User profiles and personas in the design and development of consumer health technologies

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ABSTRACT

Background: "The graying of the globe" has resulted in exponential rise in health care expenses, over-worked health care professionals and a growing patient base suffering from multiple chronic diseases, one of which is diabetes. Consumer health technologies (CHT) are considered important catalysts for empowering health care consumers to take a proactive role in managing their health and related costs. Adoption rate and usability of such devices among the aging is far from being satisfactory. Past studies noted the motivation for adoption by the aging is dependent on the suitability/relevance, perceived usability and anticipated benefits associated with usage of technological innovation. Traditional information technology (IT) development adopts a systematic approach without necessarily using a specific user model that personalizes the system to the aging user groups. The aging patient population has unique needs arising from progressive deterioration in both physiological and psychological abilities. These needs are often ignored in the design, development, trial and adoption of consumer health products resulting in low adoption and usage.

Objectives: The main objective of this research is to investigate the user-centered design (UCD), specifically user profiles and personas, as methodological tools to inform the design and development of CHT devices for an aging population. The adoption of user profile and persona has not received much attention in health care informatics research and, in particular, research involving CHT. Our work begins to fill this void in three ways. We (1) illuminate the process of developing CHT user profiles and personas for a Chinese elder population with a demanding health care needs, i.e., self-management of chronic diabetes, with the hope that the resulting profiles and personas may be used as foundational material for informing the design, development and evaluation of CHT in other similar contexts; (2) call attention to how to further enhance and complement traditional user profile and persona techniques for CHT design by integrating cognitive structures and present behavior that drive

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health care thinking, future behavior and demand; (3) show how the profiles and personas can be used to inform requirements, design and implementation decisions for a technology aimed at facilitating CHT adoption and diffusion for the elderly.

Methodology: To exemplify process and application, we use an action-research methodology, where user profiles and personas of an aging patient population were developed. The resultant profiles and personas were leveraged to improve the design, development and implementation plans of a smart phone application to assist chronically ill aging Chinese diabetic population capable of disease self-management.

Results: The results from the study show that user profile and persona can be a valuable methodological approach in capturing the conceptual model of the aging and informing the design and development decisions of CHT. The demonstration of techniques used in this study can serve as a guideline to CHT developers in bringing conceptual user modeling into the design of software interfaces targeted for users with specific health care needs. Specifically, the study provides guidance on the creation and use of profiles and personas to tap into the conceptual models of the targeted elderly population reflecting their preferences, capabilities and attitudes towards using technology in self-management care in general and the smart phone diabetes management application in particular. Insight into the mental model of the aging group has been shown to inform later stages of UCD development (e.g., the creation of prototypes and usability testing) as well as implementation and adoption strategies. The World Health Organization (WHO) predicts that by 2025, 80% of all new cases of diabetes are expected to appear in the developing countries. In fact, the number of diabetic patients in China is estimated to rise to 42.3 million in 2030 from 20.8 million in 2000. Thus, we investigate the Chinese aging population in order to demonstrate the process of developing and using user profile and persona. We hope that the resultant conceptual model of the Chinese aging diabetic population can be used in future research to guide CHT designers interested in designing health care devices for this vulnerable user group.

1. Introduction

In the wake of the 21st century, health care systems around the globe are faced with exponential rise in expenses, heavy utilization of services and limited financial as well as human resources [see [1] for an example of when this is not the case]. Another trend observed parallel to the rising health care costs is the "graying of the globe." The worldwide population of adults over 65 years of age is on the rise and expected to reach 761 million by 2025 [2]. Several studies in the past have noted the prevalence of multiple chronic diseases and co-morbidities in the aged population [1]. In the US, high-risk aged patients account for approximately 78% of all health care spending—well over a trillion dollars per year and/or over two-thirds of Medicare's annual spending [3]. A critical inference drawn from epidemiological data is that preventing occurrences of acute episodes and managing health care needs of the aging patient population holds the key to providing quality health care and reducing unnecessary health care expenses. In order to reduce preventable acute episodes from occurring it is critical to focus on preclusion of complications, proactive management of illnesses and timely detection of anomalies such that aging patients can actively participate in the management of their health care and lead a normal, healthy lifestyle outside of the hospitals [1,4].

Consumer health technologies (CHT) have the potential of empowering aging consumers to take a proactive role in managing their health and related costs. In the recent past, there has been an influx of technological tools and devices that attempt to educate and engage patients in their health care process. However, successful usage and adoption of these technological devices is fairly poor in the *aging patients*—which accounts for a large proportion of customer base for innovative health care devices.

Aging involves progressive deterioration in both physiological and psychological abilities, creating special needs among the aging population segment. In addition to age-related issues, a large proportion of the aging populace suffers from multiple chronic diseases and co-morbidities [1]. These needs are often ignored in the design, development, trial and adoption of consumer health products resulting in low adoption and usage among the aging adults [5]. This population segment not only requires more time, practice and technical assistance to acquire computer skills, they are also more error-prone than the younger generation as a result of detriments in visual, perceptual, psychomotor and cognitive abilities [6,7].

Information technology (IT) and age-related challenges in the aging population can, in part, be compensated by designing senior-friendly applications. In order to design and develop health care products that meet the unique requirements of the aging patient segment there exists the need to (1) analyze/understand the challenges and requirements of the elders; (2) study and implement methods of making information communication technologies (ICT) accessible to elder user group; (3) model and integrate preferences of the elder population segment into health technologies; and (4) evaluate outcomes. Involvement of the elder population in each

of these four phases and compensating for age-related differences by developing senior-friendly hardware and software interfaces can increase the acceptance, usefulness, information quality and utilization of IT applications [8,9].

A characteristic of the traditional IT design methodology is the limitation of user participation to a consultative role, where the bulk of the design decisions are made by the IT designers and/or developers who tend to be younger adults [10,11]. Systems designers and developers can potentially "ground" themselves (described by psychologists as "a human natural behavior of finding a known reference point in a foreign information space,") and run the risk of designing an interface for themselves, i.e., younger adults, rather than the user groups—older adults [7]. This dependency on the mental model of the younger adults in designing/developing applications for older adults results in sub-optimal applications with low usage/adoption rate by the aging patient population. Additionally, it has been found that the younger adults tend to under estimate and under appreciate the potential challenges of the aged. Consequently, the design and implementation of computer applications are often unsuitable and irrelevant for the aging populace [6]. Furthermore, the aging populace suffering from multiple chronic diseases have additional needs and challenges which might not be understood by the design team consisting predominantly of younger adults with little or no exposure to chronic illnesses. Past studies have noted that the motivation for adoption by the aged population is largely dependent on the suitability and relevance, perceived usability and anticipated benefits associated with usage of a technological innovation [5–8]. Roberts et al. [9] indicated that usability of applications depend 10% on the visual aspect of the product (the "look"), 30% on the aspect of user interaction with the product (the "feel") and an enormous 60% on the applications' aspects meeting/exceeding the user's mental model. In order to develop applications that are functional and usable, it is imperative to reach the level of personal connection that captures the essence and issues of aged patient groups by creating a reasonable approximation of their conceptual models.

Traditional IT development adopts a systematic approach without necessarily using a specific user model that personalizes the system to one or more user groups. Research and practice of end-user computing in IT development have emphasized the importance of end-user participation and involvement [10], though not much attention is given to formalized conceptual models of users as a design methodology. Furthermore, utilizing formalized conceptual models of the aged populace as a design methodology has received little attention in past research. In this study, we seek to investigate the utility of user profile and persona as a methodological tool to develop an in-depth understanding of the limitations and possibilities of the aged patient populace. The resultant conceptual model of the aged patients can be leveraged to inform design and development decisions of CHT.

