WHAT CONCERNS USERS OF MEDICAL APPS? EXPLORING NON-FUNCTIONAL REQUIREMENTS OF MEDICAL MOBILE APPLICATIONS

Complete Research

Meulendijk, Michiel C., Utrecht University, Utrecht, the Netherlands, m.c.meulendijk@uu.nl

Meulendijks, Edwin A., Utrecht University, Utrecht, the Netherlands, e.a.meulendijks@students.uu.nl

Jansen, Paul A.F., University Medical Center Utrecht, the Netherlands, p.a.f.jansen@umcutrecht.nl

Numans, Mattijs E., M University Medical Center Leiden, the Netherlands, m.e.numans@lumc.nl

Spruit, Marco R., Utrecht University, Utrecht, the Netherlands, m.r.spruit@uu.nl

Abstract

The increased use of internet through smartphones and tablets enables the development of new consumer-focused mobile applications (apps) in health care. Concerns including these apps' safety, usability, privacy, and dependability have been raised. In this paper the authors present the results of a grounded theory-approach to finding what non-functional requirements of medical apps potential users view as most important. A document study and interviews with stakeholders yielded nine non-functional requirements for medical apps: accessibility, certifiability, portability, privacy, safety, security, stability, trustability, and usability. Six of these were evaluated with two groups (differing by age) of potential users through a vignette study. This revealed differences between the age groups regarding the importance each attributed to apps' usability and certifiability. Furthermore, and contrary to consensus in literature, privacy was considered one of the least important attributes for medical apps by both groups. Trustability, security, and, for the younger group, certifiability, were considered the most important non-functional requirements for medical apps. The implications of these results for developing medical mobile applications are briefly visited.

Keywords: medical informatics, non-functional requirements, mobile applications, grounded theory, vignette study

Introduction

The increased use of internet through smartphones and tablets has enabled the development of new consumer-focused mobile applications in areas such as education, personal finances, transportation, and health care (Dabney, Dean & Rogers, 2013; Wu, Ng, Krishnaswamy & Sinha, 2012; Fox, Cooley, McGrath & Hauswirth, 2012). In this last area, health care, various initiatives have been employed to improve patients' well-being through mobile technology. These include mobile applications that aim at aiding users directly through advice or information, as well as software that collects data for research purposes or planned operations (Aanensen, Huntley, Feil & Spratt, 2009; Ozdalga, Ozdalga & Ahuja, 2012; Sarasohn-Kahn, 2010).

While these new applications have the possibility to improve both patients' empowerment and their health, they are not without risks. Concerns include applications' safety, usability, privacy, and dependability (Sarasohn-Kahn, 2010; Buijink, Visser & Marshall, 2013; Meyer, Stanzel, Moqaddem & Brohlburg, 2012; Kharrazi, Chisholm, VanNasdale & Thompson, 2012). Further exploration into these concerns is necessary in order to advance the development of patient-beneficial applications. Involvement of potential users in the assessment of these concerns has been argued for in literature (Sarasohn-Kahn, 2010).

The use of multiple different medicinal drugs by people suffering from chronic conditions is known as polypharmacy. It has been associated with problems including decreased adherence and misinformation, leading to patients having greater risks of adverse effects or hospitalization (Björkman, Fastbom, Schmidt & Bernsten, 2002; Claxton, Cramer & Pierce, 2001; Frazier, 2005; Kuyuma, Endo & Umegaki, 2000; Shi, Mörike & Klotz, 2008; Sloane et al., 2004; Steinman et al., 2006; Wright et al., 2009).

In this paper the authors present the results of a grounded theory-approach to finding what non-functional requirements of consumer-focused medical mobile applications (potential) polypharmacy patients view as most important. They aim to answer the following research question: which non-functional requirements of medical mobile applications are deemed most important by (potential) polypharmacy patients?

The research approach revolves around eliciting and subsequently evaluating these non-functional requirements by interviewing stakeholders, including developers, experts and potential users. Section 2 describes the theoretical background that provides the foundation for this study. The subsequent sections, 3 and 4, detail the research approach and discovered results. Finally, the discussion relates the results to existing theory, while the conclusion relates the findings to practical implications.

1 Background

1.1 Medical Mobile Applications (Medical "Apps")

The increase in the use of smartphones and tablets has been widely recognized as having the potential to be of great use in the medical domain (Ozdalga et al., 2012; Sarasohn-Kahn, 2010; Meyer et al., 2012; Kharrazi et al., 2012). Mobile applications, or "apps", could be applied in both professional and personal settings, by patients-consumers and professional caretakers alike.

