Report

Mobile device-based Reporting System for Sichuan Earthquake-affected Areas Infectious Disease Reporting in China

GUO Yan[§] and SU Xue Mei[§,#]

National Center for Public Health Surveillance and Information Service, Chinese Center for Disease Control and Prevention, Beijing 102206, China

Abstract

Objective To describe the experience of the China CDC in rebuilding reporting capacity and response to the Sichuan earthquake through use of mobile phones.

Methods Software engineering and business modeling are used to design and develop a cell phone-based reporting system. The PDA-based system used by the Field Adapted Survey Toolkit (FAST) was deployed

Results Approximately one week after deployment of the mobile phone-based reporting system, the cumulative reporting rate reached the same level (81%) as the same period in 2007. In the Sichuan provincial pilot investigation for infectious disease, 1339 records were collected using PDAs developed and deployed by FAST.

Conclusion The mobile-based system is recognized as a quick and effective response solution to this public health challenge. Our experience suggests that mobile-based data collection tools provide faster, cleaner, standardized, and shareable data for critical decision making. This system could be adapted as complementary to national infectious disease reporting systems after natural disaster occurrences.

Key words: Mobile; Earthquake; Surveillances

Biomed Environ Sci, 2012; 25(6):724-729 doi: 10.3967/0895-3988.2012.06.016 ISSN:0895-3988

www.besjournal.com(full text) CN: 11-2816/Q

INTRODUCTION

A national infectious disease surveillance system was implemented in China in 2004, which is a web-based reporting system. The service is provided at all medical institutions and CDC locations (from county to provincial offices to CDC headquarters in Beijing). The system uses the Internet and VPN (virtual private network) to provide accurate and timely data to decision makers. The system enables an increase in coverage of national disease surveillance and in awareness of public health emergencies[1].

For example, disease prevention divisions at the county hospital level report a national notifiable disease via the web-based reporting system to the China CDC (CCDC) and county CDC, for review and verification. The data are aggregated and analyzed on a daily, weekly, monthly, and annual basis by the CCDC, and feedback is provided at the local level. In 2007, the system covered 96% of county- to provincial-level hospitals and 79% of township hospitals nationwide. There are 68 000 users accessing the system daily at all levels[2].

A major earthquake rated at magnitude 8 on the Richter scale occurred in the Wenchuan area of

[#]Correspondence should be addressed to SU Xue Mei, E-mail: s63173957@hotmail.com or suxm@chinacdc.cn, Tel: 86-10-58900419, Fax: 86-10-58900445.

[§]GUO Yan and SU Xue Mei contributed equally to this paper.

Biographical notes of first authors: GUO Yan, male, Master, research associate, majoring in Public Health Information Management; SU Xue Mei, female, Master, senior research fellow, majoring in public health informatics studies.

Received: March 2, 2012; Accepted: August 25, 2012

Sichuan Province on May 12, 2008. It left approximately 90 000 dead, 370 000 injured, and 4.8 million people homeless[2]. Infectious diseases in developing countries are common in populations displaced by natural disasters[3]. In light of such a severe situation, the CCDC made a preliminary assessment of the extent of the infectious disease surveillance system after the earthquake. A total of 566 web-based reporting sites were disabled in earthquake-affected areas, owing to loss of telecommunication. It was difficult to assess the region's health needs or monitor potential disease outbreaks. There was only partial recovery of telecommunications systems and many computers were severely damaged, which caused a lack of infectious disease reporting. Because of these conditions, the decision was taken that in affected areas under an emergency situation, there must be rapid recovery of mobile communications. Thus, a cell phone-based reporting system was adopted to do infectious disease surveillance.

To quickly rebuild reporting capacities and respond to the public health emergency, in collaboration with several companies, the CCDC developed and implemented a cell phone-based reporting system to monitor notifiable infectious diseases and syndromes. Cell phones were donated by private Chinese companys. The phones were intended for use with no electric power; they could be recharged by sunlight or strong light source to maintain a long standby time.

After the earthquake, the United States CDC (U.S. CDC) offered to assist the CCDC public health recovery efforts. Public health informatics experts at both agencies worked together to accomplish the following goals: Finish development of a smartphone and PDA-based questionnaire using FAST (Field Adapted Survey Toolkit) software; complete establishment of a system for merging and transferring survey data from smartphones and PDAs to laptops and the FAST exchange server; provide training to CCDC staff and conduct field tests in Sichuan Province; explore future applications for routine public health surveillance, surveys, and outbreak investigations. Finally, public health informatics workers at the CCDC completed exchange and integration of the two aforementioned systems.