User-centered design (UCD) is a modern human-computer interaction (HCI) design philosophy. It is a multi-stage, problem-solving process in which the needs, desires and limitations of users are inquired and analyzed. Assumptions of user behavior are transferred into prototypes that can then be tested. UCD techniques such as user profile and user persona are structured ways of typifying a group of users in text and pictorial formats (i.e., conceptually modeling the end users). User profiles and personas go well beyond demographics, as they attempt to "capture" the user's mental model comprising of their expectations, prior experience and anticipated behavior. They attempt to understand intended CHT users—not just their demographics, but also how they think, feel and behave. This is critical to successful consumer health application adoption. Profiles and personas can either be used as part of an entire UCD methodology or they can be used to enhance existing methodology by introducing user-centered thinking into the design and development process [11].

Despite potential benefits, the use of user profiles and personas has not received considerable attention in health care informatics research in general and development of CHT in particular. Also, UCD user profile and user personas have received little or no attention as a methodology to inform the design and development of applications in the context of aged patients despite several studies' finding that assistive applications for the aged population segment should consider user-specific context, physical/cognitive impairments, differential motivational factors and perceptions of self-efficacy [12,13]. Given this background, the specific research questions addressed in the current study are:

1. How can the existing UCD tools, user profile and persona, be incorporated/enhanced in the context of capturing the conceptual model of health care technology users?
2. How can the conceptual model of the aged population segment be captured in user profile and user persona?
3. How can the captured conceptual model be utilized to facilitate system analysis, design, development and implementation of CHT?

To address these research questions, we use an action-research methodology to exemplify the creation process for user profiles and personas and help illuminate how these tools may be used in the context of UCD, particularly for CHT for the elderly. The action research context is a field study involving the aged Chinese diabetic population demonstrating the value and application of two UCD tools – user profiles and personas – as a part of the methodology to develop an application to assist the target users in self-management of their chronic condition. Diabetes is one of the primary causes of premature death and adult disability worldwide; the death rates are predicted to rise by 20% over the next decade [14]. The total number of people with diabetes in the world is projected to grow from 171 million in 2000 to 366 million in 2030 [15]. World Health Organization (WHO) predicts that by 2025, 80% of all new cases of diabetes will appear in the developing countries. The prevalence of diabetes in the Chinese population increases with age: 4–5% in adults of working age, 10% in subjects over the age of 60 and 17% in those over 75 [16]. Currently, there are 130 million Chinese over the age of 60 and by 2030, the number is estimated to reach 336 million [17]. The rise in the number of diabetic patients in China from 20.8 million in 2000 to an estimated 42.3 million in 2030 is deemed to have a considerable impact on the global burden of diabetes [18].

This study demonstrates (a) how to effectively involve an aged patient population in the design and development of

CHT; (b) how to develop user profiles and personas of an aged patient population; and (c) the utility of user profiles and personas as a methodological tool in not only capturing the mental model of the aged Chinese diabetic patients but also in assisting the development team by informing the design and development decisions of CHT. This level of understanding/communication between the user group and the development team holds the key to synergetic design, development, adoption and meaningful usage of CHT by the intended users.

The next section provides the background knowledge in the context of the current study. Section 3 provides details of the research methodology focusing on our action research context. Section 4 presents the results of the field study and discussion of the implications of the resulting data. Section 5 provides a summary of conclusions that highlights insights for further application of the process described and resulting artifacts in future practice and research.

2. Background

This study is motivated in the current health care crisis characterized by an exponential rise in elderly patients suffering from co-morbidities coupled with a parallel rise in health care costs. CHT have been widely recognized as a means of empowering aged patients and promoting proactive management of diseases [8]. Despite the potential benefits, CHT have achieved mixed success with respect to usability and consumer satisfaction. One study reported on the non-effectiveness of 72 consumer health applications in motivating a change towards positive health care behaviors [19]. Disappointing results are attributed to limited, if any, persuasive design considerations of the targeted user group that motivated or made it user friendly for adoption.

Persuasion requires an understanding of the mental model, in this case of aged patients and developing applications that mirror their physiological/psychological needs and requirements. Multiple studies have noted that aging has a detrimental effect on visual, perceptual, psychomotor and cognitive abilities [20–23]. Consequently older adults are posed with unique challenges such as: limited motor skills and range of motion affecting use of computer devices, impaired eyesight affecting interaction with interfaces featuring small font size, reduced speed, memory and spatial ability affecting the learning of software applications [20,21,24]. A study by Zimmer and Chappell [25] suggested that the elderly are more receptive towards using an assistive technology that considers the physical and cognitive needs of the aged segment. Prior studies have shown that the attitudes of elderly chronic patients were generally positive in the context of monitoring and assistive technologies supporting aged in place [26–29]. White and Weatherall [30] reported that aged patients have a cyclical relationship with the perceived usefulness of technology and their direct involvement in usage of technology. According to Magnusson et al. [31], the user-friendliness of technology in self-care is critical to adoption and usage. Anticipated benefits from using a technology [32], perceived usefulness, perceived ease of use and social norms have been found to be important predictors of usage and adoption of technology by the older

adults [5]. Given the unique challenges associated with the usage of technology by the aged patient populace it is imperative to design and develop applications that compensate these limitations. However, there is little understanding on how to effectively involve the aged patient populace in the design and development of health products. The process of capturing the mental model of the aged patients such that it can be used to inform the design decision of health products is yet not well articulated in research and practice.

2.1. Models used in developing systems

Models have been widely used in systems analysis and design process. Some ubiquitous forms of modeling, such as the various uniform modeling language (UML) diagrams, are utilized extensively in the development of information systems. Studies have found these models helpful in enabling developers and system stakeholders to visualize data processing and interaction between the system and outside entities (e.g., [28,29]). While these models semantically represent the structure and behavior of the system, they do not embody the users' conceptual model.

2.1.1. Traditional IT design and development
Traditional IT development adopts a systematic approach for conducting analysis, design and testing, without necessarily using a specific user model. Users are important sources of design information and may be partners in the design process to ensure technology to be useful, usable, elegant and desirable [30]. A characteristic of the traditional IT design methodology is that it typically limits user participation to a consultative role, where the bulk of the design decisions are made by the IT designers and/or developers [31]. Requirements gathering have been particularly problematic in traditional systems analysis and design methodologies, as it does not seem to reach the level of personal connection needed to capture the essence of user groups. Past studies indicate that a lack of shared understanding of and communications with end user groups are among the major problems of the requirements gathering process (e.g., [32,33]). Shared understanding refers to the communication among multiple individuals on the same topic in a manner such that all individuals leave the communication session with the same understanding of the topic under discussion. Freeman emphasized the importance of shared understanding among users and systems analysts (coming from distinct backgrounds, experiences, perceptions and styles) towards designing and developing usable applications [34].

2.1.2. UCD tools—user profile and persona
Since the foundation of UCD is on inquiring and analyzing the needs, desires and limitations of the end users and transferring the assumptions of the user behavior into the prototypes, it is especially useful in addressing the concerns of traditional systems analysis and design [35,36]. Basic tenets of the UCD process include: (1) placing the user at the center of the design, (2) focusing early on users and their tasks, (3) measuring usability empirically and (4) designing iteratively, whereby a product is designed, evaluated and modified with real users repeatedly in quick iterations.

Understanding users' conceptual model towards a specific context is a precursor to developing a system with appropriate requirements, usefulness, information quality and interface quality; all of which are paramount to the success of CHT. A mental model is an individualized conception of how the world works and the way it is structured. In contrast, a conceptual model is a synergized representation: designers and developers tap into users' mental models (i.e., systems analysis) to create a user conceptual model; then, they use the user conceptual model to create an application or provide a solution; finally, the conceptual model is surfaced to users via the interface (i.e., system design) [36]. Leveraging users' conceptual models is integral to many aspects of developing a persuasive design targeted to motivating change, promoting compliance and/or recognizing opportune moments for technology intervention.

