USABILITY EVALUATION OF MOBILE INFORMATION AND COMMUNICATIONS TECHNOLOGY IN HEALTH CARE

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USABILITY EVALUATION OF MOBILE INFORMATION AND COMMUNICATIONS TECHNOLOGY IN HEALTH CARE

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I hereby declared that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referred all material and results that are not original to this work.

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ABSTRACT

USABILITY EVALUATION OF MOBILE INFORMATION AND COMMUNICATIONS TECHNOLOGY IN HEALTH CARE

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Technology plays an increasingly important role in modern health care. This thesis presents an approach to usability evaluation of mobile information and communications technologies designed for diabetes patients' use in their daily lives. According to our study conducted on 60 diabetes patients, several important findings are obtained. Fifty nine (98.3%) diabetes patients were highly satisfied with the mobile health technology and expressed that they would use it, and found the measured values reliable. For 57 (95%) diabetes patients; measuring, checking and accessing the blood glucose level easily anytime and anywhere were very important. Fifty six (93.3%) said that they would wish to send their blood glucose levels to their physicians via e-mail. When participants were asked to provide a decision on future health care, predominate number of participants said they would change their lifestyle rather than visit a doctor regardless of their blood glucose level. In conclusion, little is known about such effects of mobile information and communications technologies in self-management care situations. It is clear that usability studies in the field are more difficult to conduct than laboratory evaluations. Further studies with larger sample sizes are needed to further evaluate these initial findings.

Keywords: Usability Evaluation, Mobile Health, Health Care, Diabetes

ÖZ

MOBİL BİLGİ VE İLETİŞİM TEKNOLOJİLERİNİN SAĞLIK BAKIMINDA KULLANILABİLİRLİK DEĞERLENDİRMESİ

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Modern sağlık hizmetlerinde, teknolojinin rolü ve önemi artmaktadır. Bu tezde, diyabet hastaları için tasarlanmış mobil bilgi ve iletişim teknolojilerinin, hastaların günlük hayatlarında kullanılabilirliğini değerlendiren bir yaklaşım sunulmaktadır. 60 diyabet hastası üzerinde yapılan çalışmada, önemli bulgular elde edildi. Diyabet hastalarından 59'u, (%98,3) mobil sağlık teknolojisini kullanmaktan son derece memnun kaldığını, bu teknolojiyi kullanmak isteyeceklerini ve ölçümleri güvenilir bulduklarını belirtti. Diyabet hastalarından 57'si, (%95) kan şekeri seviyelerini her an ve her yerde kolayca ölçmek, kontrol etmek ve erişebilmenin kendileri için önemini belirtti. Çalışmaya katılan diyabet hastalarından 56'sı, (%93,3) kan şekeri değerini doktorlarına e-posta ile iletmek isteyeceklerini belirtti. Çalışmaya katılan hastalara gelecekteki sağlık hizmetleri için düşünceleri sorulduğunda, büyük çoğunluk, kan şekeri seviyesinden bağımsız olarak, doktora görünmektense yaşam biçimlerini değiştirmeyi tercih edeceklerini belirttiler. Sonuç olarak, mobil bilgi ve iletişim teknolojilerinin sağlık özyönetimindeki etkileri hakkında çok az şey biliniyor. Bu alandaki "kullanılabilirlik" çalışmalarını gerçekleştirmenin laboratuar ölçümlerinden daha zor olduğu açıktır. Bu çalışma ile elde edilen ilk bulguların daha ayrıntılı değerlendirilebilmesi için daha büyük örneklem büyüklükleri ile çalışmalar yapılması gerekmektedir.

Anahtar Kelimeler: Kullanılabilirlik Değerlendirmesi, Mobil Sağlık, Sağlık Bakımı, Şeker Hastalığı

DEDICATION

To My Parents

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1. INTRODUCTION

Like the television in the 1950s and the internet in 1990s, mobile telephony has emerged as one of the defining information and communications technology of our time [1]. It has been said that the diffusion of mobile telephony has been the fastest for any information and communications technology in human history [2]. Throughout the world, information and communications technology is becoming more important in modern health care. The complexity of information and communications technology makes usability an important selection criterion when new equipment is purchased, moving the user interfaces of health care systems on to mobile devices, doctor - patient dialogues, quality in use and etc. Usability evaluation of mobile information and communications technology in health care consequently requires new ways of designing and doing tests, new ways of recording user and system behavior, and new ways of analyzing the test data.

Over the last 50 years, the number of people at age of 60 and over has tripled, and is expected to triple again up to approximately two billion by 2050 [3]. Population ageing is a global phenomenon affecting all regions. Globally, the proportion of elderly people was 8% in 1950 and 10% in 2000, and is projected to reach 21% in 2050 [4].

Population ageing is profound, having major consequences and implications for all facets of human life, including health and health care. Indeed, as we age, the incidence and prevalence of chronic diseases continue to increase. Chronic diseases have become major causes of death in almost all countries.

World Health Organization (WHO) health experts note that within 15 years policymakers and health providers in the developing world will be forced to direct their focus towards prevention and early detection of non-communicable diseases, rather than late-stage treatment [5]. This gap creates an inevitable role for mobile information and communications technology which is becoming more important in modern health care. Smart mobile devices offer media-rich and context-aware features that are highly useful for electronic health (e-health) applications. It is therefore not surprising that these devices have gained acceptance as target devices for e-health applications, turning them into mobile health (m-health) applications. M-health applications are moving into the arena of consumer health informatics as tools that support patient-centered models of health care by enhancing patient involvement and self-management capabilities.

It is projected that by the year 2014, public and private health care providers could save between $1.96 billion to $5.83 billion in health care costs worldwide by utilizing m-health technologies for health monitoring. Furthermore m-health technology market is also expected to grow 25% annually, from current $1.5 billion to $4.6 billion by 2014 [6].

Over the next 10 years, the cost of non-communicable diseases such as diabetes, heart disease, and stroke will occupy a significant portion of the government budgets. According to WHO; diabetes, heart disease, and stroke together will cost about $555.7 billion in lost national income in China; $303.2 billion in the Russian Federation; $336.6 billion in India; and 49.2 billion in Brazil [7]. Besides these countries, the cost will be significant for many other nations.

Diabetes, as being one of the major non-communicable diseases, affects 285 million people worldwide, which represents 6.4% within the age group 20-79. This value is expected to reach 438 million (7.7% of the same domain) by 2030, globally [8]. When we focus on these numbers for the same domain within Turkish population, it is observed that the percentage is 7.4% by 2010, with a health cost per capita of 572 USD/person. This cost reflects a 40% increase between 1995 – 2010 [9].

The mobile information and communications technologies were introduced in the health care market to help patients take better care of their health and also reduce the cost of health care. This thesis presents an approach to usability evaluation of mobile information and communications technologies designed for diabetes patients' use in their daily lives. Studies have shown that chronic diseases may be prevented or controlled by patients caring for themselves via self-management care and monitoring, thereby transforming the care process into a continuous collaboration between patients and health care providers. As a result of aging population, it is possible to observe an overall toward a more personalized model of health care. There is an increasing awareness of the need for higher usability of mobile information and communications technology in health care. Little is known about such effects of mobile information and communications technologies in self-management health care situations.

2. REVIEW of LITERATURE

2.1 Mobile Information and Communications Technology

There is at present no consensus on a definition of mobile technology. In, Weilenmann (2003) does a review of the literature on mobile usability and ends with a fairly open definition of mobile technology: "…a technology which is designed to be mobile" [10]. The definition by Svanes et al. (2010): Mobile technology is technology that provides digital information and communication services to users on the move either through devices that are portable per se, or through fixed devices that are easily ready at hand at the users' current physical position [11]. Mobile devices are the familiar handheld devices include Tablet Personal Computers (PCs), Personal Digital Assistants (PDAs), and smart phones, but also opens up for ubiquitous and pervasive technologies, multi-user, and multi-device systems. Modern mobile devices have advanced in capabilities over the recent past. These devices are now being used to not only review text, but also to perform a variety of health care-related tasks at the point of care [12].

Evidence from selected studies carried out by the United Nations Conference on Trade and Development (UNCTAD) shows that mobile phones have become the most important mode of telecommunication in developing countries [13]. This growing ubiquity of PDAs and smart phones is a central element in the promise of mobile information and communications technology (ICT) for health care.

Mobile information and communications technology can be a major "force multiplier" in health care. It can empower both patients and health care providers by providing them with the information they need to make inform decisions about health issues from healthy living habits, to health care provision, and monitoring of diseases [14]. Moreover, by removing boundaries, these technologies may reduce economic disparities, lessen health care costs and promote more self-management health care [15].

M-health is a general term that covers areas of networking, mobile computing, medical sensors, and other communication technologies within health care and is aimed at developing and describing the use of mobile information and communications technology for health care purposes. There are three key components in m-health service, namely mobile devices, software platforms, and m-health applications.

A mobile device, which is also referred to as a handheld, handheld device or handheld computer, is a pint-sized computing device. Most mobile devices can also be equipped with Wireless Fidelity (WI-FI), bluetooth and Global Positioning System (GPS) capabilities that can allow connections to the internet and other bluetooth capable devices. A mobile device has an Operating System (OS), and can run various types of application software, known as apps.

Apple's iPhone Operating System (iOS) and Google's Android have centralized application stores. Apple's application store has been the number one application marketplace in terms the number of applications available. Based on the statistics from m-Health Initiative Inc. [16], the number of m-health applications on Apple's mobile platform was far greater than the numbers of m-health applications on other platforms by the end of 2009. There were 1056 applications in Medical category as of January 14, 2011, and 1004 applications in the Healthcare & Fitness category as of January 18, 2011 [17]. The numbers increased every day. In the Apple Store, over 500.000 actually. There were 8037 paid and 7929 free applications (totally 15966 apps) in Medical category in Apple's application store (September 10th, 2012). The growth rate of health and fitness apps intended for use by consumers continues to accelerate. Despite challenges around regulation, discoverability, and proving efficacy, health apps have shown no signs of slowing down to date. As of September 10th, 2012, 13536 paid and 12036 free applications (totally 25572 apps) iPhone Health & Fitness apps available for consumers.

At the end of 2010, following Apple, Google also launched a brand new medical category within the Android Market [18]. Although it is certain that the impact of m-health applications published in the Android Market will continue to grow [19]. The use of mobile applications offers a highly accessible and cost-effective means of implementing motivational and self-management programs. These take advantage of computer capabilities as well as the power of networking.

2.2 Diabetes Mellitus

Diabetes mellitus and lesser forms of glucose intolerance, particularly impaired glucose tolerance, can now be found in almost every population in the world and epidemiological evidence suggests that, without effective prevention and control programs, diabetes will likely continue to increase globally.

Diabetes is recognized as a group of heterogeneous disorders with the common elements of hyperglycemia and glucose intolerance, due to insulin deficiency, impaired effectiveness of insulin action, or both. Diabetes mellitus is classified on the basis of etiology and clinical presentation of the disorder into four types: Type 1 diabetes, Type 2 diabetes, gestational diabetes, and other specific types.

Type 1 diabetes is an autoimmune disease that affects 10 – 15% of those with diabetes. It is caused by an absence of insulin produced in the body, with onset mostly before the age of 30 years, the exact cause being unknown. Type 2 diabetes affects 85 – 90% of those with diabetes and is caused by the body not effectively using the insulin it produces because its cells are resistant to the action of the insulin [20]. It is often caused by obesity, age and genetic risk factors, with onset usually after the age of 40 years.

The worldwide increase in diabetes prevalence [21], attributable to rising incidence and declining mortality [22], generates a growing demand and cost for medical care [23].

The global burden of diabetes has been estimated several times. In 1994, the International Diabetes Federation (IDF) Directory [24] included type 1 and type 2 diabetes estimates supplied by member nations. Using these data, IDF estimated that over 100 million people worldwide had diabetes. Also in 1994, McCarty et al [25], 1994) used data from population-based epidemiological studies and estimated that the global burden of diabetes was 110 million in 1994 and that it would likely more than double to 239 million by 2010.

Population ageing is a global phenomenon affecting all regions. WHO also produced a report using epidemiological information and estimated the global burden at 135 million in 1995, with the number reaching 299 million by the year 2025. In 1997, Amos et al estimated the global burden of diabetes to be 124 million people, and projected that this would increase to 221 million people by the year 2010 [26]. In the 2006 third edition of the Diabetes Atlas the estimates were of 246 million people worldwide with diabetes for 2007, and an anticipated 380 million for 2025 [27].

For the Diabetes Atlas fourth edition, Diabetes mellitus affects 285 million people worldwide, or 6.4%, in the age group 20-79. About 70% of these live in low-and middle-income countries. The worldwide estimate is expected to increase to some 438 million or 7.7% of the adult population, by 2030 (Table 1). The largest increases will take place in the regions dominated by developing economies.

Table 1. Regional estimates for diabetes (20 - 79 age group), 2010 and 2030

	2010			2030			2010/2030
	Population (20-79)	No. of people with diabetes	Comparative diabetes prevalence	Population (20-79)	No. of people with diabetes	Comparative diabetes prevalence	Increase in the no. of people with diabetes
Region	**millions**	**millions**	**%**	**millions**	**millions**	**%**	**%**
AFR	379	12.1	3.8	653	23.9	4.7	98.1%
EUR	646	55.4	6.9	659	66.5	8.1	20.0%
MENA	344	26.6	9.3	533	51.7	10.8	93.9%
NAC	320	37.4	10.2	390	53.2	12.1	42.4%
SACA	287	18.0	6.6	382	29.6	7.8	65.1%
SEA	838	58.7	7.6	1,200	101.0	9.1	72.1%
WP	1,531	76.7	4.7	1,772	112.8	5.7	47.0%
Total	**4,345**	**284.8**	**6.4**	**5,589**	**438.7**	**7.7**	**54.0%**

It is now recognized that it is the low- and middle-income countries that presently face the greatest burden of diabetes. However, many governments and public health planners still remain largely unaware of the current magnitude, or, more importantly, the future potential for increases in diabetes and its serious complications in their own countries. Diabetes is certain to be one of the most challenging health problems in the 21st century.

In addition to diabetes, the condition of impaired glucose tolerance (IGT) also constitutes a major public health problem, both because of its association with diabetes incidence and its own association with an increased risk of the development of cardiovascular disease.

Table 2. World estimates for diabetes and impaired glucose tolerance (20-79 age group), 2010 and 2030

*R=2: Cost ratio for the low- and middle-income countries.

	2010	2030
Population		
Total world population (billions)	7.0	8.4
Adult population (age 20-79, billions)	4.3	5.6
Diabetes (20 - 79 age group)		
Comparative prevalence (%)	6.4	7.7
Number of people with diabetes (millions)	285	439
IGT (20 - 79 age group)		
Comparative prevalence (%)	7.8	8.4
Number of people with IGT (millions)	344	472
Diabetes Mortality (20 - 79 age group)		
Diabetes Mortality (Male)	1.826.485	-
Diabetes Mortality (Female)	2.136.571	-
Costs of Diabetes		
Cost of Diabetes per Person (R=2*)	703 USD	

The chronic nature of diabetes and its devastating complications make it a very costly disease. When we focus on these numbers for the same domain within Turkish population, it is observed that the percentage is 7.4% by 2010, with a health cost per capita of 572 USD/person. This cost reflects a 40% increase between 1995 – 2010.

2.3 The Definition of Usability

The quality and consumer acceptability of a product mostly depends on the ease-of-use, physical, mental and psychological characteristics which are more important than the technical properties of the product. Consumers pay more attention to the ease-of-use-property of a product [28]. Therefore, designers are aware that their products need to be designed so that users can use the products to a satisfying degree. Usability is not a single property, but a combination of several properties and attributes [29].

The concept of usability was defined in the field of human-computer interaction (HCI) as the relationship between humans and computers.

Usability approach is focusing on the method of collecting data. It is based on the exploration of the user experience by knowing their perspective. It is measured by three parameters; the effectiveness and the efficiency of the design or facilities offered and the user's satisfaction.

Nielsen has defined five key attributes (*learnability, efficiency, memorability, errors, and satisfaction*) with which usability is traditionally associated [30].

According to Bevan, the objective of usability is to *achieve quality of use* as it lies in the interaction of the user with the system [31].

The International Organization for Standardization (ISO) proposed two definitions of usability in ISO 9241 and ISO 9126.

ISO 9241 defines usability as '*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*' [32].

ISO 9126, usability compliance is one of five product quality categories, in addition to *understandability, learnability, operability,* and *attractiveness* [33].

ISO 9241 standard, which provides guidance to usability professionals, has been extended with ISO 9241-210 (2010), which explicitly describes *usability* and *user experience* as converging [34].

Furthermore, the ISO 9241-210 standard describes human-centered activities and design principles for developing interactive systems.

This definition emphasizes the relation between usability and context of use:

- usability does not exist in any absolute sense,
- and it can only be defined with reference to a particular context.

A product, system or service is not itself *usable* or *unusable*, but it has attributes which will determine the usability for a particular user, task, and environment.

ISO 9241 consists of 17 parts, under the general title *Ergonomic requirements for office work with visual display terminals (VDTs)*. Part 11 which name is guidance on usability (ISO 9241-11) defines usability and explains how to identify the information which is necessary to take into account when specifying or evaluating usability of a visual display terminal in terms of measures of user performance and satisfaction. Definitions as follows;

Usability: Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

Effectiveness: Accuracy and completeness with which users achieve specified goals.

Efficiency: Resources expended in relation to the accuracy and completeness with which users achieve goals.

Satisfaction: Freedom from discomfort, and positive attitudes towards the use of the product.

Context of use: Users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used.

Work system: System, consisting of users, equipment, tasks and a physical and social environment, for the purpose of achieving particular goals.

User: Person who interacts with the product.

Goal: Intended outcome.

Task: Activities required achieving a goal. Characteristics of tasks which may influence usability should be described, e.g. the frequency and the duration of the task.

Product: Part of the equipment (hardware, software and materials) for which usability is to be specified or evaluated.

Measure: Value resulting from measurement and the process used to obtain that value.

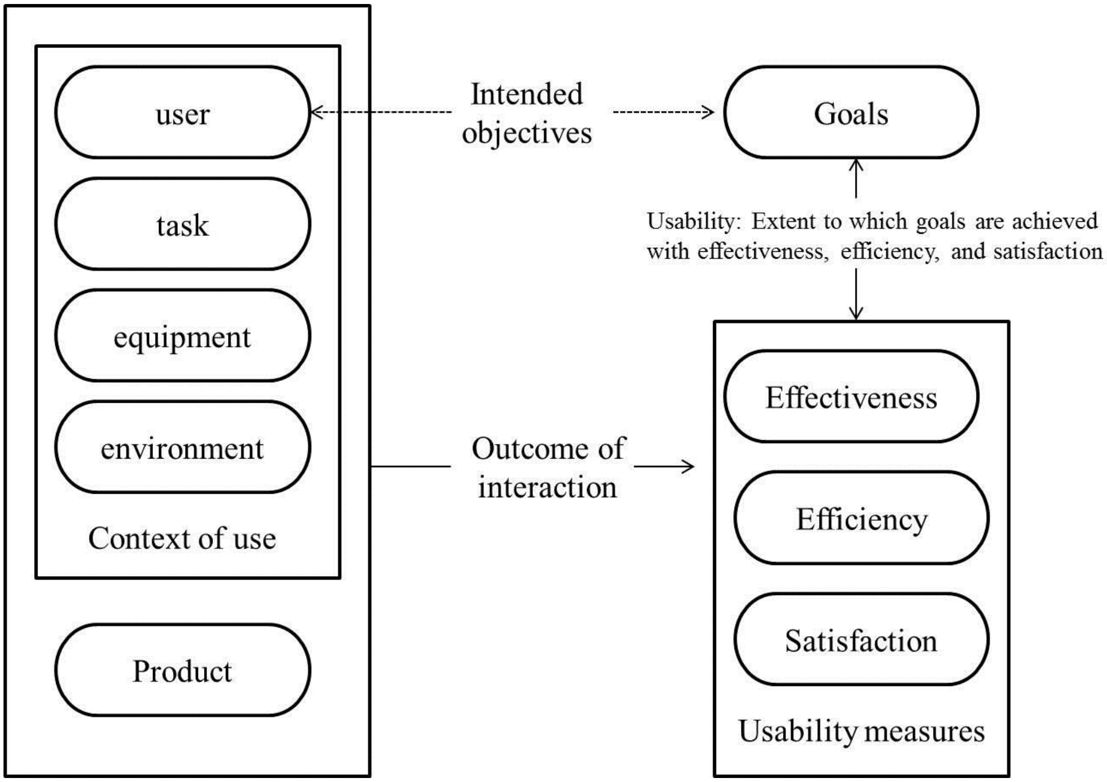


Figure 1 Usability Framework

ISO definition is difficult to use as it is not easily translated into questions that are easily answered by users. Nielsen's (1993) definition of usability is more helpful as it is focused on equipment properties and attributes and easily translates into questions. The definition states that usability is associated with five components:

Errors EFFECTIVENESS: The system should have a low error rate, so that users make few errors during the use of the system and error recovery is easy.

Learnability EFFICIENCY: The system should be easy to learn so that the user can rapidly start getting some work done with the system.

Memorability EFFICIENCY: The system should be easy to remember, so that the casual user is able to return to the system after some period of not having used it, without having to learn everything all over again.

Efficiency EFFICIENCY: The system should be efficient to use, so that once the user has learned the system, a high level of productivity is possible.

Satisfaction SATISFACTION: The system should be pleasant to use, so users are subjectively satisfied when using it.

These five components can all be translated into components of the ISO definition. The ISO component effectiveness relates to the Nielsen component few errors. The three Nielsen components learnability, memorability and efficiency all relate to the ISO component efficiency. The final Nielsen component, satisfaction, corresponds to the ISO component satisfaction.

Using Nielsen's (1993) definition, the overall concept of usability consists of five components that constitute different percentages of overall usability.

2.4 Evaluation Approaches and Methods

The usability studies started in the 1950s, emerging from various disciplines, backgrounds and fields and is widely known in relation to applications within product design, information technology and human-computer interaction [35].

While the human-computer interaction community has come a long way in developing and using methods to evaluate usability, the problem is by no means solved. There is not yet agreement in the community about which evaluation is more useful than another. The current best practice is to use a number of different evaluation methodologies to provide rich data on usability.

Evaluation methodologies were, for the most part, developed to evaluate the usability of desktop systems. The current focus in technology development of mobile and ubiquitous computing presents challenges for current usability evaluation methods. Laboratory evaluations will be hard pressed to simulate use conditions for these applications. Going out into the field to evaluate use places constraints on how early evaluations can be done. Mobile and multi-user systems must be evaluated for privacy and any usability issues entailed in setting up, configuring, and using such policies. The use of such devices in the context of doing other work also has implications for determining the context of use for usability testing.

The three main evaluation approaches are: (1) usability testing; (2) field studies; and (3) analytical evaluation. Each of these approaches has several methods associated with it. The methods used in evaluation are: observing users, asking users, e.g. through interviews and questionnaires, asking experts, user testing, inspections, and modeling users' performance. Some approaches use the same methods.

Usability testing: An evaluation approach to evaluation that involves measuring users' performance and evaluating their satisfaction with the system in question on certain tasks in a laboratory setting.

Field studies: A study that is done in a natural environment such as at home as opposed to a study in a controlled setting such as a laboratory.

Analytical evaluation: An approach to evaluation that does not involve end-users. Heuristic evaluation, walkthroughs, and modeling are forms of analytical evaluation.

Technology is being used by more people. The range of users using mobile phones, for example, means that representative users need to be selected from teenagers to grandparents. New usability evaluation methodologies will be developed to meet the demands of our technology - focused society. Researchers and practitioners in usability will need to join forces to meet this challenge. Moreover, there is an increasing awareness of the need for higher usability of mobile health. When mobile health devices are purchased, manufacturers & decision-makers usually have information about e.g. cost and functionality, but very little information about the usability of the devices under consideration for purchase. The increased complexity of mobile health makes usability an important selection criterion when new device is purchased. However, this requires an understanding of what usability is in an m-Health context and what usability evaluation methods are suitable.

2.5 Usability Evaluation Methods

Although several taxonomies for classifying Usability Evaluation Methods (UEMs) have been proposed, UEMs can in general terms be principally classified into two different types: empirical and analytical / inspection methods.

Empirical UEMs are based on capturing and analyzing usage data from real end-users. Real end-users employ the software product (or prototype) to complete a predefined set of tasks while the tester (human or specific software) records the outcomes of their work. Analysis of these outcomes can provide useful information to detect usability problems during the user’s task completion [36].

Analytical UEMs rely on the judgment of one or more evaluators and do not involve actual users.

In this study usability evaluation methods were introduced without grouping into categories as follows;

2.5.1 Interviews

Interviews can be thought of as a “conversation with a purpose” [37]. How like an ordinary conversation the interview can be depends on the type of interview method used. There are four main types of interviews: open-ended or unstructured, structured, semi-structured, and group interviews [38].

Open-ended or unstructured interviews

Questions posed by the interviewer are open, meaning that there is no particular expectation about the format or content of answers. Open questions are used when you want to explore the range of opinions. For instance, “What do you do when you feel your blood glucose level decreased or increased?”.

Structured interviews

In structured interviews, the interviewer asks predetermined questions similar to those in a questionnaire. Structured interviews are useful when the goals are clearly understood and specific questions can be identified. In a structured interview the same questions are used with each participant so the study is standardized. Example questions for a structured interview might be:

> Have you ever monitored your blood glucose level with a device?
>
> If so, how often do you monitor your blood glucose level with a device: once a day, twice a day, and etc.

Questions in a structured interview should be worded exactly the same for each participant, and they should be asked in the same order.

Semi-structured interviews

Semi-structured interviews combine features of unstructured and structured interviews and use both closed and open questions. The interviewer starts with preplanned questions and then probes the interviewee to say more until no new relevant information is forthcoming. For example:

> Would you like to buy a mobile health device?
>
> Why?

It is important not to pre-empt an answer by phrasing a question to suggest that a particular answer is expected. Also, the interviewer needs to give the person time to speak and not move on too quickly. For example, “Do you want to tell me anything else about the mobile health devices?”.

Focus groups

A focus group is a moderated discussion among six to nine users or potential users of your site. A typical focus group lasts about two hours and covers a range of topics that you decide on beforehand.

Focus groups are a traditional market research technique, so marketing departments are often more familiar with focus groups than with usability testing or contextual interviews. However, the techniques produce different kinds of information. In a typical focus group, participants talk; you hear them tell you about their work. In a typical usability test or contextual interview, users act; you watch (and listen to) them doing their work.

