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Is a mass immunization program for pandemic (H1N1) 2009 good value for money? Evidence from the Canadian Experience☆

Beate Sander[a,b,c,*], Chris T. Bauch[c,d], David Fisman[e], Robert A. Fowler[c,f], Jeffrey C. Kwong[e,g,h], Andreas Maetzel[i], Allison McGeer[j,l], Janet Raboud[e,j], Damon C. Scales[f,l], Marija Zivkovic Gojovic[c], Murray Krahn[c,k,l]

[a] Department of Health Policy, Management and Evaluation, University of Toronto, Toronto, Canada
[b] Division of Clinical Decision-Making and Health Care Research, University Health Network, Toronto, Canada
[c] Toronto Health Economics and Technology Assessment Collaborative, Toronto, Canada
[d] Department of Mathematics and Statistics, University of Guelph, Guelph, Canada
[e] Dalla Lana School of Public Health, University of Toronto, Toronto, Canada
[f] Department of Medicine and Interdepartmental Division of Critical Care Medicine, Sunnybrook Health Sciences Center, Toronto, Ontario, Canada
[g] Institute for Clinical Evaluative Sciences, Toronto, Canada
[h] Department of Family and Community Medicine, University of Toronto, Toronto, Canada
[i] Stratas Partners, Basel, Switzerland
[j] Division of Infectious Diseases, University Health Network, Toronto, Canada
[k] Faculty of Pharmacy, University of Toronto, Toronto, Canada
[l] Department of Medicine, University of Toronto, Toronto, Canada

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ABSTRACT

In response to the pandemic H1N1 influenza 2009 outbreak, many jurisdictions undertook mass immunization programs that were among the largest in recent history. The objective of this study was to determine the cost-effectiveness of the mass H1N1 immunization program in Ontario, Canada's most populous province (population 13,000,000). This analysis suggests that a mass immunization program as carried out in Ontario and many other high-income health care systems in response to H1N1 2009 was effective in preventing influenza cases and health care resource use and was also highly cost-effective despite the substantial program cost.

1. Introduction

Influenza is highly contagious and strikes a large proportion of the population each year. Human influenza is caused by influenza type A and B viruses, which undergo continuous antigenic drift and occasional antigenic shift. Antigenic shifts can result in pandemics at unpredictable intervals. In mid-March 2009, an outbreak of novel influenza A H1N1 was reported in Mexico [1]. On April 28th, the first cases were reported in Ontario, Canada's largest province (population 13,000,000) [2]. The Northern hemisphere spring wave of the outbreak peaked in early June, and subsided by the end of August when influenza-like-illness consultation rates were within the range of the expected level [3]. The fall wave started in the first week of September 2009, peaked in early November 2009 and tapered off by late January 2010 [4].

After approval of an H1N1 vaccine by regulatory authorities in Canada on October 21, 2009, the largest immunization program

Abbreviations: CI, confidence interval; CIHI-DAD, Canadian Institute for Health Information Discharge Abstract Database; CMG, Case Mix Group; ECMO, extracorporeal membrane oxygenation; ED, emergency department; GDP, gross domestic product; ICER, incremental cost-effectiveness ratio; ICU, intensive care unit; MOHLTC, Ministry of Health and Long-Term Care; OHIP, Ontario Health Insurance Plan; PHU, public health unit; QALY, quality-adjusted life year; RIW, resource intensity weight.

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* Corresponding author at: Ontario Agency for Health Protection and Promotion, 480 University Avenue, Suite 300, Toronto, Ontario M5G 1V2, Canada.
Tel.: +1 647 260 7425; fax: +1 647 260 7600.
E-mail address: beate.sander@oahpp.ca (B. Sander).

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in the country's history was rolled out. Ontario's mass immunization program started on October 26, 2009, 2 weeks before the peak. During the first 2 weeks of the program, vaccine was offered to high-priority groups (frontline health-care workers, pregnant women, children aged 6 months to 5 years, people who live with children aged less than 6 months, people under 65 with underlying medical conditions, immune-compromised people and those caring for them, and people living in remote and isolated communities) [5]. The program was subsequently expanded and H1N1 vaccine was available to every resident by November 19 [6,7]. By the end of January 2010, 45% of the Ontario population were vaccinated [8].

While the public supported the program in principle, there were mixed reactions to the scale and cost of the immunization program. Articles in the lay press called the universal immunization program an overreaction to the threat of H1N1, and called attention to the "waste" associated with universal vaccination and stockpiling of antiviral medication [9]. Moreover, in most jurisdictions, the vaccine was not available until after outbreaks had started.

While the seasonal universal influenza immunization program in Ontario, immunizing 42% of the population every year [10], has been found to be effective and cost-effective [11,12], there is, however, uncertainty about the cost-effectiveness and optimal public health policy for a new vaccine such as H1N1 when the timing of delivery is uncertain in relation to the pandemic epidemiologic curve.

