



## E-Health Preparedness Assessment in the Context of an Influenza Pandemic: Case Study in China

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**ABSTRACT**

*Objective:* To assess preparedness status of a hospital in Beijing, China for implementation of an E-Health system in the context of a pandemic response.

*Design:* This research project used qualitative methods and involved two phases: 1) group interviews were conducted with key stakeholders to examine how the surveillance system worked with ICT support in Beijing. The results provided background information for a case study at the second phase; and 2) individual interviews were conducted in order to gather a rich data set in relation to E-Health preparedness at the selected hospital.

*Setting:* In Phase 1, group interviews were conducted at Centres for Disease Prevention and Control (CDC) in Beijing. In Phase 2, individual interviews were done at a secondary hospital selected for the case study.

*Participants:* In Phase 1, three group interviews were undertaken with 12 key stakeholders (public health/medical practitioners from the Beijing City CDC, two district CDCs and a tertiary hospital) who were involved in the 2009 influenza A (H1N1) pandemic response in Beijing. In Phase 2, individual interviews were conducted with 23 participants (including physicians across medical departments, the IT manager and general administrative officer).

*Primary and secondary outcome measures:* For the case study, five areas were examined to assess the hospital's preparedness for implementation of an E-Health system in the context of a pandemic response: a) motivational forces for change; b) healthcare providers' exposure to E-Health; c) technological preparedness; d) organisational non-technical ability to support a clinical ICT innovation; and e) socio-cultural issues at the organisation in association with E-Health implementation and a pandemic response.

*Results:* This article reports a small subset of the case study results from which major issues were identified under three main themes in relation to the hospital's preparedness. These issues include poor sharing of patient health records, prescription errors, unavailability of

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3 software tools to assist physicians in answering patient questions, physicians' concerns about  
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5 the reliability of ICT and high monetary cost of E-Health implementation and uncertainty  
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7 over return on investment, and their dissatisfaction with the software in use.  
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10 *Conclusions.* Prior to the implementation of E-Health, planning must be undertaken to ensure  
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12 the smooth introduction of the system. The assessment of organisational preparedness is an  
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14 important step in this planning process. Based on the case study, deficient areas of  
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16 organisational preparedness were identified for the prospective implementation of electronic  
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18 health records (EHR). Accordingly, we suggested possible solutions for the areas in need of  
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20 improvement to facilitate E-Health implementation's success.  
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24 *Keywords.* E-Health, preparedness assessment, pandemic, hospital, case study, China  
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## BACKGROUND

Influenza pandemics can occur with the appearance of a new strain of influenza A virus against which none of the population has any immunity.[1] A severe pandemic has the potential to increase morbidity and mortality levels, and consequently cause economic losses worldwide.[2] E-Health is an application of information and communication technologies (ICT) across the whole range of functions that affect health and may mitigate the impact of a pandemic by enhancing surveillance and control (e.g., rapid case reporting), and improving performance of clinical practice (e.g., efficient documentation). [3, 4]

The implementation of E-Health systems represents a disruptive change in the healthcare workplace and requires proper planning and management.[5] The change occurs not simply due to the introduction of ICT infrastructure but also because the job design of interconnected health professionals should be re-engineered to effectively and efficiently accommodate the technology.[6] Resistance to the change can occur at the individual level as well as at the organisational level.[7] E-Health preparedness assessment becomes an essential requirement prior to the implementation of E-Health.[8, 9] The assessment is to identify problems with present clinical practice processes and activities, healthcare providers' exposure to E-Health (e.g., perceived E-Health benefits), and available resources and socio-culture of organisations to support the clinical ICT innovation for a pandemic. Subsequent action taken that addresses deficient areas of preparedness would hopefully facilitate changes resulting from E-Health systems' implementation.

Although there have been some preliminary attempts to develop a framework for E-Health preparedness assessment, there has been no work reported on a systematic study on the evaluation of E-Health preparedness for public health services. Recently, an integrated E-Health preparedness framework [10] was developed from the perspectives of the healthcare organisation and providers. Then, the authors have validated it by contextual interviews with

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3 20 domain experts: ten with E-Health implementation practitioners and the rest with  
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5 medical/public health practitioners and no modifications have been made on the constructs.  
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7 However, this framework has not yet been applied in real healthcare settings. As a research  
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9 strategy, the case study is used in many situations to contribute to our knowledge of  
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11 individual, group, organisational, social, political and related phenomena – it allows  
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13 investigators to retain the holistic and meaningful characteristics of real-life events.[11] In  
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15 light of the integrated framework, we conducted a case study at a healthcare organisation in  
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17 Beijing, which aimed to test its applicability and assess the preparedness status for the  
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19 implementation of an E-Health system in the context of a pandemic response.  
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## 23 24 **METHODS**

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26 This study used a qualitative research approach and involved two phases: 1) group interviews  
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28 with key stakeholders involved in the 2009 influenza A (H1N1) pandemic response in  
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30 Beijing to examine how the surveillance system worked with ICT support, which provided  
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32 background information for the case study; and 2) individual interviews at a selected hospital  
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34 to gather a rich data set in relation to E-Health preparedness assessment. The Medical and  
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36 Community Health Research Ethics Advisory Panel, the University of New South Wales and  
37  
38 the Beijing Center for Disease Prevention and Control (CDC) approved the study protocol.  
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### 43 *Interview guide*

#### 44 45 Phase 1

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47 It was found that there was limited information in the literature on interactions of  
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49 stakeholders involved in public health surveillance activities and ICT applications for the  
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51 purpose of surveillance in China. An interview guide was developed to examine areas such as  
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53 a) key stakeholders' interaction during the 2009 pandemic response; b) surveillance data  
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3 collection and use; and c) dissemination of information from public health authorities and  
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5 feedback mechanisms.  
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## 8 Phase 2 9

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11 Based on an integrated E-Health preparedness framework presented in [10], an interview  
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13 guide was developed to examine the following areas: a) *motivational* forces for change that  
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15 reflect the evaluator's realisation of problems and healthcare providers' dissatisfaction with  
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17 present practices or circumstances for pandemic responses; b) healthcare providers' exposure  
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19 to potential E-Health applications (*engagement* preparedness) including their perceived E-  
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21 Health benefits for a pandemic response, fears and concerns over using prospective E-Health  
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23 systems, and their willingness to make the initial investment of extra time for E-Health  
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25 training; c) *technological* preparedness that reflects the capacity of the available hardware,  
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27 software, computer networks and internal IT support particularly for troubleshooting at the  
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29 healthcare organisation, as well as the sufficiency of healthcare providers' previous IT  
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31 experience to support an ICT innovation for medical practices; d) *resource* preparedness that  
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33 is organisational non-technical ability to support a clinical ICT innovation, including decision  
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35 makers' specific knowledge of the ICT implementation, supportive policies at the  
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37 organisational level and sufficient funding to support the whole innovation process; e)  
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39 *societal* preparedness that deals with socio-cultural issues at the organisation in association  
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41 with E-Health implementation and a pandemic response. Communication links and  
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43 partnerships need to be available within and across the organisation. Questions from the  
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45 interview guide were generated to evaluate preparedness measures at the bottom level of the  
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47 hierarchical framework [10]. Here is an illustrative question: were there any problems with  
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49 the performance of medical practices during the influenza A H1N1 pandemic? For example,  
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51 were there errors in prescriptions at the hospital?  
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### *Sample and site selection*

#### Phase 1

Purposive sampling was used to recruit individuals to participate in the group interviews. Stakeholders nominated by the Beijing City CDC were provided with an overview of the study and were invited to participate. Consent was implied, if the participant agreed to undertake the interview. No identifiable information was collected in the interview.

#### Phase 2

To select a hospital for the case study, the Beijing City CDC initially recommended a small list of hospitals as possible candidates. There were a number of criteria which the hospital had to meet in order to be eligible. These included: a) the hospital must have been involved in the 2009 influenza A H1N1 pandemic response; and 2) the hospital must be planning to implement a new E-Health system. Then, two investigators made face-to-face explanations to the administrative officers and IT personnel at these hospitals on the objective of the research project. One hospital located in Beijing was finally selected, as the hospital met the case selection criteria and also the management showed their willingness to participate and offer a context for the study.

Purposive sampling was employed since the interviews required participants' knowledge of the *status quo* at the hospital to reveal its motivational, engagement, technological, resource and societal preparedness for the prospective E-Health system implementation. Due to the nature of the data collected, three groups of participants were involved, specifically: 1) Clinicians who had experience in diagnosing and reporting cases of Influenza A H1N1 and who would be an end-user of the E-Health system; 2) an IT manager who provided IT support services (e.g., troubleshooting) during the H1N1 pandemic and who was familiar with the ICT infrastructure (e.g., what were the information systems in use?) at the hospital;

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3 and 3) the Chief Information Officer/person who was in charge of the planning and  
4 implementation of the E-Health system. We also set the following inclusion criteria:  
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6 participants must have worked at the hospital for a minimum of one year, and were full-time  
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8 or part-time staff (contract workers were not included).  
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12 At the selected site, three interviews were piloted with a representative of the members of the  
13 study population of interest. The purpose was to evaluate the interview guide, for example, its  
14 readability, relevance, and difficulty of interpreting and answering the questions asked. The  
15 instrument was modified accordingly.  
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### 20 21 22 *Data collection* 23

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25 The recruitment process ended once enough detailed insights were provided to reach a point  
26 of saturation with respect to the surveillance system in Beijing during the 2009 pandemic  
27 outbreak and the preparedness areas at the selected hospital.  
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#### 31 32 Phase 1 33

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35 In February 2010, three group interviews were conducted in Chinese by one investigator. The  
36 first interview involved 2 public health practitioners from the Beijing City CDC. The second  
37 and third interviews involved 10 public health/medical practitioners from the City CDC, two  
38 district CDCs and a tertiary hospital (e.g., the director of a district CDC and a medical doctor  
39 from the hospital).  
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#### 45 46 Phase 2 47

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49 A total of 23 in-depth interviews were conducted in Chinese by three investigators at the  
50 selected hospital between October and December 2010, respectively with the general  
51 administrative officer, an IT manager, five physicians from the Respiratory Medicine  
52 Department, the director and six physicians from the Paediatrics Clinic Department, the  
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3 director and four physicians from the Internal Medicine Emergency Department, the director  
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5 and two physicians from the Infectious Diseases Department, and a health worker from the  
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7 Public Health Department. The interview with the health worker aimed to better understand  
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9 the hospital's public health responsibilities and professional relationships with the district  
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11 and city CDCs.  
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### 13 14 15 *Analysis*

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17 With the participants' permission, all the interviews were recorded with a digital voice  
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19 recorder and transcribed verbatim. To analyse the data, the transcripts of all interviews were  
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21 translated into English by the investigator who managed the data collection at the two phases.  
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23 Then, the translated scripts were checked by other bilingual investigators to ensure the  
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25 accuracy and lexical equivalence. One-quarter of the transcripts were randomly selected and  
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27 coded independently by three investigators. Subsequent discussions among these three  
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29 developed a list of themes. An agreed framework was then applied by one of the three to code  
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31 the remnant of the transcripts and the themes were further modified. Based on the themes  
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33 finally identified, all of the transcripts were analysed. No software was used in the process.  
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35 The analysis results were then discussed with the other authors. Lastly, modifications were  
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37 made according to those comments and feedback.  
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## 43 44 **CONTEXT**

### 45 46 *Surveillance system in Beijing*

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48 This section reports key findings from the group interviews. When asked how the public  
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50 health surveillance system worked during the 2009 influenza A (H1N1) pandemic outbreak,  
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52 all participants noted that various stakeholders participated in the surveillance activities in  
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54 Beijing (including personnel from national, provincial/city and district bureaus of health,  
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56 CDCs at all levels, hospitals and schools) and ICT took an important role in facilitating the  
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3 stakeholders' interaction and communication. Figure 1 shows the stakeholders and their  
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5 interactions for public health surveillance as part of the 2009 pandemic response.  
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9 When asked to explain in detail how notifiable diseases were normally reported, the  
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11 participants indicated that it was initially done by physicians either by filling out a paper-  
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13 based form or through the electronic interface of an intranet website. A health worker from  
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15 the hospital's public health department was usually designated to collect these forms in  
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17 person once or twice per day or to retrieve that information in real time through the intranet  
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19 website. The health worker was then required to check the completeness and legitimacy of  
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21 the information reported by physicians. Lastly, the health worker was responsible for  
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23 importing the updated information into the CDC website. One participant believed that the  
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25 completeness check improved the quality of case reporting and, as a result, benefited the  
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27 prospective use and analysis of the surveillance data. During the pandemic, any data collected  
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29 on the case reports were available in real time to the district CDCs through the CDC website.  
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34 *"If a patient saw a doctor in District A but resided in District B, after the case was*  
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36 *reported, both district CDCs could see the information in real time through the*  
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38 *website."*  
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41 As highlighted by some participants, these data could be shared by CDCs at all levels and  
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43 health workers at the public health department of hospitals via the CDC website; they,  
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45 nevertheless, were not given the same level of accessibility.  
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49 Aside from the healthcare facility-based reporting, schoolteachers and construction site  
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51 managers also share the responsibility of reporting cases on the basis of the person's  
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53 symptoms (fever, diarrhoea, rash, jaundice or red conjunctiva). Many felt that the system of  
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55 symptom-based reporting allowed control measures to be undertaken before the disease  
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57 started to spread.  
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3 According to the participants, the surveillance data were analysed with ICT applications (e.g.,  
4 Early Aberration Reporting System (EARS) [12]) at all CDC levels; the analysis results were  
5 reported to the bureau of health at the same level. A public health practitioner explained that  
6 the analysis was undertaken to identify trends and affected populations, so that appropriate  
7 target groups were identified and control activities were implemented.  
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### 13 14 15 *Hospital case study background* 16