You will learn about user's attitudes, beliefs, desires, and their reactions to ideas or to prototypes.

2.5.2 Questionnaires

Questionnaires are well-established technique for collecting demographic data and users' opinions. They are similar to interviews in that they can have closed or open questions. Effort and skill are needed to ensure that questions are clearly worded and the data collected can be analyzed efficiently.

Questionnaires are probably the only usability method that makes such extensive coverage feasible, with the ensuing possibility for discovering differences between various user categories as well as the specific needs of various small groups of users.

Questionnaires may contain open questions where the users are asked to write in their own reply in natural language, but users often do not bother to do so, or they may write cryptic statements that are hard to interpret. Therefore, questionnaires normally rely heavily on closed questions, where the users have to supply a single fact, go through a checklist, or state their opinion on a rating scale. Rating scales are often used to ask users how well they liked various aspects of the system or how useful they find different features.

Choosing and combining techniques

It is usual to combine data gathering techniques in any one data gathering program in order to triangulate findings. Choosing which data gathering techniques to use depends on a variety of factors pertaining to the focus of the study, the participants involved, the nature of the technique, and the resources available. For example, observation to understand the context of task performance, interviews to target specific groups, questionnaires to reach a wider population, and focus groups to build a consensus view. There is no 'right' technique or combination of techniques, but the decision will need to take all of these factors into account. Many different combinations are used in practice [39].

Table 3. Overview of data gathering techniques used in the study.

Technique	Good for	Kind of data	Advantages	Disadvantages
Interviews	Exploring issues.	Some quantitative but mostly qualitative.	Interviewer can guide interviewee if necessary. Encourages contact between developers and users.	Time-consuming. Artificial environment may intimidate interviewee.
Questionnaires	Answering specific questions.	Quantitative and qualitative.	Can reach many people with low resource.	The design is crucial. Responses may not be what you want.

2.5.3 Task Analysis

Task analysis is used mainly to investigate an existing situation, not to envision new products. It is used to analyze the underlying rationale and purpose of what people are doing: what are they trying to achieve, why are they trying to achieve it, and how are they going about it?

Task analysis is an umbrella term that covers techniques for investigating cognitive processes and physical actions, at a high level of abstraction and in in minute detail. In practice, task analysis techniques have had a mixed reception. The most widely used version is Hierarchical Task Analysis (HTA), another well-known task analysis technique called GOMS (Goals, Operations, Methods, and Selection rules) that models procedural knowledge.

Hierarchical Task Analysis (HTA)

Hierarchical Task Analysis (HTA) was originally designed to identify training needs [40]. It involves breaking a task down into subtasks and then into sub-subtasks and so on. These are then grouped together as plans that specify how the tasks might be performed in an actual situation. HTA focuses on the physical and observable actions that are performed, and includes looking at actions that are not related to software or an interactive product at all. The starting point is a user goal. This is then examined and the main tasks associated with achieving that goal are identified. Where appropriate, these tasks are subdivided into subtasks.

Indentation shows the hierarchical relationship between tasks and subtasks. And how the numbering works for the task analysis: the number of the plan corresponds to the number of the step to which the plan relates.

GOMS (Goals, Operators, Methods, and Selection)

GOMS is a method for examining the individual components of a user experience in terms of the time it takes a user to most efficiently completes a goal. GOMS is an acronym that stands for Goals, Operators, Methods, and Selection Rules [41]. Goals are defined as what the user desires to accomplish on the website. Operators are the atomic-level actions that the user performs to reach a goal, such as motor actions, perceptions, and cognitive processes. Methods are procedures that include a series of operators and sub-goals that the user employs to accomplish a goal. Selection Rules refer to a user's personal decision about which method will work best in a particular situation in order to reach a goal.

2.5.4 Heuristic Evaluation

In a heuristic evaluation, a small set of evaluators inspects a system and evaluates its interface against a list of recognized usability principles – heuristics. Typically, these heuristics are general principles, which refer to common properties of usable systems. The 10 most general principles for user interface design. They are called "heuristics" because they are more in the nature of rules of thumb than specific usability guidelines [42];

Visibility of system status: The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

Match between system and the real world: The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

User control and freedom: Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

Consistency and standards: Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

Error prevention: Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

Recognition rather than recall: Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

Flexibility and efficiency of use: Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

Aesthetic and minimalist design: Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

Help users recognize, diagnose, and recover from errors: Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

Help and documentation: Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

In performing a heuristic evaluation, each evaluator steps through the interface twice. First, to get a general idea about the general scope of the system and its navigation structure. Second, to focus on the screen lay out and interaction structure in more detail, evaluating their design and implementation against the pre-defined heuristics. Each heuristic evaluation results in a list of usability flaws with reference to the heuristic violated. After the problems are found, preferably each evaluator independently estimates the severity of each problem (as discussed below) [43]. Once all evaluations have been conducted, the outcomes of the different evaluators are compared and compiled in a report summarizing the findings.

An advantage of heuristic evaluation is the evaluator finds individual usability problems, and can address expert user issues. On the other hand, heuristic evaluation does not involve real users, so does not find “surprises” relating to their needs.

Severity Rating Scale: Severity ratings can be used to allocate the most resources to fix the most serious problems and can also provide a rough estimate of the need for additional usability efforts. If the severity ratings indicate that several disastrous usability problems remain in an interface, it will probably be unadvisable to release it. But one might decide to go ahead with the release of a system with several usability problems if they are all judged as being cosmetic in nature.

Finally, of course, one needs to assess the market impact of the problem since certain usability problems can have a devastating effect on the popularity of a product, even if they are "objectively" quite easy to overcome. Even though severity has several components, it is common to combine all aspects of severity in a single severity rating as an overall assessment of each usability problem in order to facilitate prioritizing and decision-making.

It is difficult to get good severity estimates from the evaluators during a heuristic evaluation session when they are more focused on finding new usability problems. Also, each evaluator will only find a small number of the usability problems, so a set of severity ratings of only the problems found by that evaluator will be incomplete. Instead, severity ratings can be collected by sending a questionnaire to the evaluators after the actual evaluation sessions, listing the complete set of usability problems that have been discovered, and asking them to rate the severity of each problem. Since each evaluator has only identified a subset of the problems included in the list, the problems need to be described in reasonable depth, possibly using screen dumps as illustrations. The descriptions can be synthesized by the evaluation observer from the aggregate of comments made by those evaluators who had found each problem (or, if written evaluation reports are used, the descriptions can be synthesized from the descriptions in the reports). These descriptions allow the evaluators to assess the various problems fairly easily even if they have not found them in their own evaluation session. Typically, evaluators need only spend about 30 minutes to provide their severity ratings. It is important to note that each evaluator should provide individual severity ratings independently of the other evaluators.

Often, the evaluators will not have access to the actual system while they are considering the severity of the various usability problems. It is possible that the evaluators can gain additional insights by revisiting parts of the running interface rather than relying on their memory and the written problem descriptions. At the same time, there is no doubt that the evaluators will be slower at arriving at the severity ratings if they are given the option of interacting further with the system. Also, scheduling problems will sometimes make it difficult to provide everybody with computer access at convenient times if special computer resources are needed to run a prototype system or if software distribution is limited due to confidentiality considerations.

Severity ratings from a single evaluator are too unreliable to be trusted. As more evaluators are asked to judge the severity of usability problems, the quality of the mean severity rating increases rapidly, and using the mean of a set of ratings from three evaluators is satisfactory for many practical purposes [44].

2.5.5 Cognitive Walkthroughs

The cognitive walkthrough (CW) is task – specific and methods that focus on the user tasks are regarded as more effective when user interfaces are evaluated [45]. The specific aims of the CW procedure are to determine whether the user's background knowledge and the cues generated by the interface are likely to be sufficient to produce the correct goal – action sequence required to perform a task. The method is intended to identify potential usability problems that may impede the successful completion of a task. To perform a CW analysis, a researcher performs a task simulation, "walking through" the sequence of actions necessary to achieve a goal. Both behavioral and physical actions are coded. The principal assumption underlying this method is that a given task has a specifiable goal – action structure (i.e., the ways in which a user's objectives can be translated into specific actions).

The CW method assumes a cyclical pattern of interaction as described previously. The codes for analysis include goals which can be decomposed into a series of sub goals and actions. For example, opening a Word sheet (goal) may involve locating an icon on one's desktop (subgoal) and double clicking on the application (action). We also characterize the system response (e.g., change in screen) and attempt to discern potential problems.

The CW differs from the heuristic evaluation in that the CW is highly structured and explicitly guided by the user's tasks. In a CW, a researcher evaluates a user interface by analyzing the cognitive processes required for accomplishing tasks that users would typically carry out supported by the application. The CW helps the researcher in examining the interplay between a user's intentions and the feedback provided by the system's interface. As a CW is focused on ease of learning of an application by users, the researcher is supposed to explore the interface without any guidance and supposed to simulate a user.

Table 4. Summary of the usability methods (Nielsen, 1993)

Method Name	Lifecycle Stage	Users Needed	Main Advantage	Main Disadvantage
Heuristic evaluation	Early design, “inner cycle” of iterative design	None	Finds individual usability problems. Can address expert user issues.	Does not involve real users, so does not find “surprises” relating to their needs.
Performance measures	Competitive analysis, final testing	At least 10	Hard numbers. Results easy to compare.	Does not find individual usability problems.
Thinking aloud	Iterative design, formative evaluation	3-5	Pinpoints user misconceptions. Cheap test.	Unnatural for users. Hard for expert users to verbalize.
Observation	Task analysis, follow-up studies	3 or more	Ecological validity; reveals users’ real tasks. Suggests functions and features.	Appointments hard to set up. No experimental control.
Questionnaires	Task analysis, follow-up studies	At least 30	Finds subjective users preferences. Easy to repeat.	Pilot work needed (to prevent misunderstandings).
Interviews	Task analysis	5	Flexible, in-depth attitude and experience probing.	Time consuming. Hard to analyze and compare.
Focus groups	Task analysis, user involvement	6-9 per group	Spontaneous reactions and group dynamics.	Hard to analyze. Low validity.
Logging actual use	Final testing, follow-up studies	At least 20	Finds highly used (or unused) features. Can run continuously.	Analysis programs needed for huge mass of data. Violation of users’ privacy.
User feedback	Follow-up studies	Hundreds	Tracks changes in user requirements and views.	Special organization needed to handle replies.

2.6 Conceptual Model

M-health is a growing field aimed at developing mobile information and communications technologies for health care. M-health devices help patients take better care of their health. After using the m-health devices and interpreting the results from the m-health device, the question that now arises is, “What do patients do with these results?” If the m-health device shows that the patients’ health is at risk do they visit their doctor or take home curative measures like controlling their insulin or do they simply ignore the results. If the m-health device shows that the patients are fine and do not have any health problems, do they trust the results and accept that they are healthy or do they still go and visit the doctor regularly.

The conceptual model of the factors affecting the usage of m-health device has been graphically represented in Figure 2.

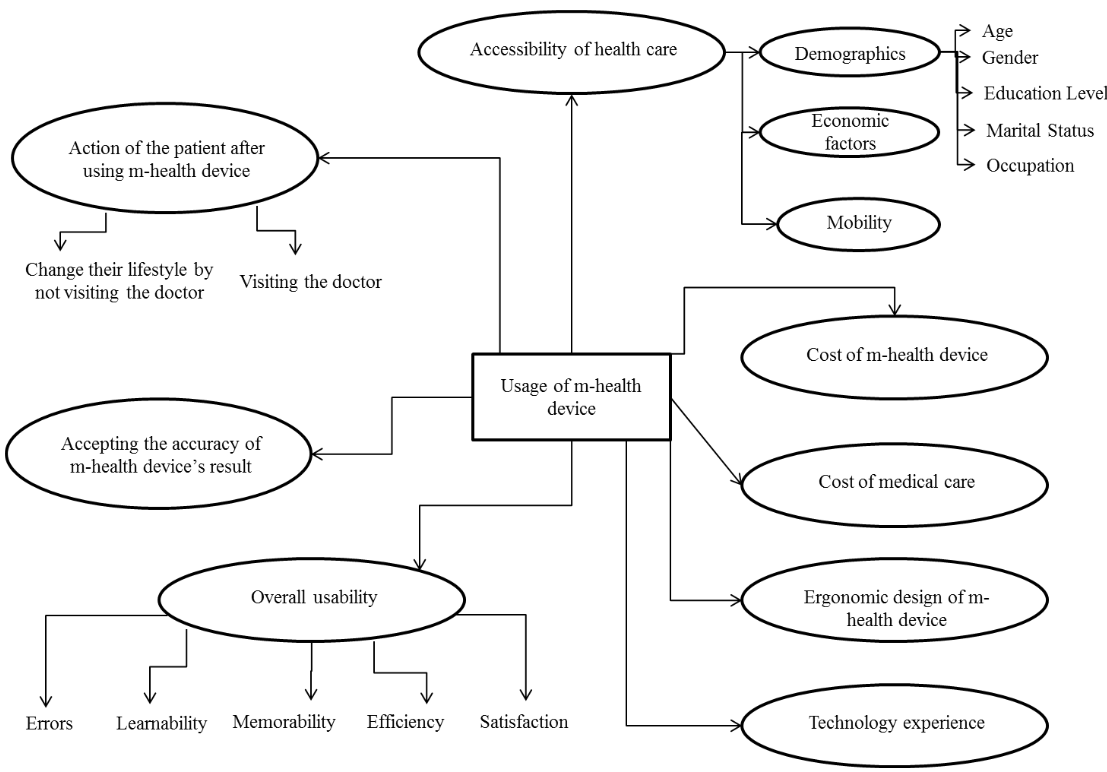


Figure 2. Conceptual model of the usage of m-health device

From the conclusions drawn from the literature review, and the conceptual model four hypotheses have been defined.

1. No difference exists in the blood glucose level measurement between m-health device and clinical evaluation (medical gold standard).
2. No difference exists in change their lifestyle rather than visit a doctor regardless of their diabetes by age, gender, education level, occupation, monthly income, marital status, type and period of diabetes, and technology experience.
3. No difference exists in the overall usability of the m-health device by age, gender, education level, occupation, monthly income, marital status, type and period of diabetes, and technology experience.
4. No difference exists in the ergonomic design of the m-health device by overall usability.

The main purpose of the study is to conduct a usability evaluation of mobile information and communications technology in health care by employing usability methods such as interviews, questionnaires, hierarchical task analysis, heuristic evaluation, and cognitive walkthrough. Each method aims to uncover complementary aspects regarding the use of mobile information and communication technologies in health care.

Standardized dimensions of usability are effectiveness, efficiency, and satisfaction. The following questions are considered to evaluate the effectiveness of the system, which aims to probe for the accuracy and completeness with which participants achieve the specified goals:

- What percentage of goals is accurately completed by the participants?
- Which subgoals are the most difficult for the participants to complete? / What kind of errors do they face when they failed to complete a subgoal?

The following questions aim to evaluate the efficiency of the mobile information and communications technology in health care:

- How long does it take participants to perform each subgoal and goal?
- What are the main design issues of mobile information and communications technology in health care in terms of established usability heuristics?

The following questions aim to probe the participant satisfaction dimension of usability:

- How do the participants rate the overall usability of the system?
- How do the participants rate the information presentation and design of the mobile information and communications technology in health care?

User satisfaction analysis is based on the participants ratings obtained from the post-questionnaire administered after the usage of mobile information and communications technology in health care.

3. METHODOLOGY

Usability evaluation is now widely recognized as critical to the success of mobile information and communications technology in health care applications. In this study several methods have been employed to investigate the usability of the m-health device selected for evaluation.

3.1 Design

A study was conducted at the Department of Endocrinology at Marmara University Pendik Training and Research Hospital, Istanbul, Turkey. Factors measured were usability questionnaire scores for mobile health device, future health care decision of the participants based on the mobile health device, and the accuracy of the mobile health device when compared to clinical evaluation.

Participants tested their blood glucose level with mobile health device. In addition, a clinical blood glucose level evaluation, the medical gold standard, was performed. Trained nurse has taken a blood sample from the participant as a clinical evaluation.

3.2 Participants

Sixty patients (mean age ± standard deviation: 49.4 ± 12.5 years; range: 18 – 68 years) who were diagnosed with diabetes (type – I and type – II) and attended their routine controls were participated. The data collection process was performed with the approval of Human Researches Ethical Committee. The only basis for excluding people from the study was the personal request of those who did not want to participate in the study and those who were pregnant.

3.3 Materials and Tools

3.3.1 Instruction Cards

Five people were interviewed before starting to prepare Instruction Cards for ease-of-use. The five people are carefully selected for effective instruction cards. The selection is determined based on the following:

- The person is interested in mobile health devices.
- The people have used computers.
- The person can promote people-to-people.
- The person gives permission to disclose personal information for the study activities as necessary.

The following questions were asked.

- Is the instruction card easy to read?
- Is the instruction card easy to understand?
- Is the instruction card taking too much time?

Generally, people had a good impression of the instruction cards.

3.3.2 Medical Gold Standard

Two nurses give training to the diabetes patients. They measure the blood glucose level of the diabetes patients as a medical gold standard by blood glucose level measurement devices.

3.3.3 Interviews

Unstructured, structured and semi-structured interviews were conducted with the participants for understanding their diabetes background and they would be willing to use a mobile health device (see Appendix A).

3.3.4 Questionnaires

The tools used in the study are the demographic questionnaire, technology experience questionnaire, knowledge, skill, and experience with the mobile health device and the post-test questionnaire. The demographic questionnaire included questions on age, gender, education level, occupation, monthly income, marital status, and nationality. The technology experience includes the experience of the diabetes patient on usage of mobile phone, personal computer, and e-mail [46]. In the post-test questionnaire, the overall usability, ergonomic design, and general comments are included. Liljegren (2006) found the overall usability components were taken from Nielsen's (1993) definition of usability and formulated as follows:

- It should be difficult to make errors (Errors).
- The equipment should be easy to learn, so you can start to use it quickly (Learnability).
- The equipment should be easy to remember, so you can start using it quickly after a period of absence (Memorability).
- The equipment should be easy to use, so you do not have to direct all attention at handling the equipment (Efficiency).
- The equipment should be pleasing and comfortable to use (Satisfaction).

The overall usability asked the participant to grade usability based on five components. The concept of overall usability was taken as 100% and the participants were asked to grade from 0 to 100% how much each of the five components made up of overall usability.

The ergonomic design includes questions on the information presentation and design such as buttons/icons, menus, devices, and text size [47, 48]. The general comments (usability questionnaire) include questions on the experience of the diabetes patient while using the mobile health device and subjective comments of the diabetes patient on the mobile health device. The diabetes patients were asked their about future health decisions, and their willingness to use the mobile health device in the future. A questionnaire was developed based on and extensive literature review. Since there is not a specific questionnaire for mobile health device in the literature, the most applicable studies, mentioned above, having the validity and reliability checks are selected and customized. The final version is translated by certified translators. Lastly, the translated questionnaire is reviewed and examined by two statistics professional. Since the questionnaire is just a part of interview to gather additional statictical information, like gender, technology experience, education level, the validity and reliability of the questionnaire is thought to be satisfactory and significative.

3.3.5 Heuristic Evaluation

M-health device was evaluated by using Jacob Nielsen's (1994) 10 heuristics and severity rating scale - which are all explained at the review of literature - with three usability experts. Each expert has participated in usability methods and has a background in Human Computer Interaction and mobile information and communications technology in health care. Each expert observed the m-health service with their background knowledge and made a rating to each heuristics with the range of between 0 (not usability problem) and 4 (usability catastrophe).

The following 0 to 4 rating scale can be used to rate the severity of usability problems:

0 = I do not agree that this is a usability problem at all

1 = Cosmetic problem only: need not be fixed unless extra time is available on project

2 = Minor usability problem: fixing this should be given low priority

3 = Major usability problem: important to fix, so should be given high priority

4 = Usability catastrophe: imperative to fix this before product can be released

For the heuristic evaluation, three evaluators are satisfactory for many practical purposes.

3.3.6 Cognitive walkthrough

The m-health service enables several distinct superordinate tasks. We can define task functionality as that which refers to interaction between the user and the system in various levels of abstraction, typically those actions required in achieving a goal. Task performance comprised of task success and task completion time.

Cognitive walkthrough was used to find menu headlines and button markings that did not support the user or could divert the user from the intended task. Cognitive walkthrough is task-specific and methods that focus on the user tasks are regarded as more effective when user interfaces are evaluated. The cognitive walkthrough analysis included seven tasks for measure blood glucose level (Goal A – see Appendix C), and four tasks for blood glucose level data expert (Goal B – see Appendix D). A seven level hierarchical structure is built, based on the main goal of measuring blood glucose level (Figure 3)

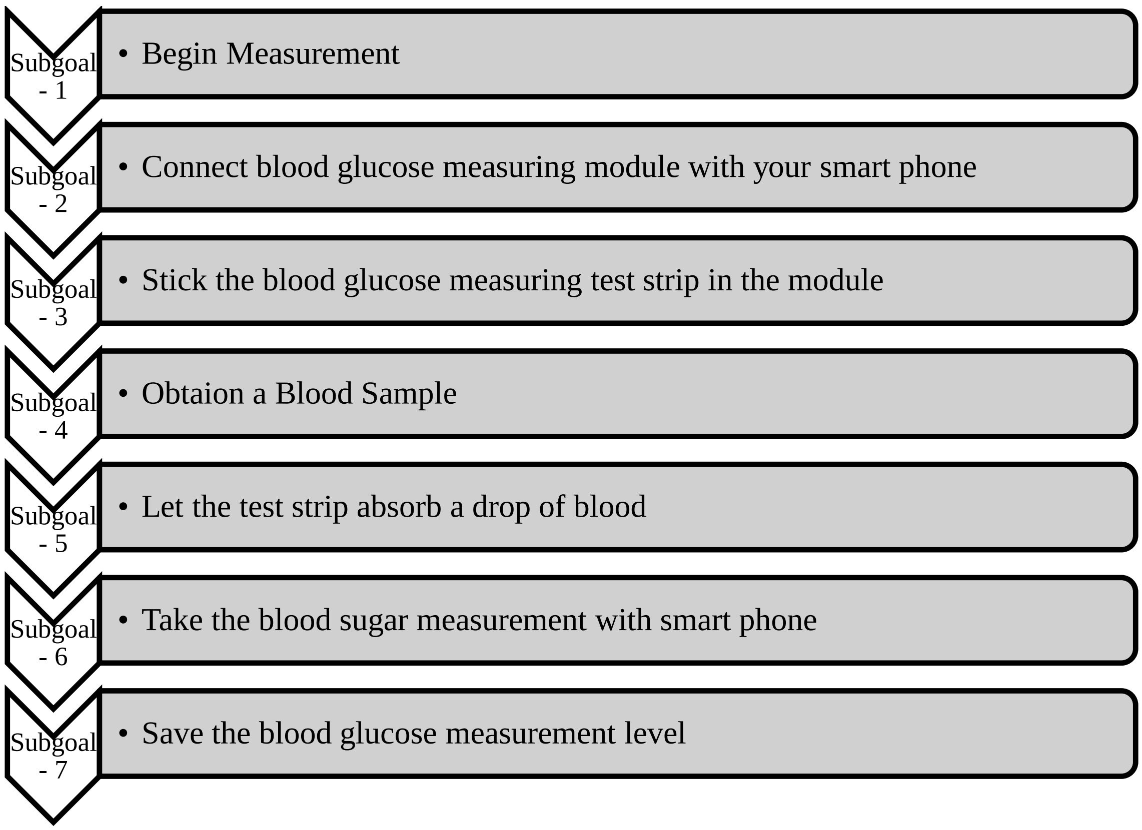


Figure 3. Structure of Goal – A: Measure Blood Glucose Level

Four level hierarchical sturucture is built, based on the main goal of blood glucose measurement data export (Figure 4).

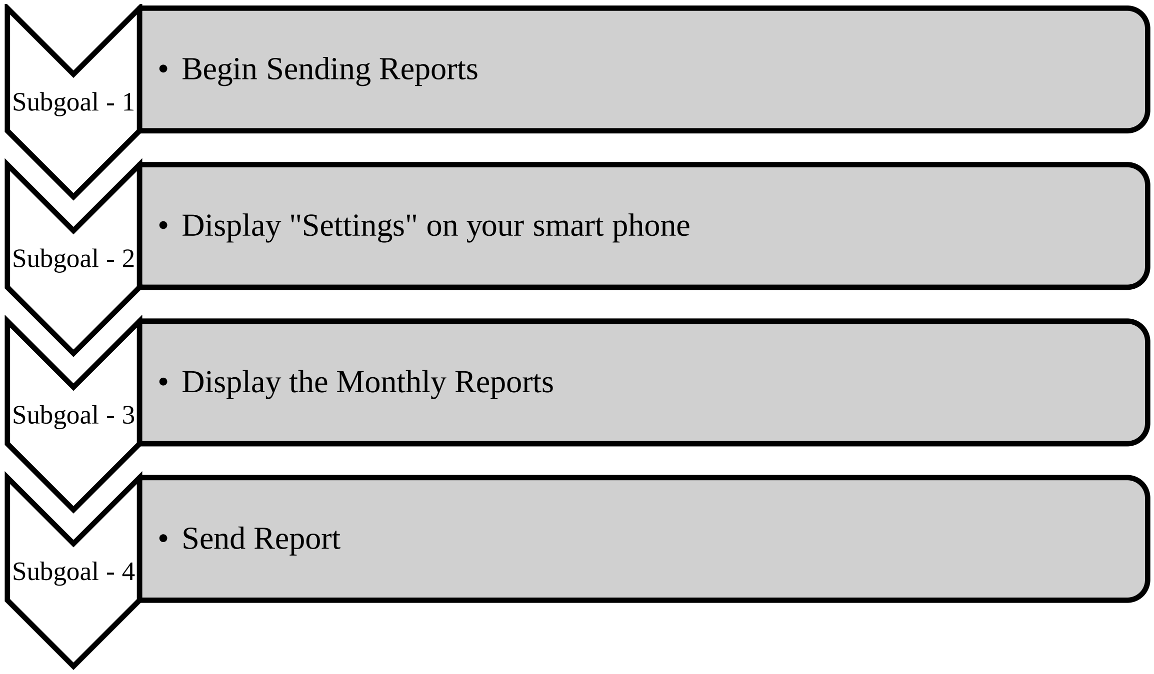


Figure 4. Structure of Goal – B: Blood Glucose Measurement Data Export

The blood glucose level measurement task employed tightly coupled goal action sequences and were reasonably easy to execute. A tightly coupled sequence is one in which an action transparently flows from a goal and the user can readily perceive that the system has responded thereby signaling the next subgoal and action sequence. A partial walkthrough of the blood glucose measurement task is illustrated below (Figure 5).

