Real-time Surveillance of Pneumonia and Influenza Mortalities via the National Death Certificate System

Wan-Jen Wu[1],   Chi-Ming Chang[2],   Ching-Hui Jiang[1]
Shiang-Lin Yang[1],   Jen-Hsiang Chuang[1]

1. Epidemic Intelligence Center, Centers for Disease Control, Taiwan
2. Secretary General Office, Centers for Disease Control, Taiwan

Abstract

After the outbreak of 2009 pandemic influenza A (H1N1) in April of 2009, Taiwan CDC and the Department of Health Office of Statistics cooperated to establish a real-time pneumonia and influenza mortality surveillance system, utilizing daily mortality reports sent by the Office of Statistics. The goal was to achieve close surveillance of the epidemics and to respond in an appropriate and timely fashion.

This report utilized mortality case data between January 1, 2008 and June 27, 2009 (up to 2009 week 26), analyzing 150,551 reports submitted via the National Death Certificate System. The 4-week moving average showed the number of pneumonia and influenza mortality cases began to rise in 2008 week 49, peaked in 2009 week 6, and finally started to decline in 2009 week 14. The average during non-epidemic period was 217 cases per week, which rose to 290 cases per week during epidemic period. The

peak was 2009 week 5, which had 373 mortality cases.

Comparison of 2008 pneumonia and influenza mortality case statistics provided by the Office of Statistics, against data collected by the real-time surveillance system, revealed the data from the latter may have overestimated the situation. Analysis of both data sets found a correlation coefficient of 0.85 (p value <0.0001). At present, this surveillance system has been incorporated into the CDC influenza surveillance network. Joining with 3 other systems, they are expected to attain complete surveillance of the evolving influenza epidemic, in order to provide real-time monitoring and early warning.

Introduction

Since April of 2009, nations all over the world began to report 2009 pandemic influenza A (H1N1) epidemics. As of the 6th of July, the World Health Organization (WHO) reported 94,512 confirmed cases worldwide, including 429 mortality cases [1]. United States of America, Mexico, and Canada have the most number of cases. With rising public concerns, Taiwan classified 2009 pandemic influenza A (H1N1) as a Class I Notifiable Disease on the 27th of April [2]. The Central Epidemic Command Center was established a day after to better monitor and respond to the evolving epidemic [3]. However, 2009 pandemic influenza A (H1N1) was reclassified as a Class IV Notifiable Disease on the 19th of June due to its mild symptoms [4].

The United States divide influenza surveillance into 5 categories: virology, outpatient, mortality, hospitalization, and geographical distribution.

The mortality surveillance is comprised of two systems: first, 122 cities provide weekly report on mortality cases that were directly caused (or suspected to have been caused) by pneumonia or influenza; second, another system monitors pneumonia and influenza mortality cases under the age of 18 [5-7]. The two systems work together to achieve immediate surveillance of the situation. The Department of Health Office of Statistics, in cooperation with Taiwan CDC, submitted daily mortality reports via File Transfer Protocol (FTP). Pneumonia and influenza mortality cases were extracted to facilitate establishing a real-time surveillance system and surveillance of influenza related mortalities. Taiwan CDC planned on assimilating this system with 3 pre-existing systems (RODS, contracted laboratories surveillance system, and complicated influenza surveillance) to establish a network that monitors 4 major aspects of the influenza epidemic: mortality, influenza-like illnesses (ILI), virology, and complicated influenza cases. This network shall enable a full grasp of the evolving epidemic trend, and to achieve timely surveillance and early warning of any changes.

Methods and Materials

1. Source of information

Information for the daily mortality report originated from the National Death Certificate System. In accordance to the Mortality Information Reporting Regulations Article 4, Paragraph 2, medical institutions should report a mortality case to the National Death Certificate System within 7 days after the case has been established. The Department of Health is then required to submit the information to the Executive Yuan within 7 days

after the case has been received via internet. Institutions not on the National Death Certificate System should submit a paper copy of the report to the Department of Health within 7 days after the case has been established. The Department of Health is then required to enter the report into the system manually within 15 days after the case has been received, then submitted to the Executive Yuan via internet [8]. The Department of Health Office of Statistics shall submit data from the National Death Certificate System to Taiwan CDC via FTP on a daily basis, to provide timely update on national death reporting status. Taiwan CDC shall use the information to establish real-time surveillance of pneumonia and influenza mortality case trends.

2. Report content and format

The daily mortality report received by Taiwan CDC is in the format of Comma Separated Value (CSV), written in Mandarin Chinese. The report includes status update, case serial name, patient name, sex, personal identification number, residential address (including area name and area code), birth date, time of death, place of death address (including area name and area code), nature of death, patient's occupation and duty, marital status, clinical cause of death, time between initial onset of infection till death, doctor's name and license number, hospital's information (name, address, license, code), and time of final update [8]. The clinical cause of death has 2 categories. The first includes injuries and diseases directly related to the death and has 4 fields; the second includes injuries and diseases indirectly related to the death and has only 1 field. The information is in Mandarin Chinese, and has not yet to be converted into corresponding International Classification of Diseases, Tenth Revision

(ICD-10) code.