User profile and persona are conceptual models of targeted user group(s) that can serve to promote the shared understanding that underpins UCD throughout the process of analysis, design, development and implementation. Past studies have argued that conceptualizations of users' mental models could be used effectively and successfully to create a shared understanding among multiple individuals over a single topic or domain and thus a better system [34]. As aggregated conceptual models, user profiles and personas should facilitate shared understanding in project communications by creating a "mutually understood context."

A user profile is a dynamic repository used to categorize, characterize and prioritize a system's target user groups, sub user groups and uses (applications) of the system. User profiles are often represented as a table of descriptors, e.g., "male, average age 45–50, intermediate-level computer user, etc." User profiles help the crafters of the systems focus on the users by serving many functions, for example, the basis for identifying user tasks and capabilities, which impact requirements and conceptual models. A persona is a fictional and super-typical characterization of a user created to represent a user group. It is a profile that comes to life, e.g., "Marty is a school teacher who uses his home computer to shop. His two kids fight over internet use, etc." The development team creates this super-typical user as a symbiosis of the real users they have observed and interviewed for each significant user group. Personas often include a name, photo, likes and dislikes, habits, background and expectations and other information needed to provide dimension. Most importantly, they explicitly highlight key goals for the user. The primary advantage of the multi-dimensional persona is to enable the development team to identify with target users, communicate effectively with them and to be a constant reminder to integrate user needs into the system. In a study of how to design effective tools to aid software developers, personas were found to be a helpful technique, with many resulting benefits, in closing the gap between a software engineering tool's functionalities and the intended users' tasks and experiences [37].

With regard to the design and development process itself, these tools have been used:

- For surrogate user testing.
- To help advocate for the users.
- To communicate user needs.
- To evaluate new features.
- To help make design decisions.
- To help weigh business decisions.
- For task analysis and use cases.
- For customer service scripts [38].

Thus, these tools can conceivably be used to facilitate analysis, design, implementation and diffusion, planning and processes for CHTs. However, user profiles and personas usage is not extensively documented in the literature, particularly with CHT or with an aged population. One exception is user modeling via persona development of aged patients in the context of ambient technologies by Casas et al. [39]. Scenario-based drama, another UCD technique, has also been utilized as a means to obtain elderly user requirements with respect to design and development of assistive user technologies [40].

3. Methods

The main objective of this research is to investigate the user-centered design (UCD), specifically user profiles and personas, as methodological tools to inform the design and development of CHT devices for an aging population. We utilize an action-research approach to exemplify the process of developing user profile and persona of aging Chinese diabetic population. The applicability of user profile and persona of the aging Chinese diabetic population in assisting and informing the design, development, and implementation decisions of a smart phone application is also explicated. The results from this study are the artifacts and data that demonstrate that both process and product in the form of the user profiles and personas, as well as insights grounded in this data and supporting research may facilitate application of these processes and tools in other contexts.

3.1. Context of the field study example

An environment with a large and growing aged diabetic population best serves the objectives of this research. Diabetes is increasing significantly throughout the world and the problem is especially severe in China. The world's most populous country is expected to soon become the nation with the largest number of individuals affected with diabetes [34]. This situation is particularly acute for the growing number of elderly Chinese for whom diabetes is a costly, chronic condition and a major cause of disability. Hence, the aged diabetic populace in China serves as an appropriate instantiation context to demonstrate how: (1) the conceptual model of an aged population segment with health care issues can be captured in a user profile and a user persona and (2) the persona and profile can be utilized to facilitate system analysis, design, development and implementation of CHT.

For this paper we use an on-going project involving the design and development of a smart phone application to facilitate self-management to call attention to key areas where the user profiles and personas can be used. The proposed tool, Chinese Aged Diabetic Assistant (CADA—see http://www.cadaproject.com/), will be used as a

Fig. 1 – Multi-phase user-centered design methodology.

self-monitoring tool for things such as the diet and exercise habits of elderly diabetics. The second goal of CADA is to increase the knowledge regarding diabetes and healthy living among the population under investigation. UCD methodology and in particular user profiles and personas, are guiding the design and development of culturally and age appropriate tools for the target population through interactive prototype iterations. Fig. 1 illustrates the UCD methodology used in this multi-phase study that we will elaborate in forthcoming sections of this paper.

3.2.   Methods of data gathering for the field study

There are multiple potential sources of data to support generating user profiles and personas, including survey, dramaturgical reading, ethnography, interview, observation, contextual inquiries and web analytics [e.g., see, 35–37,40,41], with many studies using a multi-method approach. We utilized several methods in our study to enhance research validity and reliability (depicted in Fig. 1). Our multi-phase field study approach included a broad set of data sources (e.g., published literature, archival documents, patients, providers and caregivers) accessed in China between June 2008 and April 2009. A summary of these methods is presented in Table 1, which illustrates that the data collection was iterative and expansive. This multi-method approach provides a deep understanding of the target population-elderly Chinese with diabetes and related subgroups.

Health care is an integration of patient, provider, personal caregivers (e.g., patient's supportive family and friends), tools, and resources. This may be particularly true in the health care of the elderly, who may have increased dependency on others or external tools and resources due to personal limitations and the complexity of one or more health conditions [42]. The methods chosen for this study reflect that multiple

perspectives are necessary to gain in-depth understanding of the target group of elderly users in the context of their usage of the system. Direct observations of interactions among patients, between patients and providers and, to a limited degree, between patients and their personal caregivers allowed us to observe diabetes self-management. Data analysis was on going and each data collection activity utilized data from past activities. Thus, every data collection activity added another layer of data for analysis.

Since patient experience with diabetes management and technology usage may be limited and sporadic thus precluding the development of expertise, we used focus groups to derive depth from a collective patient assessment of diabetes care and self-management [43]. We also found this method particularly conducive to the diabetic elders; the focus group method seemed to provide social enjoyment for participants

Table 1 – Methods used in the field study.
Qualitative methods
Direct observation of Chinese elders in recreation activities (20 h)
Observation and visitation of various hospitals and out-patient clinic facilities which treat Chinese (particularly units most involved with where Chinese elders with diabetes would receive care) (~8 h); observation of diet education and medical encounters with elderly Chinese patients (12 h)
Review of archival material (e.g., patient personal management tracking notes, brochures on diabetes, materials from internal presentation for providers)
Focus groups ($n = 9$) with patients (approximately 6 people per group)
Semi-structured interviews with medical providers that serve elderly diabetics (nurses, physicians, patient educators, $n = 30$)
Informal discussions with providers, patients and personal caregivers after medical encounters

and facilitated the communication process. Participants could identify with each other both from life experience and in their current situation of managing diabetes. This facilitated more open and fluid conversation and enabled prompts and inquiries from other focus group members that used language and tone members could understand.

We conducted nine focus groups with diabetic elderly (55–80 years old) patients in various geographic locations. There was an average of six patients per group. All focus group participants were diagnosed with diabetes and under a doctor's care; all had seen a doctor within 10 weeks prior to the focus group providing a reflective perspective of their managed care experience as well as their self-management situation. Protocol questions centered on patients' ability of self-management, reactions and ideas for assistive smart phone applications constraints and challenges in self-care and technology aptitude.

We also interviewed 21 physicians and 9 nurses from various health facilities. As care managers, medical providers (who will be indirect users of the technology) managed the identification and understanding of diabetes care requirements, application of typical protocols and rectification of compliance issues in ways that may not be readily apparent to patients themselves. Interview questions focused on the care management process, care management resources (such as training materials), patient challenges and patient compliance issues as well as the potential role and acceptance of smart phone applications to augment existing practices. The medical providers also provided insight into particulars in diabetes management with elderly patients.