This paper describes the experience of the CCDC in using mobile phones for infectious disease surveillance and investigation after the catastrophic Sichuan earthquake.

METHODS

Cell Phone-based Reporting System Setup

The cell phone-based reporting system, developed by the CCDC together with several companies, was composed of three parts. These were the silicon chip integrated with a questionnaire code for case reporting, which was pre-installed on the cell phone; a communication mechanism for coded data transmission and receipt; and a code/decode system for data exchange and simple analysis. Figure 1 shows the data collection and transmission[2,4].

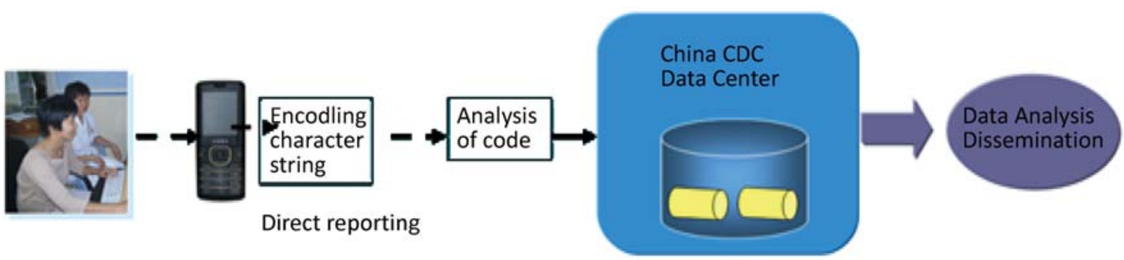

Figure1. Cell phone-based reporting system.

The information receiving terminal of the reporting system is composed of a Global Systems for Mobile Communications/General Packet Radio Service (GSM/GPRS) modem and server. Data transmission is realized by taking advantage of the short message service (SMS) of GSM mobile communications technology. Through the SMS channel of a GSM/GPRS public network, the server uses the RS232 port to communicate with the GSM/GPRS module, accepting information from the mobile terminal via the GSM/GPRS network. The server converts the PDU (Protocol Data Unit) format code, and transmits the data to other appointed terminals or phones using this system. The standard character string should be restored to the content of the reported information, and then entered into the web-based reporting system database of the surveillance network for summary, analysis and information applications. The cell phone-based reporting and web-based reporting systems could be deployed within the same network, with only data exchange links between them[2].

Syndromic and disease surveillance included respiratory syndromes with fever, rash and fever, diarrhea (watery stool), diarrhea (bloody stool), acute jaundice, encephalitis or meningitis, other febrile illnesses, and food poisoning. If a patient with one of these syndromes or diseases was found, the reporter registered case information in a daily summary, and reported this information via cell phone. If a patient was diagnosed with a notifiable infectious disease, local health workers used the pre-installed reporting system in the cell phone to report the case. Detailed information of suspected Class A infectious disease, suspected death from infectious disease, and infectious disease outbreaks was reported by SMS immediately. After this information was sent, the system performed logical verification and transmitted an automatic reply to the reporting official, to confirm that the information was successfully sent and received. Public health workers responsible for infectious disease surveillance audited the reporting data, using the interface of the cell phone-based direct reporting system. Daily data analysis began automatically at 00:00, as shown in Figure 2[2].

