine against pH1N1 only became available in the second wave of the pandemic and thus strategies for vaccine prioritization were implemented. Most countries in the developed world have listed at least one priority group in their pandemic plan (Table 1) (10, 11). The most commonly cited priority groups were healthcare workers (HCWs), followed by essential service providers and people at high risk for complications requiring hospitalization, including pregnant women (10, 12-16). Australia and Canada included people living in remote and isolated communities (i.e. local Aboriginal populations) as a priority group because of their limited access to medical care, and a heightened potential for complications due to delayed treatment or access to intensive care (17). People who live in close proximity to another (e.g. students and military personnel) were additionally classified as a priority group for vaccination in Korea (18). The WHO delivered the pH1N1 vaccine to some of the world's poorer nations, for example Azerbaijan, Afghanistan, and Mongolia in December 2009, and first targeted the HCWs of these nations with the goal to maintain a functional healthcare infrastructure (19).

Priority group compositions among nations were fairly consistent but were influenced by factors such as disparity in vaccine availability and resources for vaccine administration, as well as differences in population structure and organization of essential services (20). Clarity in the criteria used to identify priority group members is essential to ensure public acceptability (10). This notion is particularly important in neighbouring countries with noticeable differences in their respective priority groups (10). The WHO recommends that pandemic plans estimate the number of individuals included in each priority group subpopulation (20). Forecasting the demand for pandemic vaccine will aid health authorities and vaccine manufacturers in establishing realistic plans for vaccine production and deployment. The WHO also recommends that ethics committees be consulted when deciding on vaccine allocation (21).

Although many countries have provided guidelines on who should be included in priority groups, a common theme among pandemic plans was the notion that priority groups will be reevaluated in real time during the pandemic and changes to priority sequencing for vaccination will be made, if necessary, based on the context of epidemiological data. Recent data suggest that elucidating the risk factors for infection at the beginning of an epidemic or pandemic will assist in determining whether initial target groups should be based on age, sex, occupation, etc, and that this form of prioritization should occur before each country sets out to monitor risk of infection in each group (22).

Challenges associated with priority sequencing

Despite the vaccine priority group recommendations made by the WHO, each nation was responsible for assigning individuals to specific priority groups, a task made more difficult due to debate in the validity of preferential vaccination of high-risk persons, particularly the elderly (23). There are supporting evidence that a vaccination strategy aimed at

Table 1. Variation in pH1N1 Influenza Vaccination Programs in Selected Countries

	Australia	Canada	France	Italy	Korea	Maldives	Sweden	United Kingdom	United States
TARGET GROUPS									
Frontline health staff	YES plus social workers	YES	YES	YES plus essential service providers (e.g. police)	YES plus military personnel	YES	YES	YES plus social workers	YES
Pregnant women	YES	YES	YES; <3 mo only if other risk	YES; <3 mo only if other risk	YES	YES	YES	YES	YES
Children	Health risk, >9 yrs	All 6 mo- 4 yrs	Caregivers of <3 yrs	YES	All 6 mo- 6 yrs	6 mo - 10 yrs	Health risk, >9 yrs	Health risk, >6 mo - 5 yrs	Health risk, 6 mo - 4 yrs,
Adults	Health risk	Health risk	NO	Health risk	Health risk	Health risk & police	Health risk	Health risk	NO
Seniors	Health risk	NO	NO	Health risk	YES	YES	Health risk	Health risk	NO
Aboriginal	YES	YES	NO	NO	NO		NO	NO	NO
VACCINE TYPES AND TARGETS									
Adjuvanted, egg grown	NO	All groups	>9 yrs, if no special vaccine risk	All groups	All adults >20 yrs	All groups	All groups	All except egg Allergy	NO
Adjuvant-free, egg grown	All groups	Option in pregnancy	Pregnancy, <10 yrs, transplants	NO	Children 10-19 yrs, healthcare staff	NO	NO	NO	All, but some age restricted
Adjuvant-free, cell-culture	NO	NO	Egg allergy	NO	NO	NO	NO	Egg allergy	NO
Live attenuated	NO	NO	NO	NO	NO	NO	NO	NO	2-49 yrs, Pregnant or high risk
VACCINATION SITE									
School, specialist office or hospital					YES, children only	YES	YES		YES, especially with live vaccine
GP/Specialist Office or Hospital	Most vaccine	Not at beginning of pandemic	From Jan 2010	Some regions	Healthcare staff	Hospital/ health centers	Most vaccine	Most vaccine	Not at beginning of pandemic
Points of distribution									YES
Pharmacy/food stores							YES, late in pandemic		YES, late in pandemic
Other (eg Arean, community centre)		Most vaccine	Most vaccine	Most vaccine	YES; > 65 yrs, Private Clinics for high-risk people	Mobile teams will reach areas without health centres			Most vaccine at beginning of pandemic