3. Reporting period

This report utilized mortality case data between January 1, 2008 and June 27, 2009 (up to 2009 week 26), analyzing 150,551 reports submitted via the National Death Certificate System.

4. Data processing and analysis

SAS Enterprise Guide (SAS EG) software was used for primary processing and analysis of the collected data. The daily mortality report was first transformed into SAS data file. The data form, especially the 4 boxes from Cause of Death category I, was then cleared of unnecessary data (extraneous grammar marks, empty boxes, NA, etc.). Information such as week of death, age of death and age group were then extracted. The clinical cause of death was then determined via the General Principle from the WHO ICD-10: when more than one condition is entered on the certificate, the condition entered alone on the lowest used line of Part I should be selected only if it could have given rise to all the conditions entered above it. [9,10]. Mortality cases with cause of death that contained the phrase "pneumonia, flu, and influenza" were selected. This selection method does not take pathological causal relationships into account; cases are selected based purely on the last item in the Clinical Cause of Death category. Due to the large variations in the number of pneumonia and influenza mortality cases reported from week to week, and to exclude random spikes in the number of cases, the 4-week average were calculated to obtain a smoother trend-line, for the purpose of future surveillance. The moving average is calculated as follows:

$$MA_k = \frac{\sum\limits_{i=k-w+1}^{k} Xi}{w}$$

X1, X2,……, X: weekly total number of pneumonia and influenza mortality cases

w : number of weeks used for calculation

k : specific week, w~n

n : week number of latest data

Results and Evaluations

1. Mortality report data analysis

There was a total of 142,283 reported mortality case for the year of 2008, announced by Taiwan Department of Health on the June 17, 2009 [11]. 102,675 cases were reported to Taiwan CDC, reaching a reporting rate of 72.2% (102,675/142,283). Results of daily mortality report analysis between January 1, 2008 to June 27, 2009 (2008 week 1 to 2009 week 26), when compared to 4-week moving average and overall pneumonia and influenza mortality case average from the same time period, showed a rise in number of mortality cases starting in 2008 week 49, reached its peak in 2009 week 6, and started to decline in 2009 week 14.

According to results obtained through the real-time pneumonia and influenza mortality surveillance system, the average number of mortality cases per week during non-epidemic period (2008 week 21 to 2008 week 40, 20 weeks total) was about 217. This number was used to compare against future weekly results to detect any significant fluctuations and abnormalities. The average number of mortality cases per week during epidemic period (2008 week 47 to 2009 week 12, 18 weeks total) was about 290. 2009 week 5 saw the highest number of mortality cases, with 373 deaths.
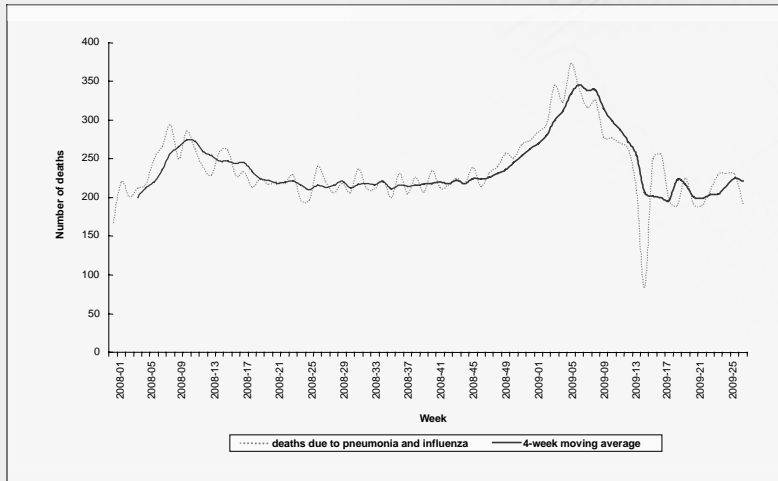
Figure 1. Pneumonia and influenza mortality cases, by week of report - Real-time Surveillance of Pneumonia and Influenza Mortalities, Taiwan, 2008 week 1 to 2009 week 26