As is evident from the research question, this study is aimed at researching what non-functional requirements consumer-focused medical apps should meet. Thus, applications aimed at professionals, or to be used during consultations, are outside of the scope of this study. A systematic literature review by Ozdalga et al. (2012) yielded a list of consumer-focused medical apps containing, among other features, monitoring, educating, and communicating. Adding to this, in the course of this study the

authors investigated the current state-of-the-art of medical apps in the Dutch market, as the research was conducted in the Netherlands.

The search was performed on the common platforms for mobile app distribution, Google Play and Apple Store. Sixteen relevant apps were found and examined. Several of the apps were mainly aimed at advising users about medical issues (e.g. advise them whether or not to visit their GP, based on analysis of a medical problem). Others' main functionalities revolved around acting as a personal assistant for patient-specific health issues (e.g. keeping track of food intake for patients suffering from diabetes, and generating alerts when necessary). Popular features of apps included maintaining users' medical records, generating alerts and reminders, and generating advice or information based on user input.

1.2   Requirements

In their book, Hull, Jackson and Dick (2011) define requirements engineering as "the subset of systems engineering concerned with discovering, developing, tracing, analyzing, qualifying, communicating, and managing requirements that define the system at successive levels of abstraction". The authors see a requirement as the basis for every project, "defining what the stakeholders in a potential new system need from it, and also what the system must do in order to satisfy that need". Stakeholders, in their view, can be any person or entity that uses, benefits from, is disadvantaged by, or is responsible for a system. The importance of continuous engagement of stakeholders throughout the development process has been recognized (Higgins, De Laat, Gieles & Geurts, 2002).

Requirements are generally divided into functional and non-functional requirements. Functional requirements state 'what the system should do', while the non-functional requirements are 'attributes of or constraints on a system' Chung and Do Prado Leite (2009) or 'how the system (should) behave' (Franch, 1998). In an attempt to minimize the ambiguity surrounding the definitions of non-functional requirements, Glinz (2007) created a taxonomy in which they have been divided into performance requirements, specific qualities, and constraints. Examples of performance requirements are timing and throughput efficiency, quality requirements include usability, reliability, and portability, and constraints can be physical or legal barriers (Glinz, 2007). Additional attempts to classify and standardize often identified quality indicators for software have resulted in a variety of industry standards (International Organization for Standardization (ISO), 2001; International Organization for Standardization (ISO), 2011; Grady, 1992).

According to Paech and Kerkow (2004) non-functional requirements are often poorly understood, and neglecting them is one of the top ten risks in requirements engineering.

1.3   Grounded Theory

Grounded theory was first described in 1967 by Glaser and Strauss (1990) as the discovery of theory from data. According to Charmaz the method was created "as a protest against what they viewed as a rather passive acceptance that all the great theories had been discovered" (as cited in Goulding (1998)). The remaining role of research was to test existing theories, not to propose new ones. Grounded theory broke with this paradigm by introducing a method to create new theory.

According to Corbin and Strauss (1990) there are a number of procedures to follow when adopting grounded theory as a research method. A first one is that data collection and analysis are interrelated processes, which means that they can and have to happen simultaneously. Concepts are furthermore the basic units of analysis, and subsequently, categories must be developed from these concepts and related to one another. Another important procedure is that the analysis makes use of constant comparison. This means that everything that is formed into concepts or categories is constantly compared to all the other elements and aspects of the study (Corbin & Strauss, 1990, p. 3).

According to Birks, Fernandez, Levina and Nasirin (2013), grounded theory can be a powerful tool for IS scholars interested in theory development, allowing researchers to conduct pioneering research with both flexibility and rigor. An important aspect of grounded theory is that 'all is data' (Glaser, 2002). This implies that not just methodical interviews, surveys and observations are data, but that anything the researcher comes into contact with, including respondents' behavior or attitudes, is data (Goulding, 1998).

2   Research Design

In order to elicit and evaluate the non-functional requirements of consumer-focused medical apps, a mixed-methods research design was adopted. This choice was made because of the broader perspectives a mixed-methods design offers, as well as the ability to evaluate findings after initial exploration. More specifically, the research design was an exploratory sequential design, as described by Creswell and Plano Clark (2011). However, due to expected difficulties with performing large-scale impersonal quantitative methods with elderly respondents, the second evaluative step was performed through vignette-guided interviews. While limiting the results' generalizability, this approach did allow for intensive interaction with respondents, in line with grounded theory.