Over 20 h of field observations of clinical interactions between patients and providers, as well as between patients and designated diabetes educators, was also part of the broader study. Direct observation captured snapshots of what users actually do in context as opposed to just what patient and providers say they do. This provides both a means of triangulation as well as revelation of what might be implicit knowledge or action that participants cannot easily recall. We also witnessed pre- and post-encounter conversations where patients were communicating among themselves and with their caregivers. At times, the pre-and-post exam situation facilitated informal inquiry particularly for learning about the caregivers and their role. Many patients either mentioned or were accompanied by a personal caregiver (often a family member). In fact, some of our elders were accompanied by multiple caregivers. Several of the caregivers were working adults who took time away from work to accompany the elders.

The review of informational diabetes materials and documentation distributed by the organizations provided a better understanding of patient information sources and the perspective of those sources (often age neutral or targeted to a younger target audience) [44].

Most patients did not indicate they used self-management tools. However, a few brought self-created tools to clinical visits and/or the focus group discussions. One notable exception was the detailed graphs prepared by a former engineer. Given these self-created tools existed, this provided some indication that at least some elders would be capable of using self-management tools.

3.3. Data analysis for persona and profile characteristics

Recordings of the focus groups and interviews were transcribed and then translated from Mandarin Chinese into English by bilingual research support staff with medical training, who were familiar with this study. The process was supervised with some review by a bilingual lead investigator in this study as a quality measure.

The translated transcripts of all interviews and focus groups were reviewed and coded independently by two culturally aware lead researchers, who were both involved with data collection. The underlying goal of the coding process was to foster conceptual power, depth and comprehensiveness [45,46] in terms of the prospective users' mental model, their challenges, and possible system requirements or constraints.

Persona templates used in general and technology specific domains were used as an initial coding schema to analyze the data regarding more "traditional" user profile characteristics such as computer skills, educational level and mobile phone ownership [47]. Open coding (see [48] for discussion of open coding) was used to identify key characteristics related to the elders' health such as, self-management practices, attitudes and perceived challenges and well as their general health attitudes. The focus of open coding was to identify themes that could be used as key characteristics to provide a more comprehensive understanding of the conceptual model of those managing a chronic health condition. During the process, the team of two lead researchers collaborated to reach consensus on profile and persona attributes for elderly Chinese diabetics. The team also wrote coding memoranda regarding any insights on how a characteristic might impact system requirements and insights to later stages of the design process and implementation.

Experts recommend consideration of subgroups when differences are important and clearly indicated in the assimilated data [11]. As coding ensued for this study, it seemed that some differences existed among data sources based on the geographic location of patients—urban versus rural. The problem of diabetes is both urban and rural, but differences between the urban and rural problem in China have been noted. Dong et al. [49] found a higher prevalence of type 2 diabetes in Chinese urban versus rural areas (6.9% vs. 5.6%). However, the proportion of undiagnosed diabetes was higher in the poorer rural areas (70.5% rural vs. 58% urban), indicative of the lack of public awareness of diabetes and shortage of rural medical facilities. Factors such as these can have an effect on potential user characteristics and, thus, on system design and diffusion plans.

To further characterize the identified sub groups, we used a form of axial coding. Axial coding facilitates the building of connections among categories and subcategories and serves to deepen the theoretical framework that underpins analyses [50]. Using selective and iterative coding, the research team revisited observation notes, archived data, open-ended survey questions and comments on the surveys to define specific characteristics of the urban and rural subgroups [46]. Profiles were specified. Personas evolved from profiles and revisiting analyzed data. The initial profiles and personas were refined
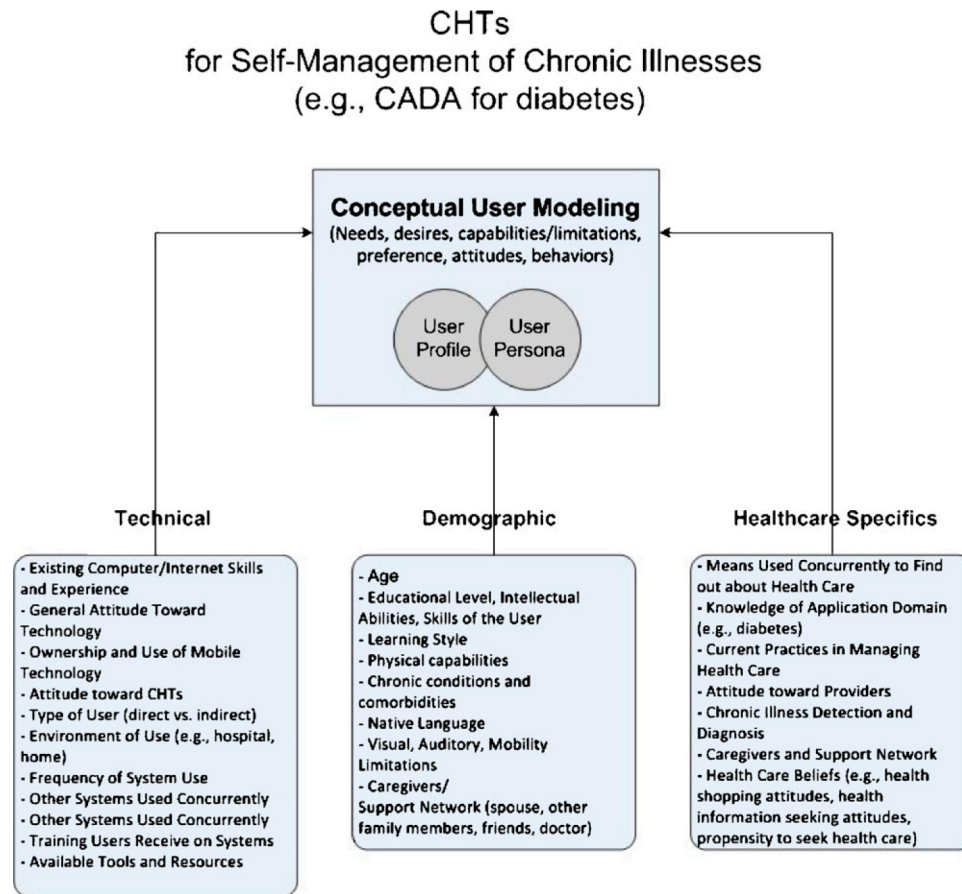
Fig. 2 – Derive conceptual user model using use profile and persona.

as a result of data from observation, document review and informal interviews.

These user profiles and personas were reviewed with the entire research team with minor revision. The team is integrating the tools into the development process (see Fig. 1 and further enumerated in the results section) beginning with a discussion of requirements and features. A few additional profile characteristics were added as the tools became embodied in the development process and various members of the research team wanted to further their understanding of the user conceptual model.

We acknowledge that the described process does take time. However, the benefits derived (e.g., use and user satisfaction), when the personas and profiles are successfully integrated as part of the design process through trained team members and conscientious execution [36], outweigh these costs [40].

4. Discussion of field study results

4.1. Augmenting "Traditional" technology user profile and persona characteristics (R1)

The final schema for coding and identifying user profile and persona attributes of significance to arrive at our conceptual model of CADA users is provided in Fig. 2. The attributes presented in this model are derived from profile and persona

literature, technology usability literature, health care literature and data from this study. Our model demonstrates that technical, demographic and specific heath care characteristics need to be considered to adequately capture the mental model of CHT user(s).