The objective of this study was to estimate the cost-effectiveness of the mass immunization program in response to pandemic H1N1 influenza 2009 outbreak in Ontario compared to no immunization from the perspective of a single health care payer (Ontario Ministry of Health and Long-Term Care (MOHLTC)).

2. Methods

2.1. Cost-effectiveness analysis

A cost-effectiveness analysis comparing the H1N1 mass immunization program in Ontario to no immunization was performed from the health care payer perspective (Ontario Ministry of Health and Long-Term Care). Health outcomes measured included number of cases, number of deaths and quality-adjusted life years (QALYs). Resource use included physician office visits, emergency department visits, and hospitalizations. Finally, costs included the costs of the immunization program and health care costs for treating H1N1 cases. Primary outcomes were QALYs, costs in 2009 Canadian dollars, and incremental cost per QALY gained (incremental cost-effectiveness ratio (ICER)). While the simulated H1N1 pandemic occurs within 1 year, a lifetime time horizon was adopted to calculate QALYs lost due to H1N1-related deaths. QALYs lost due to mortality were discounted at 5% [13]. All results are reported in discounted values.

2.2. Model

This economic evaluation utilized a simulation model to compare health outcomes and costs of the Ontario mass immunization program to a hypothetical strategy of no immunization. The model predicted how the pandemic might have unfolded if the mass immunization program had not been implemented in Ontario. For this purpose, a pre-existing individual-level simulation model of a pandemic H1N1 2009 outbreak [14] was updated using more recent Ontario pandemic H1N1 influenza data. The model simulated the spread and mitigation of pandemic H1N1 in an urban population, based on demographic data from London, a typical medium-sized city in Ontario (population 457,720) [15]. Individuals in the model were assigned an age class, a community, a household and, depending on age, a daycare, school or workplace, if employed. Every simulated individual was scheduled to spend a certain amount of time each day in each of these locations as determined by their infection status, and contact rates and transmission probabilities per contact for each location were specified. Age-assortative contact mixing was assumed within community, workplaces and classrooms, and homogeneous, age-independent mixing was assumed within households. The transmission of influenza A (H1N1) was modeled on a daily basis for a total of 300 days. Each day, susceptible individuals faced a probability of becoming infected. The probability of becoming infected depended on four major factors: susceptibility of susceptible individual (vaccination status), number of contacts with infected individuals, infectivity of infected individuals to whom close contact is established and duration of the established contacts.

The model predicted the per-capita number of symptomatic cases (attack rate) under various scenarios. The number of symptomatic cases cannot be obtained directly from surveillance data, due to the fact that most symptomatically infected individuals do not undergo confirmatory laboratory testing. The predicted attack rate was applied to the population of Ontario to estimate the number of cases across the province.

The contact rates in each location and the transmission probability per contact were calibrated so that the number of hospitalizations, intensive care unit (ICU) admissions, and deaths predicted by the model matched the reported number of these events [4]. The resulting match was good (Figure S1, supplementary material). Secondarily, the model was calibrated to ensure the model predicts an overall attack rate within the range of plausible attack rates estimated from the reported number of hospitalizations using the probability of hospitalization per laboratory-confirmed case [16] and the mean and 90% probability range for the number of symptomatic cases per laboratory-confirmed case [17].

Removing vaccination from the model predicts how the H1N1 2009 pandemic would have unfolded in the absence of the immunization program.

The model was then used to estimate mean symptomatic attack rates for four age groups under two strategies: (a) mass immunization program as implemented in Ontario, and (b) no immunization. For each defined scenario, the pandemic H1N1 influenza fall wave was simulated 300 times to ensure adequate sampling of the stochastic outcomes.

Once symptomatically infected, individuals were assigned a probability to access health care services, defined as physician visits, emergency department visits (ED) and/or hospitalizations. Hospitalized patients were assigned a probability to be admitted to intensive care units for life-supporting care including mechanical ventilation, and the most severely ill may have received specialized oxygenation-supporting therapies such as extra-corporeal membrane oxygenation (ECMO).

2.3. Data (Table 1)

2.3.1. Epidemiology of H1N1 influenza

Parameters describing the epidemiology of pandemic H1N1 influenza used in the simulation model were collected from Ontario surveillance data if available and/or published literature on previous pandemics (Table 1).

The mean incubation period was 2.62 days and the duration of infectiousness was 3.38 days [16]. The probability that an infected individual would become symptomatic was 0.7 [18]. An asymptomatic infection was assumed to be 50% as infectious as a symptomatic infection [18,19]. Based on data from Statistics Canada on work hours lost due to H1N1, it was assumed that 50% of all symptomatically ill adults stayed home from work and other