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18 ICT has been applied at the hospital since 1999. At the initial stage, the application aimed to  
19 meet the hospital's financial needs. The manager of the IT department pointed out that in  
20 2003, the hospital realised that the application should not merely focus on finance but should  
21 benefit clinical practices as well as decision-making processes at the management level. In  
22 the context of the 2009 pandemic outbreak, some interviewed physicians commented that  
23 they could proactively retrieve laboratory testing results through a Laboratory Information  
24 System (LIS) once the results became available; they could also access to an intranet website  
25 and capture health alerts (e.g., updated case definition) issued by public health authorities.  
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36 Since 2003, the hospital information system (HIS) for clinical practices has been replaced  
37 twice because neither of the first two suppliers was capable of upgrading their systems to  
38 meet increasing clinical needs. The third HIS system had been implemented for both  
39 outpatient and inpatient services. The IT manager indicated that the second system for  
40 inpatient services was still in use and explained that the second had kept all the information  
41 for inpatients who were already hospitalised before the implementation of the third. The new  
42 system for outpatient services included a range of functions and mainly focused on the entry  
43 of medicines prescriptions and connections to the billing system. The general administrative  
44 officer pointed out there was still a big gap regarding retrieval of complete patient medical  
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3 records for clinical decision making. Therefore, as the officer reported, the hospital had been  
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5 planning to implement an EHR system.  
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## 8 **E-HEALTH PREPAREDNESS ASSESSMENT RESULTS**

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11 This section reports a small subset of the case study results from which major issues were  
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13 identified in relation to the hospital's preparedness. These issues needed to be addressed prior  
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15 to the implementation of EHR.  
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### 18 *Explored area: motivational preparedness*

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#### 20 21 Poor sharing of patient health records

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24 Patient information required for clinical decision making was deemed by more than half of  
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26 the interviewed physicians to be incomplete and inaccurate. Most physicians indicated that  
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28 information could be partially obtained from the internal HIS, or the paper-based patient  
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30 medical history generated at the hospital or other healthcare facilities, or, alternatively, by  
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32 asking patients face-to-face during the physician-patient encounter. These physicians argued  
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34 that patient information in the HIS mainly included past diagnoses and prescriptions at the  
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36 hospital whereas other information (e.g., allergic history), which was also important for  
37  
38 clinical decision making, was not saved. Furthermore, if those patients who had lost their  
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40 medical card applied for a new card instead of renewing it, all information generated in the  
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42 past would be no longer available.  
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#### 46 47 Inappropriate prescriptions

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50 Physicians had utilised the HIS for prescriptions. The majority of physicians indicated that  
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52 inappropriate prescriptions were caused by operational errors. A paediatrician provided the  
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54 example that while she used an electronic interface to prescribe medicines for a patient,  
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56 another patient whom she had already seen walked in with a laboratory test report; she  
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3 switched over but used the interface to prescribe medicines for the wrong patient. A few  
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5 commented that these mistakes sometimes happened especially when there were a large  
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7 number of patients; nevertheless, they could be corrected in most cases when the patient went  
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9 to the pharmacy with a different name on their prescriptions. Some physicians pointed out  
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11 that inappropriate prescriptions could also be made in terms of medicine usage (e.g.,  
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13 intravenous drip, injection or push) and dosage. Another physician added that due to the lack  
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15 of updated information (e.g., pregnancy) in relation to patients, medicines might have been  
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17 prescribed to them despite there being contraindications.  
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#### 20 21 Lack of assistance to answering patients' questions

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24 The majority of interviewed physicians indicated that they had neither access to the Internet  
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26 nor software tools available, at least as far as they knew, to search for information in relation  
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28 to patients' questions during their visits. Others argued that there was indeed an electronic  
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30 pharmacopeia and an intranet library to assist with answering some of the patients' questions.  
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32 One of the others commented that through the library they were able to find a small number  
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34 of published papers or reports but the quality of these was uncertain.  
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#### 37 38 *Explored area: engagement preparedness*

##### 39 40 41 Physicians' concern about IT reliability

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44 Most physicians believed that information technology was always reliable. Nevertheless, the  
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46 majority of the physicians including many of those who held the positive point of view also  
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48 clearly pointed out that information technology could be unreliable from time to time. They  
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50 commented that: 1) there were pointless reminders when they prescribed medicines; 2) the  
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52 HIS crashed sometimes and had to be rebooted, and as a result all work not yet saved needed  
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54 to be redone; 3) the reliability of information stored in IT systems was another concern. They  
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56 argued that patient personal details (e.g., residential address and contact number) might not  
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3 be up-to-date; first-hand medical information collected from patients (e.g., past allergic  
4 history) might not be accurate or complete; the information in relation to past diagnoses and  
5 prescriptions saved in the HIS might not be correct and could be inappropriate in the first  
6 place; the information on medicinal drugs in the electronic pharmacopeia might be out-of-  
7 date; and (4) technical glitches in the HIS negatively impacted on physicians' work efficiency.  
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15 *"Sometimes, after physicians generated and saved patient health records with the HIS*  
16 *for inpatient services, nothing was there."* (a physician, Department of Internal  
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Medicine Emergency)

Physicians' concern about high investment and low reimbursement

For more than half of the interviewed physicians, high investment and/or low reimbursement were not their concern with using prospective E-Health systems. They argued that monetary investment was beyond their professional knowledge and there was nothing they could do about it. Some explained that those decisions on the implementation of a new system were always made at the management level and they had never been involved in that process at all. Regardless of the involvement in decision making, physicians' medical practices (e.g., work efficiency) would benefit in the long run, as a few noted.

However, the others indicated that physicians would be those who pay for what they have been given (e.g., from their bonus) and thus the monetary investment on E-Health technologies had to be of concern. They also commented that returns on the investment were dependent on the degree to which the technologies would be utilised to improve medical practices and patient care outcomes. When a large number of daily patient visits were taken into account, time which could be spent with every single patient was significantly limited and even less for the utilisation of technologies, and therefore returns on the investment could be unpredictable and appeared to be another concern, as one physician emphasised.

### *Explored area: technological preparedness*

The IT manager reported that all available ICT systems (e.g., clinical and non-clinical software) at the hospital had formed a technical base for the implementation of any E-Health systems in the future. Many of the interviewed physicians were satisfied with the current software in use but also highlighted that the HIS needed to be upgraded in order to improve its performance (including technical errors and bugs, user-unfriendly interfaces, irrational operations and unmet requirements). One provided an example, explaining that as the buttons in the HIS used icons instead of captions (i.e., text) to indicate what they do, it could take a while for end-users to remember them and become familiar with the operations.

The general administrative officer indicated that problems with the HIS encountered by physicians were being collated by the IT department, but to address these problems required a thorough analysis to check whether there could cause misalignments with the workflow defined at the hospital management level or with the requirements specified by the national Ministry of Health (e.g., medical insurance policies).

## **DISCUSSION**

E-Health preparedness assessment helps the decision maker to be well-informed of deficient areas in preparedness, and therefore serve as a guide for preventive action to combat the failure to innovate.[8, 9] There is no study internationally on the evaluation of E-Health preparedness in an organisational context. In light of an integrated five-dimension framework presented in [10], a case study was conducted at a hospital in Beijing to assess organisational preparedness for the prospective implementation of an EHR system. This study has demonstrated its applicability in a real healthcare setting in China. Only major issues identified within three preparedness dimensions were reported in the previous section. Tables 1 summarises these deficient areas of preparedness with possible solutions.

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3 Based on the assessment of motivational preparedness, identification of issues and challenges  
4 within present practices indicates needs for change.[10] Such a needs analysis for change  
5 assists the hospital in defining its problems in relation to pandemic responses and in  
6 understanding how those problems can possibly be solved with innovations (e.g., shared EHR  
7 systems).[7] Unless motivation is “activated”, individuals within the organisation are unlikely  
8 to initiate change behaviours; perceived needs by healthcare providers impact on their  
9 behavioural intention to adopt and use an E-Health system (e.g., [13, 14]). Pandemic  
10 responses at the healthcare organisation require its participation in disease surveillance and  
11 control activities as well as in the performance of medical practices.[10] In this study,  
12 possible issues particularly in relation to disease surveillance and control activities during the  
13 2009 pandemic were not fully identified. The reason behind this could be that a wide range of  
14 E-Health applications were already set in place for the pandemic response. The case reporting  
15 process, for example, had been streamlined from diagnostic physicians to the internal public  
16 health department, and subsequently to the district CDC.

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35 More serious issues were identified in medical practices including poor sharing of patient  
36 health records, prescription errors and unavailability of software tools to assist physicians in  
37 answering patient questions. Although the new HIS provides physicians with a function for  
38 prescription entry, inappropriate prescriptions can still be made due to system operation  
39 errors or the absence of updated patient information which is required for consideration of  
40 contraindications. Therefore, some broad requirements for the EHR system that should be  
41 incorporated are to: a) explore options to decrease prescription errors (e.g., automatic check  
42 of contraindication when patient information is updated and complete); b) ensure that a  
43 variety of clinicians can access patient health information efficiently when required, but also  
44 ensure that the information can be secured with patient privacy protected (further exploration  
45 is required for defining what information needs to be shared with whom and in which way);  
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3 and c) explore options to assist physicians in answering patient questions or seeking required  
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5 clinical information (e.g., a reference portal to create a filtered and customised set of content  
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7 [15]).  
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11 As part of engagement preparedness assessment, interviewed physicians raised a couple of  
12  
13 major concerns about using a potential EHR system. As healthcare providers are the key  
14  
15 driving force in pushing E-Health initiatives, their concerns would impede further  
16  
17 development of overall preparedness.[10] Firstly, their concern about the reliability of ICT  
18  
19 was partially caused by their distrust in the information stored in IT systems. The distrust  
20  
21 may evoke their anxious reactions when it comes to adopting new E-Health systems (e.g., [16,  
22  
23 17]). Secondly, interviewed physicians perceived high monetary cost of E-Health  
24  
25 implementation and uncertainty over return on monetary investment. This perception can  
26  
27 inhibit their use of E-Health or intention to use (e.g., [18, 19]). If the increase in expenses  
28  
29 outpaced that of compensation for the organisation, they would find it particularly hard to  
30  
31 justify the risk in making any investment, especially in a new technology perceived as risky  
32  
33 with uncertain returns (e.g., the EHR).[20] Healthcare providers' perception of E-Health  
34  
35 benefits determines the level of their fears and concerns.[21] Therefore, to overcome these  
36  
37 concerns, education and awareness plans need to be made and executed prior to the EHR  
38  
39 implementation. These education programs can improve healthcare providers' understanding  
40  
41 of how the EHR can benefit their performance in a pandemic situation and achieve better  
42  
43 patient care outcomes.  
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50 Under the technological preparedness dimension, physicians expressed their dissatisfaction  
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52 with the software in use (particularly the newly-implemented HIS) at the hospital, such as the  
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54 user-unfriendly interfaces and irrational operations. Negative IT experience can cause them  
55  
56 technology phobia and thus inhibit their adoption intention of a new E-Health system.[22, 23]  
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3 With respect to the EHR system being planned, there is a need to explore ways to improve  
4 the human-computer interactional design to suit end-users (e.g., involvement of clinical  
5 champions at the design phase).  
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10 The study results may be limited due to participants' over-reporting or their recall bias. In the  
11 case study, for example, the three groups of participants may have over-reported their  
12 preparedness in order to avoid embarrassment or judgement. We attempted to minimise any  
13 bias in the interpretation of the interview data by having it reviewed by three investigators.  
14  
15 Furthermore, some questions in the interview guide required participants to recall their past  
16 experiences; therefore, there may be some recall bias.  
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## 24 **CONCLUSIONS**