User profiles and personas can be used in various contexts outside of system development, such as product development or marketing plans for a non-technology product [11]. Common core demographic characteristics captured for a user group of interest include: (a) users' prior knowledge and experience (e.g., web site search proficiency), (b) physical characteristics (e.g., mobile or stationery worker), (c) cognitive characteristics (e.g., preferred learning style), (d) social and physical environment (e.g., working in isolation, distraction level) and (e) job, task and requirements (e.g., key tasks for system) [51].

Additional profile attributes that have been shown to be relevant to technology usability in past studies (e.g., [22,24,32,52–55] that we also use in this study include: (1) existing computer skills and experience, (2) educational level/intellectual abilities/skills of the user, (3) general attitude towards technology, (4) ownership and use of mobile technologies, (5) attitudes towards specific technology and (6) learning style.

Though the demographic and technology attributes may provide an adequate representation of considerations for a number of types of technologies, it was evident from our data

Table 2 – User profile rows highlighting contrast among groups.		
Characteristic	"Urban"	"Rural"
Existing computer/internet skills and experience	All over the board from low to high	Non-existence to low
General attitude towards technology	Favorable	From unfavorable to conservative
Ownership and use of mobile technology	Urban ownership of mobile phones is high (1/3 use short messages and PCs; 2/3 carry mobile phone for family to reach them and to make emergency calls)	Ownership of the cell phone is lower in rural areas
Attitude towards CADA	Overall, urban elderly are excited about CADA, if simple and straight forward to use and actually effective in helping their self-management; willing to invest even if its a little bit more expensive	More accepting to CADA if connects to a television set
Means used to find out about diabetes	Alternative resources: Face-to-face with providers Health seminars TV/Radio Print publications (newspaper, magazines, books, brochures) Internet Personal network	Alternative resources: Face-to-face with providers TV/Radio Personal network.
Knowledge of diabetes	All over the board from low to high	Non-existence to low. They tend to have more misconceptions about diabetes than urban patients
Current practices in managing	Urban population seems more likely to test blood glucose level using a glucose meter Most take long walks each day Some participate in outdoor group exercises	Rural population seems more likely to assess blood glucose level using personal feelings and symptoms Some take long walks each day, though others live inactive lifestyles
Attitude towards providers	Good at self-initiating follow-up doctor visits. Go to clinic if have questions	Most trust and listen to doctors completely; generally only see doctors when there are serious complications
Caregivers/support network (spouse, other family members, friends, doctor)	Good family support (e.g., spouses especially wives help monitor diet and exercise); most come to clinics with spouses, children, or other caregivers	Lesser level of support network

analysis that these characteristics alone did not provide a sufficient representation to fully develop a characterization of elderly health care consumers. "Traditional" user profiles and personas do not recognize the psychological/psycho-social forces within people and their impact on health care choices and outcomes. Thus, they fail to recognize research indicating that cognitive and behavioral patterns of perception and action can affect both short-term and long-term success with interventions directed towards managing a disease or adopting wellness [56]. In light of this data, we expand traditional profile and persona attributes of interest to include the following characteristics

- Means used to find out about diseases, e.g., diabetes [57,58]
- Knowledge of specific diseases, e.g., diabetes [59]
- Current disease/diabetes management practices [60]
- Attitude towards providers [60,61]
- Caregivers and support network [62]
- Disease/diabetes detection and diagnosis [57,58]

Appendices A and B provide a representative trail of evidence from the data in support of each of the added characteristics to a given user profile and persona. We also support these additions, where possible, with past literature indicating the relevance of these items to the process of health care management (see comments and cites next to each bulleted

attribute above) as indication that the relevance of the health specific attributes extend beyond the context of this study.

4.2.   Representing the aged diabetic population segment in user profiles and personas (R1)

It is important to be open to the possibilities of significant subgroups in the coding process when differences are observed [11]. In the case of this study, we found that our subjects were not a homogeneous group for system design purposes. The focus groups, interviews and other forms of data collection illuminated common traits as well as contextual differences in perceptions, beliefs and possibilities among the elderly diabetics in urban and rural areas. The design, adoption and impending diffusion of this system is potentially challenged by some belief structures and practices evident in the qualitative data (e.g., "I don't have symptoms, so I don't record the test results.") and supported by others (e.g., "This would be helpful! There are always so many patients waiting. The doc does not have much time to spend on explaining things to me."). It is advisable to recognize and respond to these opportunities and challenges in design and/or development and diffusion plans regarding technology. Excerpts of the user profile highlighting differences from the resulting urban and rural user profiles and personas subgroups are provided in Table 2. We provide a more extensive listing for the urban and
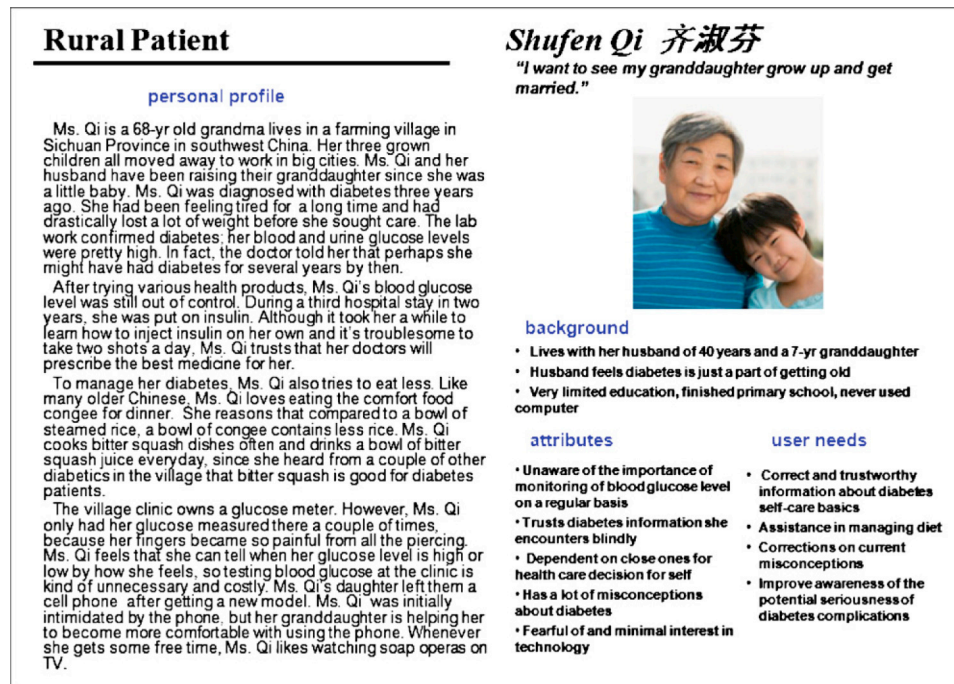
Fig. 3 – Rural patient persona.

rural Chinese elderly diabetic user profile characteristics in addition to a trial of representative evidence from the data set to illustrate support and the means to develop user profiles in Appendices A and B, respectively. To avoid redundancy, we defer discussion and detail of particular challenges faced by elders as a characteristic to the forthcoming section discussing influence on functional requirements.

We highlight some of the key differences as illustration of differences between urban and rural users as well as to emphasize the need to recognize technology, health care and demographic attributes in the coding process when developing a conceptual model for CHT users. The urban patients see their doctors for diabetes care on a regular basis. They seem more likely to test blood glucose levels at home using a glucose meter. About half of the urban elderly diabetes own mobile phones (about 1/3 use short messages, SMS and personal computers, PCs; about 2/3 carry mobile phone for family to reach them and to make emergency calls). Overall, urban elderly are excited about CADA (assuming it is well designed, easy to use and useful in helping their self-management). Urban users are willing to invest in purchasing CADA, even if it is somewhat expensive.