Table 1. Continued

	Australia	Canada	France	Italy	Korea	Maldives	Sweden	United Kingdom	United States
NOTIFICATION OF ELIGIBILITY									
Notification mechanism	Media	Media	Mailed voucher from government			Media	Media	From GPs	Media
APPOINTMENT									
How and who?	Some sites	Mainly not	Invitations sent by government for target group, time window		High-risk individuals, > 65yrs		Invitations sent by government for target group, time window	Invitations sent by government for target group, time window	Mainly not

Table adapted from Kendal & MacDonald *Can J Public Health* 2010;101(**6**):447-53.

reducing transmission would be most beneficial at preventing morbidity and mortality (24). According to mathematical modeling studies, a strategy based on mitigating the attack rate would have the greatest impact on decreasing the overall disease burden (25, 26). In line with this idea, additional reports suggest that school-aged children should be the main vaccination priority since this group is disproportionally responsible for influenza transmission and that vaccination of this group could indirectly decrease morbidity and mortality of high-risk populations (27, 28). One group cautions however, that preferential immunization of children is the preferred strategy only when vaccine is available well in advance of the epidemic peak (26). A novel "adaptive" approach to vaccine prioritization developed by Chowell and colleagues using epidemiological data obtained from Mexico during the spring wave of the 2009 pandemic demonstrated that targeting young and middle-aged adults, age 20-59 years, was the best strategy for pH1N1 vaccination (29).

The parameters used in modeling studies, as well as the overall goal of the vaccination campaign, must be taken into consideration when evaluating the computer-based outcomes. When vaccine availability is staggered, as was the case with the 2009 pandemic, a decision regarding the goal of the vaccination program should be made before priority groups can be assigned. According to one report, if the goal of the vaccination campaign is to prevent influenza-related deaths, high-risk persons should be given first priority, followed by school-aged children (5-17), then young adults (18-44). If a reduction in hospitalizations is the public health objective however, school-aged children should be given first priority, followed by young adults and finally by high-risk individuals (30).

Further to the difficulty of governments and health authorities to provide accurate estimates of individuals within each priority group or subgroup, local health departments and providers were challenged by locating these populations as no North American system is currently in place to do so (31). To mount an effective vaccination campaign, authorities must also, to the best of their ability, determine the number of people, particularly within priority groups, who intended to receive the pandemic vaccine in order to ensure sufficient quantities of vaccine were ordered and could be distributed appropriately. Some countries like Mexico (32), Singapore (33) and Canada (34) reported vaccination intention rates ranging from 69%-80%. Unfortunately, high vaccination intention rates were not representative of actual uptake as indicated by the range of reported vaccination rates, 4% in Italy (35) to 45% in Canada (36), indicating that intention alone is insufficient to predict vaccination rates. This also suggests that having well-defined vaccination goals and priority groups may be meaningless if those within the groups are unwilling to be vaccinated. This hence points to the need, on the part of public health authorities, to provide further education and better communication about influenza vaccination and to better understand the public's perception of risk.

Many countries experienced low vaccination rates during the 2009 pandemic (35, 37-40). In a cross-sectional online survey among 2,167 French representative adults conducted in mid-November 2009, only 17% of respondents had accepted pH1N1 vaccination (37). Schwarzinger and colleagues suggest that to increase vaccine acceptance by the French general public, greater efforts should have been made by the French public health authorities to include general practitioners (GPs) in the mass vaccination campaign (41), because the general public considers GPs as a trusted source of information about vaccination (42). In countries with low reported vaccine uptake, the reasons for vaccine refusal consistently and overwhelmingly included concerns regarding vaccine safety and efficacy. Participants in one study indicated that they were hesitant to use a new vaccine because of the many uncertainties surrounding the novel vaccine and that they were concerned about the safety of the adjuvant included in the vaccine (39).

In a comprehensive multinational review on the factors affecting vaccine uptake, the author noted that trust in government and public health authority is required to insure high rates of vaccine coverage (43). The review concluded that some of the lessons learned from the 2009 pandemic include the need for governments to effectively communicate the risk of influenza infection and the benefits associated with vaccination. Clear and timely dissemination of information on vaccine manufacturing procedures, testing and licensure must also be made in order to maintain the confidence and trust of the people.