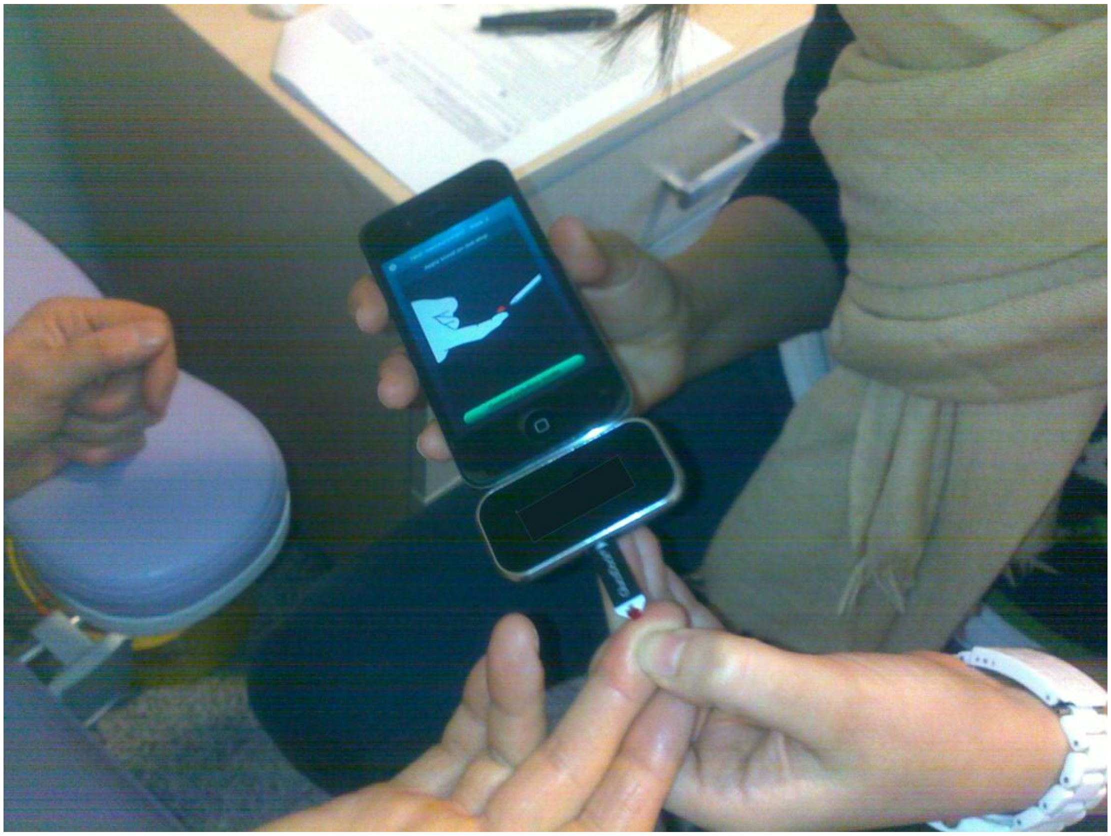


Figure 5. Test strip absorb a drop of blood

The intended way to perform these tasks was taken from the user manuals and described using Hierarchical Task Analysis [49]. Goal - A and B shows how tasks performed. Each operation represents a physical action. This structure for the Hierarchical Task Analysis descriptions was used for all tasks included in the Cognitive Walkthrough analysis.

3.4 Statistical analysis

Statistical analysis was performed with SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA). Continuous variables in this study were given with mean ± standard deviation or median [min – max] as appropriate. Categorical variables were summarized as frequencies and percentages. Agreement between the mobile health device and medical gold standard device was given by Pearson correlation coefficient. Difference between the demographic groups according to the continuous variables was evaluated by Mann Whitney U or Kruskal Wallis test. Relations between the continuous variables were given by Spearman correlation coefficient. Significance level was determined as $p<0.05$.

3.5 Physical environment information

This study was conducted at the diabetes training room which did not deteriorate in abnormal environmental conditions such as darkness, coldness, and noise (Figure 6).

Figure 6. Physical environment information

3.6 Technical environment information

To minimize effects from aesthetics, brand, and etc. the same m-health service, was deployed throughout the study.

Hardware: Smart phone, mobile health device which can measure the blood glucose level, the lancing device, the lancets, the test strips, control solution.

Smart phone has an iOS mobile operating system.

Mobile health device – blood glucose measuring system can measure in either mg/dL or mmol/L. In the study, chosen unit of measure is mg/dL. It's operating conditions of 10 °C to 40 °C and storage conditions of 2 °C to 30 °C at maximum 90% relative humidity. Test results below 60 mg/dL are an indication of hypoglycemia, meaning the blood glucose level is too low. If the reading is above 240 mg/dL, symptoms of a high blood glucose level (hyperglycemia) can occur.

The lancing device enables the participants to hygienically and easily draw a drop of blood for the blood glucose test. The lancing device can be set to the sensitivity of the participants' skin. The participants adjust the tip to 5 different lancing depths (1-2 for soft or thin skin, 3 for normal skin, 4-5 for thick or callous skin). Before using the lancing device the participant need to insert a lancet.

Used test strips and used lancets disposed carefully. Never use a lancet or lancing device on more than one person. A new sterile lancet and a new test strip used for each test. Lancets are intended to be used only once. There was no hand cream, oil or dirt in or on the lancet, lancing device and test strip. The test strips stored in their original container. To avoid contamination, only touch the test strips with clean, dry hands. The test strips used within three minutes of removing it from the container.

The permissible range for the control solution reading is indicated on the label of the test strip container. Before starting measurement, sure that compare the test result with the correct range. If the control test result lies within the range indicated on the test strip container, then the test strips, the mobile health device, and the smart phone are working accurately.

Software: Mobile health software (application) which runs on a smart phone. There is always enough memory available to back up the reading data on smart phone. For the mobile health device to function correctly, the smart phone has to be sufficiently charged. If the participants receive a call or a text message during a reading, the reading is cancelled for safety reasons. For preventing the participant's reading from being cancelled, smart phone was switched to flight mode.

The application transfers the data generated by the mobile health device to the connected smart phone. This application allows users to save, display, and analyze measurement data. The users can also transmit the measurement data to the other people via e-mail.

3.7 Procedure

All participants are asked to complete the demographic, technology experience questionnaires and knowledge, skill, and experience with the mobile health device. Besides the questionnaires, interviews are conducted with the participants. Before the study was performed on the patients, they are asked if they would be willing to use this m-health device or not.

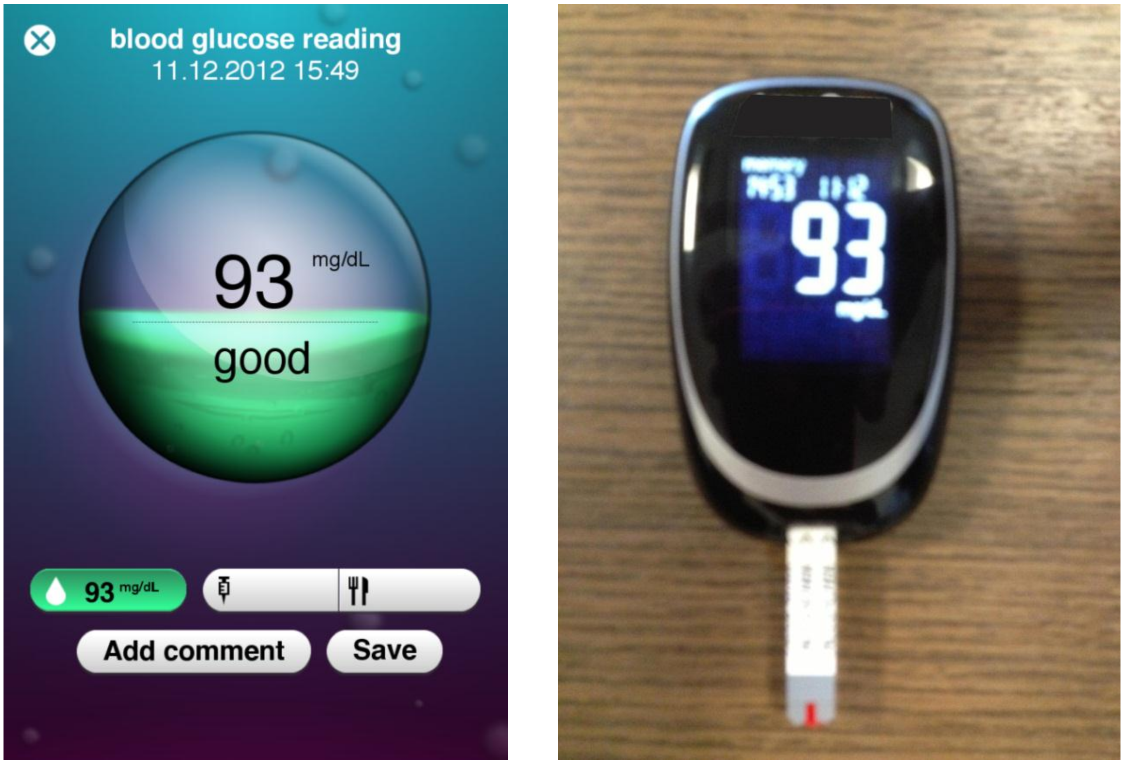
As a training material, the mobile health device features are simulated in pictures for the instruction cards. The users are asked about their preference for device training, either by instruction cards or by a researcher. All users prefered the training by a researcher. The researcher explained the mobile health device and its application in detail before the participants started to use the mobile health device (Figure 7).

Figure 7. Participants training of mobile health device

The participants are taken to the diabetes training room where a blood sample is drawn by the trained nurse (Figure 8).

Figure 8. Getting the blood sample for clinical evaluation

After measuring the participants' blood glucose level with mobile health device and medical gold standard, they are asked to evaluate the accuracy of the mobile health device (Figure 9).

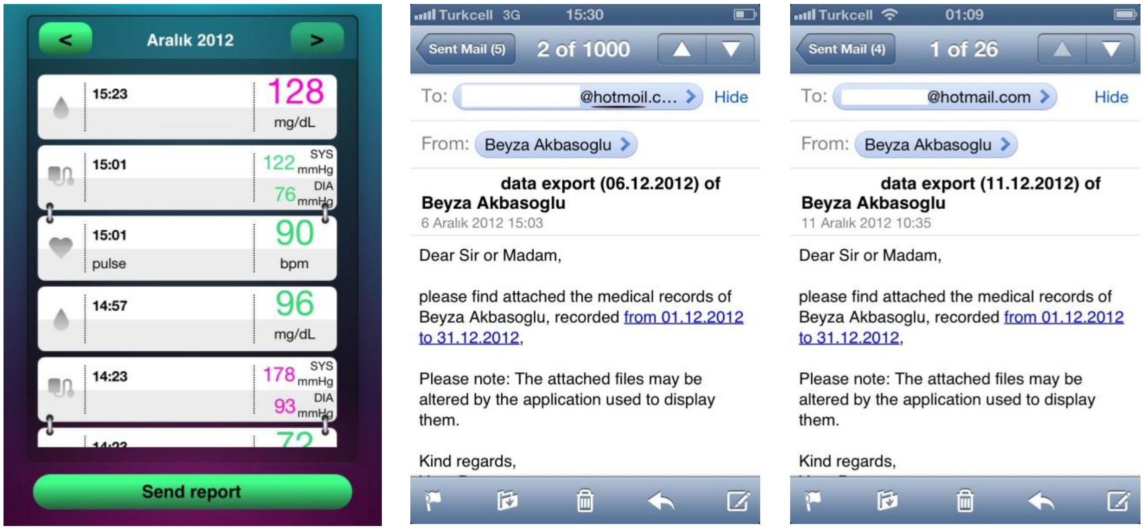


a. M-health device application's screen shot

b. Medical gold standard device's screen

Figure 9. Blood glucose level measurement with m-health device and medical gold standard.

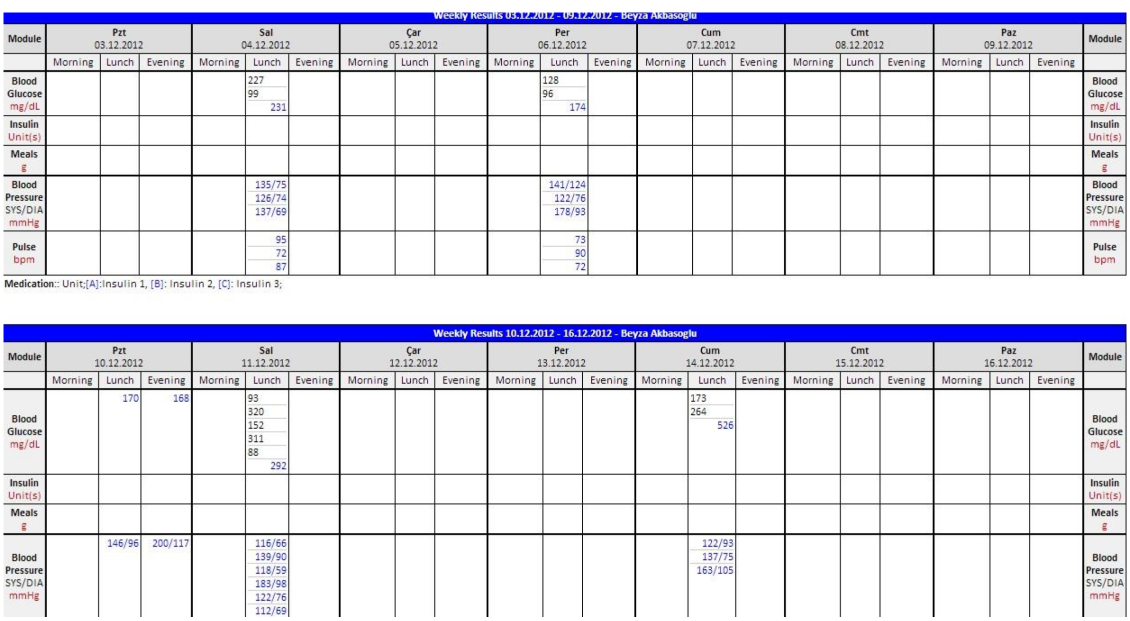
Last before the post-test questionnaire, the participants firstly find the report screen and then try to send the blood glucose level measurements by e-mail (Figure 10).



Spelling mistake at the e-mail address. No spelling mistake at the e-mail address.

Figure 10. Send report and e-mail screens' shots.

After sending the e-mail, the sending monthly report's screen shot is shown in Figure 11.



Weekly Results 03.12.2012 - 09.12.2012 - Beyza Akbasoglu

Module	Pzt 03.12.2012			Sal 04.12.2012			Çar 05.12.2012			Per 06.12.2012			Cum 07.12.2012			Cmt 08.12.2012			Paz 09.12.2012			Module
	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	
Blood Glucose mg/dL					227 99 231						128 96 174											Blood Glucose mg/dL
Insulin Unit(s)																						Insulin Unit(s)
Meals g																						Meals g
Blood Pressure SYS/DIA mmHg					135/75 126/74 137/69						141/124 122/76 178/93											Blood Pressure SYS/DIA mmHg
Pulse bpm					95 72 87						73 90 72											Pulse bpm

Medication:: Unit;[A]:Insulin 1, [B]: Insulin 2, [C]: Insulin 3;

Weekly Results 10.12.2012 - 16.12.2012 - Beyza Akbasoglu

Module	Pzt 10.12.2012			Sal 11.12.2012			Çar 12.12.2012			Per 13.12.2012			Cum 14.12.2012			Cmt 15.12.2012			Paz 16.12.2012			Module
	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	Morning	Lunch	Evening	
Blood Glucose mg/dL		170	168		93 320 152 311 88 292									173 264 526								Blood Glucose mg/dL
Insulin Unit(s)																						Insulin Unit(s)
Meals g																						Meals g
Blood Pressure SYS/DIA mmHg		146/96	200/117		116/66 139/90 118/59 183/98 122/76 112/69									122/93 137/75 163/105								Blood Pressure SYS/DIA mmHg

Figure 11. Screen shot of the monthly reports.

Participants are later asked to complete the post-test questionnaire results to assess their future health care decision based on mobile health device, change in their future health plan, and any change in their opinion on mobile health device. All items are reported in Appendix E (Answers of the remarks in the questionnaire).

The participants measured their blood glucose level and sent monthly reports via mobile health device by themselves. These two goals are conducted with cognitive walkthrough.

4. RESULTS

4.1 Questionnaires

The study included 60 patients (mean age ± standard deviation: 49.4 ± 12.5 years; range: 18 – 68 years) who were diagnosed with diabetes. Among these, 23 (38.3%) of them were males and 37 (61.7%) were females. Their average mean monthly income ± standard deviation was 1555.3 ± 623.2 Turkish Liras (range: 500 – 3000 Turkish Liras). Minimum education level among the participants is elementary school. Twenty-seven (45%) of the 60 patients' academic background was high school and above. Demographic statistics of the study are shown in Table 5.

Table 5. Demographic statistics.

		n (60)	**%**
Gender	Male	23	38.3
	Female	37	61.7
Education level	Elementary	33	55%
	High school	17	28.3%
	University	9	15.0%
	PhD and over	1	1.7%
Occupation	Student	2	3.3
	Housewife	26	43.3
	Retired	21	35.0
	Unskilled worker	4	6.7
	Skilled worker	7	11.7
Marital status	Single	4	6.7
	Married	53	88.3
	Divorced	1	1.7
	Widowed	2	3.3

During their participation in the questionnaire, it was found out that the participants' motivation was very high (100%) based on a Likert scale (1 = very low – 5 = very high), and they have no stress.

Participants' ratings of their use of and attitude to information and communication technologies are shown in Table 6.

Table 6. Technology experience.

		n (60)	%
I use mobile phone	No	4	6.7
	Yes	56	93.3
Type of mobile phone	Basic model	38	67.9
	Smart phone	18	32.1
I use internet via mobile phone	No	36	64.3
	Yes	20	35.7
I use PC, notebook, Tablet PC, iPad	No	28	46.7
	Yes	32	53.3
I use internet via PC, notebook, Tablet PC, iPad	No	1	3.1
	Yes	31	96.9
I use e-mail	No	35	58.3
	Yes	25	41.7

Twenty six (81.3%) of the 32 patients who use PC, notebook, Tablet PC, iPad feel their selves anxious (1: anxious – 5: relaxed) when they run into a problem on the computer or an application. Seventeen (68%) of the 25 patients' e-mail usage was every day (1: never – 5: every day).

Each participant filled in a background questionnaire about knowledge, skill and experience with the mobile health device. Only fifteen (25%) of the 60 patients know the meaning of mobile health device from news and/or newspapers. All patients' skill and experience about mobile health devices were 0% (Table 7).

Table 7. Knowledge, skill and experience with a mobile health device

Knowledge, skill, and experience		**n (60)**	**%**
I know the meaning of mobile health device (knowledge).	No	45	75
	Yes	15	25
I used mobile health device (skill).	No	60	100
	Yes	-	-
I used mobile health device before (experience). (1: never – 5: always)	1: never	60	100

Before the study was performed on the patients, they were asked if they would be willing to use this m-health device. Expect one patient, who did not want the mobile service providers to make money; all other diabetes patients (98.3%) expressed that they would forward their measured blood glucose level electronically to the doctor via m-health device, should they have this technology available. If the price of the m-health device are affordable, diabetes patients (98.3%) want to buy and use it.

4.2 Interviews

Of the 60 diabetes patients, 7 (11.7%) were type-I, and 53 (88.3%) were type-II. Fifty-four (90%) of the diabetes patients monitored their blood glucose level daily (mean monitoring number ± standard deviation: 2.9 ± 1.7 number/day; min-max: 0 – 7 numbers). Forty-two (77.8%) diabetes that monitored their blood glucose level daily, logged their blood glucose levels in a written fashion and shared them manually with their doctors.

Table 8. Interviews statistics.

		Frequencies	Percentage
Type of Diabetes	Type I	7	11.7
	Type II	53	88.3
Did you monitor your blood glucose level daily with a device?	No	6	10.0
	Yes	54	90.0
Do you save the blood glucose measurement and share with your doctor?	No	18	30.0
	Yes	42	70.0
What do you do when you feel your blood glucose decreased or increased?	Fruit juice	8	13.3
	Sugar cubes	31	51.7
	Dessert	1	1.7
	Sugared water	3	5.0
	All	1	1.7
Would you like to be automatically forwarded your measured blood glucose level to the doctor by a device?	No	1	1.7
	Yes	59	98.3
Would you like to buy a mobile health device of this nature?	No	1	1.7
	Yes	59	98.3
		Mean ± Standard Deviation	**Median [Minimum – Maximum]**
How long have you had diabetes?		7.9 ± 8.0	5 [1 – 42]
How often you monitor your blood glucose (daily)		2.9 ± 1.7	2 [0 – 7]
How often do you visit a doctor for control? (in a year)		6.6 ± 5.9	4 [1 – 24]

H1: No difference exists in the blood glucose level measurement between m-health device and clinical evaluation (medical gold standard).

All diabetes patients measured their blood glucose level and saved the measurements by using the touch screen of the m-health device. The training time plus blood glucose level measurement time totally was mean ± standard deviation: 16.5 ± 6.7 minutes; median [minimum - maximum]: 18 [3 - 30]. Of the 60 patients, forty three (71.7%) saved the blood glucose level at the first time. Four test strips failed to give results because of dropping too little blood in the blood sample area. The correlation coefficient between m-health device and clinical evaluation measurements was 0.98 ($p<0.001$). The usability of m-health device was evaluated through questionnaires and comparison with the clinical evaluation (Table 9).

Table 9. Comparison of m-health device and medical gold standard.

	Mean ± Standard Deviation	Median [Minimum-Maximum]
M-health device	206.0 ± 105.8	174 [88 – 526]
Medical gold standard	202.2 ± 103.5	169 [86 – 511]

Both measurements were observed to be in close proximity (Figure 12).

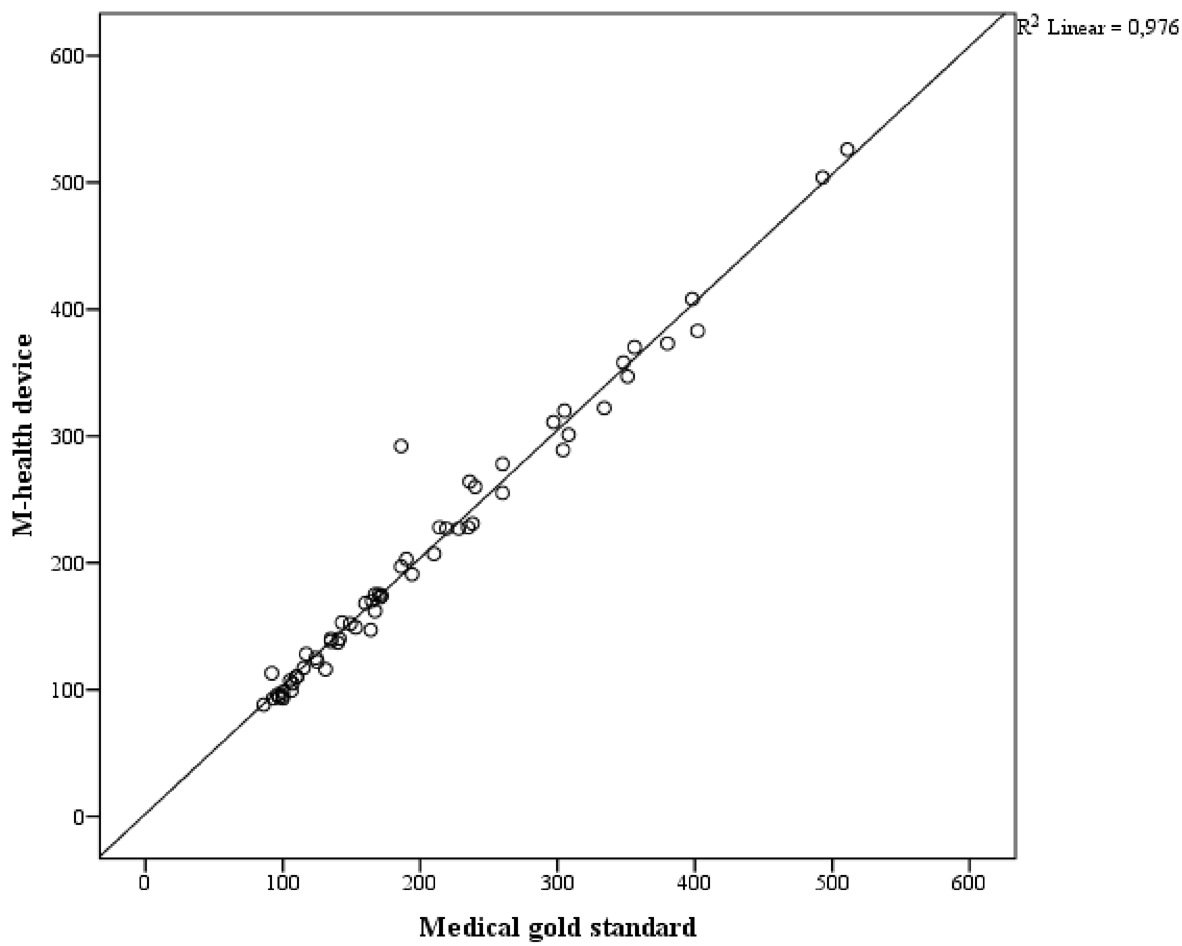


Figure 12. Scatter plot of blood glucose level measurements.

Of the 60 diabetes patients, 35 (58.4%) of them did not use e-mail before, hence they could not send the blood glucose level measurements. 23 of them (38.3%) have been using e-mail and managed to send the measurements correctly. The remaining two diabetes patients (3.3%) used e-mail before but they could not send the data as they were not comfortable with using touchscreen.

The overall usability results asked to the participant to grade usability based on five components are shown in Table 10.

Table 10. Overall usability

	Mean ± Standard Deviation	Median [Minimum-Maximum]
Errors	83.6 ± 10.5	80 [50 - 100]
Learnability	89.6 ± 10.1	90 [60 - 100]
Memorability	87.0 ± 12.5	90 [50 – 100]
Efficiency	96.0 ± 6.2	100 [70 - 100]
Satisfaction	96.5 ± 5.6	100 [80 - 100]

The majority of the users comments on information presentation and design were average and above (Table 11).