On the other hand, rural elderly diabetics generally only see a doctor when serious complications become troublesome. The rural patients seem more likely to assess their blood glucose level using personal feelings and symptoms than the urban patients. Ownership of a cell phone is lower to non-existent over urban subjects. They tend to have more misconceptions about diabetes than urban patients. Overall, rural elderly consider themselves "old" and are more hesitant about learning new technology. They indicated an increased acceptance of CADA if connected to a television set.

These and other insights from analysis were woven into the super-typical user personas represented in Figs. 3 and 4.

Given that one of the primary goals of this paper is to provide methodological guidance for the creation and use of user profile and persona tools by future researchers and developers, we provide a representative trace of moving from source data to user profile to the creation of the user person for rural elderly diabetes in Appendix B.

Identification of subgroups does not mandate the creation of various systems or functional choices within a system. However, it raises the team's awareness that there are a spectrum of key users and requirements [11]. In response to the subgroups noted in the case of CADA, the common traits among urban and rural users are being used as a unifying theme and focus for development. Common traits, reflected in the resulting profiles and personas included:

- Empty nesters;
- Good at self-initiating follow-up doctor visits;
- Referenced games as a preferred learning style and the use of learning memory aids (pneumonic, metaphors);
- Understand the need to adjust lifestyle (i.e., diet, exercise) to manage diabetes;
- Environment of system use: hospital, home and community centers;
- Diabetes management is a hassle (28 on a scale of 40 with 40 being "no problem");
- Co-morbidities;
- Potential for system use—peak after diagnosis and when diabetes educational outreach not readily available;
- Wish for better health care quality of community hospitals; hope there are more health specific community resources to utilize.

Distinct traits are being assessed in planning for field testing, implementation and technology diffusion efforts.

Fig. 4 – Urban patient persona.

In addition to the existence of subgroups, it is important to recognize that user profile and persona work is not restricted to primary users of technology (i.e., patients in the case context) [11]. In fact, analysis may help to reveal users not previously identified, resulting in previously unknown system requirements and implementation needs. This is particularly relevant in the health care context as demonstrated by a recent study of misconceptions regarding who were the primary and secondary users of a hospital system [63]. McLeod and Clark emphasize that the context for use of health care technologies differs from other technologies; health care users vary considerably in their roles, where the hands-on system user may be different from the decision maker or person assumed to be the primary user (e.g., nurse instead of doctor, caregiver instead of patient). If we do not really understand the roles of stakeholders and, in particular their "place" in deploying the system in actual task and work flow, we cannot expect to get relevant results.

The data gathering process for the present study revealed that there were actually multiple secondary user groups of CADA. We provide a listing of these user groups below, briefly highlight their attributes related to their CADA role and provide examples of resulting influences on system requirements, design and implementation. One of the key factors to come out of recognition and analysis of the secondary user groups was that they can facilitate adoption and usage and have a willingness to assist primary users to get better care.

The general format and nature of the content of our personas and profiles, which integrate technology, demographic and health care attributes may be used by others as templates to prepare profiles and personas for other health consumer target populations. In addition, our specified urban and rural Chinese elderly diabetic profiles and persona (Shuxi Gao and

Shufen Qi) may be reused by practice and research to fill a current void in China's UCD practice. The results of a recent study indicate that "UCD practice in China industries is very young and growing fast; currently almost all UCD practice are applied in IT related business; practitioners need improvement on UCD knowledge [64]." Personas and profiles do not have to be recreated from scratch for each application [11]. Thus, our resulting profiles and personas can be used directly by developers and designers in China to facilitate their UCD practice, if they are interested in our target group, or used as a starting point for a somewhat modified Chinese target group.

4.3. Using profiles and personas in system development and diffusion (R3)

Insight regarding elderly Chinese urban and rural diabetics is being used to design the CADA smart phone application prototype. Personas and profiles can be used to educate usability and design team members [52]. However, it is not enough for the design team (particularly the interaction designers), to have the know-how of using the method; they also have to integrate these tools with existing knowledge and practices in order to feel at home with it and use it efficiently [36].

The two project leaders were already experienced with personas and profiles prior to this study. In heeding insights from past studies and personal experience, they introduced the CADA team members, including programmers, first to the concept of user profiles and personas (relating how this could enhance current practices employed by individual team members and the overall project) and then to the specific elderly diabetic patient user personas (Figs. 1 and 2) and their related profiles (Appendices A and B). The personas and profiles offered all team members an early familiarity with the

Secondary user groups	Attributes with potential CADA impact	CADA influence on
Physicians	Currently lack diabetes patient trend data; most do not have extensive specialized training on diabetes care; enthusiastic to have tools to utilize	*Functionality:* share patient education data. Provide way to link patient logs *Implementation:* can serve as a conduit for CADA adoption and diffusion
Patient educators	Interested in sharing their knowledge of diabetes and experiences in diabetes self-management with other patients yet are limited by current resources; migrate to various health facilities	*Design:* would welcome CADA as a portable, mobile educational tool and also suggested television output to serve this purpose
Supportive caregivers and friends	Want to participate in the care of their loved one may use the phone with the patients	*Functionality:* consider "buddy" options
Hospital administrators	Oversee the diabetes education and outreach programs; Have limited current tools and resources	*Implementation:* integrate CADA into existing educational and support group classes

Table 3 – Highlights of secondary user groups.

target user groups by painting them a "word picture." Initial reactions were that the urban users seemed to be a more "accessible" target group in terms of technology; yet rural elderly had particular unmet needs that could not be ignored. It is of note that 62% of Chinese still live in rural areas [8]. It is of note that this early work provided tangible insight and a means to effectively convey progress to date to the project sponsor and explain the project direction.

As requirement specification progressed, the personas and profiles were especially helpful in resolving group conflict. Specifically, debate about different requirement and early design concepts were often arbitrated using a patient persona conceptual model. In such a debate, a team member would say, "What would Shufen think? Which option do you think that Shufen would like?" (See Shufen's persona in Fig. 3.) This conscious effort reminded us to leave out personal preferences and channel our compassion to truly design for the users by "walking in their shoes." Hill and Bartek note that once created, the persona can serve as the primary design communication vehicle within the product design and development teams [65].

In addition to shaping requirements and design concepts, profiles and personas can also inspire prototyping, evaluation processes, and considerations for implementation (adoption and diffusion) for the elderly. The following sections highlight some of the ways the personas and profiles either added to or extended initial thoughts about system requirements and design concepts. We also discuss how these conceptual tools provide insight for prototyping, evaluation and implementation plans.

4.3.1. Influence on functional requirements
Personas explicitly highlight key goals for the user and bridge development capabilities and the intended users' tasks and experiences [66]. The following examples illustrate how user profiles and personas informed functional requirements in our study (refer to Fig. 1—user requirements box to understand relationship to other phases of the methodology).

Co-morbidities are a common issue with elders, which is associated with a decline with many health outcomes and increases in mortality and use of health care resources [67]. Significant co-morbid conditions in elderly diabetic patients has the potential for inappropriate prescribing or treatment conflicts, thus appropriate management of co-morbidity

should be included in guidelines for the elderly with diabetes [68]. Given the common situation of co-morbidities (e.g., cardiovascular diseases, retinopathy), yet limited awareness of them due to "all over the board" diabetes knowledge with both Chinese urban and rural populations (see user profile highlights in Table 2); CADA functionality requirements include the need for a daily "symptom report" that checks for symptoms indicative of potential co-morbidities. In addition, educational features will include co-morbidity education. We found no existing literature that recognizes this need in CHT for diabetes or other chronic disease. We encourage future work to consider the relevance of functionality related to this need (Table 3).