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26  
27 Pandemic preparedness planning is necessitated during the inter-pandemic period to enable  
28 countries to be prepared to recognise and manage an influenza pandemic.[24] The first phase  
29 of this project contributes to sharing of the surveillance experience in Beijing, especially with  
30 other regions of China or countries where the public health surveillance system has been  
31 dysfunctional or not yet set up in place; some information drawn from this experience may  
32 help their preparation for a next pandemic from the surveillance perspective.  
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41 The project's second phase demonstrates the applicability of the integrated E-Health  
42 preparedness framework [10] in a real healthcare setting. It also provides the medical  
43 informatics audience with an example of how E-Health preparedness assessment can be  
44 conducted in an organisational context. The case study results may assist decision makers at  
45 the hospital to take action to address deficient areas in their preparedness and, as a result,  
46 facilitate the EHR implementation success. In the future, similar preparedness assessment can  
47 be conducted at various healthcare settings (e.g., residential aged care centres and primary  
48 healthcare centres) in countries to manage and plan the implementation of varied and specific  
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3 E-Health systems such as electronic health records, e-learning, chronic illness management,  
4  
5 telecardiology, teleradiology and teledermatology.  
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7

### 8 **FUNDING STATEMENT**

9  
10  
11 This research received no specific grant from any funding agency in the public, commercial  
12  
13 or not-for-profit sectors.  
14

### 15 **COMPETING INTERESTS STATEMENT**

16  
17  
18 No potential conflicts of interest with respect to the research, authorship, and/or publication  
19  
20 of this article.  
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22

### 23 **CONTRIBUTORSHIP STATEMENT**

24  
25  
26  
27 Junhua Li: 1) conception and design, acquisition of data, and analysis and interpretation of  
28  
29 data; 2) drafting and revising the article; and 3) final approval of the version to be published.  
30

31  
32 Holly Seale: 1) conception and design, and analysis and interpretation of data; 2) drafting and  
33  
34 revising the article; and 3) final approval of the version to be published.  
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37 Pradeep Ray: 1) conception and design; 2) revising the article; and 3) final approval of the  
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39 version to be published.  
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42 Quanyi Wang: 1) acquisition of data; 2) revising the article; and 3) final approval of the  
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44 version to be published.  
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47 Peng Yang: 1) conception and design and acquisition of data; 2) revising the article; and 3)  
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49 final approval of the version to be published.  
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52 Shuang Li: 1) acquisition of data and analysis and interpretation of data; 2) revising the  
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54 article; and 3) final approval of the version to be published.  
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3 Yi Zhang: 1) conception and design, and acquisition of data; 2) revising the article; and 3)  
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5 final approval of the version to be published.  
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7  
8 Raina MacIntyre: 1) conception and design; 2) revising the article; and 3) final approval of  
9  
10 the version to be published.  
11

## 12 13 **ARTICLE SUMMARY**

### 14 15 Article Focus:

- 16  
17  
18  
19 • How to assess organisational preparedness for the implementation of an E-Health  
20  
21 system in the context of a pandemic response?  
22
- 23  
24 • What is the preparedness status at a hospital in Beijing for the implementation of an  
25  
26 electronic health records system?  
27
- 28  
29 • How did the surveillance system work with ICT support in the 2009 influenza A  
30  
31 (H1N1) pandemic response in Beijing?  
32

### 33 34 Key Messages:

- 35  
36  
37 • The occurrence of a pandemic can place an immense burden upon healthcare services  
38  
39 and E-Health systems may facilitate the functioning of healthcare facilities. The  
40  
41 implementation of any information system in an organisational context requires proper  
42  
43 planning and management for change. Prior to the implementation of E-Health systems,  
44  
45 the assessment of organisational preparedness is an essential requirement.  
46
- 47  
48 • There has been no work reported on the assessment of E-Health preparedness at  
49  
50 healthcare facilities.  
51

Strengths:

- Part of our findings shows how IT applications were used in the functioning public health surveillance system in Beijing. This may provide decision makers at other settings with valuable insights to prepare themselves for a next pandemic from the surveillance perspective.
- Our case study at a hospital in Beijing demonstrates how organisational preparedness can be assessed for the implementation of E-Health systems. Similar studies can be conducted in the future at various healthcare settings in countries to manage and plan the implementation of varied and specific E-Health systems.
- Reported results from the case study may assist decision makers in the hospital to take action to address deficient areas in their preparedness and, as a result, facilitate the E-Health implementation's success.

Weakness:

- The study results may be limited due to participants' over-reporting or their recall bias.
- Another limitation is on the study design. This single-case study demonstrates the applicability of an integrated preparedness assessment framework that was developed and published recently. We understand that the evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust. However, the conduct of a multiple-case study requires extensive resources and time. For this project, we received no specific grant from any funding agency in the public, commercial or not-for-profit sectors; therefore, we selected a representative and typical case to achieve the study objectives.

## DATA SHARING STATEMENT

Extra data is available by emailing to the corresponding author.

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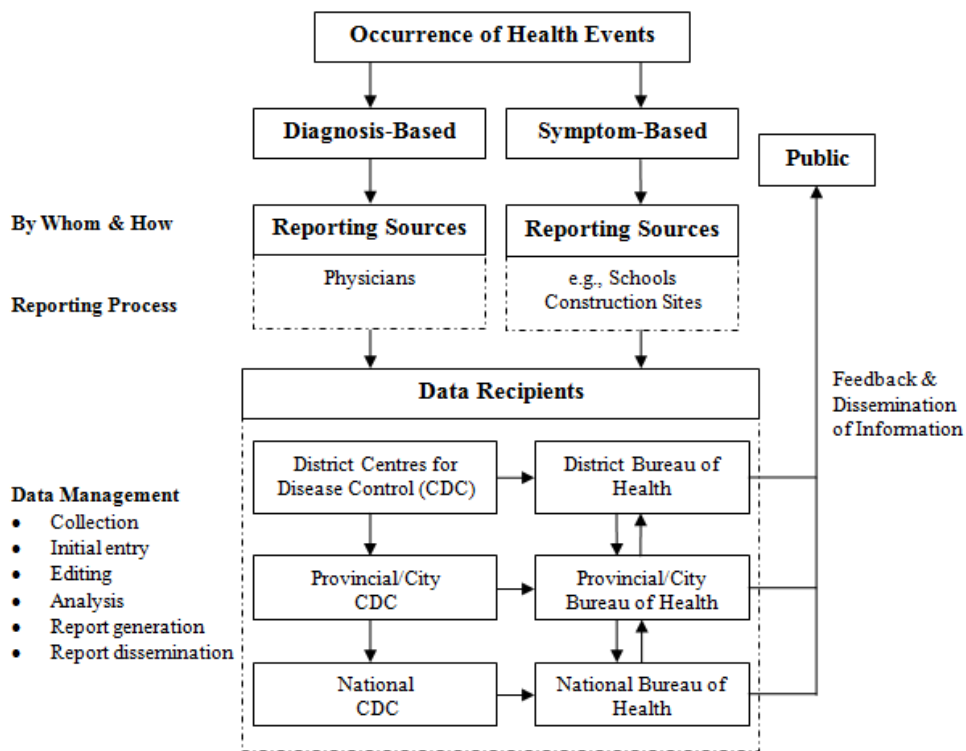


Figure 1 The major steps in the public health surveillance system in China

**Table 1 Deficient areas of preparedness at the hospital**

Areas of Deficiency	Suggestions
Sharing of patient health records	(a) Defining what information needs to be shared with whom and in which way. (b) With a prospective EHR system, ensuring that a variety of clinicians can access patient health information efficiently when required, but also ensuring that the information can be secured with patient privacy protected.
Appropriateness of prescriptions	Exploring options to decrease prescription errors such as automatic check of contraindication when electronic patient information is updated and complete.
Availability of software tools to assist physicians in answering patient questions	Using a reference portal (e.g., a clinical information website with a search engine) to create a filtered and customised set of content.
Clinicians' concern about IT reliability and high investment and low reimbursement of the system implementation	(a) Making and executing education and awareness plans prior to the EHR implementation. (b) Improving clinicians' understanding of how the EHR can benefit their performance in a pandemic situation and achieve better patient care outcomes.
Clinicians' dissatisfaction with the software in use	Exploring ways to improve the human-computer interactional design to suit end-users such as involvement of clinical champions at the design phase.



## E-Health Preparedness Assessment in the Context of an Influenza Pandemic: A Qualitative Study in China

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Secondary Subject Heading:	Health informatics, Health services research, Qualitative research
Keywords:	Health informatics < BIOTECHNOLOGY & BIOINFORMATICS, HEALTH SERVICES ADMINISTRATION & MANAGEMENT, QUALITATIVE RESEARCH

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Manuscripts

# E-Health Preparedness Assessment in the Context of an Influenza Pandemic: A Qualitative Study in China

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## ARTICLE SUMMARY

### Article Focus:

- How to assess organisational preparedness for the implementation of an E-Health system in the context of a pandemic response?
- What is the preparedness status at a hospital in Beijing for the implementation of an electronic health records system?
- How did the surveillance system work with ICT support in the 2009 influenza A (H1N1) pandemic response in Beijing?

### Key Messages:

- The occurrence of a pandemic can place an immense burden upon healthcare services and E-Health systems may facilitate the functioning of healthcare facilities. The implementation of any information system in an organisational context requires proper planning and management for change. Prior to the implementation of E-Health systems, the assessment of organisational preparedness is an essential requirement.
- There has been no work reported on the assessment of E-Health preparedness at healthcare facilities.

### Strengths:

- Part of our findings shows how IT applications were used in the functioning public health surveillance system in Beijing. This may provide decision makers at other

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2  
3 settings with valuable insights to prepare themselves for a next pandemic from the  
4  
5 surveillance perspective.  
6

- 7 • Our case study at a hospital in Beijing demonstrates how organisational preparedness  
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9 can be assessed for the implementation of E-Health systems. Similar studies can be  
10  
11 conducted in the future at various healthcare settings in countries to manage and plan  
12  
13 the implementation of varied and specific E-Health systems.  
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- 15 • Reported results from the case study may assist decision makers in the hospital to take  
16  
17 action to address deficient areas in their preparedness and, as a result, facilitate the E-  
18  
19 Health implementation's success.  
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22  
23 Weakness:

- 24 • The study results may be limited due to participants' over-reporting or their recall bias.  
25
- 26 • Another limitation is on the study design. This single-case study demonstrates the  
27  
28 applicability of an integrated preparedness assessment framework that was developed  
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30 and published recently. We understand that the evidence from multiple cases is often  
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32 considered more compelling, and the overall study is therefore regarded as being more  
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34 robust. However, the conduct of a multiple-case study requires extensive resources and  
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36 time. For this project, we received no specific grant from any funding agency in the  
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38 public, commercial or not-for-profit sectors; therefore, we selected a representative and  
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40 typical case to achieve the study objectives.  
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50 **ABSTRACT**

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53 *Objective:* To assess preparedness status of a hospital in Beijing, China for implementation of  
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55 an E-Health system in the context of a pandemic response.  
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3 *Design:* This research project used qualitative methods and involved two phases: 1) group  
4 interviews were conducted with key stakeholders to examine how the surveillance system  
5 worked with ICT support in Beijing. The results provided background information for a case  
6 study at the second phase; and 2) individual interviews were conducted in order to gather a  
7 rich data set in relation to E-Health preparedness at the selected hospital.  
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14 *Setting:* In Phase 1, group interviews were conducted at Centres for Disease Prevention and  
15 Control (CDC) in Beijing. In Phase 2, individual interviews were done at a secondary  
16 hospital selected for the case study.  
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21 *Participants:* In Phase 1, three group interviews were undertaken with 12 key stakeholders  
22 (public health/medical practitioners from the Beijing City CDC, two district CDCs and a  
23 tertiary hospital) who were involved in the 2009 influenza A (H1N1) pandemic response in  
24 Beijing. In Phase 2, individual interviews were conducted with 23 participants (including  
25 physicians across medical departments, the IT manager and general administrative officer).  
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32 *Primary and secondary measures:* For the case study, five areas were examined to assess the  
33 hospital's preparedness for implementation of an E-Health system in the context of a  
34 pandemic response: a) motivational forces for change; b) healthcare providers' exposure to E-  
35 Health; c) technological preparedness; d) organisational non-technical ability to support a  
36 clinical ICT innovation; and e) socio-cultural issues at the organisation in association with E-  
37 Health implementation and a pandemic response.  
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46 *Results:* This article reports a small subset of the case study results from which major issues  
47 were identified under three main themes in relation to the hospital's preparedness. These  
48 issues include poor sharing of patient health records, prescription errors, unavailability of  
49 software tools to assist physicians in answering patient questions, physicians' concerns about  
50 the reliability of ICT and high monetary cost of E-Health implementation and uncertainty  
51 over return on investment, and their dissatisfaction with the software in use.  
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3 *Conclusions.* Prior to the implementation of E-Health, planning must be undertaken to ensure  
4 the smooth introduction of the system. The assessment of organisational preparedness is an  
5 important step in this planning process. Based on the case study, deficient areas of  
6 organisational preparedness were identified for the prospective implementation of electronic  
7 health records (EHR). Accordingly, we suggested possible solutions for the areas in need of  
8 improvement to facilitate E-Health implementation's success.  
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17 *Keywords.* E-Health, preparedness assessment, pandemic, hospital, case study, China  
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## 47 **BACKGROUND**