Table 11. Information presentation and design

	1	2	3	4	5
Is the screen easily viewable?			1 (1.7%)	9 (15%)	50 (83.3%)
Is the display clearly arranged?				9 (15%)	51 (85%)
Is the display easily readable?			1 (1.7%)	6 (10%)	53 (88.3%)
Are the colors convenient?		1 (1.7%)		3 (5%)	56 (93.3%)
Is the touchscreen easy to use?		4 (6.7%)	6 (10%)	12 (20%)	38 (63.3%)
Buttons/Icons: Is it easy to understand the meaning of the icons?				10 (16.7%)	50 (83.3%)
Menus: Are there too much menu and difficult to understand?	58 (96.7%)	2 (3.3%)			
Is the m-health device small enough to carry comfortably?			1 (1.7%)	1 (1.7%)	58 (96.7%)

After using the m-health device, participants were asked again if they would use this device or not. Fifty nine (98.3%) of them were highly satisfied with the m-health technology and expressed that they would use it and found the measured values reliable (Table 12).

Table 12. General comments #1

		n (60)	%
Do you rely on the results measured by mobile health device?	No	1	1.7%
	Yes	59	98.3%

For 57 (95%) participants; measuring, checking, accessing and customizing the blood glucose level easily anytime and anywhere were very important (Table 13).

Table 13. General comments #2

	Very unimportant	Unimportant	Neutral	Important	Very important
Measuring the blood glucose level easily and check it anytime.				3 (5%)	57 (95%)
Accessing the blood glucose level from mobile device.				3 (5%)	57 (95%)
Customizing personal health care on mobile device			1 (1.7%)	2 (3.3%)	57 (95%)

Fifty six (93.3%) said that they would wish to send their blood glucose levels to their physicians via e-mail. Forty nine (81.7%) mentioned that they would be comfortable with not visiting their doctors and just sending their values. The remaining mentioned that they would be comfortable with the technology but would still want to see their doctors in person (Table 14).

Table 14. General Comments #3

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I want to send the blood glucose level which can be voluntarily transferred to doctors via e-mail.	2 (3.3%)	1 (1.7%)	1 (1.7%)	6 (10%)	50 (83.3%)
I would change my lifestyle rather than visit a doctor regardless of my blood glucose level.	1 (1.7%)	4 (6.7%)	6 (10%)	4 (6.7%)	45 (75%)

H2: No difference exists in changing their lifestyle rather than visiting a doctor regardless of their diabetes by age, gender, education level, occupation, monthly income, marital status, type and period of diabetes and technology experience.

Table 15. Correlation in changing their lifestyle rather than visiting a doctor regardless of their diabetes by age, gender, education level, occupation, monthly income, marital status, type and period of diabetes and technology experience.

		Correlation coefficient (r)	**p**
Age		0,135	0,303
Education level		0,251	0,053
Income (monthly)		0,078	0,554
How long have you had DM?		0,092	0,486
		Median [Min – Max]	**p**
Gender	Male	5 [1 – 5]	0,085
	Female	5 [1 – 5]	
Occupation	Student	4 [2 – 5]	**0,031***
	Housewife	5 [3 – 5]	
	Retired	5 [2 – 5]	
	Unskilled worker	3 [1 – 5]	
	Skilled worker	5 [5 – 5]	
Marital status	Single	4 [1 – 5]	0,239
	Married	5 [2 – 5]	
	Divorced	5 [5 – 5]	
	Widowed	5 [5 – 5]	
Type of DM	Type I	5 [1 – 5]	0,668
	Type II	5 [2 – 5]	
I use mobile phone.	No	5 [2 – 5]	0,413
	Yes	5 [1 – 5]	
Type of mobile phone	Basic model	5 [2 – 5]	0,577
	Smart phone	5 [1 – 5]	
I use e-mail.	No	5 [1 – 5]	0,079
	Yes	5 [2 – 5]	

When participants were asked to provide a decision on future health care, predominate number of participants said they would change their lifestyle rather than visiting a doctor regardless of their blood glucose level. There is no difference exists in changing their lifestyle rather than visiting a doctor regardless of their diabetes by age, gender, education level, monthly income, marital status, type and period of diabetes and technology experience except occupation ($p<0.05$). Housewives, retired and skilled workers would change their lifestyles rather than visiting a doctor regardless of their blood glucose level measurements.

This result shows that forty nine (81.7%) diabetes patient that they would be comfortable with not visiting their doctors and just sending their values, not affected by the age, gender, education level, monthly income, marital status, type and period of diabetes and technology experience attributes.

H3: No difference exists in the overall usability of the m-health device by age, gender, education level, occupation, monthly income, marital status, type and period of diabetes and technology experience (Table 16).

Table 16. Correlation in the overall usability of the m-health device by age, gender, education level, occupation, monthly income, marital status, type and period of diabetes, and technology experience.

		Errors		**Learnability**		**Memorability**		**Efficiency**		**Satisfaction**	
		Correlation coefficient (r)	**p**	**Correlation coefficient (r)**	**p**	**Correlation coefficient (r)**	**p**	**Correlation coefficient (r)**	**p**	**Correlation coefficient (r)**	**p**
Age		0,276	**0,033***	0,270	**0,037***	0,294	**0,023***	0,194	0,137	0,145	0,267
Education level		0,237	0,068	0,175	0,181	0,424	**0,001***	0,113	0,390	0,092	0,483
Income (monthly)		0,140	0,286	-0,021	0,876	0,095	0,471	-0,007	0,960	-0,014	0,917
How long have you had DM		-0,223	0,087	-0,216	0,098	-0,080	0,543	-0,253	0,051	-0,249	0,055
		Median [Min – Max]	**p**	**Median [Min – Max]**	**p**	**Median [Min – Max]**	**p**	**Median [Min – Max]**	**p**	**Median [Min – Max]**	**p**
Gender	Male	85 [70 – 100]	0,470	90 [60 – 100]	0,894	90 [60 – 100]	0,206	100 [70 – 100]	0,303	100 [80 – 100]	0,418
	Female	80 [50 – 100]		90 [60 – 100]		90 [50 – 100]		100 [90 – 100]		100 [80 – 100]	
Occupation	Student	83 [75 – 90]	0,795	95 [90 – 99]	0,990	100 [100 – 100]	0,172	100 [100 – 100]	0,844	100 [100 – 100]	0,868
	Housewife	80 [50 – 100]		90 [70 – 100]		86 [50 – 100]		100 [90 – 100]		100 [90 – 100]	
	Retired	80 [70 – 100]		90 [60 – 100]		90 [60 – 100]		100 [70 – 100]		100 [80 – 100]	
	Unskilled worker	88 [70 – 100]		93 [80 – 100]		90 [70 – 100]		100 [80 – 100]		100 [80 – 100]	
	Skilled worker	90 [70 – 100]		90 [80 – 100]		95 [70 – 100]		100 [90 – 100]		100 [80 – 100]	
Marital status	Single	95 [75 – 100]	0,203	100 [90 – 100]	0,142	100 [100 – 100]	**0,007***	100 [100 – 100]	0,181	100 [100 – 100]	0,252
	Married	80 [50 – 100]		90 [60 – 100]		90 [50 – 100]		100 [70 – 100]		100 [80 – 100]	
	Divorced	70 [70 – 70]		90 [90 – 90]		75 [75 – 75]		95 [95 – 95]		95 [95 – 95]	
	Widowed	78 [75 – 80]		83 [80 – 85]		80 [75 – 85]		98 [95 – 100]		98 [95 – 100]	
Type of DM	Type I	90 [70 – 100]	0,415	99 [90 – 100]	0,065	100 [90 – 100]	**0,004***	100 [100 – 100]	0,052	100 [100 – 100]	0,093
	Type II	80 [50 – 100]		90 [60 – 100]		90 [50 – 100]		100 [70 – 100]		100 [80 – 100]	
I use mobile phone.	No	78 [70 – 90]	0,306	85 [75 – 90]	0,131	85 [70 – 90]	0,292	98 [90 – 100]	0,875	100 [90 – 100]	0,764
	Yes	83 [50 – 100]		90 [60 – 100]		90 [50 – 100]		100 [70 – 100]		100 [80 – 100]	
Type of mobile phone	Basic model	80 [50 – 100]	**0,001***	90 [60 – 100]	**0,018***	90 [50 – 100]	**0,008***	98 [70 – 100]	**0,009***	100 [80 – 100]	**0,022***
	PDA-Smartphone	90 [75 – 100]		97 [85 – 100]		95 [80 – 100]		100 [90 – 100]		100 [90 – 100]	
I use e-mail.	No	80 [50 – 100]	**0,001***	90 [60 – 100]	**0,004***	85 [50 – 100]	**0,001***	100 [70 – 100]	0,089	100 [80 – 100]	0,312
	Yes	90 [70 – 100]		95 [80 – 100]		95 [70 – 100]		100 [90 – 100]		100 [80 – 100]	

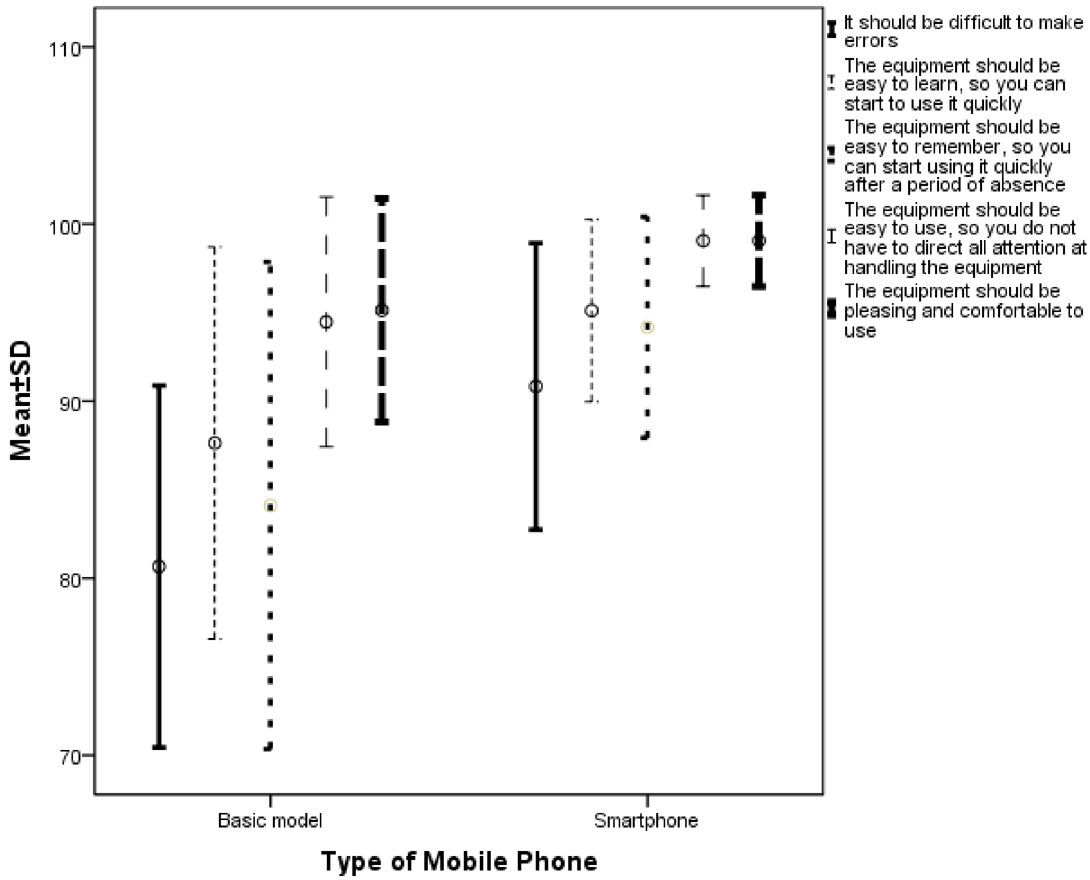


Figure 13. Type of mobile phone – overall usability Mean ± SD graph.

Overall usability scores of the smart phones' users were higher than the basic models users.

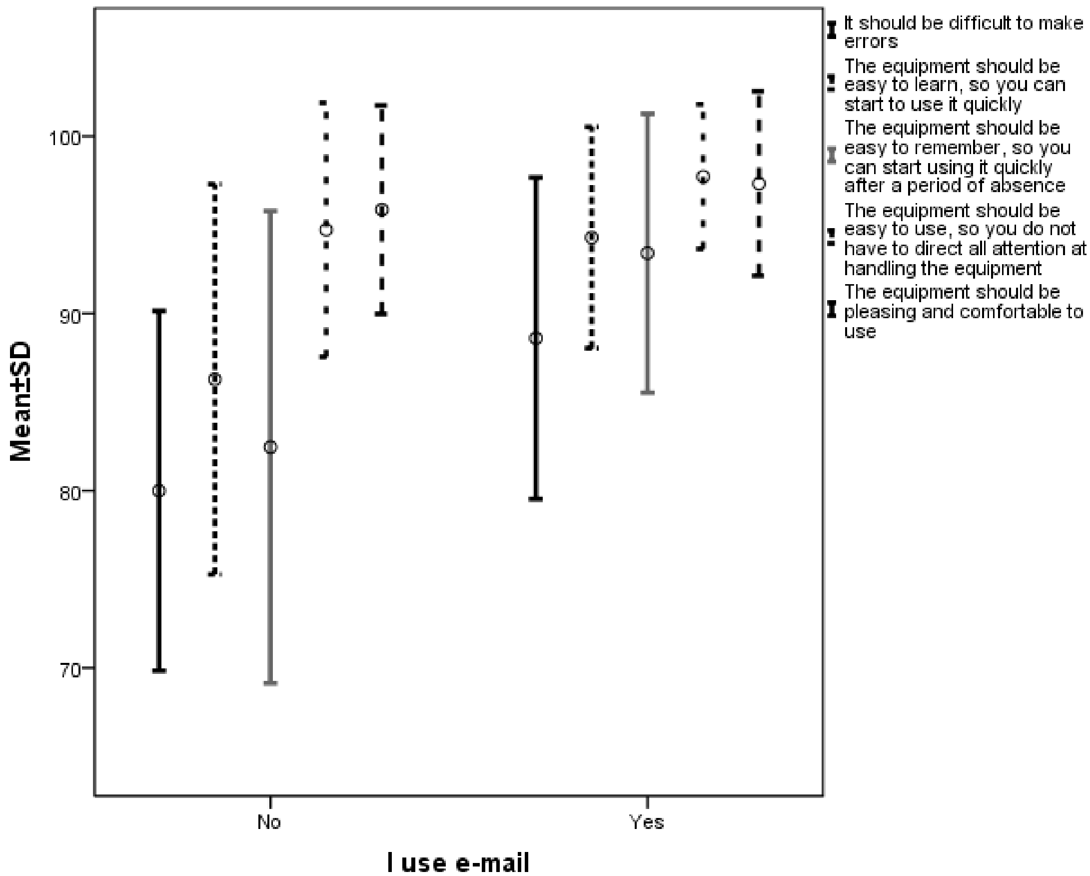


Figure 14. I use e-mail – Overall usability Mean ± SD graph.

The participants who used e-mail before overall usability scores were higher than the others.

H4: No difference exists in the ergonomic design of the m-health device by overall usability.

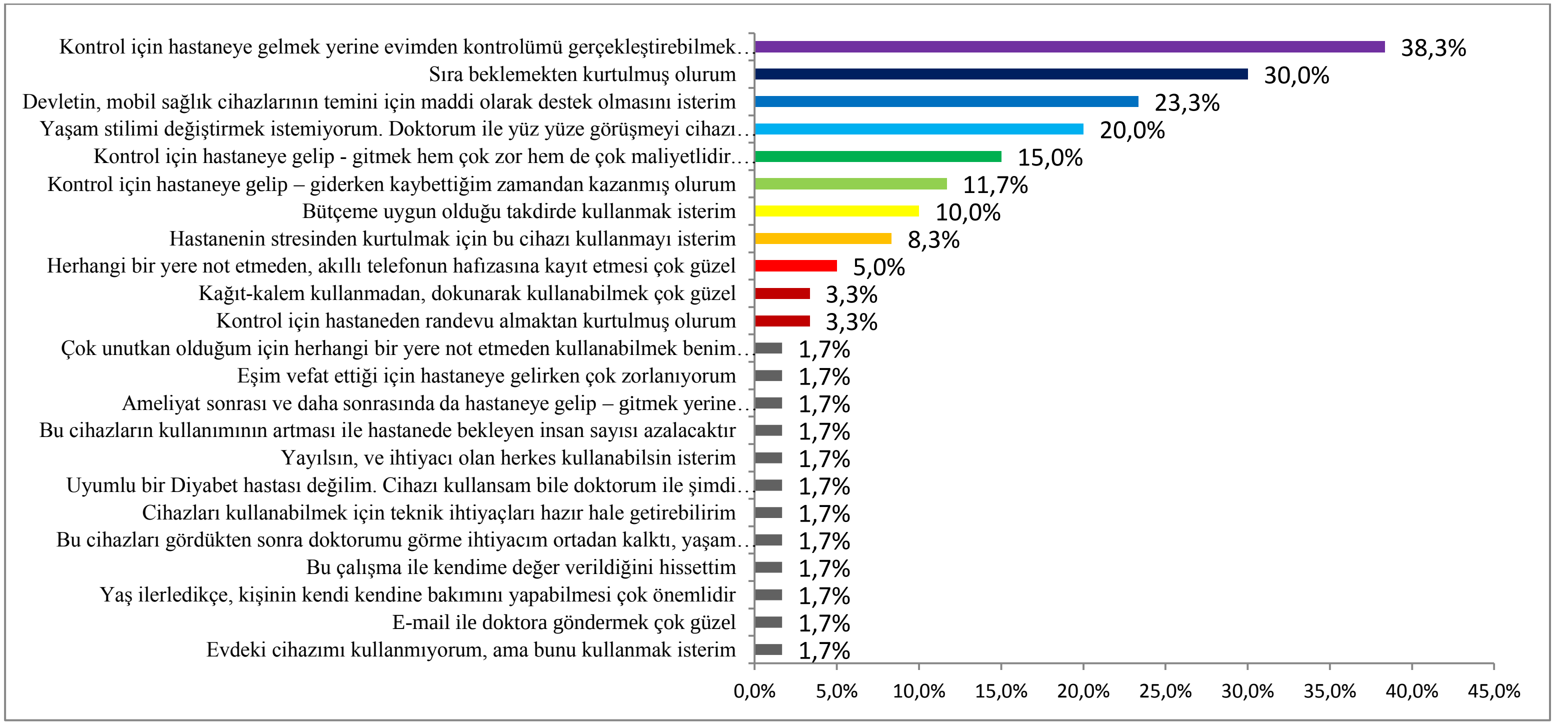
Table 17. Correlation in the ergonomic design of the m-health device by overall usability.

	Errors		Learnability		Memorability		Efficiency		Satisfaction	
	Correlation coefficient (r)	**p**	**Correlation coefficient (r)**	**p**	**Correlation coefficient (r)**	**p**	**Correlation coefficient (r)**	**p**	**Correlation coefficient (r)**	**p**
Is the screen easily viewable?	0,303	**0,018***	0,321	**0,012***	0,300	**0,020***	0,126	0,337	0,050	0,704
Is the display clearly arranged?	0,252	0,052	0,289	**0,025***	0,151	0,248	0,152	0,246	0,118	0,369
Is the display readable?	0,228	0,080	0,256	**0,049***	0,225	0,084	0,192	0,142	0,091	0,487
Are the colors convenient?	0,187	0,153	0,243	0,062	0,178	0,173	0,430	**0,001***	0,484	**<0,001***
Is the touchscreen easy to use?	0,169	0,197	0,403	**0,001***	0,278	**0,032***	0,127	0,333	0,141	0,281
Buttons/Icons: Is it easy to understand the meaning of the icons?	0,160	0,223	0,210	0,108	0,086	0,515	0,299	**0,020***	0,270	**0,037***
Menus: Are there too much menu and difficult to understand?	-0,152	0,245	-0,106	0,419	0,001	0,997	-0,222	0,088	-0,236	0,070
Devices: Is the m-health device small enough to carry comfortably?	0,174	0,183	0,263	**0,042***	0,148	0,259	0,303	**0,019***	0,311	**0,015***

Remarks/Subjective comments

According to our study conducted on 60 diabetes patients, several important findings were obtained with the interview question of "Do you want to tell me anything else about mobile health devices?". All participants' answers were given in Appendix E. It was found out that the majority found the m-health technology useful and practical. The ease that it could bring into their lives, in terms of not having to struggle to get an appointment, to wait in physician lines, to make several visits to the hospital back and forth, were the major reasons for this feedback. This could also save them time as well as preventing artificial stress that builds up in the hospital environment. Especially those who have limited mobility or who live out of town could benefit from this technology significantly. Another benefit is related to the diabetes patients having memory issues. Some patients may either forget to log the data or misremember the measured value hence resulting in misleading information. By using the mobile health technology, these risks vanish. The answers are presented graphically in Figure 15.

Figure 15. Answers & percentages of question “Do you want to tell me anything else about mobile health devices?”



4.3 Heuristic Evaluation

M-health device and application were evaluated by using Nielsen's (1993) 10 heuristics and severity rating scale stated at the methodology part with three evaluators. Each evaluator has participated in usability methods, has a background in Human Computer Interaction and mobile information and communications technology in health care and work in a private hospital group. They are not doctors but know the patient and/or hospital workflows well. Each evaluator observed the m-health service with their background knowledge and made a rating to each heuristics with the range of between 0 (not usability problem) and 4 (usability catastrophe). The results are given at the table below;

Table 18. Nielsen's Heuristics Evaluation Results

Nielsen's 10 Heuristics	Severity Rating Scale Results			
	Evaluator #1	Evaluator #2	Evaluator #3	Mean
Visibility of system status	3	3	3	3
Match between system and the real world	2	2	2	2
User control and freedom	3	2	3	2.6
Consistency and standards	3	2	3	2.6
Error prevention	1	1	1	1
Recognition rather than recall	1	1	1	1
Flexibility and efficiency of use	1	1	1	1
Aesthetic and minimalist design	1	1	1	1
Help users recognize, diagnose, and recover from errors	2	1	2	1.6
Help and documentation	4	4	4	4

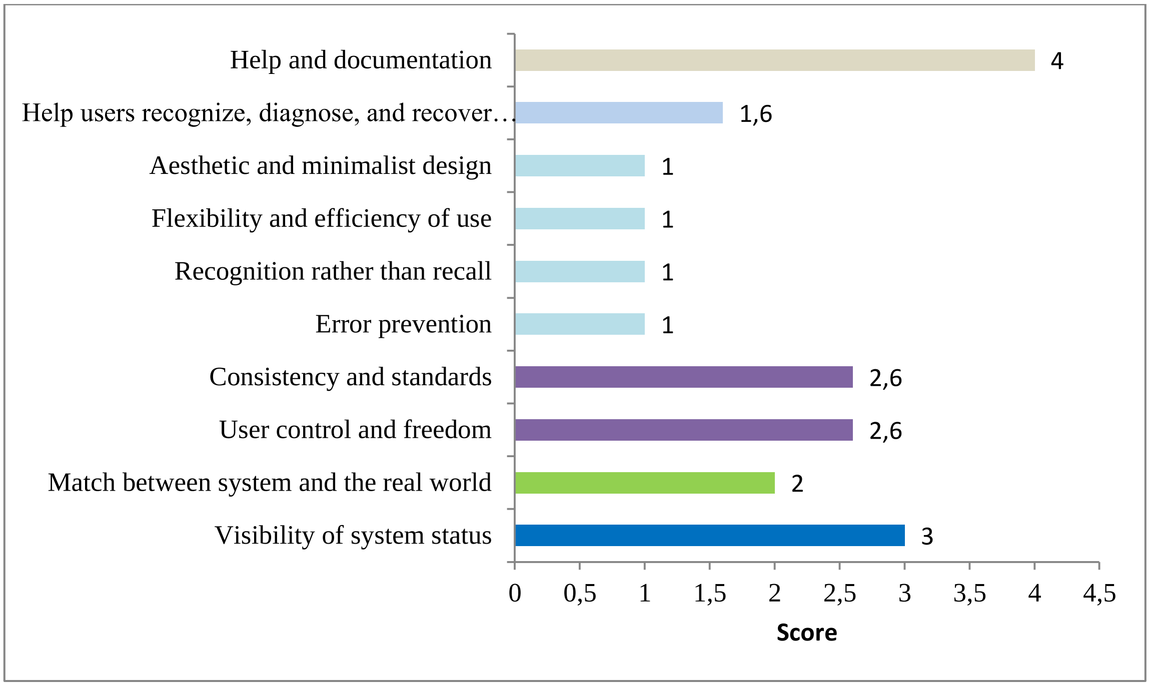


Figure 16. Nielsen's 10 Heuristics Evaluation Graph

The inter-rater agreement among the three evaluators was assessed with Intraclass Correlation Coefficient (Table 19). The Intraclass Correlation Coefficient is 0.933 ($p < 0.01$). This means that the evaluators' ratings were consistent with each other.

