USING HEALTHCARE INFORMATION SYSTEMS TO FACILITATE SMART AND SUSTAINABLE KNOWLEDGE FLOW IN HEALTHCARE: THE CASE OF ALLERGY CARE IN AUSTRALIA

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Research in Progress

Abstract

Allergy including asthma incidents are steadily increasing, and thus becoming a major health concern in developed countries. In Australia, the model used to manage patients suffering from allergy has two main problems; it is fragmented in nature, and difficult to access specialist care. In addition, there is a lack of awareness from the public about allergy management. To address these factors an ICT solution that facilitates knowledge flow between both allergy care providers and patients is proffered. The system is a web portal coupled with a mobile App, which together utilize a shared database of medical records for allergy patients. The system is used to examine the role of ICT to facilitate superior knowledge flow and transfer. This system uses the principles of Knowledge Management, and is guided by a Design Science Research Methodology. The implications of this study are far reaching to communities, healthcare systems, and national economies.

Keywords: Allergy, Database, Healthcare, Information and Communication Technology, Knowledge Flow, Knowledge Management, Mobile App, Web Portals.

1   Introduction

The Australasian society of clinical immunology and allergy (ASCIA) defines allergy as a medical condition that *occurs when a person's immune system reacts to substances in the environment that are harmless for most people. These substances are known as allergens and are found in house dust mites, pets, pollen, insects, moulds, foods and some medicines* (ASCIA, 2013). Allergy including asthma incidents are steadily increasing, and thus becoming a major health concern in many of these countries. This includes allergic rhinitis, drug allergy, food allergy, insect allergy, skin allergy, sinusitis, and general allergy (Pleis, Lucas, & Ward, 2009). These different types of allergy have different prevalence rates in different countries, but they all have an increased trend in common (AAAAI, 2015). For example, 7.5% of the population in USA were diagnosed with hay fever in 12 month in 2011-2012 and 8% of the population had a food allergy (Haahtela *et al.*, 2013). This problem appears to be more acute in Australia, where allergy and immune diseases are among the fastest growing chronic conditions in the country (ASCIA, 2013). According to latest figures (ASCIA, 2013, 2014), almost 20% of the Australian population has an allergic disease and this prevalence is increasing. Hospital admissions for anaphylaxis (severe life threatening allergic reaction) have increased 4 fold in the last 20 years. Not only has this increase occurred in adults, but it has also hit new born infants, as food-induced anaphylaxis has doubled in the last 10 years and 10% of infants now have an immediate food allergy (ASCIA, 2013). Autoimmune diseases have also caused serious

health problems to Australians. Today, there exist over 100 different autoimmune diseases that affect 5% of Australians and lead to significant disability. These figures agree with another study that reports exponential increases in food allergy diagnosis in recent decades (Wang & Sampson, 2011).

Data generated from a local Healthnuts study has also identified an increase of 20% sensitisation and a 10% challenge confirmed food allergy rate in 12 month old Melbourne infants (Osborne *et al.*, 2011). Further, there were 4.1 million Australians (19.6%) having at least one allergy, and the average Australian allergic person with 1.74 allergies, forecasting of 70% in the number of Australians with allergies affected from 4.1 million now to 7.7 million by 2050, and an increased proportion affected from 19.6% to 26.1% if the trends back then continued (Access Economics Pty Limited, 2007).

As in other developed countries, these increased rates of allergy diagnosis in Australia are representing a real concern at the national level. Not only have these figures caused significant health problems for the Australian population, but they also have had notable economic impacts. 7.8 billion Australian dollar was the calculated cost of allergies in Australia in 2007. This is due to different interrelated factors like lower productivity ("presenteeism" $4.2 billion), direct medical costs ($1.2 billion), lower employment rates ($1.1 billion), absenteeism and lost household productivity ($0.2 billion) and premature death ($83 million) (Cook *et al.*, 2007; Sampson, 2009; Sampson, 2002).

Two burdens appear to have played key roles in making the allergy management even more challenging in the Australian context. Firstly, there is a lack of public awareness about the impact and appropriate management of allergy and immune diseases (AAAAI, 2015; ASCIA, 2013). This is in part due to the fact that allergy is evolving and many do not look at allergy as a serious medical condition like cancer or diabetes (ASCIA, 2013). Secondly, access to care is difficult, even in metropolitan areas, due to the high number of patients and low number of appropriately trained health care professionals, resulting in long waiting times to see a specialist, which also causes negative consequences on patients and their possible treatment care plans (AAAAI, 2015).

