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Design and prototype of a mechanism for active on-line emerging/notifiable infectious diseases control, tracking and surveillance, based on a national healthcare card system

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ABSTRACT

Timeliness is a critical issue in preventing the spread of emerging/notifiable infectious diseases, such as severe acute respiratory syndrome (SARS) or avian influenza (bird flu). Current computerized surveillance systems in many countries have demonstrated their usefulness in detecting specified communicable-diseases. However, the off-line, daily or weekly data reporting mode induces a time lag in data collection, transmission, processing, and responses. This paper proposes an on-line real-time mechanism, named EDICTS, for emerging/notifiable infectious diseases control, tracking and surveillance. It is based on the on-line health IC card system and works at the registration process of primary care practices and emergency departments. Hence, should a disease defined by CDC (Center for disease control) be detected at the registration station, EDICTS responds in real time. Note that EDICTS is a mechanism; it is CDC that determines the policy and activates it. A prototype is designed and implemented on a simulated environment of the Taiwan's national health insurance IC card system. The proposed policy and rules are defined according to the CDC regulations. Timely, sensitive and cost-effective, EDICTS complements the existing successive level of CDC reporting system as a fast-response control channel.

1. Introduction

From May to December of 2003, an outbreak of severe acute respiratory syndrome (SARS) caused a public panic in Taiwan. A report showed that Penghu pilot health IC card experimental system [1–4] responded quickly and effectively to the contact information about SARS suspects, the clinics they had visited and the patients who were in the same hospitals. The contact information was sent to Taiwan's bureau of national health insurance (TBNHI) and joined with a database to get the lodging and affiliations of those people for CDC to conduct further examination and isolation processes [5]. The efficacy and effectiveness of the Penghu health smart card system motivated this research, since the mechanism could be further generalized to be an on-line surveillance system to automatically monitor a variety of emerging/notifiable infectious diseases (ENID), such as SARS and avian influenza (bird flu), if health IC cards were nationally distributed.

Since timeliness is critical in preventing the spread of ENIDs and quick responses to the (possible) occurrence of ENIDs reduce infections to people and to medical institutions, many countries have their own formal mechanisms and policies for reporting and controlling such diseases. For example a 24 h delay is allowed for a medical institution to voluntarily report a suspect case to CDC in Taiwan. However, such a 24 h delay may cause infection to other people and the

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medical institutions that a SARS or avian influenza patient contacted or visited. Thus, a mechanism to help to reduce the spread of community infection and to decrease public panic is important.

This paper proposes a mechanism, named EDICTS, for emerging/notifiable infectious diseases control, tracking and surveillance, which is based on the on-line national health IC card system. A national health IC card system includes health IC cards, an IDC (IC card data center), which stores all IC cardholders' information, PoPs (point of presence) in each medical institution and a health network that interconnects IDC and all PoPs. Generally a PoP is located at the register station, the first line of all primary care practices and emergency departments. A PoP consists of a smart card reader, a personal computer connected to the health network, and related software such as HIS (healthcare information system) and smart card application programs. It is assumed that each cardholder would show his or her card to a medical staff at the registration and that CDC defines the policies and checking rules for the patterns of emerging/notifiable diseases, which are called edicts, for EDICTS. Once CDC decides to enable EDICTS, CDC informs IDC. Upon receiving edicts from CDC, IDC disseminates them to each PoP via the network. The EDICTS residing in each PoP updates the policy. Then EDICTS at each PoP automatically monitors such clinical cases (suspect case—symptomatic cases only, not confirmed yet) by constantly checking the patterns, entered by medical staff, of patients' visits. EDICTS is active in both sending information to IDC and to alerting the first-line medical staff, if a case should appear.

Note that a policy defines "what will be done", while a mechanism defines "how to do something", as given in [6], and that "The separation of policy from mechanism is important for flexibility." [6]. Only the epidemiologists in CDC determine when to enable/disable EDICTS and define the rules and patterns for ENID.

EDICTS is designed to work in parallel with, not to replace, the current ENID reporting system. It serves as a fast-response control and tracking channel for ENID. EDICTS puts emphasis on preventing secondary transmission from sporadic cases and common source outbreaks. The follow-up diagnosis requires multiple test results and rigorous procedures.

EDICTS checks two kinds of information. One is the most recent medical treatment records stored in smart cards. The other is the current medical record that is to be stored into the card. In the Taiwanese national healthcare insurance IC (NHI-IC) card system (NHICS), each NHI-IC card carries the six most recent patient visits and medical treatment history. A card reader, associated with a PoP, reads the history data and sends it to EDICTS. EDICTS checks this data with CDC edicts. If there is a match, EDICTS writes a suspect case mark into the card and sends an alarm signal immediately and automatically to the PoP's user interface. Hence clinicians are advised to refer to the suspect case description for further details of the symptoms and signs of ENID. Meanwhile the abnormal case is uploaded to IDC via the network. CDC thus has fast first-hand responses and is to able to set in motion the standard operating procedures. CDC could use the reports from EDICTS to know the contact information of the suspect cases, and therefore control and track the distribution of the ENIDs.

Some computerized surveillance schemes have been established to detect the outbreak of ENIDs worldwide. Their goals are to collect information, to identify the causative viral strains, to rapidly assess related morbidity and mortality, to predict the situation, and to redistribute certified information [7–10]. EDICTS was designed neither to detect nor to predict the outbreak of infectious diseases, though such extension is possible. EDICTS could be regarded as the mechanism to invoke after CDC has analyzed the information and determines that an emerging/notifiable disease outbreak is possible.

Sensitivity, specificity, and timeliness are important metrics in evaluating public health surveillance systems. Developers use these metrics to assess data quality and timeliness as well as more difficult questions such as which outbreaks may be detected, and how early they can be detected. EDICTS runs at each PoP, which is the best time and place to detect, report and alert staff, if there should be any cases. By the on-line (intranet) communication between each PoP, IDC and CDC, both IDC and CDC have the real-time responses from PoPs. Thus EDICTS completes a timely, sensitive and cost-effective ENID control, tracking, and surveillance systems.

The paper is organized as follows. Section 2 summarizes the background of the system. It is followed by the system design objective in Section 3 and technical description in Section 4. Section 5 is a status report of the system. Discussion and conclusions are in Sections 6 and 7.

2. Background of EDICTS

A computer-aided ENID surveillance system is essentially a system to help CDC experts make right decisions by gathering information on ENID occurrences and spread, hence to control, track, and surveillance of ENID. In the last decade, substantial investments have been made in surveillance systems for early detection of natural infectious disease clusters and of intentional acts of bioterrorism. Previous studies demonstrate that surveillance is useful in detecting specified communicable diseases. Such systems include the sentinel provider system (USA) [12], sentinel physician networks (European countries) [13], influenza surveillance system (Japan) [14], Australian sentinel practice research network (Australia) [15], epidemiological surveillance networks (France) [16], electronic point-of-sale (EPOS) pharmacy (England) [17], infectious diseases surveillance system (Japan) [18], ambulatory-care-based syndromic surveillance system (USA) [19], real-time syndrome surveillance (Canada) [20], and infectious disease prevention and control system (Germany) [21].

A categorization of computerized ENID surveillance systems by the timeliness of their response is shown in Fig. 1. Most of these systems set the types of diseases under surveillance, and report the number of diseases covered, the geographical area covered, and the population covered. However, the time delay allowed is from 24 h to a week, except that [18,20], and the proposed EDICTS are on-line. There is generally one-way communication, i.e. from medical institutions to CDC, and only EDICTS is real-time and with automatic reporting, while [20], for example, is done manually and by telephone.