Trust Requirements in E-Health System: A Conceptual Framework

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***Abstract*— Resulting from the development of new technology, conventional scientific practices have migrated into computer-based infrastructures, called e-science. Specifically, e-science applied in health discipline is called e-health. It is an organized system that deals to diagnose and treat patients. Considering trust is an important role and fundamental for the provision of effective healthcare service, this paper discusses trust requirement in e-health. To highlight the importance of trust in e-health system, a conceptual framework of trust requirements in e-health system is developed. Drawn from literature search framed by STARLITE, a conceptual framework that addresses trust resulting from relationships of various actors based on two perspectives: sociotechnical and technical perspectives are presented. This framework suggests that e-health system must build a trust relationship between actors and understand trust based on sociotechnical and technical perspectives. Further, security and privacy that protect the confidentiality of patient's data, especially m-health (mobile health) also need trust in resource sharing. It can be concluded that trust requirements in e-health depend on how the media transmits a social experience, patient-system relationship, and collaboration of software engineering and healthcare professionals. The implementation of trust requirements has the potential to produce well-engineered software in a healthcare organization, resulting in the use of software for effective diagnosis and treatment of patients.**

***Index Terms*— About; E-Health System; Health Care; Requirements Engineering; Trust Requirement.**

I. INTRODUCTION

Nowadays, much of the conventional scientific practices are adopting computer-based infrastructures, called the e-Science. It involves not only new 'forms of dynamism, in which science is undertaken' but also new forms of resource sharing among individuals, institutions, and systems [1]. In practice, the implementation of e-science has been spread widely in more than one scientific discipline such as business, education, entertainment, health, and many more.

This paper focuses on the application of e-science in a health discipline, specifically the e-health system. E-health provides many innovation opportunities and improvements in devices and systems for medical care [2]. An example of the use e-health system is the migration from manual diagnosis of patients to the application of imaging technique, such as the screening-test using mammogram that can provide a clear image of the breast condition into the monitor [1]. This tool helps doctors to provide an objective diagnosis of patient's disease rather than depending on their manual diagnosis, which involves an element of subjectivity. Another example of e-health system is the processing of patient registration record [3], [4]. The use of computer-based system facilitates the storage of accurate and systematic patient's record that helps doctors to provide appropriate treatment and improve the quality of treatment [5], [6]. E-health system is also expanding into Electronic Health Record (EHR). This leads to the provision of efficient and convenient medical service, which reduces patients' financial costs [7]. Another new practice of e-health system is the development of home-remote patient monitoring using a mobile device. Combined with the Internet of Things (IoT), this system provides easy access anytime and anywhere; hence, enriching and making our lives easier [8], [9].

The usefulness of software in e-health system depends on processes involved in developing the software. For example in Agile development, the software development starts with initial requirement, design, implementation and testing processes [10]. This process is responsive to changing requirements in order to meet the needs of the stakeholder. The initial process of requirements management is important because correct and complete requirement leads the proper software process, while poor quality requirements are the major source of poor implementation [11]. Requirements can be divided into two types, which are the functional and non-functional requirements. Functional requirements specify things the software must do, while the non-functional are about qualities that the software must have. The quality of software can be derived from the trust, security, privacy, performance and many others.

This paper discusses trust requirements in e-health considering trust has an important and fundamental role and for the provision of effective healthcare service [12], [13]. In this paper, a review regarding trust requirement in e-health is conducted. After the Introduction presented in Section I, Section II explains the review strategies used in this study. Next, Section III discusses e-health system and the element of trust applicable in e-health system. Section IV elaborates how to build trust in e-health system. Finally, in Section V provides the conclusion of this paper.

II. REVIEW STRATEGIES

This paper presents a systematic literature review for the development of a conceptual framework that highlights the importance of trust requirement in e-health system. The review strategies used in this study starts with the establishment of the research concern and questions, followed by the search and selection of data from several sources.

A. Research Concern

The review explores trust requirement in e-health system for the development of a conceptual framework. The discussion aims to reveal the answer to the following research questions as shown in Table 1.