Two methods were used to perform the first step of eliciting the requirements: a document study and interviews with appropriate stakeholders. The document study was performed in order to explore the consensus in public discourse on relevant non-functional requirements. Next to this top-down approach, the stakeholder interviews were used as a bottom-up approach to discover what attitudes both potential users and experts had.

For evaluation, vignette-based interviews with potential users were performed. The vignettes were based on the non-functional requirements discovered in the previous elicitation phase. This method was employed to find out which requirements potential users viewed as most important in their decisions whether or not to use a medical app.
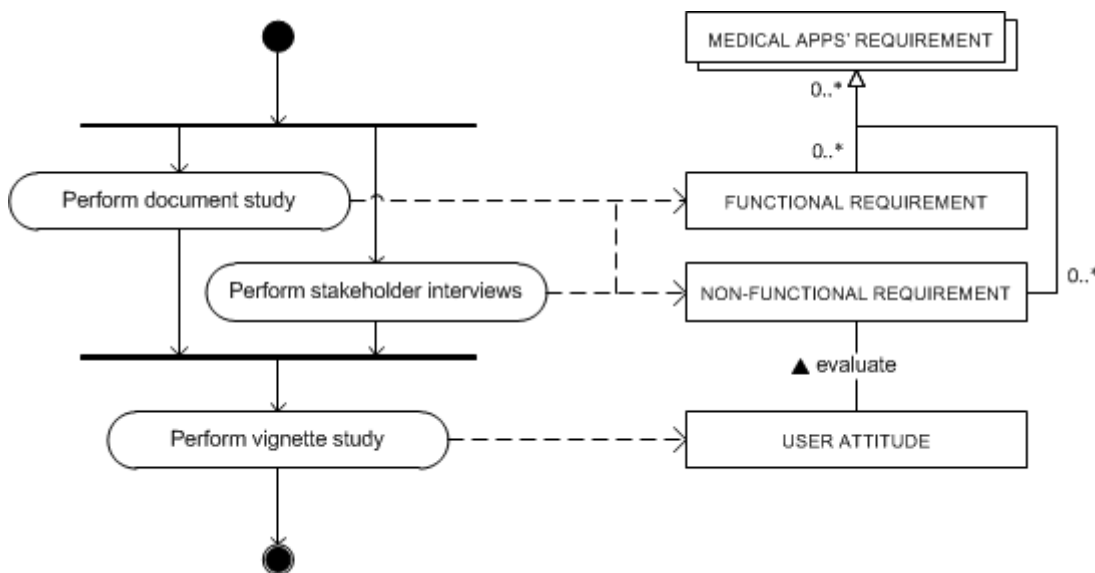

Figure 1.   Process-deliverable diagram detailing the research process and its outcomes (Van de Weerd & Brinkkemper, 2008).

2.1   Document Study

The document study was performed to discover both practical and generic sources pertaining to non-functional requirements of medical apps. Included in the study were news articles, directives, laws,

roadmaps, working instructions, and guides on polypharmacy and the development of medical applications.

The initial documents were found by searching a variety of general and domain-specific search engines: the generic Google search engine, the mobile app stores Google Play and Apple App Store, and the Dutch primary care web portal Artsennet. Initial queries consisted of combinations of 'polypharmacy' and 'medical applications' and their derivatives; Dutch equivalents of these terms were used as well.

Besides the documents found through this process, additional sources were found through the so-called ancestry approach, i.e. through reference lists and related works of included documents. All documents were judged on source quality and topical relevance; those found to be relevant and reliable were included in the study. They were processed by recording the source, summarizing the document information, and extracting the relevant data.

2.2   Stakeholder Interviews

Semi-structured interviews with a variety of stakeholders were performed to discover what requirements interviewees mentioned as essential for consumer-focused medical apps. Among the people interviewed were potential users, medical professionals and information systems developers. In total, two polypharmacy patients, two family caregivers, two professional caregivers, two information system experts, and two pharmacists were interviewed. The group of interviewees was purposefully diverse, in order to accommodate many different perspectives. The results were coded during analysis and collected in concepts. In line with grounded theory the interview phase was ended when a point of saturation was reached, i.e. when the analysed results no longer yielded new concepts.