These two challenges, and the nature of allergy conditions and required treatments, are causing allergy patients to be seen by different healthcare professionals for allergy screening and/or follow up (Haddad *et al.*, 2015). This starts with general practitioners, or family doctors, who would refer patients to a specialist if needed. Two problems face this model of provisioning allergy care in Australia. Firstly, it is not an unusual clinical practice for clinicians to provide patients with a copy of their Skin prick testing (SPT) results each time the test is performed as well as keep a record of the test in either written or electronic form in their patient database. As allergy services are currently stretched, there are frequently prolonged waiting times for food allergy review, particularly in the public sector. It is not uncommon for patients to be seen by different Allergy Practitioners for follow up testing in the longer term (Gordois *et al.*, 2007). In the interim patients are frequently encouraged to attend their general practitioner for food allergy follow up that may include intermittent evaluation of yearly or second yearly allergen-specific immunoglobulin E (sIgE) testing to the food allergen(s) in question. In the event that these levels are low or approaching negative re-referral for follow up and consideration of formal inpatient challenge may be appropriate. In this situation it is not uncommon that previous test results are not readily available for comparison. There is some evidence to suggest that the rate of change in SPT size or sIgE levels over time may help in predicting the development of tolerance (Australian Doctor, 2015; Haddad et al., 2015).

Secondly, there has been no specific or agreeable knowledge among healthcare professionals to manage these referrals. A recent study (Smith, Wade, & Frew, 2016) reviewed 100 consecutive general practitioner (GP) referrals to a hospital allergy clinic were reviewed to determine whether patients could be seen in a community-based clinic led by a general practitioner with special interest (GPwSI) allergy. The results showed that at 25-50% of allergy referrals to the selected hospital-based service could be dealt with in a GPwSI clinic, thereby diversifying the patient pathway, allowing specialist services to focus on more complex cases and reducing the waiting time for first

appointments. These two and other problems have motivated the need to redesign the model of provisioning care allergy (Warner *et al.*, 2006).

Based on these circumstances, health information exchange solutions have been touted to be helpful to address the issue of inter-organizational health information exchange (HIE) (Walker *et al.*, 2005). The literature is rich with studies that evaluate the impact of HIE in healthcare in general. Walker et al. (2005) created an HIE taxonomy and found that a fully standardized HIE that also takes interoperability into consideration may yield a net value of $77.8 billion per year upon the full implementation. Similarly, Bailey *et al.* (2013) found that HIE was associated with 64% lower odds of repeated diagnostic imaging in an emergency evaluation of back pain (p.16), and another study found that HIE access was associated with an annual cost savings of $1.9 million, and hospital readmission reductions accounted for 97.6% of the total cost reduction for the population of the study (Frisse *et al.*, 2012). Hence, this study is an attempt to leverage the possibilities of HIE to facilitate better flows of knowledge and information within and across allergy care providers and their patients.

2 Research Aim and Question

This study addresses a key practical need by designing a comprehensive solution that utilizes information and communication technology (ICT) to facilitate knowledge flow among allergy care providers and also between patients and their healthcare providers as explained below.

Hence, this study answers the following research question:

- *How can information and communication technology be designed to facilitate superior knowledge flow in the context of allergy care delivery?*

In answering this question, this study also identifies the challenges and opportunities of information and communication technology in managing allergy care delivery. Hence, the following sub-questions are also addressed:

- *What are the technical challenges face designing information systems to facilitate knowledge flow in the context of allergy care delivery?*

- *What are the enablers and barriers to design such information systems?*

To answer these questions, this study uses the approach of Knowledge Management as a theoretical underpinning.

3 The Approach of Knowledge Management

Given the increased rates of allergy diagnoses in developed countries, this study attempts to solve a current business challenge by increasing the efficiency and efficacy of the core business processes for allergy care providers. The Theory of Knowledge Management (KM) is deemed appropriate to ground this study (Holsapple, 2013; Power, Sharda, & Burstein, 2015; Wang, Noe, & Wang, 2014; Wickramasinghe, Bali, Lehaney, Schaffer, & Gibbons, 2009).