2. System evaluation

From all the mortality reports received for the year of 2008, 12,077 pneumonia and influenza mortality cases were extracted. The Department of Health extracted 8,665 pneumonia and influenza mortality cases from its own database (8,661 pneumonia cases and 4 influenza cases) [11]. The real-time surveillance system may have overestimated the situation. SAS EG software calculated the correlation coefficient between the two numbers to be 0.85 (p value <0.0001). In terms of real-time monitoring, the new system is suitable to monitor national pneumonia and influenza mortality trends. Comparison of weekly mortality reports for the year 2008, recorded by the real-time surveillance system and results published by the Department of Health, is shown below.
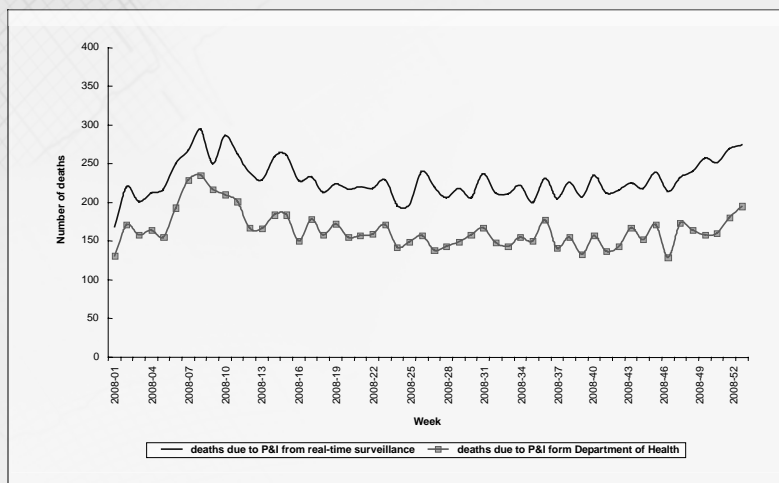
Figure 2. Pneumonia and influenza mortality cases of Department of Health data compared to real-time pneumonia and influenza mortality surveillance system data, by week of report - Taiwan, 2008

Discussion

Analysis of the daily mortality report revealed the following: there were a total of 102,675 reported mortality cases for the year of 2008, while the Department of Health reported a total of 142,283 mortality cases for the same period [11]. The difference was caused by the following: The Department of Health Office of Statistics submits information from its National Death Certificate System to Taiwan CDC via FTP on a daily basis [8]. Information from the system was reported by individual physicians/hospitals, but since reporting is not compulsive, the reporting rate is not 100%. The Department of Health Office of Statistics obtains its own data in a more traditional method: death certificate copies are submitted by local Health Bureaus on a monthly bases; the Office of

Statistics then builds the mortality cases [12]. However, the Office of Statistics' own data is not available to the public until it has been published in June of the year after. For the purpose of real-time epidemic surveillance and early warning, as well as to monitor the epidemic daily, Taiwan CDC decided to extract its information from the National Death Certificate System that's updated on a daily bases, which was also the cause of research limitations of this report.

The 4-week moving average from figure 1 showed a peak in mortality cases from 2008 week 49 to 2009 week 14, indicating there were more pneumonia and influenza mortality cases during the winter season. The weekly mortality case number can be compared to the average weekly mortality case number from the non-epidemic period, to actively detect any abnormalities. However, figure 2 indicated the data from real-time surveillance system may have overestimated the situation. For the year of 2008, the real-time surveillance system reported 40% more pneumonia and influenza mortality cases than the Department of Health Office of Statistics did (12,077/8,665). The real time surveillance system includes cases not caused directly by pneumonia and influenza, contributing to this apparent overestimation. In the daily mortality report, the clinical cause of death was selected based on the General Principle outlined in the WHO ICD-10 [9,10]. Only reports with "pneumonia, flu or influenza" (in Mandarin Chinese) in the last field of category I were selected. This method does not consider pathology causal relationships, and the cases were extracted under the assumption that all physicians complied with all guidelines when completing the death certificate. Without taking pathology causal relationships into consideration, many cases that were not "ultimately" caused by

pneumonia and influenza were included in the report, causing the apparent overestimation in mortality case numbers. This area requires ample amount of medical knowledge and experience, and in order to make the current real-time pneumonia and influenza mortality surveillance system totally automated in the future, considerations are being given to adding procedures and processes that will standardize the classification of the clinical cause of death, from the Automatic Classification of Medical Entry (ACME), established by the US CDC National Center for Health Statistics in 1968. This upgrade would decrease accidental extractions of non-pneumonia and influenza mortality cases [13,14]. In addition, mortality reports for the year of 2008 provided by the Department of Health will be analyzed to establish a logical pattern on how the ultimate clinical cause of death was determined, with the hopes of establishing a database that will increase accurate extraction of true pneumonia and influenza mortality cases, therefore improving the accuracy of the real-time surveillance system.

The goal of establishing this real-time pneumonia and influenza surveillance system was to use it for surveillance and early warning of future epidemics. This system now works along side Taiwan CDC's 3 other major surveillance systems; the 4 systems hope to attain complete surveillance of the evolving epidemic trend. However, the system is still being developed and fine-tuned; there remain many obstacles to be conquered. In the future, the system hopes to take seasons into account, to better monitor and predict impending epidemic trends [15,16]. In regards to fine-tuning the determination of clinical cause of death, the automation of the system, processes and procedures, as well as evaluation of such

cause by the surveillance system, remain to be further discussed. Accurate and timely mortality report can also improve data integrity of the Taiwan CDC Infectious Diseases Information Warehouse, and to broaden the usefulness of the data. The surveillance system shall be continuously improved, discussed, and researched, in order to face future challenges.

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