Proposal For An Early Warning System Against An AH1N1 Influenza Pandemic In America

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Proposal For An Early Warning System Against An AH1N1 Influenza Pandemic In America

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Abstract

The objective of the present work is to propose a project for the design of a real time early warning system against the influenza virus AH1N1 in America. This early warning system would carefully monitor all cases of the AH1N1 influenza in 16 countries out of the 35 that make up the American continent. From the accumulated data, we will be able to calculate the basic reproduction number R0. This number indicates when an epidemic is occurring and thus will be able to generate alerts and inhibit the spread of the influenza pandemic. This proposed system uses a color code that is based on the alert phases previously defined by the World Health Organization in order to declare an outbreak as a pandemic. Finally, this methodology is validated by calculating the value of R0 in 16 American countries where cases of AH1N1 influenza have occurred in 2016.

Keywords: Influenza, AH1N1, Ro, epidemic, WHO, America

Introduction

The influenza AH1N1 virus, also known as influenza virus, a subtype of H1N1 belongs to the family of Orthomyxoviridae RNA viruses that infect vertebrates including the influenza viruses. Other members of this virus community are the Infectious salmon anemia virus and viruses that are transmitted by ticks (Taubenberger & Kash, 2010).

The devastating outbreak of Spanish flu in 1918 was one of the most disastrous flu episodes in human history where it managed to infect approximately 20% of the population of the world with 675,000 reported deaths in the US alone. A worldwide outbreak caused by the H1N1 strain, known as the Pandemic H1N1 / 09 virus, occurred in March, 2009 with at least 900 deaths in America and Europe (Cerboino et al., 2013).

The World Health Organization (WHO) has defined 6 phases of influenza that could lead to
the designation of the disease as being a pandemic and they are listed below:

- **Phase 1**: The influenza virus circulates between animals and there is no infection in humans.

- **Phase 2**: The influenza virus is present in animals and could possibly infect some humans.

- **Phase 3**: Small groups of people become infected although it probably will not become a pandemic. In addition, a person-to-person transmission has not been corroborated.

- **Phase 4**: It is confirmed that the virus is transmitted between people and is thus capable of causing a local outbreak at the community level.

- **Phase 5**: The virus spreads among humans in at least 2 contiguous countries in the same WHO region and thus it is likely that it may become a pandemic.

- **Phase 6**: The pandemic occurs when the virus is found in two or more different regions of the world.

There should be a worldwide early warning system against the spread of all diseases. For example, the *Global Epidemic Outbreak Alert and Response Network* (known by its acronym GOARN) is a mechanism for the technical collaboration between institutions and networks to quickly identify, confirm and respond to outbreaks of international concern (details at [http://www.who.int/csr/outbreaknetwork](http://www.who.int/csr/outbreaknetwork)).

The Center for Disease Control (CDC) employed a tool to evaluate the risk of an influenza pandemic called the Risk Assessment Tool (IRAT) where the data was analyzed and evaluated in order to determine whether pre-pandemic viruses existed. However, the CDC said that the IRAT is not the correct prediction tool of an influenza pandemic because influenza is not predictable. IRAT could indicate if the virus would possibly lead to a pandemic according in the three categories served but it is not further considered here (for more details, see Trock et al., 2012).

After an exhaustive search of the scientific literature, we were unable to find a *real time early warning system* that is dedicated for the prevention of an outbreak of influenza. The objective of the present work is to propose such a system that will register and alert the populace of a possible outbreak of influenza AH1N1 in real time in the American continent. The countries that are to be monitored in this work are Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Ecuador, Mexico, Nicaragua, Panama, Paraguay, Peru, United States, Uruguay, and Venezuela.

The data for our early warning system will depend on the different epidemiological bulletins of the different countries. For example, the FUNCEI / FIDEC Epidemiological Bulletin in Argentina, the Weekly Epidemiological Bulletin (BES) in Colombia, the weekly bulletin of the Situation Epidemiological IPK of Brazil. These bulletins are published weekly and there are mailing lists available to monitor each country. All weekly bulletins are free.

Also available from these countries are databases for the examination of the influenza outbreaks. In addition, the FluNet network which is a WHO project is available (Flahault et al., 1998). The idea of the present work is that our early warning system will always have access to relevant information concerning influenza in any country on America. The fact that both the database FluNet and the data obtained from the weekly epidemiological bulletins have the same information and can be used as a confirmation of the prediction. With the rapid development of electronics, it is expected that the dissemination
of the most up to date information will become automatic.

This collected data is combined and transformed into a single parameter which is called the basic reproductive number $R_0$ (see for example Mummert & Weiss, 2017). The temporal variation of $R_0$ can also provide information about the speed with which a disease can spread in a given population.