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49 Influenza pandemics can occur with the appearance of a new strain of influenza A virus  
50 against which none of the population has any immunity.[1] A severe pandemic has the  
51 potential to increase morbidity and mortality levels, and consequently cause economic losses  
52 worldwide.[2] E-Health is an application of information and communication technologies  
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3 (ICT) across the whole range of functions that affect health and may mitigate the impact of a  
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5 pandemic by enhancing surveillance and control (e.g., rapid case reporting), and improving  
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7 performance of clinical practice (e.g., efficient documentation). [3, 4]  
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9

10 The implementation of E-Health systems represents a disruptive change in the healthcare  
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12 workplace and requires proper planning and management.[5] The change occurs not simply  
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14 due to the introduction of ICT infrastructure but also because the job design of interconnected  
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16 health professionals should be re-engineered to effectively and efficiently accommodate the  
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18 technology.[6] Resistance to the change can occur at the individual level as well as at the  
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20 organisational level.[7] E-Health preparedness assessment becomes an essential requirement  
21  
22 prior to the implementation of E-Health.[8, 9] The assessment is to identify problems with  
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24 present clinical practice processes and activities, healthcare providers' exposure to E-Health  
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26 (e.g., perceived E-Health benefits), and available resources and socio-culture of organisations  
27  
28 to support the clinical ICT innovation for a pandemic. Subsequent action taken that addresses  
29  
30 deficient areas of preparedness would hopefully facilitate changes resulting from E-Health  
31  
32 systems' implementation.  
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36  
37 Although there have been some preliminary attempts to develop a framework for E-Health  
38  
39 preparedness assessment, there has been no work reported on a systematic study on the  
40  
41 evaluation of E-Health preparedness for public health services. Recently, an integrated E-  
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43 Health preparedness framework [10] was developed from the perspectives of the healthcare  
44  
45 organisation and providers. Then, the authors have validated it by contextual interviews with  
46  
47 20 domain experts: ten with E-Health implementation practitioners and the rest with  
48  
49 medical/public health practitioners and no modifications have been made on the constructs.  
50  
51 However, this framework has not yet been applied in real healthcare settings. As a research  
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53 strategy, the case study is used in many situations to contribute to our knowledge of  
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55 individual, group, organisational, social, political and related phenomena – it allows  
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3 investigators to retain the holistic and meaningful characteristics of real-life events.[11] In  
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5 light of the integrated framework, we conducted a case study at a healthcare organisation in  
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7 Beijing, which aimed to test its applicability and assess the preparedness status for the  
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9 implementation of an E-Health system in the context of a pandemic response.  
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## 11 12 13 **METHODS**

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15 This study used a qualitative research approach and involved two phases: 1) group interviews  
16  
17 with key stakeholders involved in the 2009 influenza A (H1N1) pandemic response in  
18  
19 Beijing to examine how the surveillance system worked with ICT support, which provided  
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21 background information for the case study; and 2) individual interviews at a selected hospital  
22  
23 to gather a rich data set in relation to E-Health preparedness assessment. The Medical and  
24  
25 Community Health Research Ethics Advisory Panel, the University of New South Wales and  
26  
27 the Beijing Center for Disease Prevention and Control (CDC) approved the study protocol.  
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### 31 32 ***Interview guide***

#### 33 34 35 Phase 1

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37 It was found that there was limited information in the literature on interactions of  
38  
39 stakeholders involved in public health surveillance activities and ICT applications for the  
40  
41 purpose of surveillance in China. An interview guide was developed to examine areas such as  
42  
43 a) key stakeholders' interaction during the 2009 pandemic response; b) surveillance data  
44  
45 collection and use; and c) dissemination of information from public health authorities and  
46  
47 feedback mechanisms.  
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#### 50 51 52 Phase 2

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54 Based on an integrated E-Health preparedness framework presented in [10], an interview  
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56 guide was developed to examine the following areas: a) *motivational* forces for change that  
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3 reflect the evaluator's realisation of problems and healthcare providers' dissatisfaction with  
4 present practices or circumstances for pandemic responses. Pandemic responses at the  
5 healthcare organisation require its participation in pandemic diseases surveillance and control  
6 (such as case reporting to the state or local public health unit) as well as in the performance of  
7 medical practices (such as diagnoses and prescriptions); b) healthcare providers' exposure to  
8 potential E-Health applications (*engagement* preparedness) including their perceived E-  
9 Health benefits for a pandemic response, fears and concerns over using prospective E-Health  
10 systems, and their willingness to make the initial investment of extra time for E-Health  
11 training; c) *technological* preparedness that reflects the capacity of the available hardware,  
12 software, computer networks and internal IT support particularly for troubleshooting at the  
13 healthcare organisation, as well as the sufficiency of healthcare providers' previous IT  
14 experience to support an ICT innovation for medical practices; d) *resource* preparedness that  
15 is organisational non-technical ability to support a clinical ICT innovation, including decision  
16 makers' specific knowledge of the ICT implementation, supportive policies at the  
17 organisational level and sufficient funding to support the whole innovation process; e)  
18 *societal* preparedness that deals with socio-cultural issues at the organisation in association  
19 with E-Health implementation and a pandemic response. Communication links and  
20 partnerships need to be available within and across the organisation. Questions from the  
21 interview guide were generated to evaluate preparedness measures at the bottom level of the  
22 hierarchical framework [10]. Here is an illustrative question: were there any problems with  
23 the performance of medical practices during the influenza A H1N1 pandemic? For example,  
24 were there errors in prescriptions at the hospital?  
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### *Sample and site selection*

#### Phase 1

Purposive sampling was used to recruit individuals to participate in the group interviews. Stakeholders nominated by the Beijing City CDC were provided with an overview of the study and were invited to participate. Consent was implied, if the participant agreed to undertake the interview. No identifiable information was collected in the interview.

#### Phase 2

To select a hospital for the case study, the Beijing City CDC initially recommended a small list of hospitals as possible candidates. There were a number of criteria which the hospital had to meet in order to be eligible. These included: a) the hospital must have been involved in the 2009 influenza A H1N1 pandemic response; and 2) the hospital must be planning to implement a new E-Health system that can facilitate future pandemic response. Then, two investigators made face-to-face explanations to the administrative officers and IT personnel at these hospitals on the objective of the research project. One hospital located in Beijing was finally selected, as the hospital met the case selection criteria and also the management showed their willingness to participate and offer a context for the study.

Purposive sampling was employed since the interviews required participants' knowledge of the *status quo* at the hospital to reveal its motivational, engagement, technological, resource and societal preparedness for the prospective E-Health system implementation. Due to the nature of the data collected, three groups of participants were involved, specifically: 1) Clinicians who had experience in diagnosing and reporting cases of Influenza A H1N1 and who would be an end-user of the E-Health system; 2) an IT manager who provided IT support services (e.g., troubleshooting) during the H1N1 pandemic and who was familiar with the ICT infrastructure (e.g., what were the information systems in use?) at the hospital;

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3 and 3) the Chief Information Officer/person who was in charge of the planning and  
4 implementation of the E-Health system. We also set the following inclusion criteria:  
5  
6 participants must have worked at the hospital for a minimum of two years, and were full-time  
7  
8 or part-time staff (contract workers were not included).  
9  
10

11  
12 At the selected site, three interviews were piloted with a representative of the members of the  
13 study population of interest. The purpose was to evaluate the interview guide, for example, its  
14 readability, relevance, and difficulty of interpreting and answering the questions asked. The  
15 instrument was modified accordingly.  
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### 20 21 22 *Data collection*

23  
24 The recruitment process ended once enough detailed insights were provided to reach a point  
25 of saturation with respect to the surveillance system in Beijing during the 2009 pandemic  
26 outbreak and the preparedness areas at the selected hospital.  
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#### 31 32 Phase 1

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34 In February 2010, three group interviews were conducted in Chinese by one investigator. The  
35 first interview involved 2 public health practitioners from the Beijing City CDC. The second  
36 and third interviews involved 10 public health/medical practitioners from the City CDC, two  
37 district CDCs and a tertiary hospital (e.g., the director of a district CDC and a medical doctor  
38 from the hospital).  
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#### 45 46 Phase 2

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48 A total of 23 in-depth interviews were conducted in Chinese by three investigators at the  
49 selected hospital between October and December 2010, respectively with the general  
50 administrative officer, an IT manager, five physicians from the Respiratory Medicine  
51 Department, the director and six physicians from the Paediatrics Clinic Department, the  
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3 director and four physicians from the Internal Medicine Emergency Department, the director  
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5 and two physicians from the Infectious Diseases Department, and a health worker from the  
6  
7 Public Health Department. The interview with the health worker aimed to better understand  
8  
9 the hospital's public health responsibilities and professional relationships with the district  
10  
11 and city CDCs.  
12

### 13 14 15 *Analysis*

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18 With the participants' permission, all the interviews were recorded with a digital voice  
19  
20 recorder and transcribed verbatim. The process for coding the data was conducted manually  
21  
22 and consisted of a number of steps. One-quarter of the transcripts were randomly selected and  
23  
24 coded independently by three investigators who are bilingual and fluent in both English and  
25  
26 Chinese. Each idea was given a code in Chinese that represented the meaning of the text  
27  
28 segment. As part of this step, respondents' own words were used whenever possible. Through  
29  
30 discussions between the three investigators, a list of themes was developed inductively. An  
31  
32 agreed framework was then applied by one of the three to code the remnant of the transcripts  
33  
34 and the themes were modified. Based on the themes finally identified, the analysis results  
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36 were written in English and then discussed with the other two investigators to ensure the  
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38 accuracy and lexical equivalence. Lastly, the manuscript was modified according to other  
39  
40 authors' further comments and feedback.  
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## 48 49 **CONTEXT**

### 50 51 *Surveillance system in Beijing*

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54 This section reports key findings from the group interviews. When asked how the public  
55  
56 health surveillance system worked during the 2009 influenza A (H1N1) pandemic outbreak,  
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3 all participants noted that various stakeholders participated in the surveillance activities in  
4 Beijing (including personnel from national, provincial/city and district bureaus of health,  
5 CDCs at all levels, hospitals and schools) and ICT took an important role in facilitating the  
6 stakeholders' interaction and communication. Figure 1 shows the stakeholders and their  
7 interactions for public health surveillance as part of the 2009 pandemic response.  
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15 When asked to explain in detail how notifiable diseases were normally reported, the  
16 participants indicated that it was initially done by physicians either by filling out a paper-  
17 based form or through the electronic interface of an intranet website. A health worker from  
18 the hospital's public health department was usually designated to collect these forms in  
19 person once or twice per day or to retrieve that information in real time through the intranet  
20 website. The health worker was then required to check the completeness and legitimacy of  
21 the information reported by physicians. Lastly, the health worker was responsible for  
22 importing the updated information into the CDC website. One participant believed that the  
23 completeness check improved the quality of case reporting and, as a result, benefited the  
24 prospective use and analysis of the surveillance data. During the pandemic, any data collected  
25 on the case reports were available in real time to the district CDCs through the CDC website.  
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41 *“After cases were reported to our district CDC, we were able to immediately capture*  
42 *the information using the website.”*  
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45  
46 *“If a patient saw a doctor in District A but resided in District B, after the case was*  
47 *reported, both district CDCs could see the information in real time through the*  
48 *website.”*  
49  
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52  
53 As highlighted by some participants, these data could be shared by CDCs at all levels and  
54 health workers at the public health department of hospitals via the CDC website; they,  
55 nevertheless, were not given the same level of accessibility.  
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3           *“Every district CDC could see the number of cases in the district but not that in other*  
4  
5           *districts.”*  
6

7  
8           *“Chinese National CDC is able to see reports from all the cities/provinces whereas*  
9  
10           *the reports seen by a district CDC are only a small subset.”*  
11