The interviews were performed in person at respondents' homes, and were recorded and later transcribed. Respondents were asked about their opinions and attitudes towards a potential mobile app that would help them manage and monitor their drug use in a variety of ways. Questions included whether or not respondents valued the idea of such an app, what functionalities they thought it should have, and if they would consider using it if it were available.

2.3   Vignette-Guided Interviews

In order to evaluate the identified non-functional requirements, potential users were approached. Two groups were interviewed. As this study focused specifically on polypharmacy patients' concerns, members of the first group were 65 years or older and used five or more medicinal drugs chronically. A second group, consisting of people over 50 years of age and using at least one drug chronically, was included to examine differences in attitude between polypharmacy patients and people whose health is starting to decline and who may become reliant on multiple drugs in the future.

A vignette-study is an assessment study in which information is gathered through vignettes: "a short description of a person or situation that contains relevant information which is presented to respondents to obtain a value judgment about that described person or situation" (Veenma, Batenburg & Breedveld, 2004, p. 9). A principal characteristic of vignettes is that the presented scenario allows for researchers to include both advantages and disadvantages of a respondent's choice. Through this design, respondents are made to carefully consider the (hypothetical) implications of their decisions when answering. Although primarily a quantitative technique, vignettes have been used to guide interview sessions as well, as they have in this research (Barter & Renold, 2000; Meulendijk, Van de Wijngaert, Brinkkemper & Leenstra, 2011).

Vignette-guided interviews with the two groups of respondents were performed. The vignettes were created after the non-functional requirements discovered in the document study and stakeholder interviews. Even though a total of nine non-functional requirements were found, only six of these were

evaluated with potential users. It proved impossible for potential users of medical apps to judge technical aspects such as stability, portability and accessibility during vignette-guided interviews.

Each respondent was read all six vignettes presenting a scenario revolving around a non-functional requirement. Then they were presented with three options highlighting advantages and disadvantages of their decision, asked to pick one, and motivate their choice. Below is an example of a vignette. It contrasts the non-functional requirement usability with the app's number of functionalities; if respondents opt for a highly functional app, this will negatively impact its usability, whereas, if they decide for an app with limited functionalities, its usability will be positively impacted.

The medical app comes in multiple versions. Please pick the option that most closely resembles your attitude.

1. *The app is very easy to use, but only contains a medication overview.*
2. *Besides the medication overview, the app contains some other helpful functions and is still rather easy to use.*
3. *The app contains, among others, a medication overview, a drug reminder, information about your diseases, and an option to immediately contact your GP. Because of all these functionalities, it is somewhat harder to use.*

3 Results

3.1 Document Study

The document study yielded fourteen documents reliable and relevant to the authors' research question. Example sources of documents that were included are European Union directives, the Dutch College of General Practitioners, and the Dutch Ministry of Health, Sport, & Welfare. The most important issues that were identified as non-functional requirements were certifiability and privacy.

The first requirement, the necessity of certifiability, is based on a European Union directive, which in turn has been converted into laws in its member states. The directive defines that a medical device or aid has to be CE-certified to be used legally, and proposes a definition for what a medical device is (Council of European Communities, 1993). Software that assists patients in monitoring or preventing diseases and medications is in fact classed as a medical device.

The second requirement revolves around privacy regulations and how an application that deals with personal or medical information should incorporate those. The processing of any personal information is limited by the Dutch Data Protection Act; both the transfer and processing of information by third parties, entered by patients, will need to be approved by those patients. Apart from getting approval, other conditions that have to be met include the aspect that the patients' privacy is not disproportionately harmed, and that the process favors a 'general cause' (Actiz, FNT, GGZ, IGZ, KNMG, KNMP, LEVV, LHV, NFU, NHG, NMT, NICTIZ, NPCF, NVZ, NVZA, Orde, V&VN, VGN, Verenso, VWS, ZN, 2008).

3.2 Stakeholder Interviews

The interviews were performed with ten stakeholders, two of each of the following groups: polypharmacy patients, family caregivers, professional caregivers, information system experts, and pharmacists. All sessions were recorded and transcribed. The length of the interviews ranged from approximately twenty to sixty minutes, which an average of thirty-seven minutes. Results from the document study were incorporated in the interview questions.

Using the coding techniques common in grounded theory, the transcribed interviews were analyzed for themes. The non-functional requirements that were found using this method are accessibility, portability, privacy, safety, security, stability, trustability and usability.