Dietary compliance was not at an ideal level for either of the subgroups. Logging, particularly for diet, was referenced in most focus groups and interviews as a particular challenge. Assistance for diet management and easy and portable ways to track daily food intake are key user needs highlighted in user personas. As indicated by one elderly focus group member, "Controlling diet is difficult; eating a little more (than I should) causes higher blood glucose level, eating a little less causes hypoglycemia." Some compliance issues actually seemed to be related to misconceptions about food choices (e.g., congee/rice porridge) and tracking food quantities. In response, CADA functional requirements include dietary logging functionality that minimizes user input and also provides feedback and education on good dietary practices. The use of interactive consumer health IT by specific populations, namely the elderly, those with chronic conditions or disabilities and the underserved, was often hampered by usability problems and unreliable technology [69]. Elders, particularly in the urban context were active and ate out more often. Thus, the use of smart phone mobile technology enhances opportune timeliness for a diet management application by making an efficient dietary logging system potentially available with every meal (i.e., kairos) [19].

Individualized treatment goals are recognized as one requirement for interactive consumer health IT to have a positive impact on health outcomes [69]. The importance of goals related to diabetes self-management and the need to be able to reference these goals was also mentioned by both focus groups participants and providers interviewed. Patients, particularly indicated that diabetes self-management goal functionality should be individualized as represented by one patient, "It

is for each individual; it cannot be one-size-fits-all." In addition, urban patients desire individual attention from providers (highlighted in Shuxin's persona in Fig. 4). Elders' information needs must be personalized and reviewed carefully with the elder patients, families and caregivers, because they often do have symptoms that are different from typical education materials [70]. In response, the CADA system requirements include a personal goal reference, which is specified by the patient's provider, with moderate progress tracking features. This reference provides a succinct "note of provider recommendations" that the patient can look back on as a memory jogger as well as a short digest that can be shared with the patient's support network by just viewing the screen.

Educational content has the potential to remedy misconceptions held by rural patients as well as support urban elders' more active information seeking habits. Given the educational level and diabetes knowledge diversity of prospective users specified in the user profile, the educational component of CADA needs to be delivered in clear "doses" (modules) of up-to-date and accurate information to avoid "information overload" issues. A modular approach also accommodates targeting basic and critical knowledge for those who do not want to go further, as well as broader coverage through expansion options provided by additional modules. Many patients, particularly rural patients, were profiled as active health information seekers. Active information seeking can be supported by a modular approach through broad coverage as well as updates to ensure fresh content. Protocol adherence issues are a challenge to both rural and urban patients and a recurring theme in chronic care literature. The importance of various aspects of treatment adherence will be emphasized in the educational content.

The above discussion highlights various CADA insights that merit consideration in other CHT application requirements and evaluation considerations, particularly those targeted for the elderly.

4.3.2. Influence on design

As indicated in Fig. 1, user profiles and personas can also influence design. We indicate some of the ways our user persona and profile and underlying data are affecting the CADA design specifications. For consumer health IT, it is critical that data entry not be cumbersome and that the intervention fit into the user's daily routine [69]. Patient input options will include voice, input touch screen and limited handwriting due to physical and language keyboard challenges for both rural and urban patients (documented in the complete user profile). Icons and characters will be used instead of text wherever possible.

Because of their age, targeted users are mostly empty nesters; the personal support they received is often limited to their spouses, co-resided caregivers and health care providers (see personas in Figs. 3 and 4). Rural patients received significantly lower social support (particularly of the positive, encouraging nature) than their urban counterparts from their personal network. CADA will pay particular attention to delivering positive reinforcing feedback messages to encourage its users to pursue health behaviors.

No subgroup fully appreciated adherence and the role of logging and monitoring. Thus, the system must be engaging in

order to maintain an elderly patient's interest in these activities. Both groups included games as a method of learning. As a result, we will use the entertainment value of games for routine entry and education to entice patients into these compliance tasks. Gaming draws on the persuasive technology design principle of liking and attractiveness [19]. A variety of games have been successfully implemented in diabetes education and self-management (e.g., [71]). Video games are found to empower elderly people in addressing their cognitive, social and health care needs [72].

Elders also referred to memory schemes they used to help them understand diabetes self-management concepts. Memory schema for elderly has been proven effective in health care setting [73]. The "food pagoda" was one of the icons mentioned, which is being used as a metaphor in the diet management application. Another memory schema referenced was the five-horse wagon. In fact, one participant sung a song where this aid was put to lyrics; the essence of the lyrics was that... "Five-horse wagon of diabetes management are dependent on help of the five-horse wagons: (1) balancing diet, (2) enforcing physical exercise, (3) losing weight, don't be overweight, (4) testing blood glucose, blood pressure, cholesterol, blood congeals and uric acid regularly; BMI need to be proportional, (5) learning diabetes knowledge In order to be healthy, we should work hard to reach the standards." Given that patients and providers reported some gaps in holistic understanding of all components of self-management, the five-horse wagon metaphor will also be captured on a basic educational reference screen.

Design decision-making can be difficult and sometimes arbitrary. User profiles and personas facilitate this process by allowing designers to truly focus on and effectively communicate the needs, desires, capabilities and limitations of the intended users, especially when they are not familiar to and well researched by the development team, such as the aged population [66,74,75]. In addition to facilitation of user interface design by encouraging creativity and explicit design decision-making processes, user profile and persona information generate scenarios for future testing and evaluation of the design [38,76]. More detailed user profiles can also serve as the basis for selecting and screening users to participate in interactive prototyping activities and usability testing, which directly shape the solutions' design and development [66]. For example, in our study, user profiles and persons highlight those urban elders be more ready adopters of CADA. Understanding of why and how a system is going to be used by the targeted user group also informs the other aspects of testing design to ensure it closely resembles the actual application context.

4.3.3. Influence on implementation and diffusion

Key insights from the analysis of Chinese aged diabetic patients' profile and persona can also be leveraged to ensure successful implementation and diffusion of CHTs among aging patient groups (refer to Fig. 1—user requirements box to understand relationship to other phases of the methodology). One of the key factors surfaced by the analysis of elderly Chinese patients' profiles and personas is the relationship of trust between the health care providers and these patients in both the urban and rural setting. A key implication of this

finding is that successful implementation and diffusion of a CHT will be largely dependent on the perceptions of the health care providers. Although trust has shown to be an important factor impacting intention to use technology artifacts in IT research [77], it has not been investigated in the context of aging patients and health care providers. Thus, it would seem that if the health care providers recommend using a product or device to their elder patients, the patients will be more likely to adopt and use it. This implies that for successful patient adoption to occur, developers must realize that a key component of CHT adoption and use is provider buy-in, namely adoption of the ideal that the CHT is useful and that patients have the capabilities to use the technology. To promote CADA "buy-in" by providers, we have actively engaged health care providers from participating health care organizations through discussion, presentation, and various forms of participation in data collection and development procedures to date. It is of note that provider interviews we included as part of data collection generated some intrigue and "buzz" about CADA. There were multiple occasions of subsequent conversations subsequent to the interview about various aspects of CADA, the project team, and the research and design process. Thus, we assert that participatory design and implementation considerations in the CHT context should expand beyond focus on only the patient as primary user.

In response CADA implementation plans include allying select physicians as champions and a train-the-trainer approach, where health care providers are trained to: (a) communicate advantages of CADA, (b) provide patients with encouragement and reminders to use CHT's and (c) provide training guidelines or materials that providers or their staff may use with patients. This approach to introducing patients to CHT may be particularly critical in the case of the elderly given their individual physical limitations and needs and the provider's unique insight into the specifics of the patient situation. This communication between patient and provider involving the elder's use of a CHT may also inform the provider of technology and/or health attitude barriers to CHT use. Providers my either help the patient seek out means to overcome these barriers or make an assessment that the particular patient is not the best candidate for benefit from the CHT and find other alternatives to helping the patient achieve self-management goals.