12  
13       Aside from the healthcare facility-based reporting, schoolteachers and construction site  
14  
15       managers also share the responsibility of reporting cases on the basis of the person’s  
16  
17       symptoms (fever, diarrhoea, rash, jaundice or red conjunctiva). Many felt that the system of  
18  
19       symptom-based reporting allowed control measures to be undertaken before the disease  
20  
21       started to spread.  
22  
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24  
25       According to the participants, the surveillance data were analysed with ICT applications (e.g.,  
26  
27       Early Aberration Reporting System (EARS) [12]) at all CDC levels; the analysis results were  
28  
29       reported to the bureau of health at the same level. A public health practitioner explained that  
30  
31       the analysis was undertaken to identify trends and affected populations, so that appropriate  
32  
33       target groups were identified and control activities were implemented.  
34  
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### 36 37       ***Hospital case study background*** 38

39  
40       ICT has been applied at the hospital since 1999. At the initial stage, the application aimed to  
41  
42       meet the hospital’s financial needs. The manager of the IT department pointed out that in  
43  
44       2003, the hospital realised that the application should not merely focus on finance but should  
45  
46       benefit clinical practices as well as decision-making processes at the management level. In  
47  
48       the context of the 2009 pandemic outbreak, some interviewed physicians commented that  
49  
50       they could proactively retrieve laboratory testing results through a Laboratory Information  
51  
52       System (LIS) once the results became available; they could also access to an intranet website  
53  
54       and capture health alerts (e.g., updated case definition) issued by public health authorities.  
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3 Since 2003, the hospital information system (HIS) for clinical practices has been replaced  
4  
5 twice because neither of the first two suppliers was capable of upgrading their systems to  
6  
7 meet increasing clinical needs. The third HIS system had been implemented for both  
8  
9 outpatient and inpatient services. The IT manager indicated that the second system for  
10  
11 inpatient services was still in use and explained that the second had kept all the information  
12  
13 for inpatients who were already hospitalised before the implementation of the third. The new  
14  
15 system for outpatient services included a range of functions and mainly focused on the entry  
16  
17 of medicines prescriptions and connections to the billing system. The general administrative  
18  
19 officer pointed out there was still a big gap regarding retrieval of complete patient medical  
20  
21 records for clinical decision making. Therefore, as the officer reported, the hospital had been  
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23 planning to implement an EHR system.  
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## E-HEALTH PREPAREDNESS ASSESSMENT RESULTS

Based on our discussions with 23 participants at the selected hospital and analysis of their responses, we assessed the hospital's preparedness for implementation of an EHR system in the context of a pandemic response. The preparedness issues were discussed within the five areas: a) motivational forces for change; b) healthcare providers' exposure to E-Health; c) technological preparedness; d) organisational non-technical ability to support a clinical ICT innovation; and e) socio-cultural issues at the organisation in association with EHR implementation and a pandemic response. Due to words limit, this section reports a small subset of the case study results from which major issues were identified in relation to the hospital's preparedness. These issues needed to be addressed prior to the implementation of EHR.

### *Explored area: motivational preparedness*

- Poor sharing of patient health records

Patient information required for clinical decision making was deemed by more than half of the interviewed physicians to be incomplete and inaccurate. Most physicians indicated that information could be partially obtained from the internal HIS, or the paper-based patient medical history generated at the hospital or other healthcare facilities, or, alternatively, by asking patients face-to-face during the physician-patient encounter. These physicians argued that patient information in the HIS mainly included past diagnoses and prescriptions at the hospital whereas other information (e.g., allergic history), which was also important for clinical decision making, was not saved. Furthermore, if those patients who had lost their medical card applied for a new card instead of renewing it, all information generated in the past would be no longer available. Although the paper-based patient medical history could provide extra evidence for clinical decision making, the utilisation of the information

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3 enclosed was another concern. The director of the Infectious Disease Department provided  
4  
5 the example of a patient with a medicine allergy: the diagnosing physician knew about it but  
6  
7 still wrote down 'no medicine allergy history' in the medical history.  
8  
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10  
11 *"When I look at patient medical history generated by others, I cannot entirely trust*  
12  
13 *it."* (a senior physician, Department of Infectious Disease)  
14

15  
16 •Inappropriate prescriptions

17  
18 Physicians had utilised the HIS for prescriptions. The majority of physicians indicated that  
19  
20 inappropriate prescriptions were caused by operational errors. A paediatrician provided the  
21  
22 example that while she used an electronic interface to prescribe medicines for a patient,  
23  
24 another patient whom she had already seen walked in with a laboratory test report; she  
25  
26 switched over but used the interface to prescribe medicines for the wrong patient. A few  
27  
28 commented that these mistakes sometimes happened especially when there were a large  
29  
30 number of patients; nevertheless, they could be corrected in most cases when the patient went  
31  
32 to the pharmacy with a different name on their prescriptions. Some physicians pointed out  
33  
34 that inappropriate prescriptions could also be made in terms of medicine usage (e.g.,  
35  
36 intravenous drip, injection or push) and dosage. Another physician added that due to the lack  
37  
38 of updated information (e.g., pregnancy) in relation to patients, medicines might have been  
39  
40 prescribed to them despite there being contraindications.  
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46 •Lack of assistance to answering patients' questions

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48 The majority of interviewed physicians indicated that they had neither access to the Internet  
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50 nor software tools available, at least as far as they knew, to search for information in relation  
51  
52 to patients' questions during their visits. Others argued that there was indeed an electronic  
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54 pharmacopeia and an intranet library to assist with answering some of the patients' questions.  
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3 One of the others commented that through the library they were able to find a small number  
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5 of published papers or reports but the quality of these was uncertain.  
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9 ***Explored area: engagement preparedness***

10  
11 •Physicians' concern about IT reliability

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13 Most physicians believed that information technology was always reliable. Nevertheless, the  
14 majority of the physicians including many of those who held the positive point of view also  
15 clearly pointed out that information technology could be unreliable from time to time. They  
16 commented that: 1) there were pointless reminders when they prescribed medicines; 2) the  
17 HIS crashed sometimes and had to be rebooted, and as a result all work not yet saved needed  
18 to be redone; 3) the reliability of information stored in IT systems was another concern. They  
19 argued that patient personal details (e.g., residential address and contact number) might not  
20 be up-to-date; first-hand medical information collected from patients (e.g., past allergic  
21 history) might not be accurate or complete; the information in relation to past diagnoses and  
22 prescriptions saved in the HIS might not be correct and could be inappropriate in the first  
23 place; the information on medicinal drugs in the electronic pharmacopeia might be out-of-  
24 date; and (4) technical glitches in the HIS negatively impacted on physicians' work efficiency.  
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42 *“Sometimes, after physicians generated and saved patient health records with the HIS*  
43 *for inpatient services, nothing was there.”* (a physician, Department of Internal  
44 Medicine Emergency)  
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49 •Physicians' concern about high investment and low reimbursement

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51 For more than half of the interviewed physicians, high investment and/or low reimbursement  
52 were not their concern with using prospective E-Health systems. They argued that monetary  
53 investment was beyond their professional knowledge and there was nothing they could do  
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3 about it. Some explained that those decisions on the implementation of a new system were  
4  
5 always made at the management level and they had never been involved in that process at all.  
6  
7 Regardless of the involvement in decision making, physicians' medical practices (e.g., work  
8  
9 efficiency) would benefit in the long run, as a few noted.

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11  
12 However, the others indicated that the monetary investment on E-Health technologies had to  
13  
14 be of concern – physicians would pay for what they have been given (e.g., from their bonus).  
15  
16 They also commented that returns on the investment were dependent on the degree to which  
17  
18 the technologies would be utilised to improve medical practices and patient care outcomes.  
19  
20 When a large number of daily patient visits were taken into account, time which could be  
21  
22 spent with every single patient was significantly limited and even less for the utilisation of  
23  
24 technologies, and therefore returns on the investment could be unpredictable and appeared to  
25  
26 be another concern, as one physician emphasised.  
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### 30 31 ***Explored area: technological preparedness***

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34 The IT manager reported that all available ICT systems (e.g., clinical and non-clinical  
35  
36 software) at the hospital had formed a technical base for the implementation of any E-Health  
37  
38 systems in the future. Many of the interviewed physicians were satisfied with the current  
39  
40 software in use but also highlighted that the HIS needed to be upgraded in order to improve  
41  
42 its performance (including technical errors and bugs, user-unfriendly interfaces, irrational  
43  
44 operations and unmet requirements). One provided an example, explaining that as the buttons  
45  
46 in the HIS used icons instead of captions (i.e., text) to indicate what they do, it could take a  
47  
48 while for end-users to remember them and become familiar with the operations.  
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53 The general administrative officer indicated that problems with the HIS encountered by  
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55 physicians were being collated by the IT department, but to address these problems required a  
56  
57 thorough analysis to check whether there could cause misalignments with the workflow  
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3 defined at the hospital management level or with the requirements specified by the national  
4  
5 Ministry of Health (e.g., medical insurance policies).  
6  
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## 8 **DISCUSSION**

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11 E-Health preparedness assessment helps the decision maker to be well-informed of deficient  
12  
13 areas in preparedness, and therefore serve as a guide for preventive action to combat the  
14  
15 failure to innovate.[8, 9] There is no study internationally on the evaluation of E-Health  
16  
17 preparedness in an organisational context. In light of an integrated five-dimension framework  
18  
19 presented in [10], a case study was conducted at a hospital in Beijing to assess organisational  
20  
21 preparedness for the prospective implementation of an EHR system. This study has  
22  
23 demonstrated its applicability in a real healthcare setting in China. Only major issues  
24  
25 identified within three preparedness dimensions were reported in the previous section. Table  
26  
27 1 summarises these deficient areas of preparedness with possible solutions.  
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32 Based on the assessment of motivational preparedness, identification of issues and challenges  
33  
34 within present practices indicates needs for change.[10] Such a needs analysis for change  
35  
36 assists the hospital in defining its problems in relation to pandemic responses and in  
37  
38 understanding how those problems can possibly be solved with innovations (e.g., shared EHR  
39  
40 systems).[7] Unless motivation is “activated”, individuals within the organisation are unlikely  
41  
42 to initiate change behaviours; perceived needs by healthcare providers impact on their  
43  
44 behavioural intention to adopt and use an E-Health system (e.g., [13, 14]). Pandemic  
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46 responses at the healthcare organisation require its participation in disease surveillance and  
47  
48 control activities as well as in the performance of medical practices.[10] In this study,  
49  
50 possible issues particularly in relation to disease surveillance and control activities during the  
51  
52 2009 pandemic were not fully identified. The reason behind this could be that a wide range of  
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54 E-Health applications were already set in place for the pandemic response. The case reporting  
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3 process, for example, had been streamlined from diagnostic physicians to the internal public  
4 health department, and subsequently to the district CDC.  
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8 More serious issues were identified in medical practices including poor sharing of patient  
9 health records, prescription errors and unavailability of software tools to assist physicians in  
10 answering patient questions. Although the new HIS provides physicians with a function for  
11 prescription entry, inappropriate prescriptions can still be made due to system operation  
12 errors or the absence of updated patient information which is required for consideration of  
13 contraindications. Therefore, some broad requirements for the EHR system that should be  
14 incorporated are to: a) explore options to decrease prescription errors (e.g., automatic check  
15 of contraindication when patient information is updated and complete); b) ensure that a  
16 variety of clinicians can access patient health information efficiently when required, but also  
17 ensure that the information can be secured with patient privacy protected (further exploration  
18 is required for defining what information needs to be shared with whom and in which way);  
19 and c) explore options to assist physicians in answering patient questions or seeking required  
20 clinical information (e.g., a reference portal to create a filtered and customised set of content  
21 [15]).  
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40 As part of engagement preparedness assessment, interviewed physicians raised a couple of  
41 major concerns about using a potential EHR system. As healthcare providers are the key  
42 driving force in pushing E-Health initiatives, their concerns would impede further  
43 development of overall preparedness.[10] Firstly, their concern about the reliability of ICT  
44 was partially caused by their distrust in the information stored in IT systems. The distrust  
45 may evoke their anxious reactions when it comes to adopting new E-Health systems (e.g., [16,  
46 17]). Secondly, interviewed physicians perceived high monetary cost of E-Health  
47 implementation and uncertainty over return on monetary investment. This perception can  
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3 inhibit their use of E-Health or intention to use (e.g., [18, 19]). If the increase in expenses  
4  
5 outpaced that of compensation for the organisation, they would find it particularly hard to  
6  
7 justify the risk in making any investment, especially in a new technology perceived as risky  
8  
9 with uncertain returns (e.g., the EHR).[20] Healthcare providers' perception of E-Health  
10  
11 benefits determines the level of their fears and concerns.[21] Therefore, to overcome these  
12  
13 concerns, education and awareness plans need to be made and executed prior to the EHR  
14  
15 implementation. These education programs can improve healthcare providers' understanding  
16  
17 of how the EHR can benefit their performance in a pandemic situation and achieve better  
18  
19 patient care outcomes.  
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24 Under the technological preparedness dimension, physicians expressed their dissatisfaction  
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26 with the software in use (particularly the newly-implemented HIS) at the hospital, such as the  
27  
28 user-unfriendly interfaces and irrational operations. Negative IT experience can cause them  
29  
30 technology phobia and thus inhibit their adoption intention of a new E-Health system.[22, 23]  
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32 With respect to the EHR system being planned, there is a need to explore ways to improve  
33  
34 the human-computer interactional design to suit end-users (e.g., involvement of clinical  
35  
36 champions at the design phase).  
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39  
40 The study results may be limited due to participants' over-reporting or their recall bias. In the  
41  
42 case study, for example, the three groups of participants may have over-reported their  
43  
44 preparedness in order to avoid embarrassment or judgement. We attempted to minimise bias  
45  
46 in the interpretation of the interview data by having it reviewed by three investigators. It  
47  
48 would be useful to have an independent bilingual person to ensure the accuracy and lexical  
49  
50 equivalence of the data analysis results. As this study was undertaken as part of a PhD project,  
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52 there was no funding available for this process. Furthermore, some questions in the interview  
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54 guide required participants to recall their past experiences; therefore, there may be some  
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3 recall bias.  
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## 6 **CONCLUSIONS**