Accessibility, portability and stability are application-specific characteristics that are related. Accessibility is commonly understood as the degree to which the application is available to users, usually taking into account disability measures. Portability refers to the number of operating systems and devices the application supports, and stability to the technical robustness and dependability of the application. Information system expert #2 stressed the importance of technically catering to the right audience, saying "Family caregivers visit patients at home, and so do nurses. So smartphones, and likewise tablets, would be obvious choices.", while information system expert #1 commented on the variety in functionality that different user roles bring with them: "[We previously talked] about the two modes: whether or not having access to [a patient's] health record. You should adjust those to the different stakeholders."

Privacy, safety, and security all relate to safeguarding users' well-being when using the application. Privacy was for example discussed with pharmacist #1, who was able to tell that "if you can decide for yourself who can have access, it doesn't have to be a problem". These concepts are related to the requirement of trust, which entails the users' perceptions of these characteristics. Making sure the application is private, safe, and secure is essential for having people 'trust' the application. Pharmacist #1 warned for providing laypersons with incomplete or ambiguous advices, implying that "if you tell a patient of a [clinical] interaction [between his drugs], he will panic, risk that he stops using something, while nothing may be wrong."

Finally, the last non-functional requirement mentioned by the stakeholders is the usability of the application, which is its ease of use and learnability. Family caregiver #1 wondered if the mobile application could be made simple enough for her to understand at her old age: "Then I think, once I would get to know the application, I would certainly be willing to use it".

3.3 Vignette-Guided Interviews

To evaluate the gathered non-functional requirements with potential users, vignettes were created which forced respondents to judge the pros and cons of certain functions.

Three of the non-functional requirements had to be excluded from the study, as they were too technical to be judged by non-professional respondents; these are accessibility, portability, and stability. This leaves the requirements certifiability, privacy, safety, security, stability, and trustability to be tested in the vignette-guided interviews. The first group that was interviewed included seventeen respondents, who on average were aged 77 and used 9 drugs. The second group consisted of nineteen persons, who had an average age of 60 and used 3 drugs.

Firstly, most respondents indicated putting at least some degree of trust in an application like the one proposed. Only four people, all of the first group, chose the most conservative trust option, indicating they had no faith in automatically generated advices from a medical application whatsoever.

Secondly, the majority of respondents, especially of the second group, indicated favoring functionality over usability. The first group held more conservative attitudes toward this requirement.

The respondents showed progressive results for the requirement concerning privacy as well. Only one interviewee refused to have her personal data used at all. The others were willing to let their data be used if it would benefit the advices they would receive; about half the respondents demanded their data be used anonymously.

Regarding the security requirement, most respondents indicated wanting some form of protection for their personal data in the proposed application. Of the first group, most people favored password

protection in the app itself, while the majority of the second group settled with their smartphone's default mode of security.

Respondents of both groups indicated accepting a limited risk in the generated advices, provided the advices were customized to their situations.

Finally, the majority of the second group indicated valuing a form of certification for the proposed app. Most interviewees of the first group answered attaching more importance to recommendations by their general practitioners.

In *Figure 2* the importance the respondents attributed to each of the queried non-functional requirements is graphically displayed.
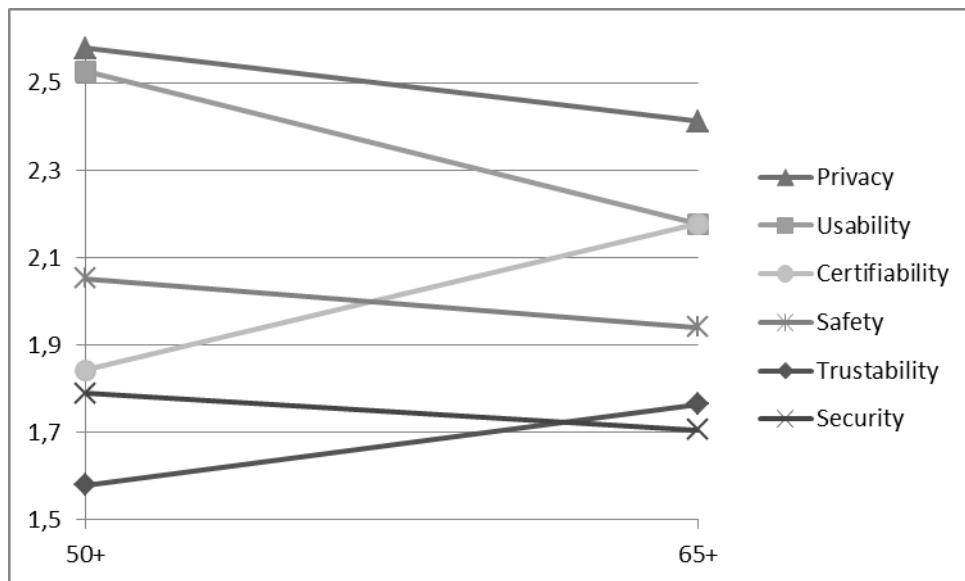

