

# Pandemic Control Measures

JMAJ 56(1): 51–54, 2013

Taro YAMAMOTO\*<sup>1</sup>

**Key words** Pandemic, Spanish flu, Novel influenza, Infectious disease epidemiology, Basic reproductive number

Today, I would like to discuss pandemics and their control measures from a historical viewpoint and their challenges. More specifically, I will define pandemics, review the history of novel influenza, and briefly refer to the epidemiologic bases that give rise to pandemics using the “Spanish flu” that occurred between 1918 and 1919 as an example.

## Definition of Pandemic

Let us begin by defining the term “pandemic.” The origin of the word lies in Greek, in which *pan* means “all” and *dēmos* means “people.” Thus, the word *pandemic* originally meant *all people*. It now refers to an infectious disease that spreads globally and causes mortality on a significant scale. In epidemiology, *endemics* refer to local outbreaks, whereas *epidemics* refer to sudden outbreaks. There have been several outbreaks of infectious diseases that have become pandemic in the course of human history (e.g.; viral infections such as smallpox, influenza, and AIDS; bacterial infections such as the plague, syphilis, cholera, tuberculosis, and typhus; and protozoan infections such as malaria).

Naturally, these infections require control measures. In terms of the swiftness of infection spread, however, influenza is unique because it only takes a few months for the infection to spread globally. Here I will discuss pandemics by examining the influenza outbreaks.

## Novel Influenza

Influenza is an infection caused by the influenza virus. There are 3 strains of influenza virus; Types A, B, and C. Type C virus causes sudden and sporadic outbreaks, but not seasonal outbreaks. Type B virus causes seasonal outbreaks, but not pandemics. On the contrary, type A virus causes seasonal outbreaks and occasionally spreads globally. This type A influenza virus has 2 epitopes in its DNA, namely hemagglutinin (HA) and neuraminidase (NA). There are 16 subtypes of HA (H1–H16) and 9 subtypes of NA (N1–N9) in type A, and the combination (16×9) of these subtypes creates new subtype combinations. As previously acquired immunity is ineffective against a new subtype virus, it is called “novel” influenza virus.

In the 20th Century alone, there have been 3 outbreaks of novel influenza. The first outbreak was the “Spanish flu” that started in 1918, which was due to a type A virus with H1N1 subsets. About 40 to 100 million people reportedly lost their lives (**Fig. 1**).

Another pandemic, the “Asian flu,” occurred about 40 years later in 1957. This outbreak was also caused by type A virus, but with H2N2 subsets. The loss of life was estimated to be 1 to 4 million. Eleven years after that, the “Hong Kong flu” struck in 1968. This was also caused by type A, but with H3N2 subsets, and 1 to 4 million people died. Technically, a mutation that can lead to a pandemic is called a “shift,” whereas a minor mutation that occurs from year to year is called

\*1 Professor of Institute of Tropical Medicine, Nagasaki University, Nagasaki, Japan (y-taro@nagasaki-u.ac.jp).

This article is based on the lecture presented at the 2012 JMAT Training Course on Disaster Medicine held on March 10, 2012.



Fig. 1 The history of emergence of the novel influenza in the 20th Century

a “drift.” The influenza virus uses these shift and drift mechanisms of mutation to ensure human susceptibility and enable outbreaks.

These novel influenza strains led to various damages in the society. I would like to introduce some descriptive narratives, which depicted the situation in the United States of America during the Spanish flu pandemic.

A public health official on the United States East Coast wrote advice to public health officials in Philadelphia or San Francisco:

*First, gather as many woodworkers and cabinet-makers and have them start making coffins. Next, gather the workers wandering in the streets and have them dig graves. This way, you can avoid the situation of running out of time for burial and having unburied bodies piled up.*

[Translated from the Japanese translation.]