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9 Pandemic preparedness planning is necessitated during the inter-pandemic period to enable  
10 countries to be prepared to recognise and manage an influenza pandemic.[24] The first phase  
11 of this project contributes to sharing of the surveillance experience in Beijing, especially with  
12 other regions of China or countries where the public health surveillance system has been  
13 dysfunctional or not yet set up in place; some information drawn from this experience may  
14 help their preparation for a next pandemic from the surveillance perspective.  
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22 The project's second phase demonstrates the applicability of the integrated E-Health  
23 preparedness framework [10] in a real healthcare setting. It also provides the medical  
24 informatics audience with an example of how E-Health preparedness assessment can be  
25 conducted in an organisational context. The case study results may assist decision makers at  
26 the hospital to take action to address deficient areas in their preparedness and, as a result,  
27 facilitate the EHR implementation success.  
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36 The integrated framework [10] lays the foundation for E-Health preparedness assessment as  
37 illustrated here in the context of an influenza pandemic. However, the framework can be  
38 adapted to a range of clinical and public health environments. The applicability of the  
39 framework with these minor modifications would also require further studies. Similar case  
40 studies can be conducted at various healthcare settings (such as residential aged care facilities  
41 and primary healthcare centres) across countries to manage and plan the implementation of  
42 varied and specific e-health systems such as electronic health records, e-learning, chronic  
43 illness management, telecardiology, teleradiology and teledermatology. These studies would  
44 engage staff members and seek their input to the specification of requirements for a clinical  
45 ICT innovation and also build organisational capacity for change.  
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3 Raina MacIntyre: 1) conception and design; 2) revising the article; and 3) final approval of  
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5 the version to be published.  
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## 8 9 **DATA SHARING STATEMENT**

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11 Extra data is available by emailing to the corresponding author.  
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**Table 1 Deficient areas of preparedness at the hospital**

Areas of Deficiency	Suggestions
Sharing of patient health records	(a) Defining what information needs to be shared with whom and in which way. (b) With a prospective EHR system, ensuring that a variety of clinicians can access patient health information efficiently when required, but also ensuring that the information can be secured with patient privacy protected.
Appropriateness of prescriptions	Exploring options to decrease prescription errors such as automatic check of contraindication when electronic patient information is updated and complete.
Availability of software tools to assist physicians in answering patient questions	Using a reference portal (e.g., a clinical information website with a search engine) to create a filtered and customised set of content.
Clinicians' concern about IT reliability and high investment and low reimbursement of the system implementation	(a) Making and executing education and awareness plans prior to the EHR implementation. (b) Improving clinicians' understanding of how the EHR can benefit their performance in a pandemic situation and achieve better patient care outcomes.
Clinicians' dissatisfaction with the software in use	Exploring ways to improve the human-computer interactional design to suit end-users such as involvement of clinical champions at the design phase.

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# E-Health Preparedness Assessment in the Context of an Influenza Pandemic: ~~Case-A~~ Qualitative Study in China

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**ABSTRACT**

*Objective:* To assess preparedness status of a hospital in Beijing, China for implementation of an E-Health system in the context of a pandemic response.

*Design:* This research project used qualitative methods and involved two phases: 1) group interviews were conducted with key stakeholders to examine how the surveillance system worked with ICT support in Beijing. The results provided background information for a case study at the second phase; and 2) individual interviews were conducted in order to gather a rich data set in relation to E-Health preparedness at the selected hospital.

*Setting:* In Phase 1, group interviews were conducted at Centres for Disease Prevention and Control (CDC) in Beijing. In Phase 2, individual interviews were done at a secondary hospital selected for the case study.

*Participants:* In Phase 1, three group interviews were undertaken with 12 key stakeholders (public health/medical practitioners from the Beijing City CDC, two district CDCs and a tertiary hospital) who were involved in the 2009 influenza A (H1N1) pandemic response in Beijing. In Phase 2, individual interviews were conducted with 23 participants (including physicians across medical departments, the IT manager and general administrative officer).

*Primary and secondary ~~outcome~~ measures:* For the case study, five areas were examined to assess the hospital's preparedness for implementation of an E-Health system in the context of a pandemic response: a) motivational forces for change; b) healthcare providers' exposure to E-Health; c) technological preparedness; d) organisational non-technical ability to support a clinical ICT innovation; and e) socio-cultural issues at the organisation in association with E-Health implementation and a pandemic response.

*Results:* This article reports a small subset of the case study results from which major issues were identified under three main themes in relation to the hospital's preparedness. These issues include poor sharing of patient health records, prescription errors, unavailability of



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7 software tools to assist physicians in answering patient questions, physicians' concerns about  
8 the reliability of ICT and high monetary cost of E-Health implementation and uncertainty  
9 over return on investment, and their dissatisfaction with the software in use.  
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12 *Conclusions.* Prior to the implementation of E-Health, planning must be undertaken to ensure  
13 the smooth introduction of the system. The assessment of organisational preparedness is an  
14 important step in this planning process. Based on the case study, deficient areas of  
15 organisational preparedness were identified for the prospective implementation of electronic  
16 health records (EHR). Accordingly, we suggested possible solutions for the areas in need of  
17 improvement to facilitate E-Health implementation's success.  
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25 *Keywords.* E-Health, preparedness assessment, pandemic, hospital, case study, China  
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## BACKGROUND

Influenza pandemics can occur with the appearance of a new strain of influenza A virus against which none of the population has any immunity.[1] A severe pandemic has the potential to increase morbidity and mortality levels, and consequently cause economic losses worldwide.[2] E-Health is an application of information and communication technologies (ICT) across the whole range of functions that affect health and may mitigate the impact of a pandemic by enhancing surveillance and control (e.g., rapid case reporting), and improving performance of clinical practice (e.g., efficient documentation). [3, 4]

The implementation of E-Health systems represents a disruptive change in the healthcare workplace and requires proper planning and management.[5] The change occurs not simply due to the introduction of ICT infrastructure but also because the job design of interconnected health professionals should be re-engineered to effectively and efficiently accommodate the technology.[6] Resistance to the change can occur at the individual level as well as at the organisational level.[7] E-Health preparedness assessment becomes an essential requirement prior to the implementation of E-Health.[8, 9] The assessment is to identify problems with present clinical practice processes and activities, healthcare providers' exposure to E-Health (e.g., perceived E-Health benefits), and available resources and socio-culture of organisations to support the clinical ICT innovation for a pandemic. Subsequent action taken that addresses deficient areas of preparedness would hopefully facilitate changes resulting from E-Health systems' implementation.

Although there have been some preliminary attempts to develop a framework for E-Health preparedness assessment, there has been no work reported on a systematic study on the evaluation of E-Health preparedness for public health services. Recently, an integrated E-Health preparedness framework [10] was developed from the perspectives of the healthcare organisation and providers. Then, the authors have validated it by contextual interviews with

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7 20 domain experts: ten with E-Health implementation practitioners and the rest with  
8 medical/public health practitioners and no modifications have been made on the constructs.  
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10 However, this framework has not yet been applied in real healthcare settings. As a research  
11 strategy, the case study is used in many situations to contribute to our knowledge of  
12 individual, group, organisational, social, political and related phenomena – it allows  
13 investigators to retain the holistic and meaningful characteristics of real-life events.[11] In  
14 light of the integrated framework, **we conducted a case study at a healthcare organisation in**  
15 **Beijing, which aimed to test its applicability and assess the preparedness status for the**  
16 **implementation of an E-Health system in the context of a pandemic response.**  
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## 25 **METHODS**

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27 This study used a qualitative research approach and involved two phases: 1) group interviews  
28 with key stakeholders involved in the 2009 influenza A (H1N1) pandemic response in  
29 Beijing to examine how the surveillance system worked with ICT support, which provided  
30 background information for the case study; and 2) individual interviews at a selected hospital  
31 to gather a rich data set in relation to E-Health preparedness assessment. The Medical and  
32 Community Health Research Ethics Advisory Panel, the University of New South Wales and  
33 the Beijing Center for Disease Prevention and Control (CDC) approved the study protocol.  
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### 41 ***Interview guide***

#### 42 **Phase 1**

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44 It was found that there was limited information in the literature on interactions of  
45 stakeholders involved in public health surveillance activities and ICT applications for the  
46 purpose of surveillance in China. An interview guide was developed to examine areas such as  
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7 collection and use; and c) dissemination of information from public health authorities and  
8 feedback mechanisms.  
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## 10 11 Phase 2

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13 Based on an integrated E-Health preparedness framework presented in [10], an interview  
14 guide was developed to examine the following areas: a) *motivational* forces for change that  
15 reflect the evaluator's realisation of problems and healthcare providers' dissatisfaction with  
16 present practices or circumstances for pandemic responses. Pandemic responses at the  
17 healthcare organisation require its participation in pandemic diseases surveillance and control  
18 (such as case reporting to the state or local public health unit) as well as in the performance of  
19 medical practices (such as diagnoses and prescriptions); b) healthcare providers' exposure to  
20 potential E-Health applications (*engagement* preparedness) including their perceived E-  
21 Health benefits for a pandemic response, fears and concerns over using prospective E-Health  
22 systems, and their willingness to make the initial investment of extra time for E-Health  
23 training; c) *technological* preparedness that reflects the capacity of the available hardware,  
24 software, computer networks and internal IT support particularly for troubleshooting at the  
25 healthcare organisation, as well as the sufficiency of healthcare providers' previous IT  
26 experience to support an ICT innovation for medical practices; d) *resource* preparedness that  
27 is organisational non-technical ability to support a clinical ICT innovation, including decision  
28 makers' specific knowledge of the ICT implementation, supportive policies at the  
29 organisational level and sufficient funding to support the whole innovation process; e)  
30 *societal* preparedness that deals with socio-cultural issues at the organisation in association  
31 with E-Health implementation and a pandemic response. Communication links and  
32 partnerships need to be available within and across the organisation. Questions from the  
33 interview guide were generated to evaluate preparedness measures at the bottom level of the  
34 hierarchical framework [10]. Here is an illustrative question: were there any problems with  
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7 the performance of medical practices during the influenza A H1N1 pandemic? For example,  
8 were there errors in prescriptions at the hospital?  
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### 10 11 *Sample and site selection*

#### 12 13 Phase 1

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15 Purposive sampling was used to recruit individuals to participate in the group interviews.  
16 Stakeholders nominated by the Beijing City CDC were provided with an overview of the  
17 study and were invited to participate. Consent was implied, if the participant agreed to  
18 undertake the interview. No identifiable information was collected in the interview.  
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#### 24 25 Phase 2