HCWs are essential to the proper functioning of the healthcare system. They are considered by some to be at high risk for infection due to direct patient contact (44, 45) or contact with infectious substances, and can themselves be efficient transmitters of virus in medical care settings. For this reason, HCWs are frequently the first priority group to be offered the pandemic vaccine (46). Despite the evidence, pH1N1 vaccination rates were low among HCWs in countries such as Turkey (39) and Spain (47). The authors of these studies performed cross-sectional, questionnaire-based surveys in December 2009 at local hospitals to determine the attitude of hospital HCWs towards the pH1N1 vaccine and possible factors associated with vaccine uptake. By the end of December 2009 most HCWs in these countries had not been vaccinated (as little as 16% acceptance) and the most frequent reasons for refusing vaccination were similar to that of the general public – fear of adverse effects and doubts about vaccine efficacy. Contrarily, pH1N1 vaccination willingness was relatively high among French GPs (61.7%) in a separate study (41). This report suggests that the level of knowledge with regard to vaccine efficacy and potential adverse effects varies considerably between occupations (GPs *versus* nurses, for example), and that this variation is responsible for the disparity in vaccine uptake. Also, a number of studies found that previous acceptance of seasonal influenza vaccination was strongly correlated with pandemic vaccine acceptance in HCWs (37, 39, 41). Study results suggest that self-protection against pH1N1, and not professional responsibility toward their patients, was the primary reason for accepting pandemic influenza vaccination among HCWs (34, 39). This finding led Torun and Torun to suggest that educational campaigns geared toward HCWs should include evidence-based information regarding the advantages of the vaccine, vaccine efficacy as well as possible adverse effects, and should focus less on preventing transmission of influenza to patients (39). Such an education campaign could then be geared toward the entire population and not just HCWs. Attempts should also be made toward increasing uptake of seasonal influenza vaccine during interpandemic phases, as this may also increase pandemic vaccine uptake. One study went so far as to suggest that public health bodies should consider implementing a mandatory vaccination policy for HCWs in the next pandemic (48), although such a strategy was initially implemented in New York and later suspended (49). Recently, a combination of mandatory vaccination and an 'opt-out' declination form for HCWs has been proposed (50). This combined approach allows any HCW to refuse vaccination while highlighting the risk of causing serious harm or death to patients through nosocomial transmission of influenza. Those HCWs who refuse vaccination would no longer be allowed to work in areas of healthcare where the most vulnerable patients are being cared for.

The availability of multiple pandemic vaccine formulations (i.e. inactivated, live-attenuated, grown in eggs, grown in cell culture, with or without adjuvant) was the basis for another common challenge faced by the public and healthcare providers. More specifically, the challenge lies in deciding which vaccine formulation should be administered to members of target groups (31). At the beginning of the 2009 pandemic, inactivated, non-adjuvanted vaccine was recommended for pregnant women as there was a lack of clinical data on the safety of the adjuvanted vaccine in this population (51). Unfortunately, this recommendation did not coincide with the availability of the vaccine. In Canada, the inactivated adjuvanted vaccine became available first (52), while in the U.S. the live-attenuated vaccine was first available (31). As clinical data relating to the safety of the adjuvanted vaccine became available, the vaccine formulation recommended for pregnant women changed, adding to the confusion surrounding which vaccine to administer to this population.

The fear of adverse effects due to the adjuvant led some countries to purchase only the non-adjuvanted vaccine formulations (see Summary Table). This resulted in a public relations nightmare when a neighboring country imported all formulations because its citizens believed they were being offered a different "quality" of vaccine (53). Similar "two-tier" criticisms were made in Germany when it was discovered that the general public was being offered one vaccine formulation, while Germany's civil servants, politicians and soldiers were offered a putatively less harmful formulation (54).

Vaccine procurement and distribution

During the 2009 pandemic, many countries took advantage of contractual agreements made during the interpandemic period with vaccine manufacturers (4, 6, 55, 56). These "advance purchase agreements" for vaccine placed by developed countries resulted in the purchase of virtually all the vaccines manufacturers could produce, and left developing countries with a limited vaccine supply. Having identified the lack of equitable access to pandemic vaccine by developing countries, the WHO negotiated a deal with vaccine manufacturers to donate or sell at a low cost a minimum percentage of their supplies to United Nations agencies to be distributed to developing countries (19, 57). Many developed countries also donated surplus vaccine to the WHO, a practice supported by their citizens, although these donations only occurred at the end of the pandemic, where they provided little benefit to developing countries (56, 58-60). Due to the inequitable access to various resources, including pandemic vaccines, the WHO is continuing negotiations with its member states to create a global access framework that will benefit the entire world population in future pandemics (61, 62).