Figure 2.   *Importance respondents attributed to non-functional requirements per age group. The horizontal axis represents the average answer respondents gave to each vignette; as lower-numbered answers were more conservative, a lower score means a requirement was considered more important.*

3.4   Recapitulation

As mentioned earlier in this paper, the field of requirements engineering is well-established, and has brought forth a multitude of theories and taxonomies attempting to list quality indicators of software (International Organization for Standardization (ISO), 2001; International Organization for Standardization (ISO), 2011; Grady, 1992). These industry standards have different perspectives on concepts regarding non-functional requirements; in *Table 1* all non-functional requirements found in this study are shown, and an attempt has been made to map the existing concepts of the main standards to the newly found ones in this study (Chung & Do Prado Leite, 2009). As can be observed, some of these concepts translate well to those in existing taxonomies, while others are new to them.

Among the concepts that are common in most frameworks is usability. This user-focused requirement has long been a part of software requirements models. While the sub concepts belonging to the concept of usability greatly differ between theories, it is principally understood as "the effort needed for use, and on the individual assessment of such use" (International Organization for Standardization (ISO), 2001). Sub concepts may include ease-of-use, learnability, aesthetical attractiveness, and, in some cases, accessibility (International Organization for Standardization (ISO), 2011). Accessibility, or software's ability to be "use[d] by people with a wide range of characteristics", is found explicitly

in only one of the references theories, but is often understood as an implicit aspect of usability (International Organization for Standardization (ISO), 2011).

Concepts aimed at more technical aspects of software are rather common in most frameworks as well. Portability, defined in the ISO 9126 standard as "the ability of software to be transferred from one environment to another" is present in most theories, although sometimes referred to as adaptability, installability or compatibility, or included as sub sets of these (International Organization for Standardization (ISO), 2001). Likewise, the concept of security, interpreted as the degree "to which a system prevents unauthorized access to data", is common throughout theory (International Organization for Standardization (ISO), 2011). Finally, stability is found in most frameworks, and is understood as systems being "operational and accessible when required" to "perform specified functions under specified conditions for a specified period of time" (International Organization for Standardization (ISO), 2011). It includes aspects such as systems' robustness, availability or *uptime*, and recoverability from errors.

While the concept of safety is present in various forms in most frameworks, it is usually implied through combinations of broader concepts such as accuracy, correctness, or reliability. The concept as found in this study is defined as the "degree to which a product or system provides the correct results with the needed degree of precision" (International Organization for Standardization (ISO), 2011).

The remaining concepts discovered in this study, privacy, trustability and certifiability, are not or hardly reflected in existing taxonomies of requirements engineering. Although privacy is included in the ISO 25010 standard as the assurance that "data are accessible only to those authorized to have access", it is non-existent in others (International Organization for Standardization (ISO), 2011). Likewise, the concept of trust is included in the ISO 25010 standard as a subjective user criterion, but the concept of trustability found in this study, i.e. the ability of systems to convince users of their dependability and responsibility, is not (International Organization for Standardization (ISO), 2011). Finally, the related concept of certifiability, the degree to which software's behavior is approved by authorities, was not found in any form in any of the referenced frameworks.

This study's NFR's	ISO/IEC 25010 International Organization for Standardization (ISO) (2001)	ISO/IEC 9126 International Organization for Standardization (ISO) (2011)	FURPS(+) Grady (1992)
Accessibility	Accessibility		
Certifiability			
Portability	Adaptability, installability	Adaptability, installability	Adaptability, installability
Privacy	Confidentiality		
Safety	Functional correctness	Accuracy	Accuracy
Security	Security	Security	Security
Stability	Availability, fault tolerance	Stability, fault tolerance	Availability, stability
Trustability	Trust (user criterion)		
Usability	Usability	Usability	Usability

Table 1.   *The non-functional requirements identified in this study and their equivalents in leading industry standards.*

4 Discussion

The grounded theory approach described in this paper resulted in a set of non-functional requirements that are applicable to the development of consumer-focused mobile software applications in a medical domain.