26 To select a hospital for the case study, the Beijing City CDC initially recommended a small  
27 list of hospitals as possible candidates. There were a number of criteria which the hospital  
28 had to meet in order to be eligible. These included: a) the hospital must have been involved in  
29 the 2009 influenza A H1N1 pandemic response; and 2) the hospital must be planning to  
30 implement a new E-Health system that can facilitate future pandemic response. Then, two  
31 investigators made face-to-face explanations to the administrative officers and IT personnel  
32 at these hospitals on the objective of the research project. One hospital located in Beijing was  
33 finally selected, as the hospital met the case selection criteria and also the management  
34 showed their willingness to participate and offer a context for the study.  
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44 Purposive sampling was employed since the interviews required participants' knowledge of  
45 the *status quo* at the hospital to reveal its motivational, engagement, technological, resource  
46 and societal preparedness for the prospective E-Health system implementation. Due to the  
47 nature of the data collected, three groups of participants were involved, specifically: 1)  
48 Clinicians who had experience in diagnosing and reporting cases of Influenza A H1N1 and  
49 who would be an end-user of the E-Health system; 2) an IT manager who provided IT  
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7 support services (e.g., troubleshooting) during the H1N1 pandemic and who was familiar  
8 with the ICT infrastructure (e.g., what were the information systems in use?) at the hospital;  
9 and 3) the Chief Information Officer/person who was in charge of the planning and  
10 implementation of the E-Health system. We also set the following inclusion criteria:  
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12 participants must have worked at the hospital for a minimum of ~~two~~ years, and were full-  
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14 time or part-time staff (contract workers were not included).  
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18 At the selected site, three interviews were piloted with a representative of the members of the  
19 study population of interest. The purpose was to evaluate the interview guide, for example, its  
20 readability, relevance, and difficulty of interpreting and answering the questions asked. The  
21 instrument was modified accordingly.  
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### 26 *Data collection*

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28 The recruitment process ended once enough detailed insights were provided to reach a point  
29 of saturation with respect to the surveillance system in Beijing during the 2009 pandemic  
30 outbreak and the preparedness areas at the selected hospital.  
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#### 35 Phase 1

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37 In February 2010, three group interviews were conducted in Chinese by one investigator. The  
38 first interview involved 2 public health practitioners from the Beijing City CDC. The second  
39 and third interviews involved 10 public health/medical practitioners from the City CDC, two  
40 district CDCs and a tertiary hospital (e.g., the director of a district CDC and a medical doctor  
41 from the hospital).  
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#### 47 Phase 2

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49 A total of 23 in-depth interviews were conducted in Chinese by three investigators at the  
50 selected hospital ~~between October and December 2010~~, respectively with the general  
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7 administrative officer, an IT manager, five physicians from the Respiratory Medicine  
8 Department, the director and six physicians from the Paediatrics Clinic Department, the  
9 director and four physicians from the Internal Medicine Emergency Department, the director  
10 and two physicians from the Infectious Diseases Department, and a health worker from the  
11 Public Health Department. The interview with the health worker aimed to better understand  
12 the hospital's public health responsibilities and professional relationships with the district  
13 and city CDCs.  
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### 20 21 *Analysis*

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24 With the participants' permission, all the interviews were recorded with a digital voice  
25 recorder and transcribed verbatim. The process for coding the data was conducted manually  
26 and consisted of a number of steps. One-quarter of the transcripts were randomly selected and  
27 coded independently by three investigators who are bilingual and fluent in both English and  
28 Chinese. Each idea was given a code in Chinese that represented the meaning of the text  
29 segment. As part of this step, respondents' own words were used whenever possible. Through  
30 discussions between the three investigators, a list of themes was developed inductively. An  
31 agreed framework was then applied by one of the three to code the remnant of the transcripts  
32 and the themes were modified. Based on the themes finally identified, the analysis results  
33 were written in English and then discussed with the other two investigators to ensure the  
34 accuracy and lexical equivalence. Lastly, the manuscript was modified according to other  
35 authors' further comments and feedback.  
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47 ~~To analyse the data, the transcripts of all interviews were translated into English by the~~  
48 ~~investigator who managed the data collection at the two phases. Then, the translated scripts~~  
49 ~~were checked by other bilingual investigators to ensure the accuracy and lexical equivalence.~~  
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51 ~~One quarter of the transcripts were randomly selected and coded independently by three~~  
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~~investigators. Subsequent discussions among these three developed a list of themes. An agreed framework was then applied by one of the three to code the remnant of the transcripts and the themes were further modified. Based on the themes finally identified, all of the transcripts were analysed. No software was used in the process. The analysis results were then discussed with the other authors. Lastly, modifications were made according to those comments and feedback.~~

## CONTEXT

### *Surveillance system in Beijing*

This section reports key findings from the group interviews. When asked how the public health surveillance system worked during the 2009 influenza A (H1N1) pandemic outbreak, all participants noted that various stakeholders participated in the surveillance activities in Beijing (including personnel from national, provincial/city and district bureaus of health, CDCs at all levels, hospitals and schools) and ICT took an important role in facilitating the stakeholders' interaction and communication. Figure 1 shows the stakeholders and their interactions for public health surveillance as part of the 2009 pandemic response.

When asked to explain in detail how notifiable diseases were normally reported, the participants indicated that it was initially done by physicians either by filling out a paper-based form or through the electronic interface of an intranet website. A health worker from the hospital's public health department was usually designated to collect these forms in person once or twice per day or to retrieve that information in real time through the intranet website. The health worker was then required to check the completeness and legitimacy of the information reported by physicians. Lastly, the health worker was responsible for importing the updated information into the CDC website. One participant believed that the completeness check improved the quality of case reporting and, as a result, benefited the



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7 prospective use and analysis of the surveillance data. During the pandemic, any data collected  
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9 on the case reports were available in real time to the district CDCs through the CDC website.

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11 *“After cases were reported to our district CDC, we were able to immediately capture*  
12 *the information using the website.”*  
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16 *“If a patient saw a doctor in District A but resided in District B, after the case was*  
17 *reported, both district CDCs could see the information in real time through the*  
18 *website.”*  
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22 As highlighted by some participants, these data could be shared by CDCs at all levels and  
23 health workers at the public health department of hospitals via the CDC website; they,  
24  
25 nevertheless, were not given the same level of accessibility.  
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28 *“Every district CDC could see the number of cases in the district but not that in other*  
29 *districts.”*  
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33 *“Chinese National CDC is able to see reports from all the cities/provinces whereas*  
34 *the reports seen by a district CDC are only a small subset.”*  
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38 Aside from the healthcare facility-based reporting, schoolteachers and construction site  
39 managers also share the responsibility of reporting cases on the basis of the person's  
40 symptoms (fever, diarrhoea, rash, jaundice or red conjunctiva). Many felt that the system of  
41 symptom-based reporting allowed control measures to be undertaken before the disease  
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43 started to spread.  
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47 According to the participants, the surveillance data were analysed with ICT applications (e.g.,  
48 Early Aberration Reporting System (EARS) [12]) at all CDC levels; the analysis results were  
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50 reported to the bureau of health at the same level. A public health practitioner explained that  
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7 the analysis was undertaken to identify trends and affected populations, so that appropriate  
8 target groups were identified and control activities were implemented.  
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### 10 11 *Hospital case study background* 12

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14 ICT has been applied at the hospital since 1999. At the initial stage, the application aimed to  
15 meet the hospital's financial needs. The manager of the IT department pointed out that in  
16 2003, the hospital realised that the application should not merely focus on finance but should  
17 benefit clinical practices as well as decision-making processes at the management level. In  
18 the context of the 2009 pandemic outbreak, some interviewed physicians commented that  
19 they could proactively retrieve laboratory testing results through a Laboratory Information  
20 System (LIS) once the results became available; they could also access to an intranet website  
21 and capture health alerts (e.g., updated case definition) issued by public health authorities.  
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30 Since 2003, the hospital information system (HIS) for clinical practices has been replaced  
31 twice because neither of the first two suppliers was capable of upgrading their systems to  
32 meet increasing clinical needs. The third HIS system had been implemented for both  
33 outpatient and inpatient services. The IT manager indicated that the second system for  
34 inpatient services was still in use and explained that the second had kept all the information  
35 for inpatients who were already hospitalised before the implementation of the third. The new  
36 system for outpatient services included a range of functions and mainly focused on the entry  
37 of medicines prescriptions and connections to the billing system. The general administrative  
38 officer pointed out there was still a big gap regarding retrieval of complete patient medical  
39 records for clinical decision making.

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47 records for clinical decision making. **Therefore, as the officer reported, the hospital had been**  
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49 **planning to implement an EHR system.**  
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## E-HEALTH PREPAREDNESS ASSESSMENT RESULTS

Based on our discussions with 23 participants at the selected hospital and analysis of their responses, we assessed the hospital's preparedness for implementation of an EHR system in the context of a pandemic response. The preparedness issues were discussed within the five areas: a) motivational forces for change; b) healthcare providers' exposure to E-Health; c) technological preparedness; d) organisational non-technical ability to support a clinical ICT innovation; and e) socio-cultural issues at the organisation in association with EHR implementation and a pandemic response. Due to words limit, this section reports a small subset of the case study results from which major issues were identified in relation to the hospital's preparedness. These issues needed to be addressed prior to the implementation of EHR.

### *Explored area: motivational preparedness*

- Poor sharing of patient health records

Patient information required for clinical decision making was deemed by more than half of the interviewed physicians to be incomplete and inaccurate. Most physicians indicated that information could be partially obtained from the internal HIS, or the paper-based patient medical history generated at the hospital or other healthcare facilities, or, alternatively, by asking patients face-to-face during the physician-patient encounter. These physicians argued that patient information in the HIS mainly included past diagnoses and prescriptions at the hospital whereas other information (e.g., allergic history), which was also important for clinical decision making, was not saved. Furthermore, if those patients who had lost their medical card applied for a new card instead of renewing it, all information generated in the past would be no longer available. Although the paper-based patient medical history could provide extra evidence for clinical decision making, the utilisation of the information

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enclosed was another concern. The director of the Infectious Disease Department provided the example of a patient with a medicine allergy: the diagnosing physician knew about it but still wrote down 'no medicine allergy history' in the medical history.

*"When I look at patient medical history generated by others, I cannot entirely trust it." (a senior physician, Department of Infectious Disease)*

#### • Inappropriate prescriptions

Physicians had utilised the HIS for prescriptions. The majority of physicians indicated that inappropriate prescriptions were caused by operational errors. A paediatrician provided the example that while she used an electronic interface to prescribe medicines for a patient, another patient whom she had already seen walked in with a laboratory test report; she switched over but used the interface to prescribe medicines for the wrong patient. A few commented that these mistakes sometimes happened especially when there were a large number of patients; nevertheless, they could be corrected in most cases when the patient went to the pharmacy with a different name on their prescriptions. Some physicians pointed out that inappropriate prescriptions could also be made in terms of medicine usage (e.g., intravenous drip, injection or push) and dosage. Another physician added that due to the lack of updated information (e.g., pregnancy) in relation to patients, medicines might have been prescribed to them despite there being contraindications.

#### • Lack of assistance to answering patients' questions

The majority of interviewed physicians indicated that they had neither access to the Internet nor software tools available, at least as far as they knew, to search for information in relation to patients' questions during their visits. Others argued that there was indeed an electronic pharmacopeia and an intranet library to assist with answering some of the patients' questions.

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7 One of the others commented that through the library they were able to find a small number  
8 of published papers or reports but the quality of these was uncertain.  
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### 10 11 *Explored area: engagement preparedness*

#### 12 13 Physicians' concern about IT reliability

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16 Most physicians believed that information technology was always reliable. Nevertheless, the  
17 majority of the physicians including many of those who held the positive point of view also  
18 clearly pointed out that information technology could be unreliable from time to time. They  
19 commented that: 1) there were pointless reminders when they prescribed medicines; 2) the  
20 HIS crashed sometimes and had to be rebooted, and as a result all work not yet saved needed  
21 to be redone; 3) the reliability of information stored in IT systems was another concern. They  
22 argued that patient personal details (e.g., residential address and contact number) might not  
23 be up-to-date; first-hand medical information collected from patients (e.g., past allergic  
24 history) might not be accurate or complete; the information in relation to past diagnoses and  
25 prescriptions saved in the HIS might not be correct and could be inappropriate in the first  
26 place; the information on medicinal drugs in the electronic pharmacopeia might be out-of-  
27 date; and (4) technical glitches in the HIS negatively impacted on physicians' work efficiency.  
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40 *"Sometimes, after physicians generated and saved patient health records with the HIS*  
41 *for inpatient services, nothing was there."* (a physician, Department of Internal  
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44 Medicine Emergency)

#### 45 46 Physicians' concern about high investment and low reimbursement

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49 For more than half of the interviewed physicians, high investment and/or low reimbursement  
50 were not their concern with using prospective E-Health systems. They argued that monetary  
51 investment was beyond their professional knowledge and there was nothing they could do  
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7 about it. Some explained that those decisions on the implementation of a new system were  
8 always made at the management level and they had never been involved in that process at all.  
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10 Regardless of the involvement in decision making, physicians' medical practices (e.g., work  
11 efficiency) would benefit in the long run, as a few noted.  
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15 However, the others indicated that the monetary investment on E-Health technologies had to  
16 be of concern – physicians would ~~be those who~~ pay for what they have been given (e.g., from  
17 their bonus) ~~and thus the monetary investment on E-Health technologies had to be of concern.~~  
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21 They also commented that returns on the investment were dependent on the degree to which  
22 the technologies would be utilised to improve medical practices and patient care outcomes.  
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24 When a large number of daily patient visits were taken into account, time which could be  
25 spent with every single patient was significantly limited and even less for the utilisation of  
26 technologies, and therefore returns on the investment could be unpredictable and appeared to  
27 be another concern, as one physician emphasised.  
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### 32 33 *Explored area: technological preparedness*

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35 The IT manager reported that all available ICT systems (e.g., clinical and non-clinical  
36 software) at the hospital had formed a technical base for the implementation of any E-Health  
37 systems in the future. Many of the interviewed physicians were satisfied with the current  
38 software in use but also highlighted that the HIS needed to be upgraded in order to improve  
39 its performance (including technical errors and bugs, user-unfriendly interfaces, irrational  
40 operations and unmet requirements). One provided an example, explaining that as the buttons  
41 in the HIS used icons instead of captions (i.e., text) to indicate what they do, it could take a  
42 while for end-users to remember them and become familiar with the operations.  
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52 The general administrative officer indicated that problems with the HIS encountered by  
53 physicians were being collated by the IT department, but to address these problems required a  
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7 E-Health applications were already set in place for the pandemic response. The case reporting  
8 process, for example, had been streamlined from diagnostic physicians to the internal public  
9 health department, and subsequently to the district CDC.