Table 1
Research Questions

Research Question	Objective
Q1. What is trust in e-health system?	To provide a brief explanation regarding e-health system and trust in an e-health system
Q2. How to build trust in e-health system?	To provide a systematic review of the development of a conceptual framework applicable

B. Literature Search

This study adopted STARLITE literature search commonly used in the medical field of study. The process search literature is based on a sampling strategy, type of study, approaches, range of years, limitations, inclusion and exclusions, terms used and electronic sources [11]. The search strategy involved using the terms "e-health system," "trust requirement," and "trust requirement in e-health system". The study covers journal, conference, and an article. The searching process was limited to the English language drawn from the database such as IEEE, Science Direct, and Google Scholar.

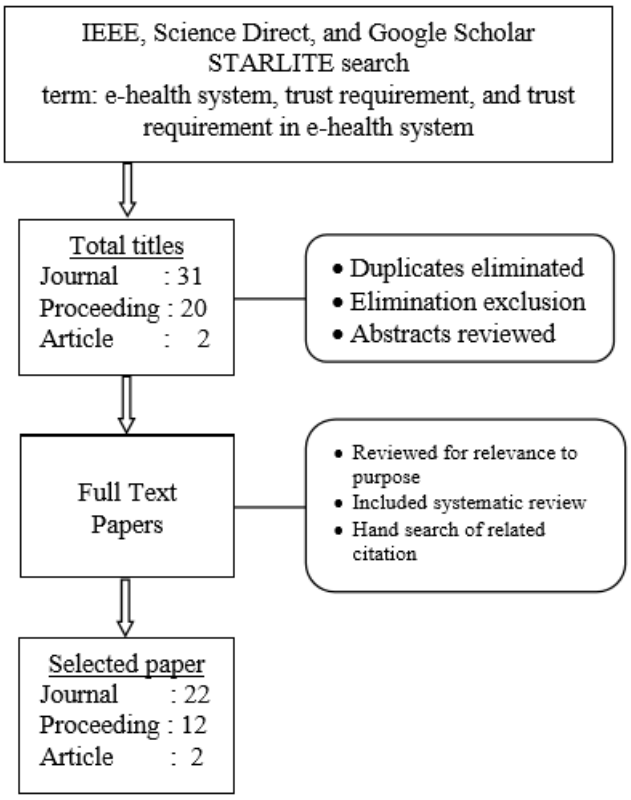

Figure 1: The search strategy

Figure 1 shows the search strategy for this study. 53 papers were selected through online databases. The selection process involves eliminating duplicates and exclusion followed by reviewing the abstracts. Next, the selection of relevant papers to be reviewed was conducted by systematic review and hand search of related citations.

C. Literature Search

The literature search resulted in the selection of 36 papers. As shown in Table 2, it comprises 22 journal papers, 12 proceedings, and 2 article papers.

Table 2
Relevant Research Paper to Review

	Journal	Conference Proceeding	Article
Papers from	[1], [3]–[11], [14]–[25] [2], [36]	[12], [13], [26]–[35]	[2], [36]

III. Trust in e-Health System

A. E-Health System

In a simple definition, e-health is the use of technology in healthcare. It started 40 years ago when computer applications were applied in billing and accounting afterward in automating admission, transfer, and discharge [9]. Nowadays, that idea becomes Health Care Information System (HCIS) and Electronic Health Record (EHR) [3]–[7]. Giorgini conducted the system that comprises the following actors [6]:

- Patient: the actor who receives appropriate treatment;
- Hospital: a place that provides medical treatment depending on the patient's problem;
- Clinician: the actor who works in the hospital and provides accurate medical advice and medical treatment (whenever needed);
- Health Care Authority (HCA): the actor who controls and guarantees the resources allocation and delivers services correctly;
- Medical Information System (MIS): a system, which manages patients' data such as personal information and history of the medical treatments they have received.