Knowledge management is an emerging management approach that aims at responding to the increasing need to better management of the ever increasing data stored in databases or even information that is being exchanged throughout different and complex networks (Geisler & Wickramasinghe, 2009). The literature shows a number of definitions of knowledge management. For example, Lee (2001) looks at knowledge management as a disciplines that promotes an integrated approach to identifying, managing, and sharing all of an enterprise's information needs. These information assets may include databases, documents, policies, and procedures as well as previously

unarticulated expertise and experience resident in individual workers (Geisler & Wickramasinghe, 2009). Another perspective is also centred on collecting data and transferring these data from raw materials into information elements, which in turn are assembled and organized into context –relevant structures that represent knowledge (Saint-Onge, 1996). Another interesting aspect on defining knowledge management is centred on enabling individuals in an organization to collectively acquire, share, and leverage knowledge to achieve business objectives (Duffy, 2001; Geisler & Wickramasinghe, 2005).

The tools, techniques, and tactics of knowledge management approach are increasingly being used and recognized by organizations (Geisler & Wickramasinghe, 2009; Wickramasinghe et al., 2009). The primary drivers for knowledge management in the last decades have been: 1) the global trend to invest in information and communication technology since late 1980s, and 2) the dilemma of lack of tools that domesticate the expertise within the organizations when senior executives leave their organizations (Holsapple, 2013; Wickramasinghe et al., 2009).

Knowledge management is not limited to the context within organizations, but it also covers the inter-organizational activities pertaining to knowledge flow, transfer, and management (Agrawal, 2001; Wang et al., 2014). in their review of the factors affect knowledge flow and sharing between different unities (organizations or individuals), Battistella, De Toni, and Pillon (2015) found that trust, intensity of the connections, and they added the distances that exists between parties, in particular the organizational distance, the physical distance, the distance of the knowledge base, the cultural distance and the normative play key roles in determining the success of knowledge management practices both inter-personally and inter-organizationally.

Even though knowledge management has been used to highlight the inter-organizational knowledge flow, examining this concept in healthcare is still developing in the literature (Holsapple, 2013; Power et al., 2015; Wang et al., 2014; Wickramasinghe et al., 2009). This research is a contribution to this effort.

3.1   Knowledge Management for Healthcare

The allure of knowledge management to control and facilitate knowledge transfer and flow has been appealing for the healthcare context, and it is becoming an established discipline with many applications and techniques (El Morr & Subercaze, 2010). It is especially useful given the nature of healthcare, as a data and an information-intensive industry (Wickramasinghe & Schaffer, 2010).

Further, with the ever increasing volume of data being produced daily in the electronic medical records (EMR) and clinical databases, knowledge management approaches provide a tools-rich platform to perform pattern-identification tasks, such as detecting associations between certain risk factors and outcomes, ascertaining trends in healthcare utilization, or discovering new models of disease in populations (Holmes *et al.*, 2002).

Today the literature has a plethora of studies that utilize the principles of knowledge management in the context of healthcare, such as clinical decision making (Balas *et al.*, 2004; Lobach *et al.*, 2012), knowledge translation (Straus, Tetroe, & Graham, 2013) and flow (Lin, Wu, & Yen, 2012), and mobilization of knowledge (Davies, POWELL, & NUTLEY, 2016).

In their comprehensive assessment of applying knowledge management in the healthcare industry, Wickramasinghe et al. noted that the gap between data collection and data comprehension and analysis is becoming more problematic, given the increased volume and complexity of clinical data, which, in on one or other, reflects the complexity of the healthcare itself (Wickramasinghe et al., 2009).

3.2 The Application of Knowledge Management on this Study

Utilizing the tools, tactics, and techniques that knowledge management offers is deemed appropriate for this research for the following reasons: First, the designed data base is expected to produce high volumes of data on different types of allergy in different age groups. Not only is the volume demanding, but also the complexity of the produced data is an issue. Those two factors combined, make the use of knowledge management prudent to maximize the benefit of using the designed database. Second, knowledge management will help bridge the gap between data collection as a routine procedure and data comprehension and analysis as an innovative and iterative process. This is highly important based on the explanation aforementioned.

Third, it will help clinicians to better understand their patients' data with less effort and time, which, in turn, increases the efficiency and efficacy of their daily operations.

Fourth, the aim of this study is to create a reliable and exchangeable knowledge among different allergy treatment providers, rather than merely creating the database. This is the core interest of knowledge management approach, by moving from raw knowledge (data), which is much context-dependent, to knowledge and then wisdom, which are much more context-independent (Wickramasinghe et al., 2009).

4 The Proposed System

The proposed solution is a web portal and a mobile App that utilize a comprehensive database at the back end as Figure 1 illustrates.