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13 More serious issues were identified in medical practices including poor sharing of patient  
14 health records, prescription errors and unavailability of software tools to assist physicians in  
15 answering patient questions. Although the new HIS provides physicians with a function for  
16 prescription entry, inappropriate prescriptions can still be made due to system operation  
17 errors or the absence of updated patient information which is required for consideration of  
18 contraindications. Therefore, some broad requirements for the EHR system that should be  
19 incorporated are to: a) explore options to decrease prescription errors (e.g., automatic check  
20 of contraindication when patient information is updated and complete); b) ensure that a  
21 variety of clinicians can access patient health information efficiently when required, but also  
22 ensure that the information can be secured with patient privacy protected (further exploration  
23 is required for defining what information needs to be shared with whom and in which way);  
24 and c) explore options to assist physicians in answering patient questions or seeking required  
25 clinical information (e.g., a reference portal to create a filtered and customised set of content  
26 [15]).

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41 As part of engagement preparedness assessment, interviewed physicians raised a couple of  
42 major concerns about using a potential EHR system. As healthcare providers are the key  
43 driving force in pushing E-Health initiatives, their concerns would impede further  
44 development of overall preparedness.[10] Firstly, their concern about the reliability of ICT  
45 was partially caused by their distrust in the information stored in IT systems. The distrust  
46 may evoke their anxious reactions when it comes to adopting new E-Health systems (e.g., [16,  
47 17]). Secondly, interviewed physicians perceived high monetary cost of E-Health  
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7 implementation and uncertainty over return on monetary investment. This perception can  
8 inhibit their use of E-Health or intention to use (e.g., [18, 19]). If the increase in expenses  
9 outpaced that of compensation for the organisation, they would find it particularly hard to  
10 justify the risk in making any investment, especially in a new technology perceived as risky  
11 with uncertain returns (e.g., the EHR).[20] Healthcare providers' perception of E-Health  
12 benefits determines the level of their fears and concerns.[21] Therefore, to overcome these  
13 concerns, education and awareness plans need to be made and executed prior to the EHR  
14 implementation. These education programs can improve healthcare providers' understanding  
15 of how the EHR can benefit their performance in a pandemic situation and achieve better  
16 patient care outcomes.  
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26 Under the technological preparedness dimension, physicians expressed their dissatisfaction  
27 with the software in use (particularly the newly-implemented HIS) at the hospital, such as the  
28 user-unfriendly interfaces and irrational operations. Negative IT experience can cause them  
29 technology phobia and thus inhibit their adoption intention of a new E-Health system.[22, 23]  
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31 With respect to the EHR system being planned, there is a need to explore ways to improve  
32 the human-computer interactional design to suit end-users (e.g., involvement of clinical  
33 champions at the design phase).  
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41 The study results may be limited due to participants' over-reporting or their recall bias. In the  
42 case study, for example, the three groups of participants may have over-reported their  
43 preparedness in order to avoid embarrassment or judgement. We attempted to minimise ~~any~~  
44 bias in the interpretation of the interview data by having it reviewed by three investigators.  
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46 Furthermore, It would be useful to have an independent bilingual person to ensure the  
47 accuracy and lexical equivalence of the data analysis results. As this study was undertaken as  
48 part of a PhD project, there was no funding available for this process. Furthermore, ~~ss~~some  
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7 questions—in the interview guide required participants to recall their past experiences;  
8 therefore, there may be some recall bias.  
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## 10 11 CONCLUSIONS

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13 Pandemic preparedness planning is necessitated during the inter-pandemic period to enable  
14 countries to be prepared to recognise and manage an influenza pandemic.[24] The first phase  
15 of this project contributes to sharing of the surveillance experience in Beijing, especially with  
16 other regions of China or countries where the public health surveillance system has been  
17 dysfunctional or not yet set up in place; some information drawn from this experience may  
18 help their preparation for a next pandemic from the surveillance perspective.  
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20  
21 The project's second phase demonstrates the applicability of the integrated E-Health  
22 preparedness framework [10] in a real healthcare setting. It also provides the medical  
23 informatics audience with an example of how E-Health preparedness assessment can be  
24 conducted in an organisational context. The case study results may assist decision makers at  
25 the hospital to take action to address deficient areas in their preparedness and, as a result,  
26 facilitate the EHR implementation success.  
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29 The integrated framework [10] lays the foundation for E-Health preparedness assessment as  
30 illustrated here in the context of an influenza pandemic. However, the framework can be  
31 adapted to a range of clinical and public health environments. The applicability of the  
32 framework with these minor modifications would also require further studies. Similar case  
33 studies can be conducted at various healthcare settings (such as residential aged care facilities  
34 and primary healthcare centres) across countries to manage and plan the implementation of  
35 varied and specific e-health systems such as electronic health records, e-learning, chronic  
36 illness management, telecardiology, teleradiology and teledermatology. These studies would  
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7 engage staff members and seek their input to the specification of requirements for a clinical  
8 ICT innovation and also build organisational capacity for change.

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10 ~~In the future, similar preparedness assessment can be conducted at various healthcare settings~~  
11 ~~(e.g., residential aged care centres and primary healthcare centres) in countries to manage and~~  
12 ~~plan the implementation of varied and specific E-Health systems such as electronic health~~  
13 ~~records, e-learning, chronic illness management, telecardiology, teleradiology and~~  
14 ~~teledermatology.~~

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22  
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24 This research received no specific grant from any funding agency in the public, commercial  
25 or not-for-profit sectors.

#### 28 **COMPETING INTERESTS STATEMENT**

29  
30  
31 No potential conflicts of interest with respect to the research, authorship, and/or publication  
32 of this article.

#### 35 **CONTRIBUTORSHIP STATEMENT**

36  
37  
38 Junhua Li: 1) conception and design, acquisition of data, and analysis and interpretation of  
39 data; 2) drafting and revising the article; and 3) final approval of the version to be published.

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42 Holly Seale: 1) conception and design, and analysis and interpretation of data; 2) drafting and  
43 revising the article; and 3) final approval of the version to be published.

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46 Pradeep Ray: 1) conception and design; 2) revising the article; and 3) final approval of the  
47 version to be published.

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50 Quanyi Wang: 1) acquisition of data; 2) revising the article; and 3) final approval of the  
51 version to be published.

Peng Yang: 1) conception and design and acquisition of data; 2) revising the article; and 3) final approval of the version to be published.

Shuang Li: 1) acquisition of data and analysis and interpretation of data; 2) revising the article; and 3) final approval of the version to be published.

Yi Zhang: 1) conception and design, and acquisition of data; 2) revising the article; and 3) final approval of the version to be published.

Raina MacIntyre: 1) conception and design; 2) revising the article; and 3) final approval of the version to be published.

## ARTICLE SUMMARY

### Article Focus:

- How to assess organisational preparedness for the implementation of an E-Health system in the context of a pandemic response?
- What is the preparedness status at a hospital in Beijing for the implementation of an electronic health records system?
- How did the surveillance system work with ICT support in the 2009 influenza A (H1N1) pandemic response in Beijing?

### Key Messages:

- The occurrence of a pandemic can place an immense burden upon healthcare services and E-Health systems may facilitate the functioning of healthcare facilities. The implementation of any information system in an organisational context requires proper planning and management for change. Prior to the implementation of E-Health systems, the assessment of organisational preparedness is an essential requirement.

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7 • There has been no work reported on the assessment of E-Health preparedness at  
8 healthcare facilities.  
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17 Strengths:

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19 • Part of our findings shows how IT applications were used in the functioning public  
20 health surveillance system in Beijing. This may provide decision makers at other  
21 settings with valuable insights to prepare themselves for a next pandemic from the  
22 surveillance perspective.  
23  
24 • Our case study at a hospital in Beijing demonstrates how organisational preparedness  
25 can be assessed for the implementation of E-Health systems. Similar studies can be  
26 conducted in the future at various healthcare settings in countries to manage and plan  
27 the implementation of varied and specific E-Health systems.  
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29 • Reported results from the case study may assist decision makers in the hospital to take  
30 action to address deficient areas in their preparedness and, as a result, facilitate the E-  
31 Health implementation's success.  
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41 Weakness:

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43 • The study results may be limited due to participants' over-reporting or their recall bias.  
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46 • Another limitation is on the study design. This single-case study demonstrates the  
47 applicability of an integrated preparedness assessment framework that was developed  
48 and published recently. We understand that the evidence from multiple cases is often  
49 considered more compelling, and the overall study is therefore regarded as being more  
50 robust. However, the conduct of a multiple-case study requires extensive resources and  
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7 time. For this project, we received no specific grant from any funding agency in the  
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9 public, commercial or not-for-profit sectors; therefore, we selected a representative and  
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11 typical case to achieve the study objectives.  
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### 13 DATA SHARING STATEMENT

14  
15 Extra data is available by emailing to the corresponding author.  
16

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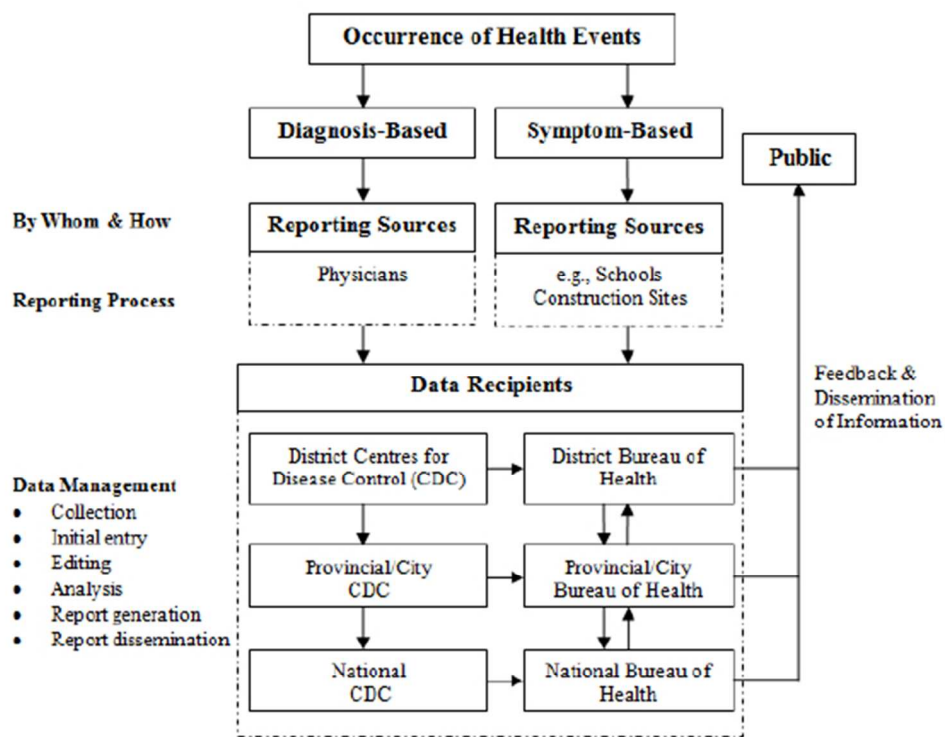


Figure 1 The major steps in the public health surveillance system in China

The major steps in the public health surveillance system in China