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One criticism to these advance purchase agreements was the unforeseen finding that only a single vaccine dose was sufficient to protect against pH1N1 in almost all age groups of the general population, except young children (63). The extra doses of vaccines incurred additional costs to developed nations and resulted in a significant number of unused vaccines, which in turn, could have been directed to developing countries.

In addition to vaccine procurement, national governments were also responsible for vaccine distribution to local health providers. The Government of Canada oversaw the distribution of pandemic vaccine from the manufacturer to the provinces and territories, and as of mid-December 2009, enough vaccine was distributed or stored to cover approximately 80% of the Canadian population (64). In the U.S., the Centers for Disease Control and Prevention (CDC) contracted a logistics company to organize the distribution of vaccine (31), which was ultimately allocated according to state population size (65). State and local health officials and vaccination providers were then told to make decisions regarding vaccine administration and distribution according to the local and state conditions (66).

An approach that worked well for some local health departments within the U.S. was the categoriza-

tion of providers, particularly private providers (e.g. GPs) into tiers as a way of managing and prioritizing vaccine distribution (31). For example, obstetricians were initially prioritized above pharmacies. Once more doses became available, vaccine was provided to a larger number of private providers. Some health departments also created or expanded high-priority provider registries so that these groups could place orders online, communicate with their health departments and maintain immunization records. Other health departments felt that healthcare provider based vaccination methods were too time-consuming and costly and opted to solely hold mass vaccination clinics (31).

Mass vaccination clinics, held in public health facilities, public schools and community centres, were the most common means of pandemic vaccine distribution and administration (see Summary Table). The U.S. CDC published an *Outline for Planning and Operating a Large-Scale Influenza Vaccination Clinic* (67), a document that provides recommendations and guidance to public and private vaccine providers under the auspice of eight headings, including leadership roles, human resource needs, and clinic location. The fact that the highest vaccination rates in the U.S. were in states that held school-based vaccination clinics (65) suggests that the American population favours this method of vaccine distribution and that mass vaccination clinics were essential in reaching those individuals that do not have a medical home (31). Not all people support community-based mass vaccination clinics, however. A report from Australia indicated that 11% of those surveyed would no longer be willing to accept vaccination if it were to take place in a community hall rather than through their GPs (58). Therefore, it appears that a combination of public and private vaccine provider options would be ideal.

Another mostly positive aspect to the mass vaccination clinics held in North America was the fact that people were asked to self-report their eligibility for vaccination; in other words, they were not asked to prove that they belonged to a priority group (68). Although this meant that some people who received the vaccine were not part of a priority group, it also made implementation of the clinics easier.

To supplement mass vaccination clinics, various regions throughout the U.S. also operated community-based “Points of Dispensing” (PODs) (69). The PODs plan was initially developed to distribute prophylactic medication to the general population in the event of a bioterrorist attack, and it was modified during the 2009 A/H1N1 pandemic. PODs were set up in community venues such as libraries and churches on Saturdays and Sundays. In New York City PODs, approximately 100 staff, comprised of volunteers from various medical agencies and the Medical Reserve Corps (MRC; an American program made up of HCWs, public health officials and non-medical personnel), were required per shift, 85% of whom were non-medical personnel. Six pre-trained core team members were responsible for primary leadership within each POD. Approximately 50,000 people were vaccinated over the course of five consecutive weekends at seven different POD locations in New York City (69).

Unlike Canada and the U.S., EU countries with national health systems, for example, France and Germany, administered vaccine to high priority groups mostly by invitation (70). In addition, each medical practice in Britain's National Health Service received 500 doses of vaccine to be distributed to priority group members, which prevented long lines at vaccine clinics. Rambhia and Nuzzo concluded that the U.K.'s national health system allowed for easier identification of, and communication with, people prioritized for vaccination. This, combined with scheduled vaccination, limited the confusion surrounding eligibility and vaccine availability (70).