4.1 Uncommon Non-Functional Requirements

Some of the concepts discovered in this study can easily be mapped to those prominent in existing taxonomies, as shown in *Table 1*; this is not true for all of them, though. It is notable to see how concepts revolving around trustworthiness of both the output of the software and the intentions of its developers are found important in this study, although they are generally underrepresented in existing theory.

Indeed, issues revolving around the safety of medical apps' output have been recognized. Buijink et al. (2013) argue that users should be made aware that "some apps contain unreliable, non-peer-reviewed content". In studies where the quality of medical apps' advices was assessed, they varied greatly from product to product (Wolf et al., 2013; Visvanathan, Hamilton & Brady, 2012; Haffey, Brady & Maxwell, 2013; Ferrero, Morrell & Burkhart, 2013). As incorrect advices of medical apps can negatively impact users' health by delaying correct diagnoses or advocating incorrect self-medication, measures to ensure their reliability have been proposed, including testing apps before publication and certification (Buijink et al., 2013; Wolf et al., 2013; Visvanathan et al., 2012; Ferrero et al., 2013). While in most taxonomies the concept of safety is present in an implicit form or through combinations of other requirements, in the medical domain it seems to take a more prominent and explicit role.

It has been proposed that the scientific evidence for medical apps' quality should be reflected in certifications by recognized authorities (Buijink et al., 2013; Visvanathan et al., 2012; Ferrero et al., 2013). Buijink et al. (2013) call for "government health authorities to provide official certification marks guaranteeing the quality of apps". While the changeable nature of apps conflicts with the process of certification, this measure is advocated for by several authors in the field, and is reflected by findings in this study (Buijink et al., 2013; Wolf et al., 2013; Visvanathan et al., 2012; Ferrero et al., 2013).

The issue of privacy has long been at odds with information technology in the medical domain, with research showing caretakers and patients alike being concerned about using health data for multiple purposes (Perera, Holbrook, Thabane, Foster & Willison, 2011). In the words of (Sarasohn-Kahn, 2010): "keeping personally identifiable health information secure is a long-standing challenge". In the domain of apps, studies have shown apps often do not provide users with adequate control over and visibility into how applications use and share their personal data (Smith, 2010; Enck et al., 2010). Marceglia et al. mention privacy breaches, through technical, organizational, or human factors, as one of the foremost concerns regarding apps in the medical domain (Marceglia, Bonacina, Zaccaria, Pagliari & Pinciroli, 2012).

Trust is a cornerstone of the medical practice and is essential in patient-caretaker relationships Croker et al. (2013), in the literature on medical apps, this aspect is underexposed. Marceglia et al. (2012) mention it as an aspect pertaining to their concern of privacy, but as a requirement in itself it is usually considered implicit.

Finally, the concept of accessibility, or ensuring users with diverse physical and psychological abilities are able to use software, has long been included as a success factor for software (International Organization for Standardization (ISO), 2011). It has, however, often been considered an implicit requirement, or categorized as a sub-concept of usability. From the results of this study it appears to have a more explicit role in the medical domain. An explanation for this finding can be sought in the likeliness that consumer-focused medical apps are to be used by people with medical histories, and

thus form a diverse group regarding abilities. While apps show great promise for empowering frailer users Sarasohn-Kahn (2010), users differing in age or ability have different usability needs from one another (Culén & Bratteteig, 2013; Nandigam, Symonds, Kayes & McPherson, 2010; Newell, Gregor, Morgan, Pullin & Macaulay, 2011; Werner, Werner & Oberzaucher, 2012).

4.2   Relative Importance Attributed To Non-Functional Requirements

After eliciting the non-functional requirements through interviewing stakeholders and investigating documentation, potential users were presented with vignettes to evaluate six relevant ones. The two groups of interviewees differed on age and amount of medication. In *Figure 2* the results of this evaluation are depicted in a graph, in order to highlight the differences between the groups. While not a quantitative study, these averages do reveal some unexpected findings that are in line with the researchers' understanding of the interviews.