The analysis also indicated that urban patients hoped for more individualized attention from the health care providers while the health care providers indicated a preference for tools that can help extend their stretched resources (e.g., time). Thus, it will be important for the team to provide CADA product literature and training materials directed towards providers that explicates how they can use CADA screens and output (particularly summaries of results) to efficiently and effectively provide individualized attention and feedback to patients. Likewise, patient product literature and training materials should include guidance on "how to share information from CADA with your health care provider". This may also be a lesson for other CHT developers—namely to explicate how the CHT can and should be used as part of the communication process between patient and provider.

Urban patients have greater capacity and skills to use smart phone technologies than rural patients. Thus, the level and extent of their training (and associated costs with these measures) can be reduced. Medical providers, particularly nurse educators, can use the smart phone as a mobile teaching tool—either one-on-one or in small groups if television output is available. Rural patients were found to lack the resources that could foster awareness and knowledge about diabetes. In some ways this may be advantage as more centralized and standardized training can be provided by a mobile provider in a group setting (especially if television output is available). On the other hand, since the urban patients have access to multiple other information sources (much of which are incomplete or inaccurate), successful adoption and implementation of a CHT should emphasize the comparative quality and reliability of an information source.

Another important finding was associated with the limited income resources of the aging patients. While urban patients may have stable pension, increasing health care costs could consume a large proportion. Although in China elderly parents are often financially supported by their children, two primary concerns were acquisition and maintenance costs associated with a technology solution. Although the patients or their family and friends indicated they were willing to make one time expensive investment in a CHT (given that the health care providers deem it worthwhile), a unanimous demand was for updated information at little or no extra cost. Consequently, successful implementation and diffusion of a CHT will be critically dependent on associative costs. Cost has also been found to be an important determinant of IT use by the aging population in previous research [24]. A lower priced or government subsidized CHT might have a higher chance of successful implementation and diffusion among the aging patient group than a CHT with a higher cost price, even if it came with more features.

5. Conclusions

Elders have specific capabilities, limitations and experiences that affect their interactions with technologies. CHT have the potential to provide value in providing proactive support in disease management if they are adopted and used by elders. However, many challenges remain to develop technologies that meet the needs of older adults, accommodate their cognitive and perceptual declines, capitalize on their intact abilities, support them in performing everyday activities, and protect their privacy, independence and security [78]. One of the challenges to the effective design of such technologies is the understanding of the conceptual model of the elderly. Traditional IT models are not sufficient to meet user requirements, in particular for elderly users. In addition, design and development is typically done by younger, presumably healthy adults who tend to put in their own biases in the CHT—designing for themselves and not necessarily the aging patients.

Profiles and personas (based on the profile data, aims and behavior) have become an increasingly popular way to customize, incorporate and share the research about users; they can fulfill the need of mapping and grouping a huge number of users [40]. In another study using personas of a specific age group (namely children), the research team discovered that the method of constructing child-personas provides a way to

(1) systematically incorporate concepts from developmental psychology into design and (2) capture design knowledge for subsequent projects [79]. Similarly, we found that constructing user profiles and personas provided an effective way to (1) engage older adults in design, (2) capture the demographics and psycho-social perspectives (regarding health) for a targeted elderly population and (3) capture design knowledge for subsequent projects and offer this insight as an extension to existing literature.

Few, if any, existing studies indicate how to effectively understand and model the aging patients such that the design and development of CHT can mirror the unique mental model of the aging. The present study makes a contribution that addresses this void by revealing process and resulting artifacts with considerable detail through the use of a specific action research example. Our methodology demonstrates (a) how to effectively involve an elderly users in the design and development of CHT, (b) how to develop user profile and personas of an aging patient population and (c) the utility of user profiles and personas as a methodological tool in capturing the mental model as well as assisting the development team by informing the design and development decisions of CHT. Our resulting models (process diagram—Fig. 1, attribute diagram—Fig. 2, user profile highlights—see Table 2 as well as entries under the "user profile characteristics" column in Appendices A and B, and user personas—see Figs. 3 and 4) can be used in future research to guide designers/developers interested in designing CHT based on the conceptual models of the user group. Our specified user profiles and personas of the Chinese aged diabetic population may be particularly welcomed for direct use or adaptation to another Chinese CHT target population by the Chinese UCD practice community, which is currently quite young, but growing fast [80].

Past research contends that adoption of user profiles and personas may arguably enhance CHT design and development performance for the elderly in three complementary ways: (1) empathy with users, (2) social richness by enhancing communication through text and visual cues in the profile and persona, and (3) social integration supporting free flowing conversation [80,81]. All three were shown to be true with respect to the CADA project. Enhanced richness in understanding elderly diabetic patients and their context was achieved by expanding traditional profile and persona content to include psycho-social health care beliefs and attitudes and other health care behavioral considerations. This enriched understanding provided insights for functional requirements, design, and implementation considerations for the elderly Chinese diabetic target population. We provided indications throughout our discussion of results regarding how our experiences with CADA personas and profiles may provide insights into other CHT target groups. For example, it is highly likely that recognition of the need to identify the health care provider as an important ally that can champion adoption and diffusion of CHT by patients is specific to our target population. Additionally, we have grounded our insights with existing literature to allow the reader to consider application beyond the current study.

We readily admit, these tools are not without problems and limitations (e.g., they take time to develop, particularly if user models do not already exist that can be adapted to context)

Summary points
What is already known:

- It is useful to promote CHT as a means of disease management among the elderly.
- CHT have generally not been successful in becoming a pervasive means of disease management.
- UCD tools, such as user profiles and personas, are known to aid in the design and development of innovative technologies that map closely to the mental model of users primarily in non-health care contexts.
- Little is understood about the elderly users, yet it is necessary for effective CHT design and adoption.

What this study adds:

- Enhanced existing user profile and persona tools in the context of health care technology user.
- Explicates process for developing user profile and personas as part of UCD.
- Captured the mental model of a specific user segment—elderly diabetic Chinese population, via user profiles and personas.
- Demonstrated user profiles and personas can be leveraged in the design, development and implementation of CHT that can eventually lead to adoption and use.

and can be used inappropriately (e.g., if all team members are not trained with their particular roles and vested interest recognized). However, our investigating of the utility of user profile and persona as a methodological tool in capturing the mental model of the aging Chinese diabetic population, demonstrates the potential and promises of the methodology [11]. Not only can user profiles and personas serve as powerful tools for true participation in design, but they also force designers to consider social and health attitude aspects in design that otherwise often go unexamined in CHT development and evaluation. Thus, we hope this study serves as a catalyst to promote further research needed to empirically assess the value of adoption and detailed application of user profiles and personas to all stages of the design process and diffusion efforts of CHT.

Authors' contribution

Cynthia LeRouge—As the lead author, she conceptualized and organized the paper. She performed data collection and analysis for the referenced study and contributed to the development of the exemplified user profiles and personas. *Jiao Ma*—As the second author, she performed data collection and analysis for the referenced study and was the lead in development of the exemplified user profiles and personas. *Sweta Sneha*—As the third author, she contributed to the development of the manuscript from the start to the final submission. Her contributions are reflected in the abstract, introduction, background, and in the discussion of the implications/contributions of the referenced study. *Kristin Tolle*—As

the fourth author, she contributed to overall insights regarding the initial direction of the exemplified study and its relation to other work in CHI. Her generalized insight is reflected in the conclusion.

Conflict of interest

No authors had any financial and personal relationships with other people or organizations that could inappropriately influence (bias) this work.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ijmedinf.2011.03.006.

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