Distribution Challenges

There were many logistical, practical and operational issues involved in distributing millions of doses of pandemic vaccine as they became available. For example, the use of multi-dose vials in some countries was a hindrance to the organization of vaccinations in GP offices due to the concern about wasting vaccine and the potential for disease transmission (12, 71). However, the use of single-dose vials also posed problems, including storage of single-dose vials which take up approximately six times more refrigerator space than multi-dose vials, as well as production delays since filling the vials results in a bottleneck during manufacturing.

An additional challenge in vaccine distribution was the maintenance of the "cold-chain". Both the inactivated and live-attenuated formulations of the pandemic vaccine required storage at 4°C and could not tolerate freezing. Therefore, shipping and warehousing the vaccine required pre-existing infrastructure, a particular problem in developing countries. Participants at a workshop evaluating the 2009 vaccination campaign suggested that distribution contracts should be awarded to those that can guarantee maintenance of the cold-chain (68). An additional solution would be the development of vaccine formulations that do not require a cold-chain during their procurement (68).

The main distribution issue faced during the 2009 A/H1N1 pandemic was meeting the "supply *versus* demand" challenge. During the early months of the pandemic, the demand for vaccine far outweighed the supply, while in later months supply far outweighed demand (68). During the summer months and into the fall, expectations regarding vaccine supply were overly optimistic and extensive media coverage surrounding the impending vaccination campaign fueled demand by the public. Unfortunately, unforeseen vaccine production problems resulted in slower than expected vaccine supply, which ultimately caused major disruptions in planned distribution strategies. The delay in vaccine supply was exacerbated by the lack of communication between vaccine producers and the government and subsequently between the government and vaccine administrators. In the U.S., many vaccine providers noted that often they only received a portion of their vaccine order and were only given a few days notice of its delivery, which ultimately caused distribution problems (31).

To help improve wait times, some clinics handed out appointment tickets (wristbands) on a first come first serve basis.

The confusion surrounding vaccine supply and availability also caused the public to lose confidence in the vaccination program (31). The lack of confidence stems from people having to wait in long lines at vaccination clinics only to be told that they were not a priority or to be turned away due to vaccine shortage. To help improve wait times, some clinics handed out appointment tickets (wristbands) on a first come first serve basis (72). Lineups at the vaccination clinics in Sault Ste. Marie, Ontario were virtually nonexistent due to scheduled appointments (73). For one week prior to the clinic opening, 23 staff at a local call centre worked 12 hours a day booking appointments for those on the priority list. Patients simply had to call the hotline, make an appointment and show up at the designated time and clinic. The sole problem with this system was the inability to get through due to high call volume for booking appointments. Although many communities might not have the infrastructure to support call centres, it has been suggested that the Public Health Agency of Canada could contract with commercial call centres and offer 1-800 numbers to facilitate appointment bookings for community clinics (73).

Staffing shortages for all positions appeared to be a ubiquitous problem for all mass vaccination clinics. The California Department of Public Health outlined the following positions as being critical to the smooth operation of a vaccination clinic: greeters/educators, priority client screeners, registration personnel, medical screeners, forms collectors, clinic flow controllers, vaccination assistants, vaccination administrators, security, emergency medical personnel, and runners to maintain stations stocked with supplies and equipment (74). To adequately staff clinics, many locations enlisted the aid of MRC volunteers (75), as well as volunteers from nonprofit home health and hospice agencies (76). Both groups were instrumental in aiding local health departments in the coordination and implementation of mass vaccination programs. Despite the success of these combined efforts, continued education of nursing and volunteer staff focusing on specific administration skills, as well as vaccination information about possible adverse effects, patient education, and follow-up is imperative prior to any future vaccination clinic (75).

In addition to traditional HCWs and volunteer organizations like the MRC, various other occupations, such as paramedics and dentists could be employed as vaccine providers. The city of Austin, Texas also used off-duty firefighters as vaccinators for city employees (68). Teams would go out at any time, day or night, to meet city employees at their job site. This approach was cited as being more efficient than hiring contract workers.

Data collection, vaccine monitoring and communication

Although efficient vaccine targeting and distribution are the pillars of any mass vaccination strategy, collection of immunization data, monitoring for adverse events following immunization and clear and effective communication with vaccine providers and the public are also important in any vaccination campaign.

Many countries, including Canada, chose to collect individual level immunization data during the 2009 pandemic using either paper forms; electronic systems, which included computers and swipe-cards; or a combination of the two systems (77, 78). The data collected were important for monitoring the vaccine delivery process, for timely assessment of vaccine coverage, for statistical purposes, and for compiling vaccine safety and efficacy information. A Canadian *time and motion study* reported that the use of an entirely electronic reporting system was the most efficient, although most Canadian health regions in the study used both paper forms and computer filing as they lacked the infrastructure for a completely electronic system (78).