A doctor who treated flu patients wrote:<sup>1</sup>

*“These men start with what appears to be an ordinary attack of la grippe or influenza, and when brought to the hospital they very rapidly develop the most vicious type of pneumonia that has ever been seen. Two hours after admission they have the mahogany spots over the cheek-*

*bones, and a few hours later you can begin to see cyanosis extending from their ears and spreading all over the face, until it is hard to distinguish the colored men from the white...”*

[Page 36, R, Lines 15–25.]

A comment by a British physician in *The Great Influenza* by John M. Barry (2004):<sup>2</sup>

*“One thing I have never seen before—namely the occurrence of subcutaneous emphysema”—pockets of air accumulating just beneath the skin—“beginning in the neck and spreading sometimes over the whole body.”... One navy nurse later compared the sound to a bowl of rice crispies.*

[Page 235, Lines 17–23.]

The Spanish flu that started in the United States crossed the Atlantic Ocean and spread to Europe, and then to Russia, Africa, and Asia. There was no commercial airline travel at this time. Yet, it only took a half year for the virus to spread around the world.

Incidentally, this novel influenza outbreak, which first started in the United States and prevailed in Europe, came to be known as the “Spanish flu.” A widely accepted story for this name has to do with the information disclosure

policy among countries at that time. Europe was at war, and the countries that were involved, namely England, France, Germany, Australia, and the United States, treated the news that their young soldiers were dying one after another not in battle but by an unknown disease as highly confidential information. These countries strictly controlled information, trying not to reveal this information to their enemy, and more importantly, to the people in their own countries. On the other hand, Spain, which had proclaimed neutrality in the war, released relatively accurate information regarding the outbreak. Thus, people learned that a strange bad cold causing high mortality was prevailing in Spain. Hence, it became known as the “Spanish flu.”

### Consequences of the Spread of Infectious Disease

There are epidemiological foundations to a pandemic. Spread of an infectious disease can be explained by a very simple equation:

$$R_0 = \beta \times \kappa \times D$$

$R_0$ , which denotes a *basic reproduction number*, is the number of people that 1 infected individual can infect on average in a completely susceptible population. When this figure is less than 1 ( $R_0 < 1$ ), there will be no outbreak. When it is 1 ( $R_0 = 1$ ), the infection will never disappear, but will not spread either. When the infected individual will infect more than 1 person ( $R_0 > 1$ ), the infection will spread. The basic reproduction number ( $R_0$ ) is a function of 3 factors; the infection rate per contact ( $\beta$ ), the frequency of contacting others per unit of time ( $\kappa$ ), and the duration of the infectious period ( $D$ ). Simply said, an infection will spread when  $R_0$  is greater than 1 and subside when less than 1.

The rate of infection per contact ( $\beta$ ) for influenza is extremely low, at around 0.00001. The frequency of contacting others per unit of time ( $\kappa$ ) is the number of people who come in close contact with the infected individual (e.g., the number of people who pass within 2 m of the infected individual in a day) within a given time period. The duration of the infectious period ( $D$ ) will be, for example, 7 or 10 days. Thus, the basic reproduction number ( $R_0$ ) is simply a multiplication of these 3 variables. The infection rate per

contact and the duration of the infectious period vary among diseases, but the frequency of close contacts considerably differs depending on the era and society. The basic reproduction number for the Spanish flu was approximately 1.8, meaning 1 person infected 1.8 other individuals on an average. This figure was enough to give rise to a global pandemic in 6 months. Incidentally, the basic reproductive number for measles is 12. If a completely susceptible population is exposed to a single measles patient, the extent of the outbreak will be 6 to 7 times stronger than that of the Spanish flu. The Spanish flu that spread worldwide brought significant damage with the loss of 50 to 100 million lives. India suffered the most, with a loss of about 20 million people. In China, 5 to 10 million people died. The world population was estimated to be 1.8 to 2 billion in 1918, and the Spanish flu took the lives of 50 to 100 million of them. However, the mortality was roughly only 2%.

So what about the world in which we live now? What will we have to face when a pandemic occurs in this society?