Table 19. Intraclass Correlation Coefficient

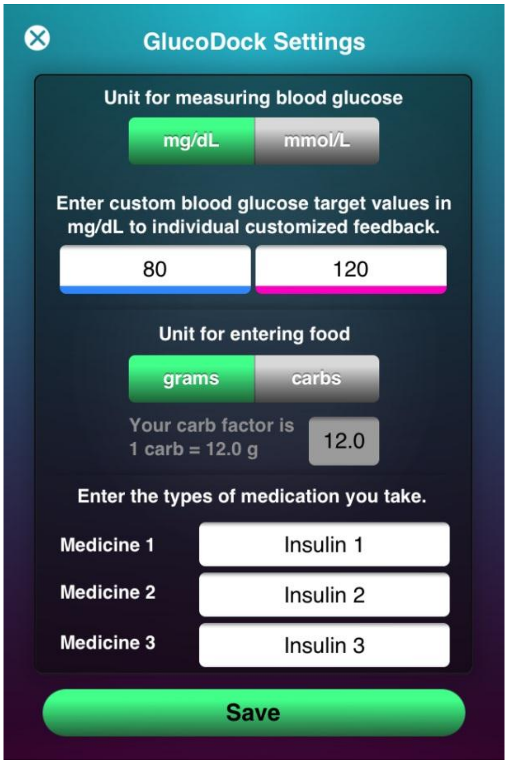
		95% Confidence Interval		F Test with True Value 0			
	Intraclass Correlation	Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	0.933[b]	0.820	0.981	42.857	9	18	0.000
Average Measures	0.977[c]	0.932	0.994	42.857	9	18	0.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

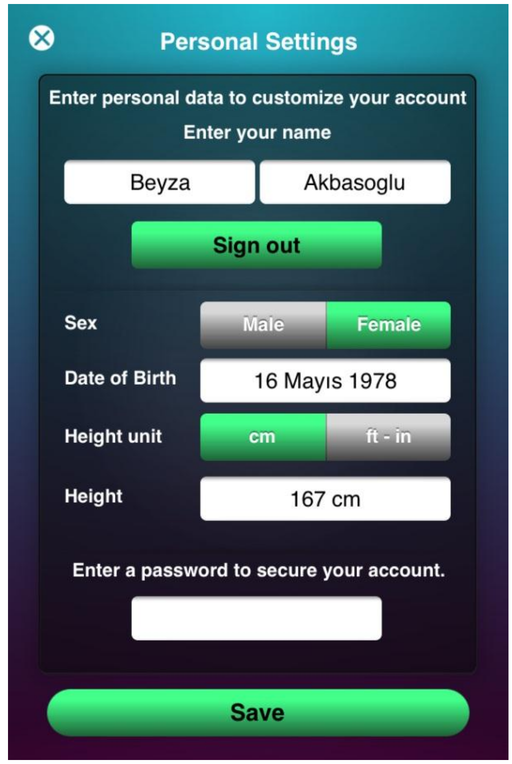
a. Type C intraclass correlation coefficients using a consistency definition-the between-measure variance are excluded from the denominator variance.
b. The estimator is the same, whether the interaction effect is present or not.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

4.3.1 Visibility of system status

The first time that the system is started, the user is prompted to complete the initial configuration first before making any measurement. For instance, in blood glucose level measurement settings screen, the user is asked to select the unit for measuring blood glucose (mg/dL or mmol/L), unit for entering food (grams or carbs); moreover the user is asked to enter the custom blood glucose target values for individual customized feedback and the types of medication s/he takes. In order to customize the account, the user is asked to complete personal settings, having questions like name, sex, date of birth, height and also a password to secure the account.



Settings Screen Shot



Personal Settings Screen Shot

Figure 17. Measurement and Personal Settings Screen Shots

After completing the blood glucose measurement and personal settings, there must be an information screen for having enough smart phone's battery charge capacity for accurate measurements and having enough memory capacity for storing results. This is a critical information message for preventing wrong and duplicated measurements.

Blood glucose measurement module never charged, but smart phone's battery charge level must be controlled. If the smart phone's battery charge is under 20%, the blood glucose measurement will be wrong. Thus, a system warning message indicating the low battery level before measurement would be a solution. However, if the user does not take care of the message, an inaccurate data can be obtained. On the otherwise, if the user considers the warning and do the measurement after charging smart phone, an accurate data can be obtained. As a second solution; the system can limit the user for measurement. If the user does not have a chance to continue the measurement without charging, inaccurate data never occurs. But, this approach has one main disadvantage; the user may give up using the mobile health technology.

Smart phone’s memory capacity must be controlled. If the smart phone does not have enough memory for storing the blood glucose measurement, the user must do the measurement again. As a solution; the system can give a warning message before the measurement. If the user does not take care of the message, the user must do the measurement again, due to lack of free space to record the data. When the user take cares and empties the memory, s/he starts measurement. As a second solution; the system can limit the user for measurement. If the user does not have a chance to continue measurement, the user can not repeat the measurement. But, this approach has one main disadvantage; the user may give up using the mobile health technology.

To avoid disruption from an incoming call or text message during a reading, the smart phone should be switched to flight mode. As a solution; the system can give a warning message before measurement. If the user does not take care of the message, disruption may occur and the user must do the processes from the start. If the user switches to flight mode, no disruption occurs. On the other hand, if the user wants to switch to flight mode, but does not know how to do it, there must be a guide or help documentation electronically. The main problem here is that there is no help documentation. As a second solution; the system can limit the user for measurement. If the user does not have a chance to continue measurement, no disruption occurs. But, the main disadvantage of this approach is that the user may give up using the mobile health technology. As a third solution; the application automatically switches to flight mode when the blood glucose measurement module connected and no disruption occurs by incoming call or text message during a reading.

Visibility deals with the system’s functions which can be monitored by the user. At the m-health device’s application for measuring the blood glucose level, all steps can be seen by the user (Figure 18).

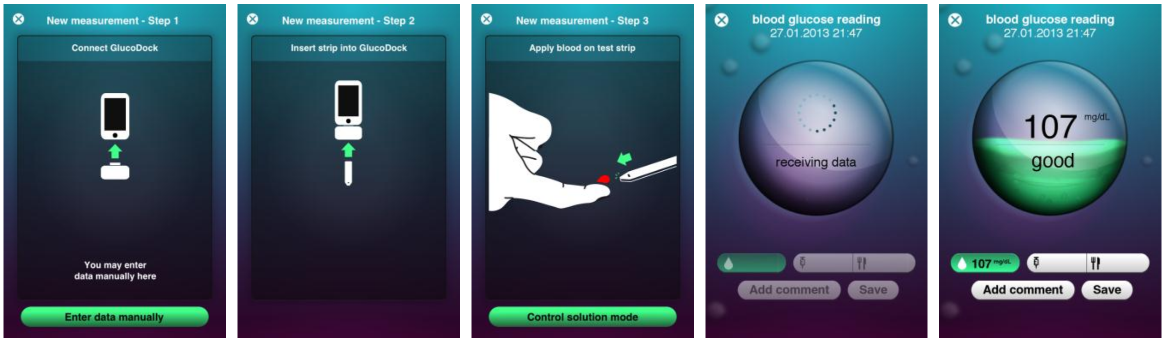
Step 1: Connect m-health device’s module with the smart phone.

Step 2: Stick the m-health device’s test strip in the module.

Step 3: Let the test strip absorb a drop of blood.

Step 4: Take the blood glucose measurement with smart phone.

Step 5: The blood glucose measurement result is completed and appears in the display.



Step 1 Step 2 Step 3 Step 4 Step 5

Figure 18. Steps for blood glucose level measurement.

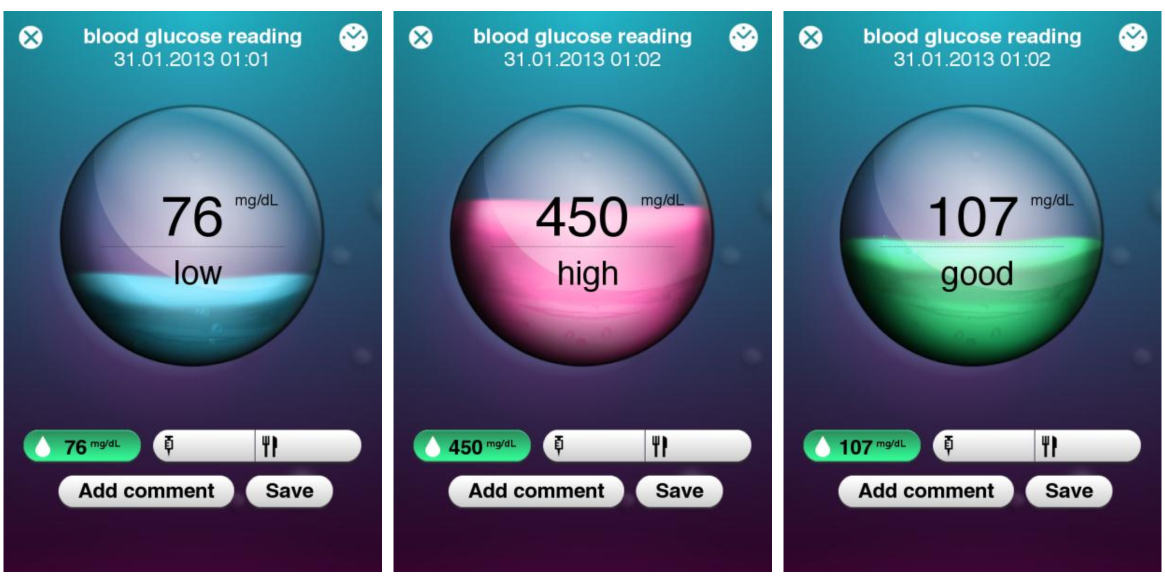
These five steps are visible; the user understands the next state of the system by the information display. The device does the reading at step 4. It takes approximately five seconds. However, there is no information about the duration of reading. For increasing the visibility, the system can give an information message on the display like; "It takes approximately five seconds." By this information, the user does not wait more than five seconds for getting the blood glucose measurement result and understands that something goes wrong if it takes for a longer time.

Measured blood glucose level is displayed on the screen at three different ways:

Display "Low", blue color: values below the target range specified by the doctor.

Display "High", red color: values above the target range specified by the doctor.

Display "Good", green color: values in the target range specified by the doctor.



'Low' Result Screen Shot 'High' Result Screen Shot 'Good' Result Screen Shot

Figure 19. Measured blood glucose displays screen shots

Low, High and Good results are not enough for feedback. It should be more helpful and show the next step messages at this state like as follows:

"The blood glucose measurement result is "High", please call your doctor urgently."

"The blood glucose measurement result is "High", please take your medicine in 5 minutes."

"The blood glucose measurement result is "Low", Please do your Insulin 5 mg/dL more".

The mobile health technology can use like a small decision support system for self-management health care.

The diabetes patients generally have a remembering problem. By using the mobile health devices, the measured blood glucose result is stored in the memory of the smart phone. So, there is no problem about the measured data like; "What was my last blood glucose measurement result?" If the user did not remember the measured blood glucose result, s/he can open the m-health application and view it on the smart phone. They do not measure again and again because of their remembering problems. On the other hand, there is no duplication for measured blood glucose result. If they did not remember their last measurement time, they can check their smart phone and easily see their last measured blood glucose result. However, when we evaluate it for sending the blood glucose results report, there is no information about the sending data period and whether the data sent to the doctor or not. There may be duplicated sending errors. The doctors lose so much time for opening the e-mails and understanding which one is true. There can be an information message when the user sent the blood glucose measurement results. Moreover, if the necessary report is sent to the doctor, there must be an information message on the screen while the user wants to send it again like: "The dd.mm.yyyy – dd.mm.yyyy report was sent to your doctor. Do you want to send it again?" Options: "YES / NO". By this information message, the user understands that he/she sent this report. The user can send it again because there can be an error while sending the report, or maybe the doctor did not get the report and wants the patient to send it again.

On the other hand, there is no date selection option for sending the report. The user can have a chance to send the blood glucose measurement results only for monthly. If the user wants to send three months period result, there is no option for that. It must be send month by month.

The m-health application attends the blood glucose measurement results to the arranged day time period. There must be an alarm to alert the user for measuring the blood glucose level. Otherwise, the user may forget the blood glucose measurement and does the measurement at the wrong time or fully forgets and does not do the measurement. The on-time and correct measurements are important for the self-management health care. In the contrary, the doctor could not take a necessary action in time.

There must be a pre-defined area for writing the doctor's e-mail address at the "Settings" menu. The user does not want to write it every time manually. Moreover, diabetes have usually memory problem. They can forget the e-mail address and could not send their reports. A pre-defined area will be very helpful for them.

4.3.2 Match between system and the real world

The interfaces are consistent. One of the benefits of the consistent interfaces is that users have to learn only a single mode of operation that is measuring the blood glucose level. There are no hundreds of operations or buttons.

The icons are designed as concentrated manner and have familiar nature. The user can have the ability to "ON/OFF" the other menus like sounds, blood glucose, blood pressure, temperature, and kilogram measurement at "Settings" menu. At the beginning of the study, all other measurement menus are closed for a clearly arranged display. So, there are no interdependent fields appear on the screen. Menu choices fit logically into the categories (settings, blood glucose, blood pressure, temperature, kilogram measurement) that have readily understood meanings. Menu titles are in parallel with the relevant actions grammatically, like enter blood glucose, enter insulin and enter food.

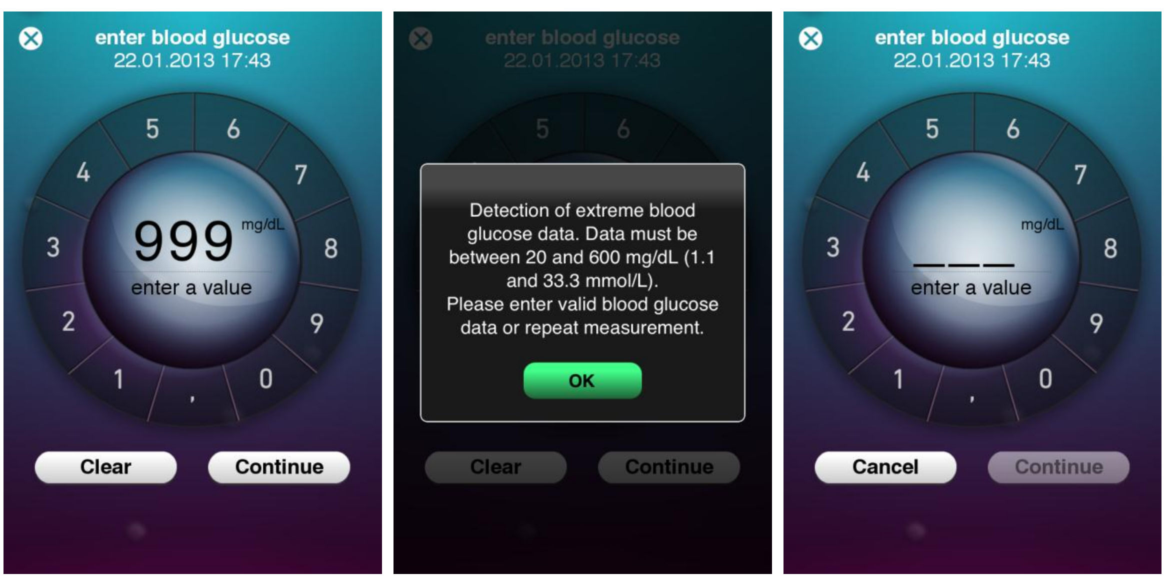
The selected colors (green, red and blue) correspond to common expectations about color codes in daily life.

On manual data entry screens, tasks are described in terminology which is familiar to users (diabetes patients) (Figure 20).

Enter blood glucose Enter insulin Enter food

Figure 20. Example of menu titles

Input data codes are meaningful. If the user manually enters a blood glucose level which is outside of the default ranges, an error message occurs and the user is not allowed to ‘save’ the data. The user is directed to blood glucose level data entry screen to re-enter the correct data (Figure 21).



Wrong data entry Information message Turn back to enter blood glucose screen

Figure 21. Manual data entry screen shots with error messages

4.3.3 User control and freedom

There is no way to undo actions, which is especially useful and necessary when users do something wrong like entering a wrong blood glucose level manually. In case of entering a wrong blood glucose level, the user should delete the measurement from the application and then enter the correct data which means to do an extra 3 steps to correct the erroneous entry (Figure 22).

Wrong Data Screen Shot Delete Data Screen Shot Warning Message Screen Shot

Figure 22. Deleting the wrong blood glucose level measurement

Moreover, before saving the blood glucose level, there is a redo/undo function to change actions to the previous condition with one step.

Entering the wrong blood glucose level | Save screen | Cancelling save, turn back to the main screen

Figure 23. Enter blood glucose level manually, do not save, and cancel the saving.

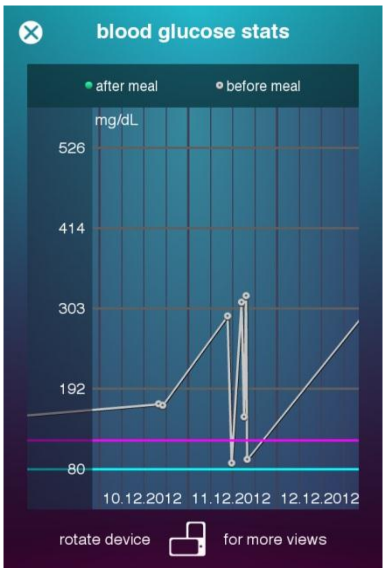
Before sending the monthly report to the doctor, there is no option to delete blood glucose level measurements from the report list. The only way for doing this operation is to open the blood glucose menu, selecting the last measured data from the screen and find the data to be deleted (Figure 24).

Figure 24. There is no option to delete the results one by one at the report screen.

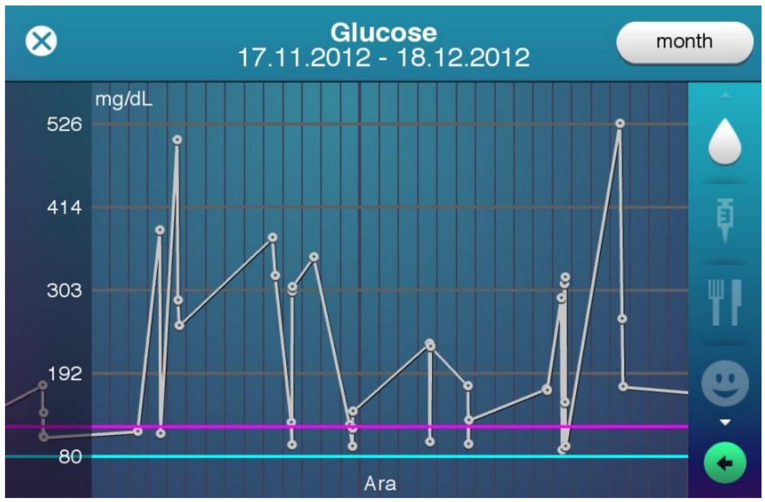
Limiting the options of deleting measurement results let a more accurate database. Moreover, data deleting options may let users not to send poor measurement results to the doctor or not feel like a patient every time. Thus, a control mechanism is necessary for more accurate patient measurement history.

4.3.4 Consistency and standards

M-health application icons are labeled. There are no more than twelve to twenty icon types. Each window has a title. All menu titles are centered. The menu structures match the task structure. Attention-getting techniques are used with care (intensity, size, font, blink, color and sound). Vertical usage of the screen is possible for all window. Only blood glucose statistics screen can be usable in vertical and horizontal screen. Moreover, when the blood glucose statistics screen is in horizontal form, more statistical views are available (Figure 25).



Statistics Screen Shot
(Vertical View)



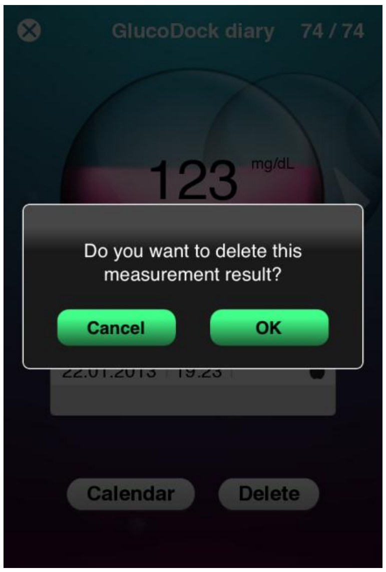
Statistics Screen Shot
(Horizontal View)

Figure 25. Statistics Screen Shots – Vertical and Horizontal Views

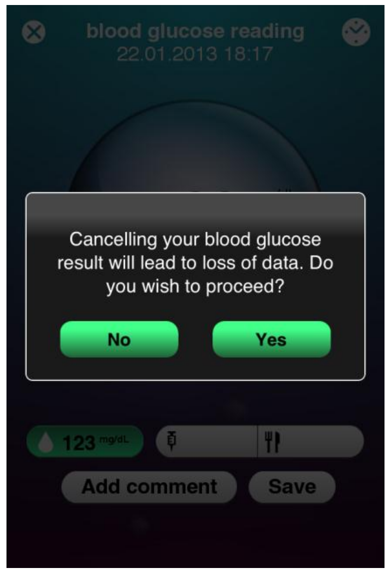
4.3.5 Error prevention

The sound is used to signal an error. The error messages are grammatically correct. All error messages in the system use consistent grammatical style, form, terminology and abbreviations.

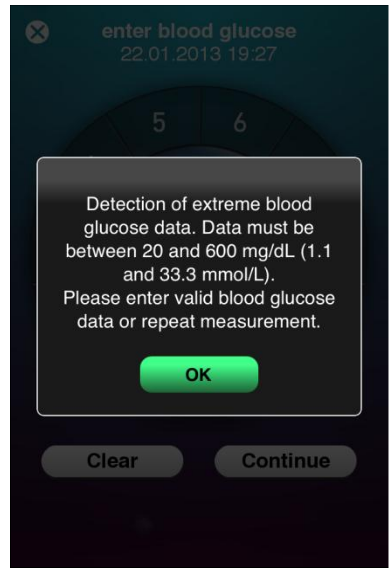
The user eliminates error-prone by error messages screens.



Error Message #1 Screen Shot



Error Message #2 Screen Shot



Error Message #3 Screen Shot

Figure 26. Example of error messages

As shown in the error message #3, the user is informed about the necessary action to correct the error.

For instance, to avoid contamination while sticking the blood glucose level measurement test strip in the module, user hands should be clean and dry. Although the diabetes patients generally know this situation, sometimes they try to use the same test strip more than once. In such a case, an error message is issued to prevent the use of already used test strip.

Figure 27. Error message screen shot of the used test strip

The permissible range for the control solution reading is indicated on the label of the test strip container. Before starting measurement, the user should compare the test result with the correct range. Control test result fall within the range indicated on the test strip container, means that the test strips, the mobile health device and the smart phone are working accurately.

Test strips have a best - before date. The participant must be careful at this point for correct measurement. If the test strip best before date was expired, and the user did not take care, the blood glucose measurement could be wrong (The test strip maybe worked). If the user saves the blood glucose measurement results and continues in this manner, it would let a wrong self-management health care case. Thus, there must be an alert on the application for checking the best before date of test strips when they are inserted into the m-health device.

The device can display a warning message like “Control the best-before date of the test strips” or use a Quick Response (QR) code to control the best-before date of strips.

4.3.6 Recognition rather than recall

Visual cues are used to distinguish instructions and user input. The cues and messages are placed where the eye is likely to be looking on the screen.

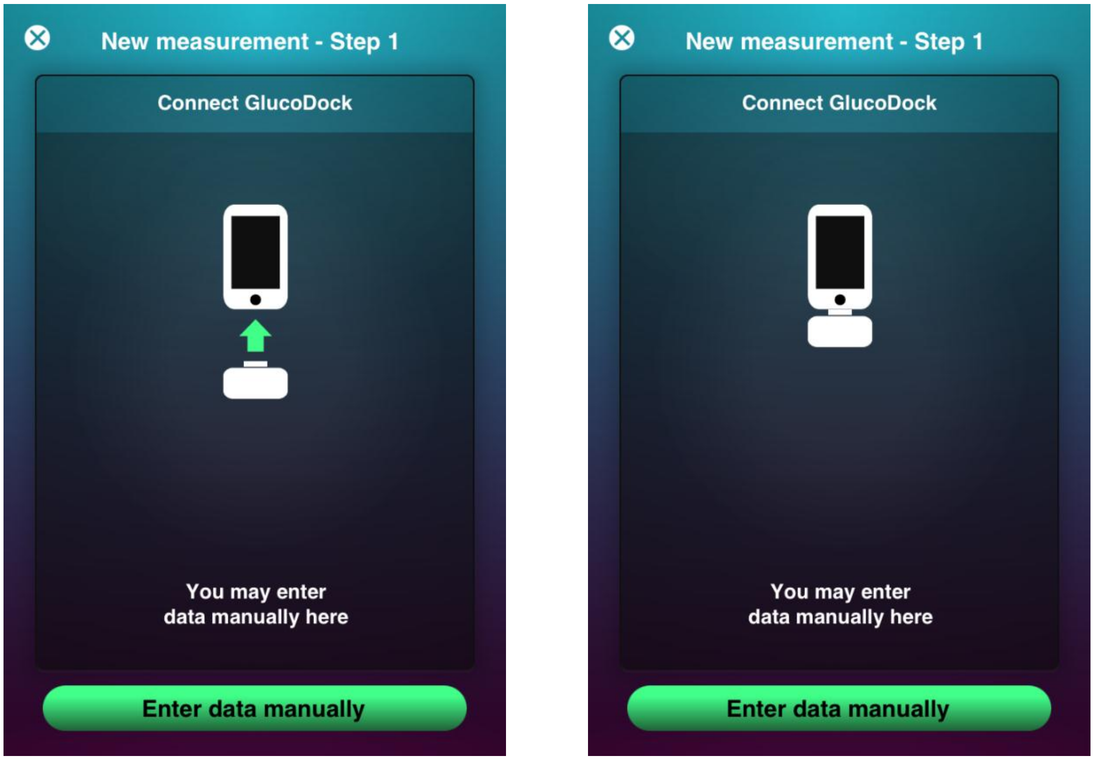


Figure 28. Connect blood glucose module with smart phone (screen shots)

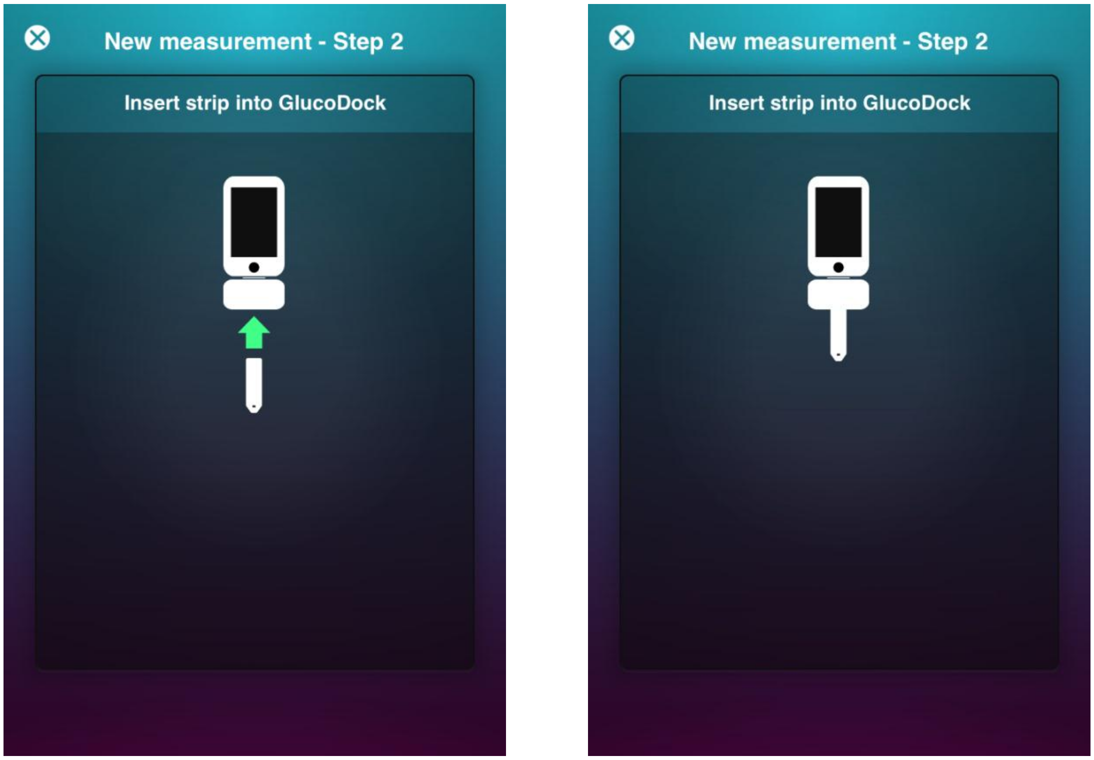
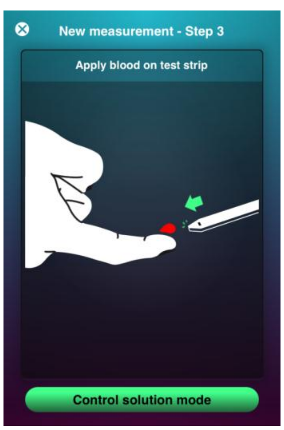


Figure 29. Stick the blood glucose test strip in the module (screen shots)



A test strip absorbs a drop of blood (screen shot)

Receiving data (screen shot)

Measurement completed (screen shot)

Measurement saved (screen shot)

Figure 30. Some other visual cues' screen shots

Text areas have “breathing space” around them. The manual data entry fields are clearly marked. The same color has been used to group related items. The color coding is consistent throughout the system. There is a good color and brightness contrast between icons and background colors. Menu selections are not default, the user can be limited the other menu options via ON/OFF in the “Settings” menu.