The patient's data are collected by clinicians and stored into MIS in hospital. MIS allows the clinicians to access the data to provide rapid and correct medical advice and medical treatments, whenever needed. However, HCA is allowed to access the data in order to control and guarantee the resources allocation and delivered services correctly.

There is also Dental Information System for storing and managing dental-related data [14]. Further, all of the collected patient's data are useful for recommender systems. The system is able to suggest the users and the required items based on the previous patient-item interactions [26].

There is e-health system that helps to assist doctors, such as the software for acid-based status disorders. It helps doctors to focus on the treatment in the intensive care unit and the clinical practice. The software is easy to access, practice and useful in terms of reducing the time and calculating the excess bicarbonate [27]. The diagnostic imaging technique is based on the application that not only displays the condition of the parts in the human body but also displays the graphical interface for further analysis. An example is the temperature skin at transtibial amputee. The input sensor that detects the skin temperature called thermistors and the graphic displayed on the monitor can help doctors to conduct their analysis [28].

In this era, the technology is expanded into a mobile device. Mobile devices allow people to access information anytime and anywhere. E-health that uses mobile is often called with m-health. M-health has the potential to serve as widely available medical diagnostic devices. For instance, a smartphone application that could quantify the severity of

Parkinson's disease motor symptoms, and in particular, bradykinesia [29]. Another example is the smartphone application that could identify discrimination of falsified medicines [30] and many more smartphone-based application in e-health system.

M-health also has the potential for the delivery of health services [9]. Its potential can cover from patient's home to unreached community. Patients with a mobile phone can contact the doctor. The doctor who receives the patient's call has access to a computer-based hospital database to support the patient [31]. The architecture of m-health is shown in Figure 2.

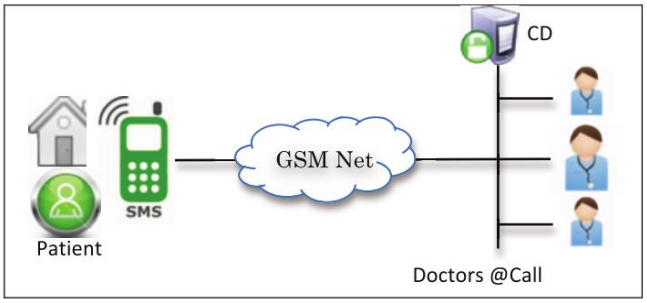

Figure 2. The architecture of m-health [31]

In patient's home, they can send the condition of their heart through a smartphone application to their doctor. This application is very useful to solve the problem of distance between patient and doctor, the difficulty of regular check-ups, and assist the doctor in monitoring patient's heart condition regularly [32]. The combination of M-health with the Internet of Things (IoT) can enrich and ease our lives. The service can spread to the unreached community and make smart wearables, smart home, smart mobility and smart cities [8].

B. Trust in E-Health System

Trust had many definitions and based on Schoorman, Mayer, and Davis; trust is defined as the "willingness of a party to be vulnerable to the actions of another party" [15]. In other word, trust is a psychological condition that intends to accept vulnerability based upon positive expectations of the intentions or behavior of other party regardless of the ability to monitor or control them [16], [17].

Trust is applied in every single activity of human being, inclusive e-health system. It is necessary to understand how trust environment cooperates between human and electronic devices.

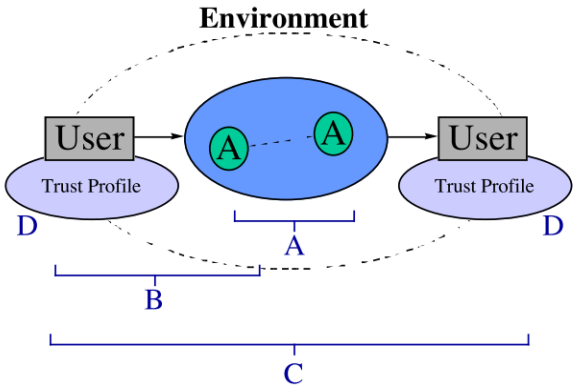

Figure 3. Trust domain [19]