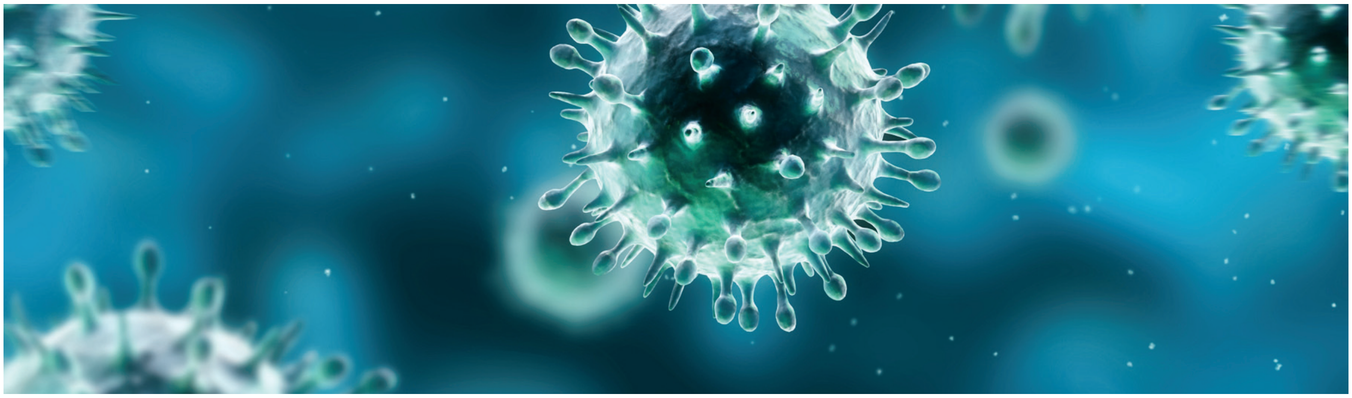
Safety and effectiveness monitoring are major components of any vaccination program. Monitoring the effectiveness of the pH1N1 monovalent vaccine was especially difficult due to the temporal overlap between the second pandemic wave and vaccine administration (79). Some people may have already been infected with pH1N1 at the time of their vaccination, or were infected shortly thereafter, thus reducing the vaccine's apparent effectiveness.

A major downfall to the data collection and vaccine monitoring methods used during the 2009 pandemic was the lack of consistency in the collection and reporting systems between regions (regional and provincial). The Public Health Agency of Canada has recognized this limitation and has suggested that an integrated surveillance system for immunizations be implemented (80). This surveillance system should include the development of technologies that facilitate real-time data collection and reporting to improve situational awareness and guide program implementation during a public health emergency (68).

As noted to above, effective communication with the public regarding the formulation, safety, efficacy and priority sequencing of the vaccine presented an unforeseen challenge during the 2009 influenza A/H1N1 pandemic. This communication dilemma occurred despite the use of classical and novel media outlets, including specific websites, hotlines, flyers and newsletters in most countries. Anti-vaccine sentiments aired in the media, particularly on the Internet, added to the confusion regarding the safety and effectiveness of the pandemic vaccine. Seeman and colleagues (81) suggest that public health communication and education strategies regarding influenza vaccine could be complemented by web analytics that identify, track and neutralize anti-vaccine sentiment on the Internet. The Public Health Agency of Canada intends to work on strategies to improve its ability to communicate science, risk, uncertainty and shifts in scientific knowledge to various audiences (80).

Conclusion

According to health officials in both Canada and the U.S., the overall timelines outlined in their respective pandemic preparedness plans were met and a safe vaccine was made available. Despite this, many challenges were faced during the 2009 influenza A/H1N1 pandemic, including how to prioritize target groups for vaccination; how to convince target groups to get vaccinated; how to deliver vaccines more effectively; how to interpret, collate and analyze data and how to effectively communicate with the public (12). The most obvious lesson learned from this pandemic is that there is a limitation on how quickly a new vaccine could be developed, produced on a large-scale and distributed to the people who need it; and once a vaccine is produced, the public must be willing to accept



vaccination. Increased investments to enhance production times and public acceptance will yield substantial returns. More effective communication that is coordinated at the local, national and international levels should facilitate a better response to future pandemics. Given these difficulties, pandemic preparedness plans should be developed with built-in flexibility to accommodate immunization strategies that address local needs and concerns.

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