One of the outstanding insights is the difference in judgment of usability between the two groups; the group of older respondents indicated assigning greater importance to applications' ease of use over extended functionality. As is evident from the requirement frameworks shown in *Table 1*, usability has long been recognized as a crucial factor for software's success. This holds true for all demographics, but research has shown elderly have different usability needs from younger users (Culén & Bratteteig, 2013; Werner et al., 2012). Reading small-sized text or clicking small areas for several seconds may pose problems for some elderly (Culén & Bratteteig, 2013). Renaud and Van Biljon (2008) prove that in their senior-focused extension of Davis (1989) technology acceptance model, software's limited ease of use may make elderly users reject it. Thus, while the rise of touch interfaces on smartphones and tablets is often seen as presenting new opportunities for catering to an aging user base, the importance of usability for this demographic is evident. Family caregiver #1 expressed her concerns regarding this: "I cannot use those [smartphones or tablets]. I even used to find phones difficult back in the day. [...] I do not think I would learn to use new devices quickly at my age."

Another relative difference between the younger and older response groups can be observed with the concept of certifiability. The younger respondents indicated valuing certified apps more than older respondents, the majority of whom put more confidence in their GPs' suggestions. A sense of certifiability, thus, may be related to the authority people assign to their physicians. A recent study by Croker et al. (2013) showed that people's trust in their GPs increases with their age. This finding is reflected in the results of this study. As polypharmacy patient #2 remarked, "I would rather leave [my drugs management] to my GP; he knows what he is doing."

A final insightful observation is the fact that most the respondents rated privacy as one of the least important non-functional requirements. Only one of them indicated not wanting to share their information with other patients at all; the others were willing to share their data, either anonymously or personally, if it would benefit their own experiences with the software. This finding does not reflect the importance that is generally attributed to matters of privacy (Perera et al., 2011; Marceglia et al., 2012). It does reflect the findings of a recent study on laymen's perspectives on health technology, which found that "especially for the chronically and acutely ill, privacy is of far less concern to patients than to health professionals" (Walker, Ahern, Le & Delbanco, 2009). The benefits software brings to polypharmacy patients managing taxing daily routines may outweigh the disadvantages of privacy infringement.

5   Conclusion

In this study, the authors sought to explore non-functional requirements that apply to mobile medical apps. Through methods of stakeholder interviews, document analyses, and user evaluations, the following nine non-functional requirements were found: accessibility, certifiability, portability, privacy, safety, security, stability, trustability, and usability.

Six of these were evaluated with potential users of medical apps, which revealed that the importance placed in apps' certification decreases with age and destitution, in favor of the GPs' judgment. In contrast, the value placed in usability increases with age and destitution. The concept of privacy was the concept least valued by respondents of any age group. Trustability, security, and, for the younger group, certifiability, were considered the most important non-functional requirements for medical apps.

5.1   Implications for Design

If these non-functional requirements lead to augmentations or limitations of software depends on the context and implementation of the application. Glinz (2007) argues that "the notion of non-functional requirements is representation-dependent", meaning that requirements can take the form of constraints, performance requirements, quality attributes, or even functional requirements, depending on how they are modeled.

Depending on which age group the app is focused on, more or less attention should be placed on certifiability or usability. Older, frailer users would adopt an application quicker if it were recommended by their GPs, while younger, healthier persons would put more faith in certifications. Moreover, and in contrast to older people, younger persons would favor more extended functionality over ease of use.

During the evaluation interviews, respondents were asked what features they would like to see included in a mobile medical application (out of a shortlist of ten preselected items). Out of these, respondents rated the more comprehensive features (overview of their health records, ability to log side effects or complaints, automatic medicine checks) higher than the more conventional ones (medicine reminders, sharing experiences with other patients, directly contacting their GPs). These more comprehensive features come into conflict with the non-functional requirements quicker than the other ones, which implies that a careful trade-off between user-requested functionalities and the infringements these make on non-functional requirements should be made.

5.2   Limitations & Further Research

Even though the utmost care was taken in the conduction of this study, some reservations should be made when interpreting its results. Even though a total of nine non-functional requirements were discovered in the elicitation process, only six of these were evaluated with potential users. This decision was made because it proved impossible for potential users of medical apps to judge technical aspects such as stability, portability and accessibility during vignette-guided interviews. In future studies, other methods, such as semi-structured interviews or card sorting, may be applied to further discover the importance potential users attribute to these non-functional requirements.

A wide variety of stakeholders and potential users were included in this study to gain insights into non-functional requirements for medical mobile applications. However, the qualitative nature of the research and the limited number of interviewees make generalizing its results difficult. In future studies, the results of this study should be validated by quantitatively testing them with a representative sample of potential users.

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