The proposed system addresses the need for a timely access to latest information of allergy patients irrespective of their care providers. This system will be designed to do the following:

1. Enabling allergy care providers and receivers to access accurate real time and digitized data on their patients' care plans, treatments, and progress.

2. Raising the awareness of allergy care by providing educational materials on allergy and its needed treatments.

3. Enhancing the knowledge flow between patients and their care providers by including the system smart alerts and notifications on needed follow ups.
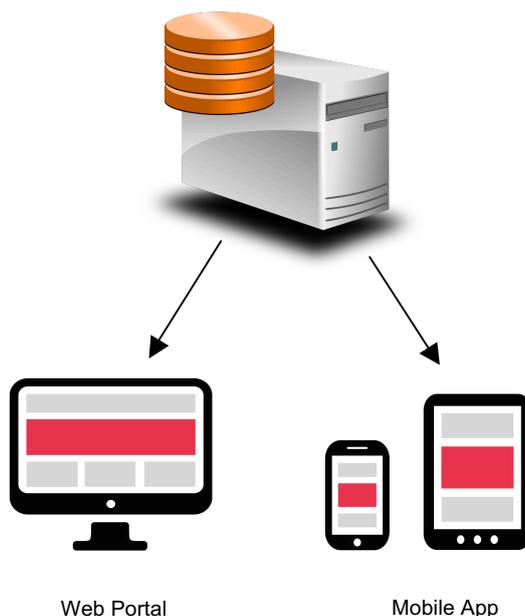

Web Portal   Mobile App

Figure 1 The generic design of the proposed solution.

The system will enable two way communications between allergy patients and their care providers, so patients will be able to ask their health professionals questions on their care needs and allergy management plans.

Building the system has two phases: first building the prototype by using MySQL, PHP JavaScript. This includes building the back-bone database and testing it against the design requirements. The design requirements are determined by discussions with allergy care providers at the selected case as the next section will show. The next step is to test the designed system and how it fits the design requirements, and the purpose it addresses, i.e. facilitating superior knowledge flow in the context of allergy care delivery.

Patients' data will be secured using recommended protocols by industry partners. During the prototype phase, the researchers are using a dummy data set.

5 Methodology and Research Design

This study adopts single case study (Yin, 2003) and Design Science Research Methodology (DSRM) (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). Case study research has proven to be *'well-suited to capturing the knowledge of practitioners and developing theories from it'* (Benbasat, Goldstein, & Mead, 1987, p. 370). Also, the main focus of this study is to design an IS/IT that facilitates knowledge transfer and sharing among different allergy care providers. Hence, the use of (DSRM is deemed appropriate for this study (Peffers et al., 2007). DSRM is a process model that helps carry out researchers on designing artifacts to serve in the area of IS. This methodology is widely used quantitatively to improve existing solutions, or qualitatively to create new solutions to unsolved problems (Gregor & Hevner, 2013). In this research, this methodology is used qualitatively given the nature of this study as it aims at creating a novel solution for an existing problem (von Alan, March, Park, & Ram, 2004), namely the fragmented chain of knowledge sharing among allergy care providers. Hevner (2007) conceptualizes DSRM in three cycles, namely Relevance Cycle, Rigor Cycle, and Design Cycle. According to this framing, design science research starts with the relevance cycle whose role in centred on providing the requirements for the research by identifying the opportunity/ problem to be addressed. The rigor cycle is centred on providing past knowledge to the research project to insure its innovation (p.90), and the design cycle concentrates on building the artifacts and processes, and evaluating them (Hevner, 2007). As this research is in its initial stages, the relevance and design cycles are relevant to this study at this stage. Upon the building of the solution, the rigor cycle will be addressed. Table 1 summarizes how the relevance and design cycles are mapped to this study.

DSRM Activity	Activity description	Application on this study
Problem identification and motivation	Defining the specific research problem and justifying the value of a solution based on knowledge of the state of the problem.	With the increasing rates of food allergy diagnosis (Osborne et al., 2011), and the stretches allergy care is experiencing (Bell & Busse, 2013), the lack of a computerised information and communication system to support knowledge flow among allergy care providers is clear, and the need to address this gap is established.

