Advanced Science and Technology Letters
Vol.40 (Healthcare and Nursing 2013), pp.1-4
http://dx.doi.org/10.14257/astl.2013.40.01

An E-health Infrastructure Design to Support Management of Lifestyle Disease

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Abstract. This paper describes an e-health infrastructure approach that promises improved healthcare service provision through enhanced interaction between citizens and modern government services. The Internet of Things concept suggests an infrastructure for personal health management through intelligent technologies accessible by all citizens. For the illustrative case of diabetes we describe a design artifact and its applicability to lifestyle disease monitoring and advice in Bangladesh, showing its benefits to government and citizens alike. We note its suitability for web-based applications using smart end user devices, including wearable as well as conventional access devices.

Keywords: e-health; Internet of things, diabetes, intelligent systems, UAE, Bangladesh

1 Introduction

Governments have a duty to provide key services, such as healthcare infrastructure, and accessible education and support services around personal health matters. Many regions suffer however, from digital divide, with little access to, for example, relevant or current medical expertise. Lifestyle diseases, such as type II diabetes, present a serious problem for many nations including the UAE and Bangladesh. Despite awareness and education programmes, diabetes prevalence continues to increase.

Today many citizens rely on technology enabled devices for everyday activities. Pervasive telecommunication capacities allow citizens easily to access a variety of services. Increased network capacity also brings increased potential for traditional services provision, (e.g. personal health management). In the ubiquitous “Internet of Things” environment Internet technologies can be used to manage information associated with citizens, and facts, such as location, can be recorded unobtrusively, and yield data of non-immediate value e.g. in epidemiology. Using an illustrative case of managing diabetes in Bangladesh, our design employs intelligent capabilities for advice and monitoring services using information from the Internet of Things.

ISSN: 2287-1233 ASTL
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Our study recognises the requirement for a comprehensive e-health service system that assumes the provision of an Internet of Things, (readily achievable in many locations), scalable to a national infrastructure. We outline a general process of government healthcare service delivery, with interplaying roles defined for three non-technical end-user groups (government managers, healthcare workers and citizens). We apply design science using a paradigm in which the end user can supply relevant choices in their context and an intelligent solution model based on a tailorable design theory [3]. Decision makers both at agency and end user levels require benefit from access to the system: it will facilitate government monitoring of specific patient groups and advise diabetic patients on home-based healthcare decision making. The paper is organized as follows. The next section describes the problem area and technological background and then section 3 presents the artifact design together with the general infrastructure for e-health services using this solution.

2 Technological and Problem Background

In Bangladesh access to healthcare services is shockingly poor, with few physicians per capita, only 58% of whom receive basic expertise about diabetes during their medical training, and only 24% are taught about diabetes [4]. When diabetic Bangladeshis become ill, they go to local government clinics but may not receive the needed care information e.g. on food, nutrition and lifestyle, often resulting in death. The government has made healthcare a national priority, but faces enormous and complex issues of administration to deliver healthcare for particular patient groups. In the UAE 31% of deaths are due to diabetes and treatment costs are 40% of the healthcare budget, 1.8% of GDP (Booz Allen, 2012). Traditional diabetes management has shown disappointing results, attributed partially to “insufficient communication between patients and care providers (and) an absence of reasonable and powerful decision support systems to transfer existing knowledge and experience” [6]. In a patient-centric approach, a localised monitoring and advisory system is required, provided the data to inform the personal decision support is available. Safe, affordable healthcare depends on collaboration and use of supporting technologies, but, with limited resources, also on achieving citizens‘ engagement.

Capturing requirements for e-health infrastructure is, however, traditionally problematic. The tension between standardisation (reusable, globally controlled) and flexibility (local fit) implies design attention must be paid to the interplay of infrastructure components. A component architecture approach allows non-technical users to select and apply settings, functions and parameters within a larger system that fits their use context. This means relevant modifications, applicability and updates do not depend on being anticipated by the original designer. Instead a design environment infrastructure allows specific designs to be developed in use.