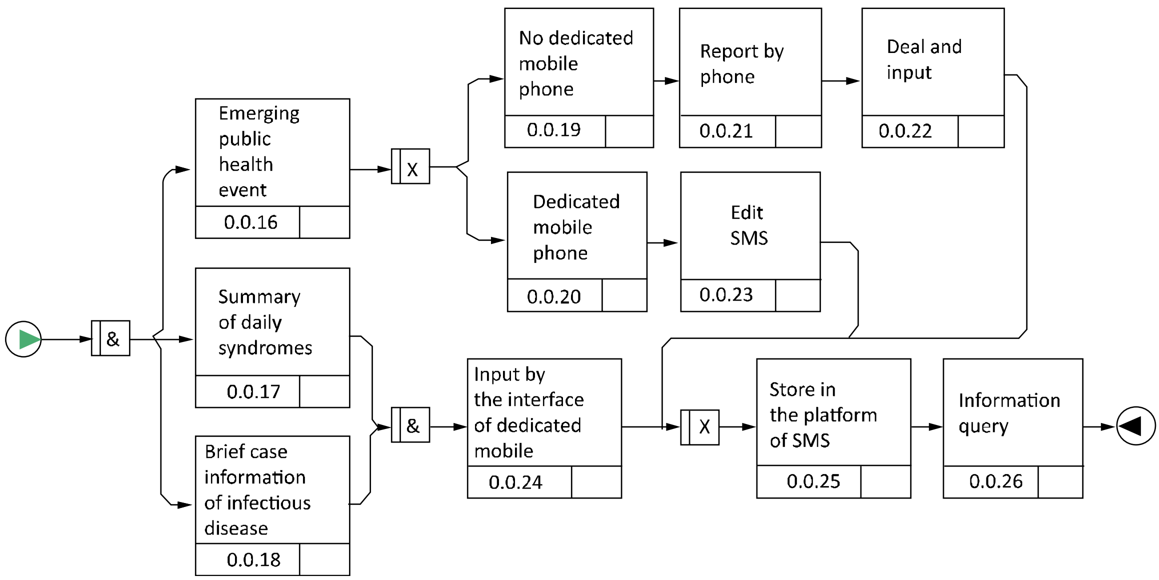

Figure 2. Flowchart of reporting system after earthquake.

Implementation of FAST

The FAST allows information to be rapidly collected on mobile devices, using customizable forms. U.S. CDC experts provided the FAST software developed by GeoAge, who gave permission for the copyrighted FAST system to be used at no charge in Sichuan Province. The software provides multi-language support, and can be used to quickly build an electronic smart survey and rapidly deploy survey instruments. It features integrated GPS/GIS for use with Environmental Systems Research Institute (ESRI) ArcGIS and Google Earth. FAST provides cross-platform installation and implementation, easy data consolidation, and quick analysis. The system can be deployed either in workgroup or enterprise modes. The workgroup mode can be used in areas with no wireless or Internet service. Data is sent from hand-held devices to laptops via a wired connection. Then data can be sent to the server via Internet. In enterprise mode, the collected data can be sent to the server through Wi-Fi hotspots and Internet. Once data arrives at the server, a summary report can be created in chart form, or the data exported to SAS or SPSS for statistical analysis. The data can be also seen on the default map that comes with FAST, or by use of a custom MXD file for ESRI or Google Earth. In June 2008, several public health informatics experts at the U.S. CDC and China CDC worked together to deploy the PDA-based system using FAST. Subsequent in-house testing of data collection, transmission, analysis, and reporting showed the system worked properly and met the needs of CCDC's public health relief efforts. In the design process, data collection items and term dictionary were standardized, so data collection via questionnaire was more efficient. After we completed the paper survey questionnaire design, public health informatics experts at the CCDC used the FAST software to prepare an electronic version of the questionnaire. After testing and pre-investigation, we made a revision. This PDA-based questionnaire met general requirements of the investigation.

RESULTS

The Sichuan earthquake interrupted cable networks, and paralyzed infectious disease and public health emergency reporting system. In the face of such a serious situation, the CCDC proposed cell phone-based case reporting for infectious disease prevention and control to the Ministry of Health (MOH). With support of the MOH, the CCDC quickly organized and coordinated their internal technical staff and external social forces to develop a mobile emergency disease reporting system. It only took three days to develop the system. Five public health informatics workers at the CCDC were assigned to the disaster areas on May 21, 2008, executing tasks of pre-testing, mobile phone distribution, training, and deployment. On the same day, there was a successful connection between the cell phone-based reporting system and the existing national infectious disease reporting system at CCDC. On May 22, the tenth day after the earthquake, the first case report was received by cell phone-based reporting. Later, with support from local government, the assigned team conducted training courses for local public health workers responsible for infectious disease reporting in 14 heavily stricken counties and temporary settlements. As of May 31, the system had covered the areas in which mobile telecommunication was restored (Figure 3). Approximately a week after deployment of the mobile phone-based reporting system, the cumulative reporting rate reached the same level (81%) as in the same period in 2007. At end of 2008, the reporting rate of hospitals in the disaster area was 88%, significantly higher than the rate in 2007, and higher than the rate (83%) in non-disaster areas of Sichuan Province[2,4] (Figure 4).