Globally speaking, there are some avian flu outbreaks mainly in the Southeast Asia. As of March 2012, about 600 people have been infected, with 350 deaths. A simple calculation shows that the mortality is over 50%. If the avian flu is to become pandemic at the level of the Asian flu or the Hong Kong flu, the global economic loss is estimated to be 0.8% of the world GDP (as of 2005), which converts to 330 billion USD (or 31 trillion yen<sup>\*2</sup>). If it is to become a severe pandemic that would equal the Spanish flu, the world will suffer economic loss of over 1.1 trillion USD (100 trillion yen). Furthermore, if the avian flu virus H5N1 is to mutate to a human type, the expected economic loss may be as much as 4.2 trillion USD (400 trillion yen).

Incidentally, the economic loss by SARS was 18 billion USD, whereas the Great East Japan Earthquake had cost Japan about 16 trillion yen (168 billion USD). It is estimated that 25% of the Japanese population will become infected if a medium-level pandemic is to occur globally, producing about 20 million patients, of which 0.5 to 2 million will be hospitalized and 170,000 to 600,000 will die. England and the United States are expected to suffer similar damage as

\*2 US dollar/JPY exchange rate: US\$1=95 yen.

well. If a novel influenza is to emerge somewhere in the world, it will reach other countries within 1 or 2 months, and the duration of the infectious period will be 2 to 3 months. The authorities have developed some countermeasures under these assumptions.

When a pandemic just emerges, medical inspections are conducted at the borders in order to contain the infection at sites during the early phase of the outbreak. During the heat of a pandemic, reducing mortality and morbidity and avoiding the breakdown of social functions are the primary goals. Thus, the basic strategy is to select and concentrate effort for these goals and start vaccine production at the same time. With the basic reproduction number ( $R_0$ ) equation in mind, we may temporarily close schools, voluntarily refrain from having group meetings, encourage people to wear masks, and prophylactically administer anti-influenza medicine to slow down outbreak. Public health measures such as closing schools and not having meetings will act to lower the contact frequency ( $\kappa$ ), and medical measures such as administering anti-influenza medicine will decrease the number of viruses in the body when infected and reduce the infection rate ( $\beta$ ). The principle of anti-pandemic measures is to save individuals and slow down outbreak in the society by combining these 2 types of measures

### Swine Flu and Concluding Remarks

In 2009, there was an outbreak of the swine flu in Mexico. Some criticize that the measures taken were very excessive, but personally, I feel they

worked well. This incident, however, left us some issues to consider. One such example is the problem of risk communication, but I will save the discussion of this topic for another time. For now, I would like to mention that there are some aspects that can be improved, such as the handling of infected people by society and the media or the Minister of Health, Labour and Welfare of Japan having a press conference at mid-night.

Now that we have faced the Great East Japan Earthquake of March 2011, which is often referred to as an “unexpected” disaster, there is another thing that we must reevaluate. We should run a simulation again from the standpoint of what can be “expected,” in terms of what measures should have been implemented if the swine flu outbreak in 2009 had been extremely severe. Hypothetically speaking, what if such a pandemic is to occur immediately before or after Tokyo is hit by a major earthquake? Such situation has not been anticipated at this point. The question “is it really enough?” will be important from now on.

In conclusion, I believe that the administration of anti-influenza medicine is one of the reasons that the swine flu had very low mortality in Japan. However, we do not know how the administration of anti-influenza drug affected the population in terms of acquiring immunity. We must also evaluate its effect on the population if the second and third “waves” of outbreak is to strike within a pandemic. There are many other issues at question besides these examples. We must not discount them as “unexpected” but rather include them in our future planning.

### References

1. Carter L. Cold comfort. *Dartmouth Medicine*. 2006;31:36–42, 56–57.
2. Barry JM. *The Great Influenza: The Epic Story of the Greatest Plague in History*. USA: Penguin Groups; 2004.