Figure 3 illustrates the trust domain of e-health, which consists of [19]:

- trust between intelligent agents within a system (A)
- trust user within a system (B)
- trust in user-to-user and system-mediated trust (C)
- user's trust profile in the environment (D)

In order to build patient's confidence, the system must prepare trust requirement. For example, in HCIS and HER system, patient owns his personal information and aims to receive appropriate treatment based on that data. Patient trusts the clinician and HCA to access his data, and HCA trusts the hospital for it. Otherwise, hospital trusts HCA for controlling and guarantee the resource distribution [6], [33]. Further, the model of trust requirement is shown in Figure 4.

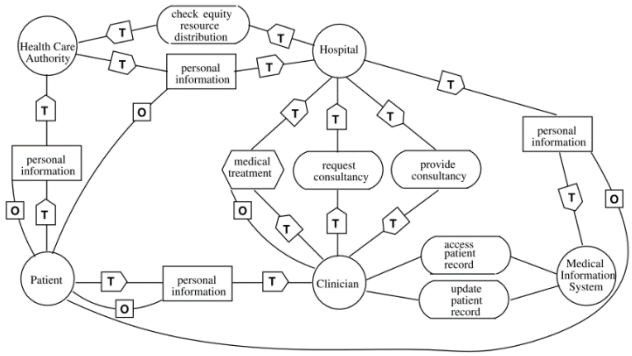

Figure 4. Requirement trust model in hcis and her [6], [33].

E-health is a combination of social and technical aspects, and every aspect has the trust relationships with the actors as shown in Figure 5.

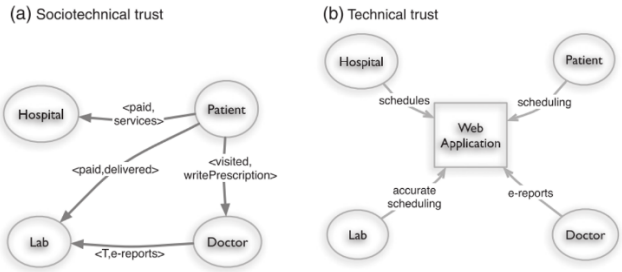

Figure 5. Sociotechnical and technical trust [18]

Sociotechnical trust is related to social entities, such as a hospital, patient, laboratories, and doctor. Patient has trust to pay hospital through their services, pay the lab through their deliveries. There is also trust to visit the doctor through the doctor's written prescription. The doctor trusts the lab by giving patient's report that will be used further to check the needs of the patient [18]. Patient's trust will be conducted when every entity gives proper service.

The technical aspect centralized at the web application in which the trust elements are related to four main actors: patient, doctor, hospital, and lab. The hospital or organization owns the web application. They provide schedules for the entire activity through the website. Laboratories have real and accurate scheduling, and patients receive accurate scheduling. The doctor also put the e-reports of the patient on the website. These activities are conceptually centralized, and they can be deployed and evaluated. However, these trusts do not exist in the sociotechnical perspective due to lack of individual assessment in between entities[18].

Zheng, Hui, and Yang suggest that consumer's purchase intention is related to organizational trust and interpersonal trust [16]. Organizational refers to the hospital that provides health care, while interpersonal means a person who provides

health care, such as a doctor, clinician, and so on. The accurate knowledge about the hospital reputation can be benefitted by the patient's trust in doctors and the confidence based on their judgments. Not only influenced by the doctor, but it is also based on trust of the hospital resulting from the purchase that takes place. Therefore, the organization must build a strong brand in order to get patient's trust [16].

Not only from gathered trust in the environment, sociotechnical, and technical, trust need to be addressed in security and privacy. Security trust can be achieved when the e-health could solve security issues, such as issues related to the lost and stolen of storage device or the attack of virus and Trojan horse [20]. In privacy concerns, e-health must protect the confidentiality of patient's data [21].