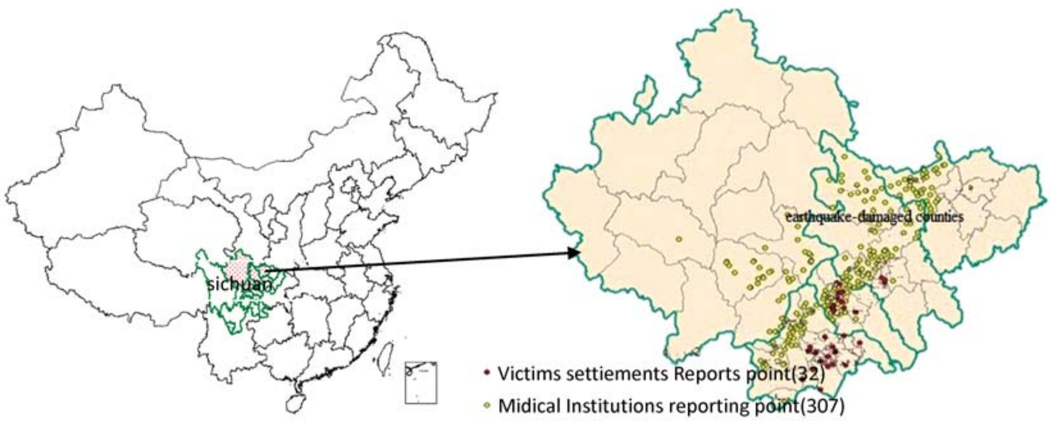

Figure 3. Geographic distribution of hospital-based reporting in earthquake-damaged counties.

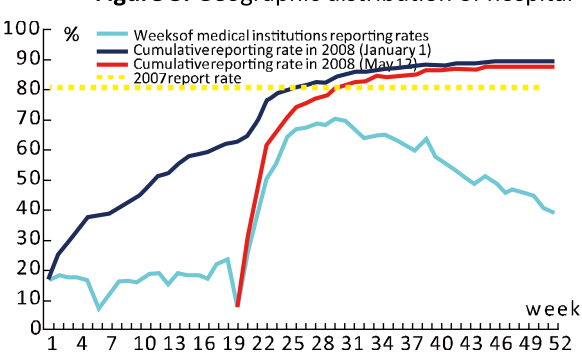

Figure 4. Recovery of hospital-based reporting in earthquake-damaged counties, by week.

In the three-month period after the earthquake, compared with the average level of notifiable disease reporting over the same period in the previous three years, the number of notifiable intestinal infectious disease reported cases decreased by 21.01%. Notifiable respiratory infectious disease reported cases decreased by 41.15%. Clusters of cases were not evident. Infectious diseases that increased more significantly were acute hemorrhagic conjunctivitis (14.16%) and rubella (4.39%).

Throughout the symptom surveillance system, there were 30 reporting units participating in the symptom observation system from May 15 to June 14, 2008. There were 10 994 reported fever cases, 15,308 diarrhea cases, and 82 689 common cold cases in the city of Mianyang. Among medical institutions and medical service groups, there were 9 reporting units in Mianyang. These reported that the incidence rates of fever, diarrhea and common cold were 1.309%, 1.430%, and 14.303%, respectively. The establishment of a symptom surveillance system was influential in determining the disease condition in the disaster area and in early investigation of disease case aggregation[5].

The Sichuan provincial pilot investigation for PDA-based infectious disease reporting developed by FAST was successfully implemented and deployed in October 2008. The project team designed a questionnaire with 14 questions, most of which were multiple-choice options for accelerated data entry. There were 16 public health workers participating in the investigation. Four groups were formed, with four people in each group. To compare advantages and disadvantages of different investigation systems, three people used PDAs and one used a paper form. A total of 637 householders, with 1708 individuals, were investigated. There were 1339 records collected with the PDA, and 201 records using the paper form. Given the same amount of time for data collection and entry, the PDA group had 446 records per group, and the paper group 201 records. The time for collecting one record was about 1.65 minutes in the PDA group, and 2.29 minutes in the paper group. From interviews of PDA-based survey participants, the following advantages of a PDA-based survey were established: 1. Operational flexibility, such as more options to choose from, easy to fill out, and fast entry; 2. Work efficiency improvement; 3. Respondents pay more attention to the PDA, which enhances their acceptance of the survey; 4. PDAs are easy to carry and of small size, and loss of paper survey forms is avoided; 5. Reduction of entry errors because of logical verification; 6. Rapid deployment and flexible customization; 7. Simple data collection, entry and transmission processes relative to the traditional investigation process. However, there are some disadvantages, such as Chinese localization errors, poor stability and lack of Chinese district codes.

DISCUSSION

A mobile-based reporting system for infectious disease and symptom surveillance solved the challenge of data collection and transmission in the aftermath of a natural disaster. The system was important in improving report timeliness and interventions. Local staff could easily use the reporting method after a short training period.