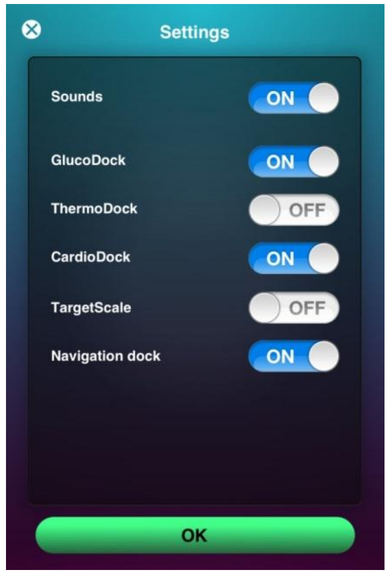
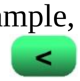
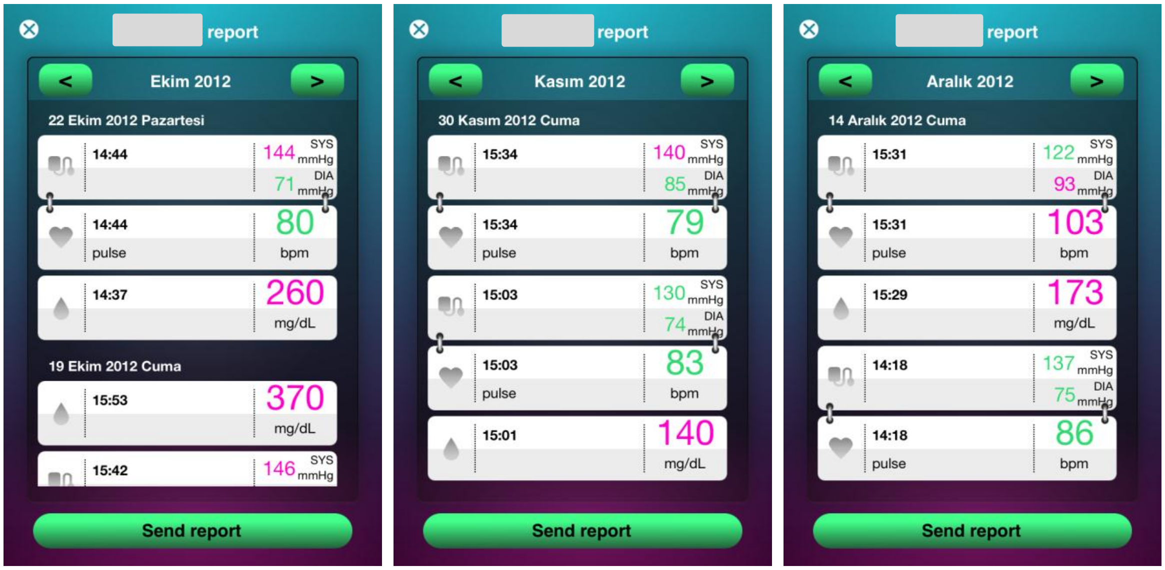


Figure 31. Settings Menu Screen Shot

4.3.7 Flexibility and efficiency of use

The system offers “find next” and “find previous” shortcuts for report screen. For example, if the user wants to see the list of measurements of November, simply touching the  icon when the screen is on December, or touching the  icon when the screen is on October is enough (Figure 32).



Touch > to see November report screen

November report screen

Touch < to see November report screen

Figure 32. Different monthly reports screen shots

On manual data entry screens, users have the option of touching directly to the screen. On menus, users have the option of touching directly on a menu icon.

4.3.8 Aesthetic and minimalist design

All icons are in a set which are visually and conceptually distinct. Each data entry screen has a short, simple, clear and distinctive title. The error messages are short and easy to read. So the user can understand the messages quickly and efficiently.

The blood glucose measurement module is small enough to carry comfortably.

4.3.9 Help users recognize, diagnose and recover from errors

Error messages are expressed in plain language (no code), precisely indicate the problem and constructively suggest a solution.

4.3.10 Help and documentation

There is no help option/icon or menu on the application. When the user is confused about a function and wants to get help, there are no instructions available. Relevant documentation is available only in hard copy. There is an information icon on the system. When the user touches this icon, the manufacturer contact information (telephone, fax, mail, and web sites) is available.

4.4 Cognitive Walkthrough

Goal - A (Measure Blood Glucose Level) and B (Blood Glucose Level Data Export) shows how tasks performed as shown before at the methodology. Each operation represents a physical action. This structure for the Hierarchical Task Analysis descriptions was used for all tasks included in the Cognitive Walkthrough analysis.

4.4.1 Goal – A: Measure Blood Glucose Level

Goal - A (Measure Blood Glucose Level) includes seven subgoals. All subgoals' task successes and task completion times are given in Appendix F.

Total Time (ToT - minutes) including the Training Time (TrT - seconds) and Total Subgoal Time (TsT – seconds) mean ± standard deviation was 16.5 ± 6.7 minutes. The training time mean ± standard deviation was 738.6 ± 352.3; range: 114 – 1449 seconds. The total subgoal (subgoal – 1, subgoal – 2, subgoal – 3, subgoal – 4, subgoal – 5, subgoal – 6, subgoal – 7) mean ± standard deviation was 248.4 ± 57.4 seconds.

Subgoal – 1, "✔" means that the participants achieved to open the m-health application, touch the blood glucose measurement menu and open the "New reading – Step 1" window. The Subgoal – 1 mean ± standard deviation was 24.2 ± 5.2 seconds; range: 17 – 46 seconds. All participants had succeeded at Subgoal – 1.

Subgoal – 2, "✔" means that the participants inserted the blood glucose measurement module into the smart phone. The Subgoal – 2 mean ± standard deviation was 18.9 ± 3.5 seconds; range: 12 – 37 seconds. All participants had succeeded at Subgoal – 2.

Subgoal – 3, "✔" means that the participants inserted a test strip into the blood glucose measurement module in the direction of arrow. All participants had succeeded at Subgoal – 3. The participants are diabetes patients and they know the meaning of 'direction of arrow'. They did not make any mistake at this subgoal. The Subgoal – 3 mean ± standard deviation was 19.1 ± 3.3 seconds; range: 13 – 34 seconds.

Subgoal – 4, "✔" means that the participants obtained a blood sample. The Subgoal – 4 mean ± standard deviation was 134.8 ± 30.2 seconds; range: 91 – 190 seconds.

Normally, they are very familiar to obtain a blood sample; it takes approximately 60 seconds. The participants generally do not clean the area of skin in every measurement. If they clean the area with alcohol, they do not wait a few seconds until the alcohol has completely evaporated from the skin to avoid causing incorrect. Moreover, they generally drop the first blood to the test strip. However, the second/new blood sample must drop to the strip for accurate results. In this study, the participants attend all these factors, so obtaining a blood sample period is a little bit longer than the other subgoals.

Subgoal – 5, "✔" means that the participants place the drop of blood onto the transparent blood sample area on the end of the test strip.

Subgoal – 5, "✖" means that the participants do not get any blood on the top of the test strip. When the participants miss this subgoal, they turn back to the subgoal – 3. But they do not obtain a new blood sample (subgoal – 4). They achieved the subgoal at their second test.

The Subgoal – 5 mean ± standard deviation was 27.5 ± 17.7 seconds; range: 19 – 102 seconds.

Subgoal – 6, "✔" means that the blood glucose measurement is done automatically by the mobile device. After approximately five seconds, the blood glucose measurement result is completed and appears in the display. So, for every participant this period is five seconds.

Subgoal – 6, "✖" means that the participants failed in the Subgoal – 5, so the measurement must be done again. The five seconds multiplied twice here, and the time period is assigned to 10 seconds.

The Subgoal – 6 mean ± standard deviation was 5.3 ± 1.3 seconds; range: 5 – 10 seconds.

Subgoal – 7, "✔" means that the participants saved their blood glucose level measurement results at their first time by using touch screen.

Subgoal – 7, "✖" means that the participants saved their blood glucose level measurement results at their second or third trying. When they tried to save the measurement result using a touch screen, they tapped the 'Save' button on the screen. Over a long term period, they hold their fingers on the 'Save' button and could not save. Extra information was given to these participants to tap the 'Save' button, and immediately take finger away. The Subgoal - 7 is completed after this explanation.

The Subgoal – 7 mean ± standard deviation was 18.7 ± 11.2 seconds; range: 6 – 45 seconds.

4.4.2 Goal – B: Blood Glucose Level Data Export

Goal - B (Blood Glucose Level Data Export) includes four subgoals. All subgoals' tasks are succeeded and task completion times are given as below. There is no training time here; this goal's training was given in the Goal – A (Measure Blood Glucose Level).

Subgoal – 1, "✔" means that the participants are achieved to open the m-health application.

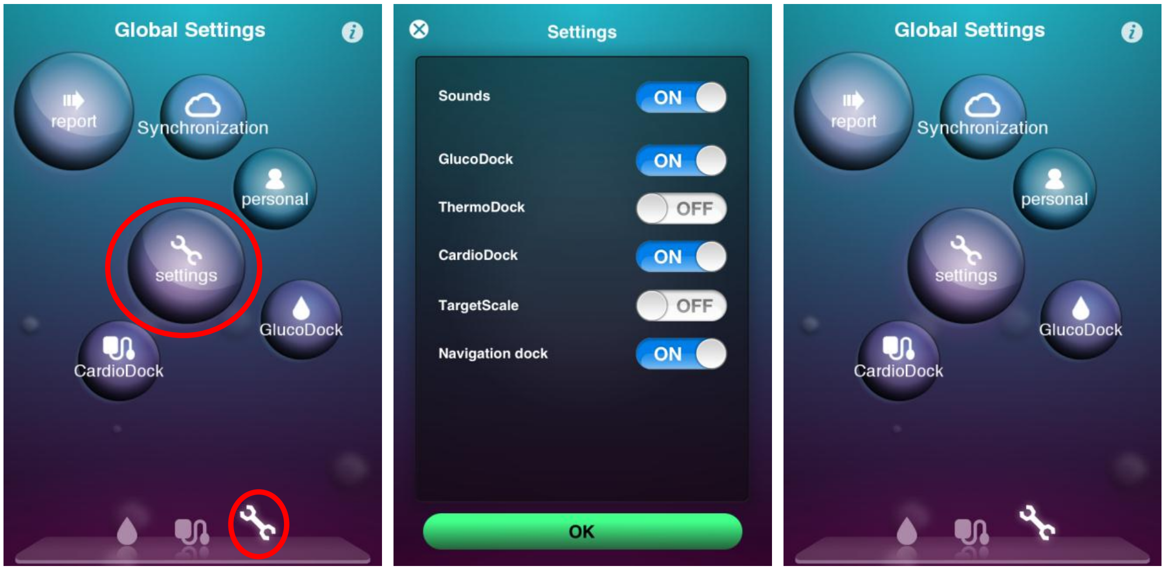
The Subgoal – 1 mean ± standard deviation was 17.6 ± 2.4 seconds; range: 13 – 22 seconds. All participants had succeeded at Subgoal – 1.

Subgoal – 2, "✔" means that the participants touched the "Global Settings" icon, and displayed the "Global Settings" screen.

The Subgoal – 2 mean ± standard deviation was 8.6 ± 2.2 seconds; range: 5 – 13 seconds. All participants had succeeded at Subgoal – 2.

Subgoal – 3, "✔" means that the participants displayed the monthly reports screen successfully. All the participants found the screen. But, all of them touched the "Settings" icon first and they could not find the "Report" screen. Then, they turned back to the "Global Settings" menu and then touched the "Report" icon. This happened because of the usage of same icons for "Global Settings" and "Settings". The participants thought that the "Report" icon comes after touching the "Settings" icon. They struggled with this subgoal.

The Subgoal – 3 mean ± standard deviation was 36.5 ± 7.4 seconds; range: 26 – 48 seconds. All participants had succeeded at Subgoal – 3.



Touch the icon and slide the display "**Global Settings**".

Tap "Settings" icon wrongly.

Close "Settings" and slide the display "**Global Settings**" again.

Figure 33. Global Settings and Settings Screens' Shots

Subgoal – 4, " ✔ " means that the participants sent their monthly reports to the doctor. 23 of them (38.3%) have been using e-mail and managed to send the measurements correctly. The differences between basic model phone and smart phone users' total sending time (it includes the writing e-mail address via touch screen) are shown in table 19. The total time (including sending e-mail) of basic model users is more than the smart phone users. This is statistically meaningful ($p < 0.001$).

Table 20. Total Time (ToT) differences between basic model phone users and smart phone users (n=23).

		Basic model (n=9)	Smart phone (n=14)	p
Total	Mean ± SD	172.1 ± 17.9	132.9 ± 21.7	0.001
Time	Median [Min-Max]	177 [149 – 194]	125 [105 – 178]	

Subgoal – 4, "✕" means that the participants could not send their monthly reports to the doctor. Of the 60 diabetes patients, 35 of them (58.4%) did not use e-mail before; hence they could not send the blood glucose level measurements.

The remaining two diabetes patients (3.3%) used e-mail before but they could not send the data as they were not comfortable with using touch screen.

The participant's actions and thoughts for trying to send reports via e-mail are shown in Figure 34.

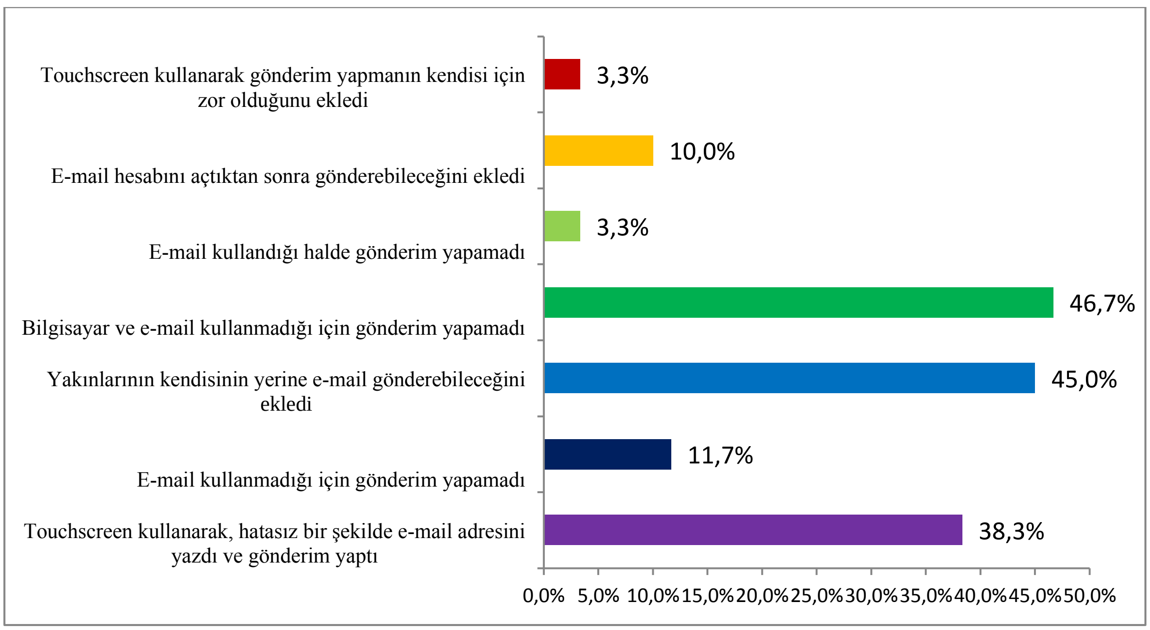


Figure 34. The reasons of sending monthly report or not.

In this study, interview, questionnaire, hierarchical task analysis, heuristic evaluation and cognitive walkthrough methods are used. These methods served different aims and needs in different phases of the study. Interview, for example, was used to obtain information about how the participants save the blood glucose measurement and share with their doctor. Moreover, interview was used to obtain information about the participants, like to automatically forward their measured blood glucose level to the doctor by a device or not. With the help of information obtained from an interview, the participants' usage of any blood glucose measurement device, usage frequency and their data sharing styles with the doctors are defined.

With the questionnaire, the participants' demographics, technology experiences, knowledge, skill and experiences about mobile health technology, overall usability, information presentation and design of mobile health technology, and their general comments are analyzed.

Data collected from all of these methods are analyzed and their results are reported at the previous chapter. One important observation from them is m-health device and medical gold standard measurements were in close proximity. In fifty nine (%98.3) diabetes patients, the gold standard agreed the measurement which was done by the mobile health device. Secondly, when participants were asked to provide a decision on future health care choices, pre-dominate number of participants said they would change their lifestyle rather than visiting a doctor regardless of their blood glucose level. There is no difference exists in changing their lifestyle rather than visiting a doctor regardless of their diabetes by age, gender, education level, monthly income, marital status, type and period of diabetes, and technology experience except occupation ($p<0.05$). Housewives, retired and skilled workers prefer to change their lifestyles rather than visiting a doctor regardless of their blood glucose level measurements. Results showed that various human profile want to use mobile health technology rather than visiting a doctor. Thirdly, type of mobile phone (basic model or smart phone) affected the overall usability (errors, learnability, memorability, efficiency, and satisfaction) of the mobile health technology. These results showed that the participants who use smart phones were more comfortable and use the mobile health technology easier than the basic model phone users. It is exactly the same like the participants who use e-mail before. Lastly, the information presentation and design of mobile health technology affected the overall usability. For example, the screen's viewability, readability and clearly arranged screens affected the learnability.

When the usability measures, effectiveness, efficiency and satisfaction are investigated, following observations are noted:

To evaluate the *effectiveness*, these are the accuracy and completeness of mobile information and communications technology in health care;

- What percentage of goals are accurately completed by the participants?
- Which subgoals are the most difficult for the participants to complete? / What kind of errors do they face when they failed to complete a subgoal?

To evaluate the *efficiency*, these are the resources expended in relation to the accuracy and completeness of the mobile information and communications technology in health care:

- How long does it take participants to perform each subgoal and goal?
- What are the main design issues of mobile information and communications technology in health care in terms of established usability heuristics?

To evaluate the *satisfaction*, these are the freedom from discomfort, positive and negative comments of the mobile information and communications technology in health care:

- How do the participants rate the overall usability of the system?
- How do the participants rate the information presentation and design of the mobile information and communications technology in health care?

are discussed.

What percentage of goals is accurately completed by the participants?

This question is aimed to evaluate the effectiveness of the mobile information and communications technology in health care. The first goal is the blood glucose measurement which has seven subgoals. Subgoal – 1, Subgoal -2, Subgoal -3, and Subgoal - 4 accurately completed by the all participants (100% respectively). Subgoal – 5 was completed by 56 diabetes patients (93.3% success rate), Subgoal – 6 was completed by 56 diabetes patients (93.3% success rate), Subgoal – 7 was completed by 43 diabetes patients (71.6% success rate). For Subgoal – 5, Subgoal – 6 and Subgoal – 7, the participants repeated them, and finished their blood glucose measurements. All the subgoals were completed accurately by 41 diabetes patients (68.3% success rate). The results of the subgoals completion times are presented in Appendix F. The second goal which was the blood glucose measurement data export was not accurately completed by the all participants. Of the 60 diabetes patients, 35 (58.4%) did not use e-mail before; hence they could not send the blood glucose level measurements. The remaining two diabetes patients (3.3%) used e-mail before but they could not send the data as they were not comfortable with using touch screen. On the other hand, subgoal – 1, 2, and 3 of the second goal was accurately completed by them. Subgoal – 1, Subgoal – 2, and Subgoal - 3 are completed by 60 diabetes patients (100% success rate). Subgoal – 4 was completed by 23 diabetes patients (38.3% success rate), so this goal was completed accurately by 23 diabetes patients (38.3% success rate).

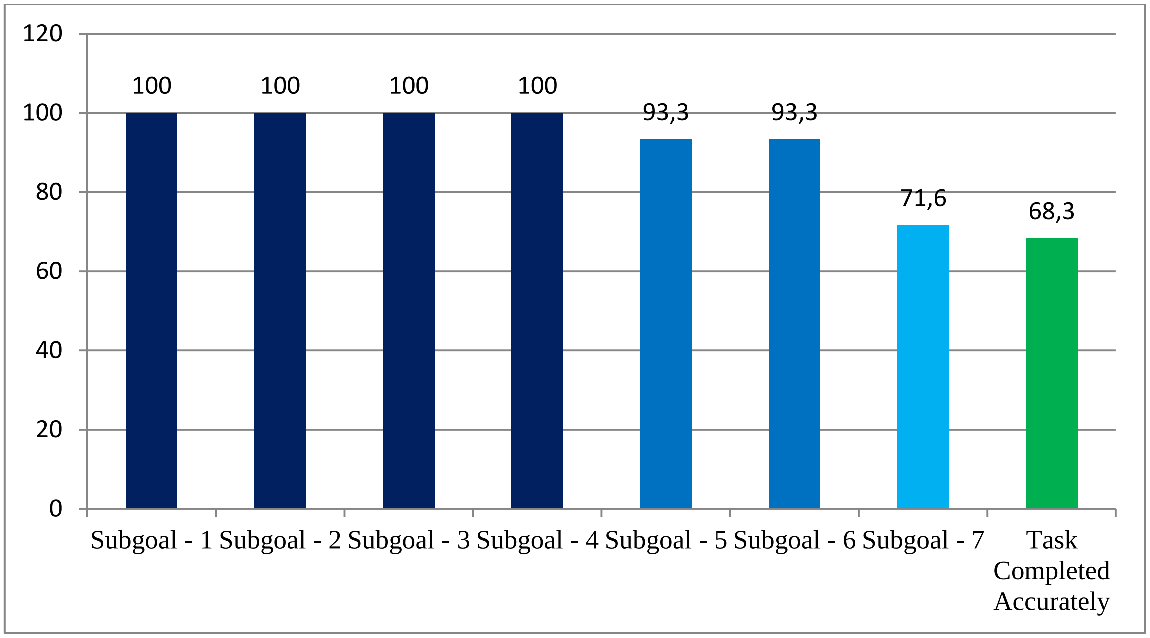


Figure 35. Goal – A: What percentage of goals is accurately completed by the participants?

68.3% of Goal-A is accurately completed by the participants.

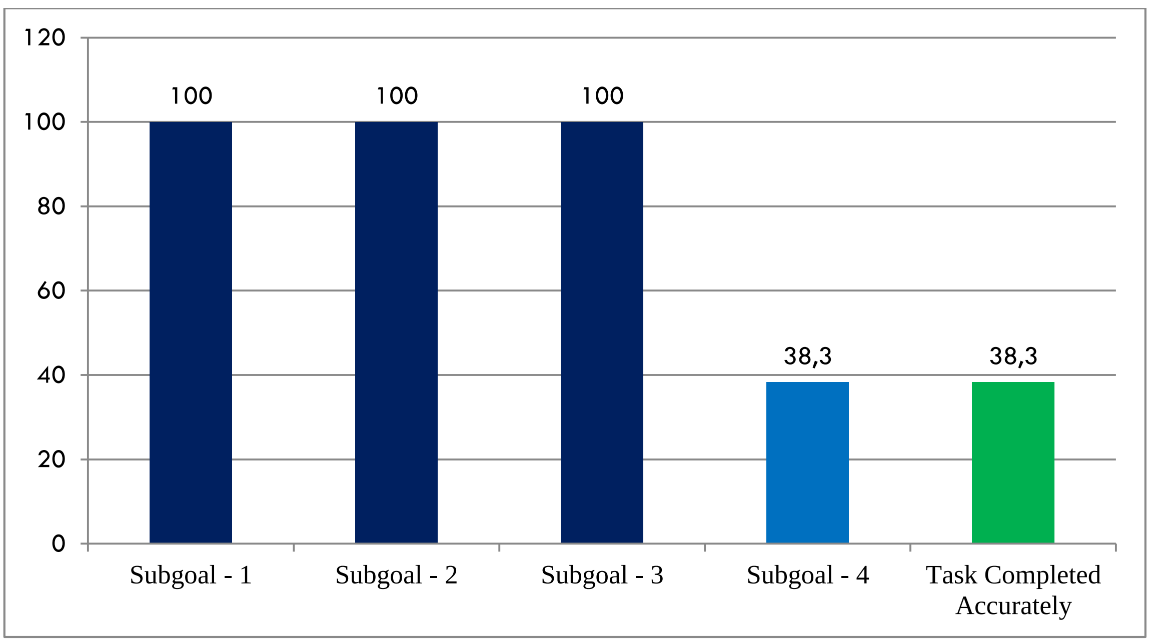


Figure 36. Goal – B: What percentage of goals is accurately completed by the participants?