Combining ambient intelligence and autonomous control the Internet of Things concept assumes wide-spread smart device use and Internet access. Bangladesh has a considerable (68%) population of mobile phones users and tagging is also relatively affordable and easy. The Internet of Things can become a non-deterministic and open network providing an intelligent and adaptable infrastructure for government services

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that fits well with a general component based architecture of user-tailorable systems. While large data sources can be intelligently analysed to identify patterns and trends, application relevant parameterising, augmented with other, non-represented contextual knowledge from the user ensures decisions are not purely determined by a limited dataset or a fixed problem conceptualisation.

The capacity to collect and analyze the digital traces left when people interact with everyday smart things means details, for example of diet, weight and heart rate elevation (as a proxy for exercise) are personally identifiable data and readily gathered within daily life activities, including from wearable devices. Drawing from this conceptual idea, this project extends the above views towards the operational realm by considering e-health service development where a user's own personalised advisory service in their specific situation is enabled throughout identifiable interactions or participation processes.

3 Study methods and solution artifact

Our artefact design has modules addressing both monitoring and advisory provisions. The user-tailored approach to decision support requires an infrastructure to host flexible, locally generated designs. Design science involves a rigorous, iterative process that includes evaluations with users and communication of the solution to both operational and management users, including subsequent modifications by target decision makers in its context of use [7]. Guided by design science principles we employ case-based reasoning for the monitoring module to inform the healthcare professional's decision making but rule-based reasoning for advisory prescription to patients. These functionalities are prototyped prior to evaluation with potential users.

Different classes of user are defined by specific industry requirements and by their relevant responsibility. Patients form one target stakeholder group, with their specialised healthcare professional forming the second. A third (higher-level) group has the authority to assign and monitor the interactions between these, retaining options to aggregate, analyse and reconfigure the system design, or deploy the artifact for other lifestyle diseases. New knowledge, (e.g. legal or medical), is made available to other users from this layer, ensuring access to the latest treatments and information.

The design artefact therefore proposes three layers of functional processes for providing these three distinct groups of users with decision support. Although specialised healthcare professionals and their managers will build scientifically informed domain models, the choice and focus of these is a policy matter, whilst their use and customization is an end-user matter. On initial access to the web based system, the citizen will obtain screens and customisable options that will help calculate diabetic risk. When they subsequently upload their data, which can be done wirelessly and unobtrusively, it will be automatically stored within the database associated with the individual's information. Figure 1 shows the advisory module of the system. Once registered and a monitoring programme is being followed, relevant data can be updated and advice adjusted.

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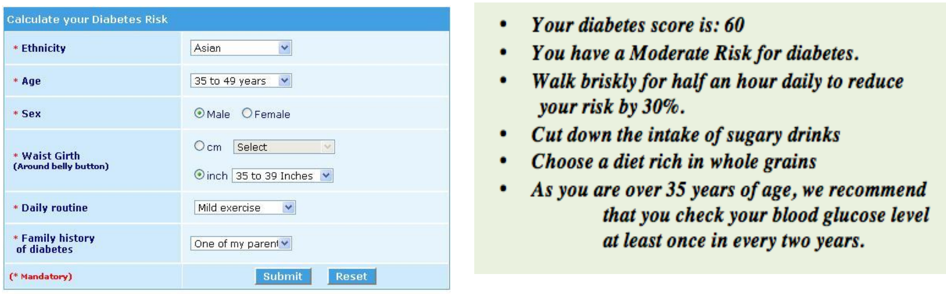

Fig. 1. Advisory module of the system showing input parameters and example report

Our innovative design creates a new infrastructure where standardization is assured at higher levels but tailored decision support based on current knowledge is flexibly provided. Although design is complete, it is yet to be evaluated with stakeholders. Initial preparations for this are currently in process within Bangladesh and the UAE.

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