With extraordinary events such as earthquakes, there are important questions to be answered. What surveillance must be done? Is a baseline necessary for symptom surveillance? Owing to differences in the number of people and activities in monitored areas relative to the past, the original data cannot reflect the current situation. Therefore, monitoring for clusters of illness should focus on specific symptoms, or short-term baselines should be considered as a basis for issuing warnings. For certain emerging infectious diseases (e.g., avian influenza and *streptococcus suis*) or severe infectious diseases (e.g., cholera), the surveillance objective should be “key symptoms” instead of baseline[6].

However, there were problems in data collection for the symptom surveillance system after the earthquake: 1. Case information with enumeration data was not detailed enough to do further analysis; 2. The casualties and frequent movements of people in the disaster area led to failure in performing statistical analysis of demographic data, and even in calculating morbidity and attack rates; 3. Frequent relocations of relevant workers resulted in partial data loss from some surveillance locations; 4. The surveillance system did not include enough of the population, owing to limitations of human and material resources. For these reasons, system operation needs further scientific appraisal[5].

As for system function, the CCDC cell phone-based system can meet basic public health needs. However, there are some necessary features the system should provide, such as GPS integration and GIS enabling. Some system weaknesses were also identified. For example, pre-installation of the survey form is required, which makes customization difficult. A new survey requires a new installation. Other issues, such as a greater data transmission capability, improved data management, data security, and confidentiality must be addressed. Compared with the CCDC cell phone-based system, the smartphone/PDA-based system provided by the U.S. CDC can be configured flexibly so that the questionnaire can be rapidly and accurately customized, in addition to the convenient data management and analysis of that system.

Given technological feasibility, we shall develop the mobile phone reporting system for use with Symbian, Windows Mobile, Linux, IOS, and other operating systems. The aim is for users to be able to download and install the reporting system conveniently, which avoids delays in awaiting delivery of specific mobile phones. This allots more time for prevention and control work in disaster areas, and increases the speed of public health emergency response. The necessary surveillances within a public health emergency response plan should be prepared in advance[7].

CONCLUSION

A mobile-based reporting system was recognized as a quick and effective solution for public health practice in post-natural disaster situations. Our experience suggests that mobile-based data collection tools can provide faster, cleaner, standardized, and shareable data for critical decision making. This system could be adapted as a complement to current Chinese national infectious disease reporting systems for natural disaster events. Upon successful application of this project, the CCDC also succeeded in data collection and reporting via a PDA-based system in a 2008 national investigation of infectious disease underreporting. This embodied a wider application than the Sichuan project, with positive results. In the Yushu earthquake relief work of April 2010, a mobile-based reporting system also played a key role as a means of infectious disease surveillance and reporting.

ACKNOWLEDGMENTS

We would like to acknowledge our U.S. CDC colleagues in the Beijing and Atlanta offices, especially Drs. Li Wei, Li Wen Kai, and Terry D. Boyd. Thanks also to the CDC Foundation, our China CDC colleagues, and private sector partners GeoAge and others, who donated software and hardware to support our recovery efforts.

REFERENCES

1. MA Jia Qi, YANG Gong Huan, SHI Xiao Ming. Disease surveillance based information technology platform in China. Disease Surveillance, 2006; 21, 1-3.
2. MA Jia Qi, ZHOU Mai Geng, LI Yan Fei, et al. Design and application of the emergency response mobile phone-based information system for infectious disease reporting in the Wenchuan earthquake zone. Journal of Evidence-Based Medicine, 2009; 115-21.
3. Watson JT, Gayer M, Connolly MA. Epidemics after natural disasters. Emerg Infect Dis, 2007; 13, 1-5.
4. YANG Chang Hong, YANG Jun, LUO Xiang Shu, et al. Use of mobile phones in an emergency reporting system for infectious disease surveillance after the Sichuan earthquake in China. Bulletin of the World Health Organization, 2009; 87, 619-23. doi: 10.2471/BLT.08.060905.
5. LI Yong Qing, LIU Chang Di, XIANG Ding Quan, et al. Analysis of symptom monitor after 5.12 wenchuan earthquake in mianyang. Modern Preventive Medicine, 2010; 37(1), 147-50.
6. FENG Zi Jian, ZU Rong Qiang. Thought on the development of syndromic surveillance. Disease Surveillance, 2007; 22(2), 73-5.
7. GUO Yan, WANG Li Ping, MA Jia Qi. Analysis on Application Effect of Emergency Response Mobile Phone Based Information System for Infectious Disease Reporting Used in Wenchuan Earthquake-striken Areas. Practical Preventive Medicine, 2009; 17(11), 2193-5.