Definition of objectives of the solution	The objectives can be qualitative or quantitative i.e. create or improve an artifact respectively based on knowledge of the state of the problem and current solutions, if any, and their efficacy.	The objective is qualitative, as this research aims to create an artifact to address the fragmented nature of allergy care (Duncavage & Hagaman, 2013). Not only does the designed solution attempts to address the technical, cultural, and principle challenges, but it also explores the role of information and communication technologies in managing knowledge flow among allergy care providers and patients and their communities.
Design and development	Creating the artifact, including the desired functionality and its architecture based of knowledge of theory that can be used to bear in a solution.	The artifact is to be designed to facilitate knowledge sharing and flow among different allergy care providers by having a central database that can be accessed by care providers and receivers to have instant access to latest results and treatment plans. To do so, the design phase is conducted collaboratively between the researchers and the clinicians at the selected case.
Demonstration	Demonstrate the use of the artifact to solve the problem.	The artifact is to be tested and tried, and then in-depth analysis will be performed to measure the extent to which the proposed system helps solve the problem.
Evaluation	Iterate back to better design the artifact if needed.	As needed, iteration back will take place, based on in-depth analyses to identify rooms of improvement
Communication	Publish and let the value of the solution talk about itself.	Conference publications and other presentation activities to develop the project further and share the findings with interested stakeholders.

Table 1 Mapping DSRM (Peffers et al., 2007) to the proposed system

5.1 Settings and Participants:

The design phase of this study was guided by discussions with clinicians in the selected case. The selected case is a pediatric allergy clinic in Melbourne, Australia. The output of these discussions was a set of design requirements and recommendations. Randomly selected de-identified existing patients' records from this clinic will be used to help establish the main structure of the proposed system. Upon completing the design phase, the prototype will be tested at the selected case.

5.2   Data Collection Plan and Techniques

Through the initial discussions with the clinicians at the selected case we have established that the need for an information system that enables knowledge sharing and flow among different allergy care providers and their patients is greatly needed. Once the prototype is designed, a focus group will target up to 5 clinicians who work for the selected clinic. They are recruited based on their daily interaction with patients and their records. Those who participate in the focus group will be requested to complete a follow up survey for data triangulation. Patients who visit the clinic during the 3 month trial period will be asked if they wish to participate in the study (again subscribing to all ethical requirements) and if so will then be randomly selected into the respective arms of the two arm trial (as described above). All patients will receive equal care and attention irrespective of their participation or not in the study.

6   Results to Date and Discussion

Currently, the initial prototype has been designed including the structure of the backbone database, and the web portal, and testing them both by using a dummy data set. The initial results show that the

database is capable to be the back-bone supporting system. The next step is to use real de-identified data to test its scalability in real time. The majority of design requirements were met during the design, plus subscribing to the DSRM approach. This also will be confirmed during the second phase of the study.

This research has a number of implications for both theory and practice. From theoretical perspective, this research addresses an urgent need to address the inter-organisational knowledge flow and the potential role of information technology and communication in this regard, specifically in a healthcare context. It also aims at highlighting the technical challenges that may affect the use of such systems and limit their usability. In addition, a further theoretical aspect is the application of DSRM in a healthcare context.

From the perspective of practice we highlight several key aspects as follows:

First, the proposed solution is an attempt to address the three problems facing the current model of allergy care; namely the lack of awareness of allergy care requirements (by enabling educational contents for allergy patients), difficulty accessing specialized allergy care (by increasing the efficiency of care delivery through the use of information technology), as well as the nature of allergy care and the need for higher coordination among different care providers.

Secondly, this solution has the potential to enhance the long term follow up of patients attending for comprehensive food allergy management at healthcare contexts.

Thirdly, this project has great potential to be patented and commercialized again bringing kudos and financial benefits to healthcare contexts.

Fourthly, the outputs of this study are far reaching to patients and their communities in developed countries, particularly in Australia, where allergy rates are among the highest in the world. It is expected that there will be instant and long-term clinical benefits by facilitating proactive and protective allergy care and management practices.

The next step of this research is to examine the usability and fidelity of the proposed system at the selected case. The outputs of this testing will be used to further enhance different design and functionality aspects of the proposed system.

7   Conclusion

The proceeding has served to outline a research in progress study that serves to address a healthcare need drawing upon the tools, techniques, and tactics of knowledge management. Specifically, a knowledge-based ICT solution is designed and developed using a DSRM to address current key issues in the delivery of care for patients suffering from allergies. The developed prototype will now be tested to establish usability, fidelity, and patient-centeredness. In this way, the impact of the proffered system as a decision support tool powered by integrating key aspects of the tools, techniques, and technologies of knowledge management to enable superior value-based care delivery will be identified and realised.

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