Laboratory and Epidemiology Communications

Common Features of 2009 H1N1 Influenza Pandemic in Different Parts of the World Revealed by Log-Log Plot of the Cumulative Numbers of Infected and Deceased Cases

Hiroshi Yoshikura*
National Institute of Infectious Diseases, Tokyo 162-8640, Japan

Communicated by Ichiro Kurane
(Accepted February 16, 2010)

The log-log plot of the cumulative numbers of infected and deceased cases through the progress of the 2009 H1N1 pandemic gave a relation given by the equation \( \log Y = k \log X - k \log N_0 \), where \( Y \) is the cumulative number of infected cases, \( X \) the cumulative number of deaths, \( k \) the coefficient representing the slope of the curve, and \( N_0 \) the value of \( X \) when the curve crosses the \( X \) axis (1). The analysis was made with the data obtained up to July 6, 2009, when the epidemic was limited almost solely to the American continent and mortality on other continents was rare.

Since then, the influenza pandemic has spread all over the world. An overwhelming number of new infections made the laboratory testing of all the suspected patients no longer practicable. Reporting of all infected cases was discontinued in many countries, including Japan. Currently, the WHO website gives data only by region, not by country. This paper reports on a further analysis made of the influenza pandemic using the data updated up to November 22, 2009 (http://www.who.int/csr/disease/swineflu/updates/en/index.html; http://www.mhlw.go.jp/bunya/kenkou/kekkaku-kansenshou04/rireki/091228-03.html; http://idsc.nih.go.jp/disease/swine_influenza/index.html).

Fig. 1 shows the log-log plot of the cumulative numbers of laboratory confirmed cases versus deceased cases for WHO Regional Offices except for the Americas (AMRO). The slope of the curve was almost the same, \( k = 1.7 \) for Africa (AFRO), South-East Asia (SEARO), and the Eastern-Mediterranean (EMRO), and \( k = 1.8 \) for Europe (EURO) and the Western Pacific (WPRO). \( N_0 \) was about 600 for AFRO, EMRO, and SEARO, and 5,000 for EURO and WPRO. The curves of EURO and WPRO had a breakpoint near \((X, Y) = (60,000, 300)\). The log-log plot for Japan of the estimated cumulative number of infected cases (not laboratory-confirmed cases) versus the cumulative number of deceased cases had a breakpoint near \((X, Y) = (1,000,000, 20)\) after a short initial steep rise with \( k = 2 \) and \( N_0 = 300,000 \). For all of WPRO, EURO, and Japan, after the break, slope \( k \) of the curve was about 0.8–0.9 (about 0.9–1.0 after reset at break point; here, “reset” means that the cumulative number before the reset date was subtracted from all the subsequent cumulative numbers).

Fig. 2 shows the log-log plot of the cumulative numbers of laboratory confirmed cases versus cumulative number of fatal cases for AFRO, EMRO, SEARO, EURO, and WPRO, and the plot for the cumulative number of estimated (not necessarily laboratory-confirmed) influenza cases versus the cumulative number of fatalities in Japan. The first plot is August 6 for AFRO, July 31 for EMRO, July 1 for SEARO, June 24 for EURO, and June 24 for WPRO. The last plot is November 22 for all regions. For Japan, the data are from the 33rd week (August 10–16) to the 49th week (November 30–December 6). The data from EURO have the qualification of “over” for “cases” since August 6, and “at least” for deaths since August 23. Horizontal axis, cumulative number of laboratory-confirmed influenza cases for WHO regions and estimated influenza cases for Japan. Vertical axis, cumulative number of deceased cases.
laboratory-confirmed influenza cases versus deceased cases for AMRO. The original plot (AMRO: 4.30–11.08) followed a near sigmoid curve. The plot was reset on May 18 (AMRO: 5.22–6.17), June 18 (AMRO: 6.22–7.31), and July 31 (AMRO: 8.6–11.08). The initial slow rise with $k = 0.6$ of the original plot of AMRO (AMRO: 4.30–11.08) was represented by the Mexican epidemic, where the pandemic started (1).

The slope of the curves with reset at May 18 (AMRO: 5.22–6.17) was $k = 1$. The curve reset at June 18 (AMRO: 6.22–7.31) was an upward concave. The curve reset at July 31 (AMRO: 8.6–11.08) was convex and the slope in its terminal portion, where the plot was almost on the straight line, was around 0.6. Fig. 2 contains, in addition, the plot up to July 6 of AMRO excluding Mexico. The slope of the curve was $k = 1.7$.

The following observations were made.

1. In all countries/regions except Mexico (1), there was an initial steep rise of the case-fatality rate with a $k$ value of 1.7–1.8.

2. The number of patients when the first mortal case appeared (obtained by extrapolation to the horizontal axis, $N_0$) was variable among countries/regions. It was in the range of 600–5,000. However, as the value of $N_0$, but not $k$ (2), is strongly influenced by the sensitivity of the reporting system, the different $N_0$ values among regions should be interpreted with caution.

3. For EURO and WPRO, there was a break after the sharp rise. A similar break was observed for Japan as well as for the 1918–1919 pandemic in San Francisco (2).

I previously explained the initial steep rise of the case-fatality rate ($k > 1$) by postulating more rapid virus spread among vulnerable groups causing higher mortality than in the general population (2). However, the mortal cases, including those in the initial phase, were sporadic and unrelated to each other, at least in Japan (although about three-fourths of the mortal cases (96/128) had chronic ailments). Detailed epidemiological analysis in other countries with higher mortality may clarify the events behind the sharp initial rise, including the possible systematic reporting bias.

A $k$ value less than 1 ($k < 1$) occurs when the virus spreads slowly with high mortality in one population and rapidly with low mortality in the other population. There are two possible situations; one is co-circulation of virulent and less virulent strains as proposed for the Mexican epidemic (2), and the other is spread of the virus in the general population and in the population vulnerable to the virus where the virus spreads more slowly but with higher mortality. $K = 0.6$ of the terminal portion of AMRO: 8.6–11.08 could be explained by the latter.

Finally, it was found to be important to reset the log-log plot at intervals (1). Compare the end portion of the curve AMRO: 4.30–11.08 with AMRO: 8.6–11.08, which may give entirely different messages.

I thank Dr. Kazuyo Yamashita, National Institute of Infectious Diseases, and Mr. Keisuke Nakajima, Ministry of Health, Labour and Welfare, for information of the website data.

REFERENCES
