SUPPLEMENT ARTICLE

Using Results From Infectious Disease Modeling to Improve the Response to a Potential H7N9 Influenza Pandemic

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As the Centers for Disease Control and Prevention (CDC) and other government agencies prepared for a possible H7N9 pandemic, many questions arose about the virus's expected burden and the effectiveness of key interventions. Public health decision makers need information to compare interventions so that efforts can be focused on interventions most likely to have the greatest impact on morbidity and mortality. To guide decision making, CDC's pandemic response leadership turned to experts in modeling for assistance. H7N9 modeling results provided a quantitative estimate of the impact of different interventions and emphasized the importance of key assumptions. In addition, these H7N9 modeling efforts highlighted the need for modelers to work closely with investigators collecting data so that model assumptions can be adjusted as new information becomes available and with decision makers to ensure that the results of modeling impact policy decisions.

Keywords. H7N9; modeling; pandemic influenza; infectious disease.

A novel avian influenza A(H7N9) virus [H7N9] identified in China in March of 2013 quickly raised the concerns of public health professionals and policy makers [1]. Although the virus has not developed the ability to spread easily between humans, several characteristics suggest that it has the potential to develop this capability and to possibly cause a worldwide pandemic of severe illness. For example, the virus has several mutations associated with mammalian transmission [2], and structural analysis suggests that it may already be better adapted to infecting mammals than avian influenza A (H5N1), a virus closely monitored since 2003 because of its pandemic potential [2]. In contrast to highly pathogenic influenza A(H5N1), a virus that sickens and kills infected poultry, H7N9 is low pathogenic in birds (ie, infected birds are asymptomatic), meaning that avian outbreaks will be difficult to identify and that culling flocks of poultry based on symptoms alone, will not be possible [3]. In addition, similar to H5N1 but different from 2009 H1N1, the last virus to cause a worldwide pandemic, H7N9 appears to have a high level of virulence, with a reported case fatality rate of about 30% [4].

As the Centers for Disease Control and Prevention (CDC) and other government agencies worked to prepare for a possible H7N9 pandemic, many questions needed to be answered about the possible burden of the virus and the effectiveness of different interventions. To assure that the greatest effort is directed toward the most effective interventions, public health decision makers need an objective comparison of interventions to evaluate those that are most likely to have the greatest impact in terms of morbidity and mortality averted. Some of these questions include:

1. What is the potential impact of an H7N9 pandemic in terms of illnesses, hospitalizations, and deaths?
2. Should a vaccine against H7N9 be developed? If an H7N9 vaccine is developed, what are the expected benefits in terms of fewer illnesses, hospitalizations, and deaths? How are these benefits affected by characteristics of the virus (ie, severity and transmissibility) and of the vaccine (eg, timing of the vaccine campaign, vaccine effectiveness, 1-dose vs 2-dose regimen)?

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3. How does the trajectory of the pandemic affect the benefit of a vaccine campaign? What are the consequences of starting a vaccination program at different points in time after widespread human-to-human transmission is occurring?
4. Are the numbers of medical countermeasures, including antiviral medications to treat ill patients and ventilators to support those that are critically ill, currently available in the U.S. Strategic National Stockpile sufficient if a severe H7N9 pandemic were to occur, or are additional purchases necessary?
5. Are sufficient numbers of respiratory protective devices available to protect healthcare workers? If not, what options are available to address the gap?
6. What nonpharmaceutical interventions (eg, school closures) would have the greatest effects in delaying or reducing influenza transmission and dampening the pandemic?

To answer these and other questions and to guide our decision making, CDC's pandemic response leadership turned to experts in modeling for help. The articles included in this special issue show the results of those modeling efforts. These modeling results were used to guide the decision to build a small stockpile of H7N9 vaccine. Future decisions on purchases of antiviral medications, ventilators, and other medical countermeasures will also be guided by modeling results such as these to determine the number of countermeasures needed as well as the number that can be used, considering other issues (eg, the number of available intensive care unit beds and trained personnel need to be considered when making decisions regarding mechanical ventilators).

Apart from providing a quantitative assessment of the impact of different interventions, these modeling efforts bring focus to the importance of key assumptions for each of the interventions. For example, the benefits of a vaccination campaign are dependent on developing, producing, and delivering vaccine as early as possible and having a system capable of vaccinating tens of millions of people each week. Similarly, for the antiviral drug stockpile to be optimally effective, the distribution and dispensing system must have the capacity to deliver large quantities of drugs to multiple locations across the country and to prescribe the drugs to those who need them, and in addition, people need to have access to the drugs. Modeling results have focused efforts on making sure that the underlying infrastructure can support the delivery and administration of these countermeasures; in other words, ensuring that the assumptions used in the models are valid.

The modeling results reported in this supplement are far from the end of the road. As additional information becomes available and assumptions evolve, these models will require updating. If H7N9 develops sustained and efficient human-to-human transmission, many more questions will arise, and data from epidemiologic studies will be needed to answer these questions. However, as demonstrated early on in the 2009 H1N1 pandemic, early epidemiologic information may be scarce and at times in conflict with information gathered later in the outbreak [5]. Therefore, modeling can provide a data-based method to explore a variety of potential outcomes to guide planning. Modelers will need to work closely with epidemiologists to ensure that the latest epidemiologic data are used appropriately to guide updating of these models. Efficiency of viral transmission, length of viral shedding, spectrum of illness, identification of high-risk groups, case hospitalization rate, and case fatality rate are just a few of the data from epidemiologic investigations that will be needed to update these models. The impact of an H7N9 vaccination campaign depends on results from clinical trials regarding number of vaccine doses needed for protection, whether an adjuvant will be necessary, and expected vaccine effectiveness, as well as information on vaccine uptake among different populations. The articles in this supplement highlight the need for tight links among modelers, investigators collecting these data so that model assumptions are adjusted as soon as new information is available, and policy makers to ensure that the results of modeling will effect actual policy decisions. The articles also show that identifying critical assumptions can often be just as important as the results of models.

Notes

Disclaimer. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).

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