There are two different methods to determine the value of the parameter $R_0$. The first method is based on mathematical models such as the Dengue model (Yang, 2014), the Chikungunya model (Agusto et al., 2016) and the Zika disease model (Lee et al., 2017). The second method is based on direct probabilistic calculations describing the outbreak of an influenza epidemic in a particular country. This methodology has been developed by Cauchemez et al (2006) and this is the method that will be used in this work. The calculation is based on a Bayesian statistical framework for the real time inference of the temporal pattern of the reproduction number of an epidemic.

This methodology has already been applied in other studies such as SARS (Cauchemez et al 2006), H1N1 (Cauchemez et al 2009), Chikungunya (Cauchemez et al 2014), and others. We suggest that the same methodology also be applied to create an early warning alert system dedicated just to the disease AH1N1. After obtaining the value of the parameter $R_0$, it is possible to know if an epidemic of AH1N1 is in existence in a particular country. For values of $R_0 < 1$, there is no epidemic in the particular country and when $R_0 > 1$, there is an epidemic (Mummert & Weiss, 2017).

We believe that a constantly updated color coded map which would be widely broadcasted and appear on television screens, computer screens and smart phones would be an excellent reliable mechanism for sharing the up to date information with the general populace. In addition, the health organizations in the various countries would receive electronic or hard copies of the map. We suggest that a three color scheme be used with an additional caveat to indicate whether the particular level is increasing or decreasing. A solid color would indicate that the particular level is increasing and a crosshatched color would indicate that the particular level is decreasing. The lack of information for a particular country would be indicated with no color.

- **Green Alert Level**: Corresponds to a value of $R_0$ between 0 and 0.5, i.e. there is an insignificant number of cases of influenza AH1N1 to justify the label of being an epidemic.
- **Yellow Alert Level**: Corresponds to a value of $R_0$ between 0.5 and 0.99, i.e. there are a number of cases that may eventually trigger an epidemic.
- **Red Alert Level**: $R_0$ greater than 1 in a country that results in an epidemic.
- **Blank Alert Level**: No Information is available.

Figure 1 shows a potential presentation using the early warning system for AH1N1 influenza. The left side shows the alert using a map of America using our methodology. Finally, we studied the temporal evolution of the disease in sixteen countries in the Americas where cases of AH1N1 influenza occurred in 2016 is shown in Figure 2. It is useful to examine temporal evolution of the values of $R_0 > 1$ in order to determine if the epidemic is of a short duration (focal cases) or a longer duration. This figure shows that Bolivia, Brazil, Mexico, Panama, and Paraguay had an epidemic that was of short duration. However,
Argentina, Canada, Chile, Colombia, Nicaragua, Peru, United States, and Uruguay had a prolonged epidemic.

The calculated values of $R_0$ are presented in Table 1. In addition, we indicate when the epidemic begins and ends in each country and also the standard deviation of this value as obtained using this methodology. The countries of Uruguay and Venezuela have the highest values of $R_0$ with respect to the other countries as well as the highest standard deviation in this calculation. These values should be analyzed in the future because both countries have the lowest number of outbreaks of influenza and therefore, a different method of calculating $R_0$ must be used.

Conclusion

This paper indicates that one should design and implement an early warning system to monitor the evolution of AH1N1 in America. The data of the alert system comes from the different epidemiological bulletins of each country. It is proposed to analyze this data in real time in order to calculate the correct current value of $R_0$ and thus determine whether an epidemic is actually occurring. The alert system should lead to an easily identifiable warning and be widely consulted free of charge using the color coding system. In the future, it may be necessary to implement such a system on an internet platform and if possible also on mobile phones.

References


Legends

Figure 1. Tentative presentation of the results that could be obtained from the early warning system against an influenza AH1N1 pandemic. The system monitors 16 countries of the 35 of the American continent. There was a localized epidemic in the United States and there was no data available for Ecuador this particular time.

Figure 2. Sixteen graphs corresponding to the annual distribution of all the countries that form the early warning system occurring in 2016. From these data, the value of $R_0$ was calculated, which is indicated in Table 1 according to the procedure described by Cauchemez et al. (2006).
Table 1. We calculate the $R_0$ in 16 countries in America. To do this calculation, we need to know the initial and final values during the week according to the methodology explained by Cauchemez et al. (2006). Finally, we obtained the error deviation of $R_0$.

<table>
<thead>
<tr>
<th>Country</th>
<th>Week initial</th>
<th>Week final</th>
<th>$R_0$</th>
<th>Error $R_0$</th>
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<tr>
<td>México</td>
<td>1</td>
<td>19</td>
<td>1.4139</td>
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</tr>
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Figure 1

- Pandemic Alert

Last Week: Feb 2017
Figure 2