The use of portable computing device in m-health also needs trust in resource sharing. Jiang et al. found that goodwill trust matters more to tangible than to intangible resource sharing, whereas competence trust matters more to intangible than to tangible resource sharing [22]. Thus, it can be concluded that m-health trust can comprise of the trusted environment, trusted hardware and trusted mobile application [20].

IV. System Build Trust in e-Health System

E-health is an organized system that deals to diagnose and treat patients. Based on Saranummi, e-health is made up of five interacting horizontal layers [9]:

1. The first layer deals with communications infrastructure, data stores, etc
2. The second layer provides healthcare IT applications that help and support services
3. The third layer is where health service is delivered
4. The fourth layer is the place where reimbursement of health services is dealt
5. The fifth layer deals with setting the laws, regulations and policies that govern how health services are delivered and consumed.

Rosenbloom stated that trust and trustworthiness depend on how the media transmits a social experience [36]. Here, media transmits in e-health such as the web-based on HCIS and HER system and smartphone on M-health. Trust also includes patient's cultural and personal cues. It is not text-based value. Hence it may not be visible to any of the parties [36].

Lind et al. listed the requirement of IT system support of e-health [23]. They have gathered information from many sources:

1. Ogawa et al. gathered requirements from a biomedical engineering perspective:
    a. Data acquisition should be non-invasive and unobtrusive
    b. Systems should be fully automated
    c. Simultaneous measurement
    d. Long-term storage of multiple parameters
2. Bellazi et al. argued that requirements from web-based telemedicine systems should be based on the perspectives of:
    a. Architecture and technology
    b. Security
    c. Usability and acceptance
3. Gritzalis and Lambrinoudakis discussed evaluation criteria for remote vital signs monitoring based on these aspects
    a. Quality of service
    b. Interoperability of IT components
    c. Conformity to medical devices regulations
    d. Data protection

Not only trust is gathered from the patient-system relationship, but the e-health trust also considers a patient-psychiatrist relationship. The trustful relationship is a base requirement of effective healthcare service [13]. Kiritani and Ohashi stated that the quality of trust between the stakeholders depends on the circumstances of the project. A model of trust management in a relation to the requirements definition [24] is outlined below:

1. Communication efficiency improved by the development of trust relationships minimizes the gap between requirements
2. Realization of the effective negotiation process with the development of trust relationships

E-health concern is to provide patient's safety, outcome and care. To achieve this goal, the software engineering and health care professionals must be well educated in e-health system. Software engineering should know Requirements Engineering for Medical Devices software and Medical Device Software Regulations. Likewise, healthcare professionals should know about Health Informatics and Connected Health. The collaborations between both will support the implementation of well-engineered software in a healthcare organization that results in the ease of usage of the software for diagnosis and treatment of patients [34]. Further, collaboration with customers can extend discoveries in new application [25].

Carroll and Richardson stated the core stages to gather healthcare software requirements [35], which are:

1. Identify healthcare problem's need focusing on health care requirements through a Design Thinking structure;
2. Identify software capabilities that examine the aspect that influence the solution design, such as requirements, regulations, feasibility, solution specification requirements;
3. Align requirements specific to innovation development process; and
4. Management healthcare and software solution to ensure that healthcare requirements clearly meet the development of a software solution.

V. Conclusion

In this paper, we explain trust requirement in e-health system. The discussion has covered several aspects such as definition, purpose, benefit, and implementation of trust requirement in e-health system. This paper also presented a conceptual framework for the various types of trust and how to address trust in e-health system. To get the patient's trust into the system, e-health must build a trust relationship between actor, understanding trust in the sociotechnical and technical side, build a hospital or organizational branding. E-health must also have trust in security and privacy that protect the confidentiality of patient's data. Trust requirement in e-health depends on how the media transmits social experience, patient-system relationship, and collaboration of software engineering and healthcare professionals. In this case, it is necessary for developers to address trust in the requirement for well-engineered software in a healthcare organization that can result in the effective use of software for diagnosis and

treatment of patients.

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