38.3% of Goal-B is accurately completed by the participants.

Which subgoals are the most difficult for the participants to complete? / What kind of errors do they face when they failed to complete a subgoal?

This question also aimed to evaluate the effectiveness of mobile information and communications technology in health care. In the light of the question "*What percentage of goals is accurately completed by the participants?"*, it can be stated that the most difficult subgoal for the diabetes patients to perform was Subgoal -4 in Goal B – Blood Glucose Measurement Data Export. One of the reasons for this situation was that the thirty five participants did not use e-mail before. Two of the diabetes patients had e-mail accounts, but they could not get any success in Subgoal -4 because of lack of ability to use the touch screen.

The other difficult subgoal for the diabetes patients to perform was Subgoal – 7 in Goal A – Blood Glucose Measurement. One of the reasons of this situation was that the thirty eight participants use basic model phones. They did not experience to use a touch screen smart phone. They pushed the icons like a normal button, getting false response for this action, and they could not 'save'.

The subgoals task completion times are compared by Friedman test. Multiple comparisons are done by Bonferroni adjusted Wilcoxon test (Table 20 and 21).

Table 21. Goal – A: Which subgoals are the most difficult for the participants to complete?

Time (seconds)	Subgoal
134,8	4
27,5	5
24,2	1
19,1	3
18,9	2
18,7	7
5,3	6

There is a difference between subgoals' length of completion time (p<0,001).

No difference between Subgoal -1 and Subgoal – 5 (p=0,802).

No difference between Subgoal - 2 and Subgoal – 3 (p=0,208).

No difference between Subgoal -2 and Subgoal – 7 (p=0,436).

No difference between Subgoal- 3 and Subgoal – 7 (p=0,438).

The others have differences (p<0,001).

Table 22. Goal – B: Which subgoals are the most difficult for the participants to complete?

Time (seconds)	Subgoal
36,5	3
17,6	1
8,6	2

Subgoal -1, Subgoal -2, and Subgoal – 3 are different from each other in terms of length of subgoal completion time (p<0,001).

How long does it take participants to perform each subgoal and goal?

This question aimed to evaluate the efficiency of the mobile information and communications technology in health care. Goal - A (Measure Blood Glucose Level) includes seven subgoals. All subgoals' task successes and task completion times are given as in Results part. Moreover, in Appendix F total time (minutes), training time (seconds), total subgoal time (seconds), subgoals' task success, and task completion time in seconds of blood glucose measurement are presented.

Goal - B (Blood Glucose Level Data Export) includes four subgoals. All subgoals' task successes and task completion times are given as in Results part. There is no training time here; this goal's training was given in the Goal – A (Measure Blood Glucose Level). Moreover, in Appendix G, total time (seconds), subgoals' task success, and task completion time in seconds of Blood Glucose Level Data Export are presented.

When calculating the mean ± standard deviation of the participants' task completion time values, participants who repeated the subgoal is not eliminated from the analysis. Their task completion time values includes their repeats.

With the usability evaluators, ideal times for the subgoals are obtained. Before calculating these times, all evaluators used the system several times. They calculated the time continuously.

Goal – A: Measure Blood Glucose Level

Subgoal - 1: 15 seconds, Subgoal - 2: 10 seconds, Subgoal - 3: 15 seconds, Subgoal - 4: 80 seconds, Subgoal - 5: 15 seconds, Subgoal - 6: 5 seconds, and Subgoal - 7: 5 seconds.

Goal – B (Blood Glucose Level Data Expert)

Subgoal - 1: 10 seconds, Subgoal - 2: 5 seconds, Subgoal - 3: 20 seconds, Subgoal - 4: 40 seconds.

When Figure 37 and 38 are interpreted, it can be seen that all the subgoals are completed in longer time compared to ideal time.

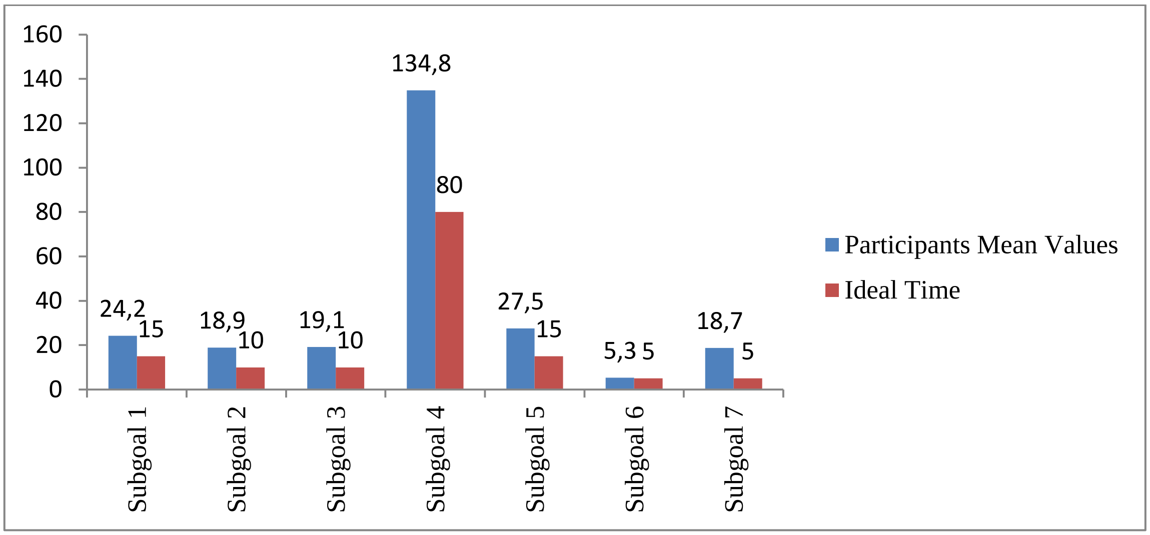


Figure 37. Goal – A, Measure Blood Glucose Level / Ideal Time

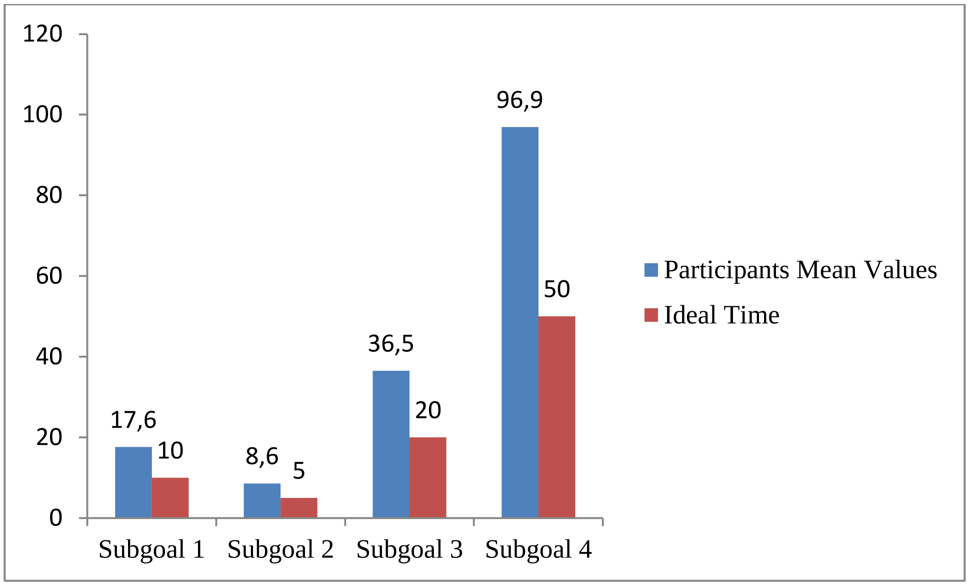


Figure 38. Goal – B, Blood Glucose Level Data Expert / Ideal Time

What are the main design issues of mobile information and communications technology in health care in terms of established usability heuristics?

This question is aimed to display design errors of the mobile information and communications technology in health care. To display design errors of the mobile information and communications technology in health care, Nielsen's (1993) heuristics evaluation are applied by three evaluators. The results of these evaluations are reported before. The most critical design errors were:

- To avoid disruption from an incoming call or text message during a reading, there is not an automatic switch to flight mode operation or an information message.
- To avoid false measurement, there is no cancellation of measurement or an information message about the minimum battery charge level for a valid measurement.
- To avoid regular measurement, there is no alert or reminder about the blood glucose measurement duration.
- To avoid repeated measurement, there is no information message about enough memory necessary for storing blood glucose measurement.
- To avoid methodological sending reports, there is no alert or reminder.
- There is no selection dates option for sending reports. Only monthly reports can be send.
- There is no extra information for the participants about their "Good", "High", and "Low" measurement results.
- There is no restraint about doing the personal "Settings" for the first usage of device.
- There is no help menu.

How do the participants rate the overall usability of the system?

The question is aimed to present the user satisfaction which is the dimension of usability. To measure users' satisfaction with ratings overall usability of the mobile information and communications technology in health care, the overall usability questions is administrated after the usage of m-health service. The results of overall usability is represented in Reports part.

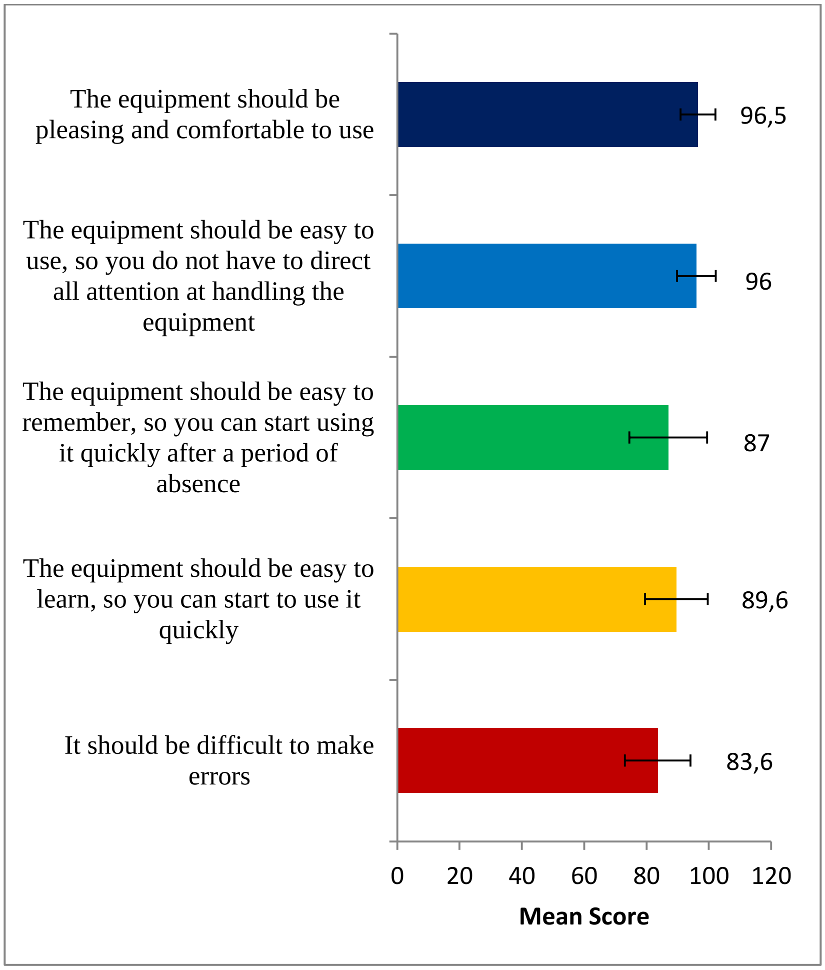


Figure 39. How do the participants rate the overall usability of the system?

In order to address this research question, the remarks of the questionnaire results are also examined and some positive and negative comments are given as follows:

Positive comments:

- ✔ "*Kontrol için hastaneden randevu almaktan kurtulmuş olurum.*"
  "I get rid of from getting an appointment for control."
- ✔ "*Sıra beklemekten kurtulmuş olurum.*"
  "I get rid of from waiting in physician lines."
- ✔ "*Herhangi bir yere not etmeden, akıllı telefonun hafızasına kayıt etmesi çok güzel.*"
  "It is great to save the measurement to my smart phone rather than entering in a book."
- ✔ "*E-mail ile doktora göndermek çok güzel.*"
  "It is great to send it to my doctor by e-mail."
- ✔ "*Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim." [Tekerlekli sandalyeye bağlı yaşıyorum.]*
  "Making visits to the hospitals back and forth is difficult and costly. I like to use it." [I am leaving wheelchair ridden.]
- ✔ "*Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.*" [*Üç ayda bir, kontrol için hastaneye gelmekten yoruldum.*]
  "It is better to make the controls at home rather than visiting hospital. [Visiting the hospital quarterly wearied me.]"
- ✔ "*Hastanenin stresinden kurtulmak için bu cihazı kullanmayı isterim.*"
  "I would like to use this device to prevent the hospital stress."

Negative comments:

- ✕ "*Touchscreen kullanarak gönderim yapmak benim için zor.*"
  "It is hard for me to send it by using a touch screen."
- ✕ "*Mobil Servis Sağlayıcılarına para kazandırmak istemiyorum, bu nedenle de kullanmak istemiyorum.*"
  "I do not want to use it because I do not want the mobile service providers to make money."

How do the participants rate the information presentation and design of the mobile information and communications technology in health care?

The majority of the users comments for information presentation and design are average and above (Table 11). Screen is easily viewable, clearly arranged, and easily readable. The colors are convenient. It is easy to understand the meaning of the icons. There are not too much menu and not difficult to understand. Fifty of the diabetes patients thought that touch screen is easy to use. For the blood glucose measurement module, the participants said that it is small enough to carry comfortably.

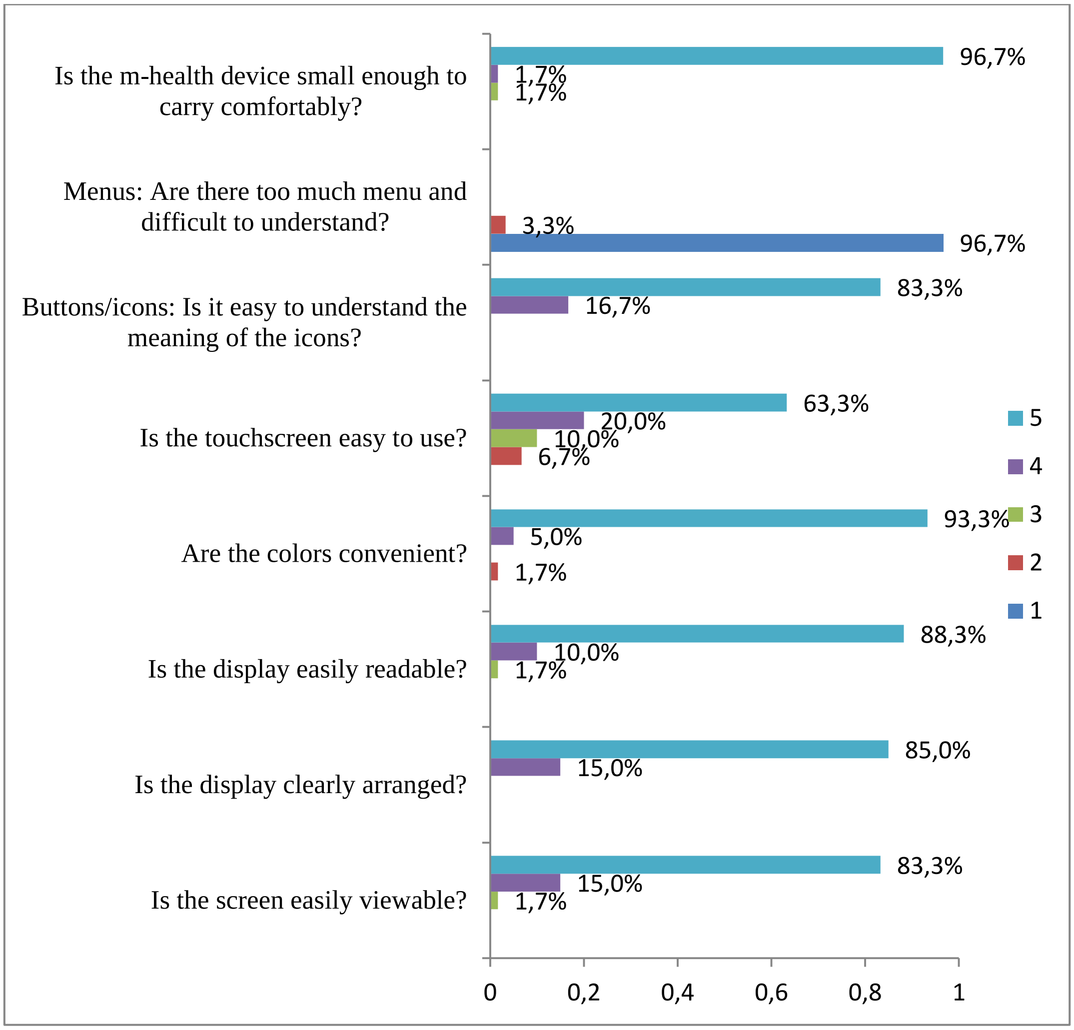


Figure 40. How do the participants rate the information presentation and design of the mobile information and communications technology in health care?

5. CONCLUSION

Technology plays an increasingly important role in modern health care. The use of mobile health technologies offers a highly accessible and cost-effective means of self-management tools. These allow providers to help patients improve their health on a real-time basis, enabling them to personalize health care options and to monitor the progress.

According to our study conducted on 60 diabetes patients, several important findings are obtained. It was found out that the majority finds the m-health technology useful and practical. The ease that it could bring into their lives in terms of not having to struggle to get an appointment, to wait in physician lines, to make several visits to the hospital back and forth was the major reason for this feedback. This could also save them time as well as preventing artificial stress that builds up in the hospital environment. Especially those who have limited mobility or who live out of town could benefit from this technology significantly. Another benefit is related to diabetes patients having memory issues. Some patients may either forget to log the data or misremember the measured value hence resulting in misleading information. By using the mobile health technology, these risks vanish.

E-mailing the results seemed to be a problem for some of those who were not familiar with it. However, there was a good amount of patients who mentioned that someone in the family can send the results via e-mail. About 11.6% of the patients said that they can use this technology and send the results to their physician via e-mail; however they still would want to see their physician in person. This could be related to them having more peace of mind when they talk to their physician face to face.

When participants are asked to provide a decision on future health care, predominate number of participants said they would change their lifestyle rather than visiting a doctor regardless of their blood glucose level. Some of the patients mentioned that it would be great if the government supported the use of this technology financially. However they added that even if there was no government support they could still consider purchasing these kinds of devices.

In conclusion, little is known about such effects of mobile health technologies in self-management care situations. It is clear that usability studies in the field are more difficult to conduct than laboratory evaluations. Further studies with larger sample sizes are needed to further evaluate these initial findings.

Limitations of the Study

An important limitation of this study is that participants used the mobile health technology only one time except the training period. Maybe after their second or more usage of mobile health technology, the task success would increase and task completion time would decrease.

The participants’ technology experiences were limited. Thus, Goal – B’s Subgoal – 4 could not be realized with all the participants.

Contributions of the Study

The study contributed to the willingness of the participants for using mobile health technologies. Participants’ future decisions are on changing their life-style rather than visiting a doctor. This study also quantitatively investigated how participants’ demographics, technology experience, and ergonomic design of mobile health technologies affected the overall usability. Another contribution of the study was the critical design errors. The usability evaluation results were given by real users and environment not unreal users, and laboratory environment.

Comparison of Usability Evaluation Methods Used in this Study

There is not yet an agreement in the community about which evaluation is more useful than other. The current best practice is to use a number of different evaluation methodologies to provide rich data usability. So, in this study interview, questionnaire, task analysis, heuristics by Nielsen (1993), and cognitive walkthrough are used.

Recommendations to Improve Usability of Mobile Health Technologies

In the light of the usability evaluation methods used in this study, a number of significant usability problems are found and explained in the discussion part. To solve these problems some recommendations are made. They are listed as follows;

- The mobile health technology involves only monthly sending report screen. To solve this issue, the interface should be re-designed and added an option for time period selection to improve the efficiency.
- The mobile health technology interface includes some texts that can hardly be read by elder people (e.g. insulin, food, statistics, and etc.). The participants do not use such menus. So, their answers for the screen readable are good. But, the other font sizes should be made suitable for users from different ages.
- The mobile health technology has some error and warning messages, but not enough. To solve this issue, for the flight mode, battery charge, memory capacity as discussed before, new error and warning messages must be added to improve the effectiveness and efficiency of the mobile health technology.
- The mobile health technology stores the measurements in the smart phone's memory. There must be a cloud solution for this problem or maybe a central system within Sağlık-Net. Diabetes is a chronic disease and the smart phones capacity is not enough for storing yearly periods.
- The mobile health technology must issue an alarm to alert the user for measuring the blood glucose level. On-time and correct measurements are important to improve the effectiveness and efficiency of the mobile health technology.
- The mobile health technology displays the last measured blood glucose on the screen. For preventing the duplicate measurements, there must be a warning message (e.g. Today's first fasting / postprandial glucose are measured. Do you want to measure again?)
- The mobile health technology displays the blood glucose measurement result as "Good", "High", and "Low". For improving the efficiency and effectiveness of the mobile health technology, detailed information must give to the users. The data stored in the memory, and with a decision system, extra detailed information can be given about treatments to the users.
- The mobile health technology has a capability for storing the insulin, and food data also. Like decision systems again, mobile health technology can give treatment cues to the users.
- The mobile health technology can integrate to the hospital information system and it improves the efficiency and effectiveness. The users may use a third party solution, but they must know that it works coordinated with the hospital.
- The mobile health technology uses the same icon for the "Global Settings" and "Settings". If the users only attend to the icons, they choose the wrong menu. To solve this issue, the icon must change for one of them.
- The mobile health technology does not have help menu on the application, only paper-based. To improve efficiency, online help documentation must be prepared and/or direct call to customer service.

- The mobile health technology has a capability to send reports to the doctor. There must be a pre-defined area for entering the doctor's e-mail address. It improves the effectiveness of the mobile health technology. The user defines the doctor's e-mail address for once, and do not write it the same thing every time. It can be helpful for the users who could not use the touch screen comfortably.
- The mobile health technology uses test strips for measurement. The best before date is written on the test strip container. If the test strip's best before date is passed, a warning message is not issued when the test strip is inserted into the blood glucose measurement module. To solve this issue, there must be a warning message for the best before date of the test stip. It increases the effectiveness of the mobile health device.
- The mobile health technology application's screens are available for vertical usage, but not horizontal. Only blood glucose statistics screen is available vertically and horizontally. For increasing the efficiency, the other screens must be designed for horizontal use also. Smart phone users have an experience for both of them and want to use the screens in both forms.
- The mobile health technology has an option for entering data manually. There can be an option for voice recognition rather than entering by hand to increase the effectiveness of the mobile health technology. It will also prevent the false data entries manually.
- The mobile health technology is designed for those who can hear and see. The mobile health technology is very important for handicapped people since they have less chance to visit hospitals than the others.
- Creating awareness for the need of mobile health technologies in the society and for the support of these devices by MoH.

Recommendations for Future Research

Based on the discussion of the findings, this study may be extended in several ways, such as;

- To compare two or more mobile health technologies for the same treatment.
- To send the data to the doctors via e-mail and evaluate the usage of mobile health technologies from their side.
- To define guidelines for designing an application to mobile health technologies.

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APPENDICES

APPENDIX A: INTERVIEWS

Do you have diabetes (Type 1 / Type 2)?	**[ ]** Yes	**[ ]** No
How long have you had diabetes?		
Did you monitor your blood glucose level daily with a device?	**[ ]** Yes	**[ ]** No
If *"Yes*", please specify how often?		
Do you save the blood glucose measurement and share with your doctor?	**[ ]** Yes	**[ ]** No
If "*Yes*", please specify:		
How often do you visit a doctor for control?		
What do you do when you feel your blood glucose decreased or increased?		
Please explain:		
Would you like to be automatically forwarded your measured blood glucose level to the doctor by a device?	**[ ]** Yes	**[ ]** No
Would you like to buy a mobile health device of this nature?	**[ ]** Yes	**[ ]** No

EK A: MÜLAKAT

Diyabet hastası mısınız? (Tip 1 / Tip 2)?	**[ ]** Evet	**[ ]** Hayır
Ne kadar süredir diyabet hastasısınız?		
Kan şekeri seviyenizi, bir cihazla günlük olarak takip ediyor musunuz?	**[ ]** Evet	**[ ]** Hayır
Cevabınız "Evet" ise, lütfen ne sıklıkta olduğunu belirtiniz.		
Kan şekeri ölçümünüzü kaydedip doktorunuzla paylaşıyor musunuz?	**[ ]** Evet	**[ ]** Hayır
Cevabınız "Evet" ise, lütfen açıklayınız.		
Kontrol için ne sıklıkla doktora gidiyorsunuz?		
Kan şekerinizin arttığını veya azaldığını hissettiğinizde ne yaparsınız?		
Lütfen açıklayınız:		
Ölçülen kan şekeri seviyenizin bir cihaz ile otomatik olarak doktorunuza iletilmesini ister misiniz?	**[ ]** Evet	**[ ]** Hayır
Bu özelliğe sahip bir mobil sağlık cihazını satın almak ister misiniz?	**[ ]** Evet	**[ ]** Hayır

APPENDIX B: QUESTIONNARIE

1. USER INFORMATION					
1.1. Demographics					
1.1.1. Age / Date of Birth:					
1.1.2. Gender	**[ ]** Male		**[ ]** Female		
1.1.3. Race / Nationality					
1.1.4. Academic background	**[1]** Elementary	**[2]** High School	**[3]** University	**[4]** Graduate School	**[5]** PhD and over
1.1.5. Occupation					
[ ] No job			**[ ]** Unskilled worker		
[ ] Student			**[ ]** Skilled worker		
[ ] Housewife			**[ ]** Own business		
[ ] Retired			**[ ]** Other		
1.1.6. Marital Status	**[ ]** Single	**[ ]** Married	**[ ]** Divorced	**[ ]** Widowed	
1.1.7. Income (monthly):					
1.1.8. Mobility / Do you have any physical limitations and disabilities?				**[ ]** Yes	**[ ]** No
If "*Yes*", please specify:					
1.2. Emotional / Psychological Characteristics					
1.2.1. Stress	**[1]** Bad	**[2]** Poor	**[3]** Average	**[4]** Good	**[5]** Great
1.2.2. Motivation	**[1]** Bad	**[2]** Poor	**[3]** Average	**[4]** Good	**[5]** Great
2. TECHNOLOGY EXPERIENCE					
2.1. Do you have Mobile Phone?				**[ ]** Yes	**[ ]** No
[ ] Basic Model	**[ ]** Smartphones (e.g. iPhone, BlackBerry, and etc.)				
2.2. How long have you had Mobile Phone?					
2.3. Do you have an internet connection at your Mobile Phone; Smartphones (e.g. iPhone, BlackBerry, and etc.)?				**[ ]** Yes	**[ ]** No
2.4. Do you have Personal Computer (PC); Notebook; Tablet PC; iPad?				**[ ]** Yes	**[ ]** No
2.5. How long have you had Personal Computer (PC); Notebook; Tablet PC; iPad?					
2.6. Do you have an internet connection at your Personal Computer (PC); Notebook; Tablet PC; iPad?				**[ ]** Yes	**[ ]** No
2.7. Do you use e-mail before?				**[ ]** Yes	**[ ]** No
2.7.1. I use e-mail (1: never – 5: every day)					

3. Knowledge, Skill, and Experience					
3.1. Do you know the meaning of "Mobile Health Devices"?				**[ ]** Yes	**[ ]** No
If "Yes", please specify:					
3.2. Did you use before "Mobile Health Devices"?				**[ ]** Yes	**[ ]** No
If "Yes", please specify:					
3.3. How often do you use Mobile Health Devices before?					
[1**]** Never	**[**2**]** Very rarely	**[**3**]** Occasionally	**[**4**]** Very frequently	**[**5**]** Always	

4. OVERALL USABILITY (Five components of Nielsen's definition of usability) [%]	
4.1. It should be difficult to make errors.	
4.2. The equipment should be easy to learn, so you can start to use it quickly.	
4.3. The equipment should be easy to remember, so you can start using it quickly after a period of absence.	
4.4. The equipment should be easy to use, so you do not have to direct all attention at handling the equipment.	
4.5. The equipment should be pleasing and comfortable to use.	

5. INFORMATION PRESENTATION and DESIGN					
5.1. Is the screen easily viewable?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**
5.2. Is the display clearly arranged?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**
5.3. Are the text and the font easily viewable? / Is the display readable?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**
5.4. Are the colors convenient?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**
5.5. Is the touchscreen easy-to-use?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**
5.6. Buttons / Icons: Is it easy to understand the meaning of the icons?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**
5.7. Menus: Are there too much menu and difficult to understand?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**
5.8. Device: Is the blood glucose measuring module small enough to carry comfortably?	**[**1**]**	**[**2**]**	**[**3**]**	**[**4**]**	**[**5**]**

6. GENERAL COMMENTS				
6.1. Do you rely on the data measured by mobile health devices?			**[ ]** Yes	**[ ]** No
If "*No*", please specify:				
6.2. How important is it for you to measure your blood glucose easily and check it at any time?				
[1**]** Very unimportant	**[**2**]** Unimportant	**[**3**]** Neutral	**[**4**]** Important	**[**5**]** Very important
6.3. How important is it for you to have access to mobile communication on blood glucose measurements from smart mobile phone? / Your data is available at all places and times.				
[1**]** Very unimportant	**[**2**]** Unimportant	**[**3**]** Neutral	**[**4**]** Important	**[**5**]** Very important
6.4. How important is it for you to have the possibility of mobile customized personal healthcare on smart mobile phone?				
[1**]** Very unimportant	**[**2**]** Unimportant	**[**3**]** Neutral	**[**4**]** Important	**[**5**]** Very important
6.5. I want to send the blood glucose measurements which can be voluntarily transferred to physicians or family members via e-mail.				
[1**]** Strongly disagree	**[**2**]** Disagree	**[**3**]** Neither agree nor disagree	**[**4**]** Agree	**[**5**]** Strongly agree

6.6. I would change my lifestyle rather than visit a doctor regardless of my blood glucose measurements.				
[1**]** Strongly disagree	**[**2**]** Disagree	**[**3**]** Neither agree nor disagree	**[**4**]** Agree	**[**5**]** Strongly agree
6.7. REMARKS [Do you want to tell me anything else about the mobile health devices?]				

I confirm that this form is completed to the best of my knowledge and the information above is correct.

Date: _ _ / _ _ / 2012
Signature: ………………

EK B: ANKET

1. KULLANICI BİLGİSİ					
1.1. Demografik Bilgiler					
1.1.1. Yaş / Doğum Tarihi:					
1.1.2. Cinsiyet	**[ ]** Erkek		**[ ]** Kadın		
1.1.3. Irk / Milliyet					
1.1.4. Akademik geçmiş	**[1]** İlköğretim	**[2]** Lise	**[3]** Üniversite	**[4]** Yüksek Lisans	**[5]** Doktora ve sonrası
1.1.5. Meslek					
[ ] İşsiz			**[ ]** Vasıfsız işçi		
[ ] Öğrenci			**[ ]** Vasıflı çalışan		
[ ] Ev hanımı			**[ ]** Kendi işine sahip		
[ ] Emekli			**[ ]** Diğer		
1.1.6. Medeni Hal	**[ ]** Bekar	**[ ]** Evli	**[ ]** Boşanmış	**[ ]** Dul	
1.1.7. Gelir (aylık):					
1.1.8. Mobilite / Herhangi bir fiziksel engel veya özrünüz var mı?				**[ ]** Evet	**[ ]** Hayır
Cevabınız “evet” ise, lütfen açıklayınız:					
1.2. Duygusal / Psikolojik Özellikler					
1.2.1. Stres	**[1]** Çok kötü	**[2]** Kötü	**[3]** Orta	**[4]** İyi	**[5]** Çok iyi
1.2.2. Motivasyon	**[1]** Çok kötü	**[2]** Kötü	**[3]** Orta	**[4]** İyi	**[5]** Çok iyi
2. TEKNOLOJİ DENEYİMİ					
2.1. Mobil telefonunuz var mı?				**[ ]** Evet	**[ ]** Hayır
[ ] Normal Model	**[ ]** Akıllı Telefon (ör: iPhone, BlackBerry, vb.)				
2.2. Ne kadar süredir mobil telefon kullanıyorsunuz?					
2.3. Mobil telefonunuzda internet bağlantısı var mı? Akıllı Telefon (ör: iPhone, BlackBerry, vb.)?				**[ ]** Evet	**[ ]** Hayır
2.4. Kişisel bilgisayar, notebook, tablet PC, iPad’den en az birine sahip misiniz?				**[ ]** Evet	**[ ]** Hayır
2.5. Ne kadar süredir bir kişisel bilgisayar, notebook, tablet PC, iPad’den en az birine sahipsiniz?					
2.6. Sahip olduğunuz kişisel bilgisayar, notebook, tablet PC, iPad’den en az biri üzerinden internet bağlantısına sahip misiniz?				**[ ]** Evet	**[ ]** Hayır
2.7. Daha önce e-posta kullandınız mı?				**[ ]** Evet	**[ ]** Hayır
2.7.1. Ne sıklıkta e-posta kullanıyorsunuz? Lütfen uygun olan sayıyı belirtiniz (1: hiç – 5: her gün)					
3. Bilgi, Yetenek ve Deneyim					
3.1. “Mobil Sağlık Cihazları” ifadesinin anlamını biliyor musunuz?				**[ ]** Evet	**[ ]** Hayır
Cevabınız “evet” ise, lütfen açıklayınız:					
3.2. Daha önce bir “Mobil Sağlık Cihazı” kullandınız mı?				**[ ]** Evet	**[ ]** Hayır
Cevabınız “evet” ise, lütfen açıklayınız:					
3.3. Daha önce ne sıklıkta bir “Mobil Sağlık Cihazı” kullandınız?					
[1] Hiç	**[2]** Nadiren	**[3]** Zaman zaman	**[4]** Sıklıkla	**[5]** Her zaman	

4. GENEL KULLANILABİLİRLİK KRİTERLERİ (“Nielsen Kullanabilirlik Tanımı”nın Beş Bileşeni) [%]	
4.1. Güvenilirlik: Doğru çalışıyor mu ve kullanıcının doğru, hata yapmadan kullanmasına yardımcı oluyor mu?	
4.2. Öğrenilebilirlik: Cihazı kullanmayı öğrenmek ne kadar kolay?	
4.3. Hatırlanabilirlik: Cihazı bir sure kullanmayınca, nasıl kullanıldığını hatırlamak ne kadar kolay?	
4.4. Verimlilik: Cihaz kullanıcıyı ne kadar uğraştırıyor? Kolay kullanılabiliyor mu?	
4.5. Kullanıcı memnuniyeti: Kullanıcı cihazı kullanmaktan ne kadar memnun kalıyor?	

5. BİLGİ SUNUMU ve TASARIM					
5.1. Ekran kolaylıkla görülebiliyor mu?	[1]	[2]	[3]	[4]	[5]
5.2. Ekran açık ve net olarak düzenlenmiş mi?	[1]	[2]	[3]	[4]	[5]
5.3. Metin ve yazı fontları kolayca görülebiliyor mu?/ Cihaz ekranı okunabiliyor mu?	[1]	[2]	[3]	[4]	[5]
5.4. Renkler uygun mu?	[1]	[2]	[3]	[4]	[5]
5.5. Dokunmatik ekran rahat kullanılabiliyor mu?	[1]	[2]	[3]	[4]	[5]
5.6. Butonlar / İkonlar: İkonların ne anlama geldiği kolayca anlaşılabiliyor mu?	[1]	[2]	[3]	[4]	[5]
5.7. Menüler: Menü sayısı çok fazla mı ve anlaşılması zor mu?	[1]	[2]	[3]	[4]	[5]
5.8. Cihaz: Kan şekeri ölçüm cihazı rahatça taşınabilecek ölçüde mi?	[1]	[2]	[3]	[4]	[5]

6. GENEL YORUMLAR				
6.1. Mobil sağlık cihazı ölçümüne güveniyor musunuz?			**[ ]** Evet	**[ ]** Hayır
Cevabınız “hayır” ise, lütfen açıklayınız:				
6.2. Kan şekeri seviyenizi kolayca ölçmek ve istediğiniz zaman kontrol edebilmek sizin için ne kadar önemli?				
[1] Hiç önemli değil	**[2]** Önemli değil	**[3]** Nötr	**[4]** Önemli	**[5]** Çok önemli
6.3. Bir akıllı telefon üzerinden kan şekeri değerinize mobil olarak erişim imkanınız olması sizin için ne kadar önemli? Kan şekeri değeriniz yer zaman ve her yerde elinizde olacak.				
[1] Hiç önemli değil	**[2]** Önemli değil	**[3]** Nötr	**[4]** Önemli	**[5]** Çok önemli
6.4. Akıllı telefon üzerinde mobil kişiselleştirilmiş mobil sağlık uygulamasına sahip olmak sizin ne kadar önemli?				
[1] Hiç önemli değil	**[2]** Önemli değil	**[3]** Nötr	**[4]** Önemli	**[5]** Çok önemli
6.5. Kan şekeri değerimi kendi isteğimle doktoruma veya bir aile bireyine e-posta ile göndermek isterim.				
[1] Kesinlikle katılmıyorum	**[2]** Katılmıyorum	**[3]** Kararsızım	**[4]** Katılıyorum	**[5]** Kesinlikle katılıyorum
6.6. Kan şekeri değerimden bağımız olarak, doktora gitmektense yaşam tarzımı değiştirmeyi tercih ederim.				
[1] Kesinlikle katılmıyorum	**[2]** Katılmıyorum	**[3]** Kararsızım	**[4]** Katılıyorum	**[5]** Kesinlikle katılıyorum

6.7. NOTLAR [Mobil sağlık cihazları hakkında belirtmek istediğiniz başka hususlar var mı?]

İşbu anketin bilgim dâhilinde doldurulduğunu ve yukarıda verilen bilgilerin doğru olduğunu onaylarım. Burada attığım imza ile mobil sağlık cihazları ile elde edilen şeker ölçümlerimin saklanması ve gereği halinde kimlik bilgilerim saklı kalmak koşulu ile elde edilen verilerin doktora gönderilmesini ve desteklenen bilimsel çalışmalarda kullanılmasını kabul ediyorum ve bu onayı verirken çalışmayı anladığımı ve kabul ettiğimi de tasdik ediyorum.

1) Araştırmacı, sonuçların gizliliğini sağlayacaktır ve sonuçlar bilimsel çalışmalar dışında herhangi bir amaçla kullanmayacaktır. Kimlik bilgilerinizde gizlidir ve diğer araştırmacılara iletilmeyecektir.
2) Bu anlaşma konusundaki uyuşmazlıklarda T.C. mahkemeleri yetkilidir.

Tarih: _ _ / _ _ / 2012

İmza: ………………………

APPENDIX C: GOAL – A: Measure Blood Glucose Level

Note: To avoid disruption from an incoming call or text message during a reading, the researcher switching the smart phone to flight mode.

A - Goal: Measure Blood Glucose Level

1. **Subgoal**: Begin Measurement

Action: Open m-health Application

System response: Smart Phone Displays m-health Application

Action: Touch the "**Blood Glucose Measurement**" application and tap on the "**New**" icon.

System response: The "New reading - Step 1" window opens. You are prompted to connect the blood glucose measuring module (or enter the value manually).

2. **Subgoal**: Connect blood glucose measuring module with your smart phone.

Action: Insert the blood glucose measuring module into the smart phone.

3. **Subgoal**: Stick the blood glucose measuring test strip in the module.

Action: Insert a test strip into the module in the direction of the arrow.

Potential problem: To avoid contamination, only touch the test strips with clean, dry hands.

Note that the test strips must be used within 3 minutes of being removed from the container.

4. **Subgoal**: Obtain a Blood Sample

Subgoal: Use a new sterile lancet for each test.

Action: Replace lancet (if necessary)

Subgoal: Clean the area of skin.

Action: The alcohol pads are only intended for cleaning the surface of the skin if there is no opportunity to wash your hands.

Potential problem: Wait a few seconds until the alcohol has completely evaporated from the skin to avoid causing incorrect readings.

Subgoal: Draw a drop of blood (approx. 0,6 μl) by gently massaging the area.

Action: Place the lancing device on a finger tip (preferably at the side) and press the trigger button. Then remove the lancing device from your finger.

Potential problem: Make sure that the blood droplet does not smudge.

5. **Subgoal**: Let the test strip absorb a drop of blood.

Action: Place the drop onto the transparent blood sample area (capillary) on the end of the test strip.

Potential problem: Do not get any blood on the top of the test strip.

Make sure not to place too little blood in the blood sample area. This can lead to an incorrect reading.

6. **Subgoal**: Take the blood glucose measurement with smart phone.

Action: The device starts the reading.

System response: After approximately 5 seconds the blood glucose measurement result is completed and appears in the display.

7. **Subgoal**: Save the blood glucose measurement result.

Action: Press "Save" button 

after displaying the result.

System response: The last blood glucose measurement result is seen on the blood glucose measuring module.
Display "Good", green color: values in the target range specified by the doctor.
Display "High", red color: values above the target range specified by the doctor.
Display "Low", blue color: values below the target range specified by the doctor.

EK C: A - HEDEF: KAN ŞEKERİ SEVİYESİNİ ÖLÇME

Not: Çalışma sırasında gelecek bir çağrı veya mesaj nedeniyle dikkatin dağılmaması için araştırmacı telefonunu uçuş moduna alır.

A - Hedef: Kan Şekeri Seviyesini Ölçme

1. **Alt hedef**: Ölçüm başla

Aksiyon: m-sağlık uygulamasını aç

Sitem yanıtı: Akıllı telefon m-sağlık uygulamasını görüntüler.

Aksiyon: "**Kan Şekeri Ölçümü"** (Blood Glucose Measurement) uygulama butonuna bas ve "**Yeni"** (New) ikonuna tıkla.

Sistem yanıtı: "Yeni okuma – 1. adım" ("New reading - Step 1") ekranı açılır. Kan seviyesi ölçüm modülünü bağlamanız istenir. (veya değeri elle giriniz)

2. **Alt hedef**: Kan seviyesi ölçüm modülünü akıllı telefonla bağlantısını sağlayın.

Aksiyon: Kan seviyesi ölçüm modülünü akıllı telefona takın.

3. **Alt hedef:** Kan şekeri ölçüm test şeridini modüle takın.

Aksiyon: Modüle ok yönünde bir test şeridi takın.

Olası sorun: Kirlenme olmaması için, test şeridine sadece temiz ve kuru el ile dokunun.

Lütfen, test şeridinin kutusundan çıkarıldıktan sonra 3 dakika içinde kullanılması gerektiğini göz önünde bulundurun.

4. Alt hedef: Kan örneği alma

Alt hedef: Her test için yeni steril lanset kullanın.

Aksiyon: Lanceti değiştirin (gerekiyorsa).

Alt hedef: İlgili bölgeyi temizleyin.

Aksiyon: Alkollü pedler, ellerinizi yıkama imkanınızın olmadığı durumlarda kan alınacak bölgeyi temizlemek amacıyla kullanılır.

Olası sorun: Yanlış bir okumaya neden olmamak için alkolün deri yüzeyinden tamamen buharlaşmasını sağlayacak kadr bekleyin.

Alt hedef: Birkaç damla kanı (yaklaşık. 0,6 µl) deriyi ovarak alın.

Aksiyon: Parmak delme cihazını parmak ucuna (tercihen kenarına) yerleştirin ve butona basın. Sonra cihazı parmağınızdan alın.

Olası sorun: Kan damlasının etrafa bulaşmadığına emin olun.

5. Alt hedef: Test şeridinin kan damlasını emmesini etmesini sağlayın.

Aksiyon: Kan damlasını, test şeridinin sonundaki şeffaf kan örneği alanına (kapiler) yerleştirin.

Olası sorun: Test şeridinin üstüne kan gelmesin.

Kan örneği alanında çok az kan olmadığına emin olun. Bu durum yanlış okumaya sebep olabilir.

6. Alt hedef: Kan şekeri seviyesi ölçümünü akıllı telefonla alın.

Aksiyon: Cihaz okuma işlemine başlar.

Sistem yanıtı: Yaklaşık 5 saniye sonra, kan şekeri ölçüm tamamlanır ve ekranda görüntülenir.

7. Alt hedef: Kan şekeri seviyesini kaydet.

Aksiyon: Sonucu gördükten sonra 

butonuna basarak kaydedin.

Sistem yanıtı: Kan şekeri ölçüm modülünde, son ölçülen kan şekeri ölçüm sonucu görülecektir.

Ekranda "İyi" yazısı, yeşil renk: Değerler, doktor tarafından belirtilen hedef aralık içinde.

Ekranda "Yüksek" yazısı, kırmızı renk: Değerler, doktor tarafından belirtilen hedef aralığın üzerinde.

Ekranda "Düşük" yazısı, mavi renk: Değerler, doktor tarafından belirtilen hedef aralığın altında.

APPENDIX D: GOAL – B: Blood Glucose Measurement Data Export

Note: To avoid disruption from an incoming call or text message during a reading, the researcher switching the smart phone to flight mode.

Goal - B: Blood Glucose Measurement Data Export

1. **Subgoal**: Begin Sending Reports

Action: Open m-health Application 

System response: Smart Device Displays m-health Application

2. **Subgoal**: Display “Settings” on your smart phone.

Action: Touch the icon  and slide the display to “Settings”.

System response: Tapping the icons takes you directly to the program.

3. **Subgoal**: Display the Monthly Reports

Action: Touch the “Report” icon to display the monthly reports.

System response: Tap the arrows to reach the previous  or next  month. Slide the display up or down to view the individual days in the month.

4. **Subgoal**: Send Report

Action: Tap “Send report” 

to send the data by e-mail.

System response: Sending monthly reports for the active user profile by e-mail to the doctor.

EK D: B - HEDEF: KAN ŞEKERİ ÖLÇÜMÜ VERİ AKTARIMI

Not: Çalışma sırasında gelecek bir çağrı veya mesaj nedeniyle dikkatin dağılmaması için araştırmacı telefonunu uçuş moduna alır.

B - Hedef: Kan Şekeri Ölçümü Veri Aktarımı

1. **Alt hedef**: Rapor göndermeye başla.

Aksiyon: m-sağlık uygulamasını aç

Sistem yanıtı: Akıllı Mobil Telefon m-sağlık uygulamasını çalıştırır.

2. **Alt hedef**: Akıllı telefonda “Genel Ayarlar” (Global Settings) ekranını aç.

Aksiyon: ikonuna bas ve “Genel Ayarlar”a gel.

Sistem yanıtı: ilgili ikonlara dokunmak programı açacaktır.

3. **Alt hedef**: Aylık Raporları göster.

Aksiyon: Aylık raporları görmek için “Rapor” (Report) ikonuna bas.

Sistem yanıtı: veya oklarına basarak önceki veya sonraki aylara ulaş. Yukarı, aşağı kayarak ilgili ayın günlerini görüntüle.

4. **Alt hedef**: Rapor Gönderme

Aksiyon: butonuna basarak veriyi e-posta olarak gönder.

Sistem yanıtı: Aktif kullanıcı profili için doktora, e-posta ile aylık raporlar gönderme.

APPENDIX E: ANSWERS OF THE REMARKS IN THE QUESTIONNARIE

"***Do you want to tell me anything else about the mobile health devices?***"

1: "Bütçeme uygun olduğu takdirde kullanmak isterim."

"Kontrol için hastaneden randevu almaktan kurtulmuş olurum."

"Sıra beklemekten kurtulmuş olurum."

"Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur."

2: "Bütçeme uygun olduğu takdirde kullanmak isterim."

"Evdeki cihazımı kullanmıyorum, ama bunu kullanmak isterim."

"Herhangi bir yere not etmeden, akıllı telefonun hafızasına kayıt etmesi çok güzel."

"E-mail ile doktora göndermek çok güzel."

3: "Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim."

4: "Yaş ilerledikçe, kişinin kendi kendine bakımını yapabilmesi çok önemlidir."

5: "Bütçeme uygun olduğu takdirde kullanmak isterim."

"Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur."

6: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

7: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

8: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

9: “Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.” [Tekerlekli sandalyeye bağlı yaşıyorum.]

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.” [Tekerlekli sandalyeye bağlı yaşıyorum.]

10: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

11: “Sıra beklemekten kurtulmuş olurum.”

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

12: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.” [Daha güvenilir bir yöntem olduğunu düşünüyorum.]

13: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

14: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

“Herhangi bir yere not etmeden, akıllı telefonun hafızasına kayıt etmesi çok güzel.” [Unutkanlığım var.]

15: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.” [Üç ayda bir, kontrol için hastaneye gelmekten yoruldum.]

16: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

17: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

18: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

19: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

20: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

21: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

22: “Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.” [Balıkesir’de yaşıyorum.]

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.” [Balıkesir’de yaşıyorum.]

23: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

24: “Kontrol için hastaneye gelip – giderken kaybettiğim zamandan kazanmış olurum.”

25: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

26: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

27: “Sıra beklemekten kurtulmuş olurum.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

“Bu çalışma ile kendime değer verildiğini hissettim.”

28: “Sıra beklemekten kurtulmuş olurum.”

“Kontrol için hastaneye gelip – giderken kaybettiğim zamandan kazanmış olurum.”

29: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

“Bu cihazları gördükten sonra doktorumu görme ihtiyacım ortadan kalktı, yaşam stilimi kullanarak, değiştirmek istiyorum.”

30: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

“Cihazları kullanabilmek için teknik ihtiyaçları hazır hale getirebilirim.”

31: “Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.” [Yazın Karadeniz’de yaşıyorum.]

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.” [Yazın Karadeniz’de yaşıyorum.]

32: “Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

“Uyumlu bir Diyabet hastası değilim. Cihazı kullansam bile doktorum ile şimdi olduğu gibi cihazı kullanarak da verilerimi paylaşmak istemem.”

33: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

34: “Sıra beklemekten kurtulmuş olurum.”

35: “Bütçeme uygun olduğu takdirde kullanmak isterim.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

“Kontrol için hastaneye gelip – giderken kaybettiğim zamandan kazanmış olurum.”

“Kağıt-kalem kullanmadan, dokunarak kullanabilmek çok güzel.”

36: “Sıra beklemekten kurtulmuş olurum.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

37: “Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.” [Köyde yaşıyorum.]

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.” [Köyde yaşıyorum.]

38: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.” [Kanser hastasıyım, doktorumu görmek bana moral oluyor. Eğer kanser hastası olmasaydım, kullanmak isterdim.]

39: “Sıra beklemekten kurtulmuş olurum.”

“Hastanenin stresinden kurtulmak için bu cihazı kullanmayı isterim.”

40: “Bütçeme uygun olduğu takdirde kullanmak isterim.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

41: “Yayılsın, ve ihtiyacı olan herkes kullanabilsin isterim.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

42: “Bu cihazların kullanımının artması ile hastanede bekleyen insan sayısı azalacaktır.”

43: “Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

“Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.” [Bartın’da yaşıyorum.]

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.” [Bartın’da yaşıyorum.]

44: “Ameliyat sonrası ve daha sonrasında da hastaneye gelip – gitmek yerine kullanmayı isterim.”

45: “Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.”

46: “Sıra beklemekten kurtulmuş olurum.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

“Hastanenin stresinden kurtulmak için bu cihazı kullanmayı isterim.”

47: “Sıra beklemekten kurtulmuş olurum.”

“Kontrol için hastaneye gelip – giderken kaybettiğim zamandan kazanmış olurum.” [Çocuğu olan bir insan için çok kullanışlı.]

48: “Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

“Sıra beklemekten kurtulmuş olurum.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

49: “Sıra beklemekten kurtulmuş olurum.”

“Hastanenin stresinden kurtulmak için bu cihazı kullanmayı isterim.”

50: “Sıra beklemekten kurtulmuş olurum.”

“Kontrol için hastaneye gelip – giderken kaybettiğim zamandan kazanmış olurum.”

51: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

52: “Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

“Sıra beklemekten kurtulmuş olurum.”

“Kontrol için hastaneye gelip – giderken kaybettiğim zamandan kazanmış olurum.”

53: “Yaşam stilimi değiştirmek istemiyorum. Doktorum ile yüz yüze görüşmeyi cihazı kullanıp, e-mail göndersem bile tercih ederim.”

54: “Hastanenin stresinden kurtulmak için bu cihazı kullanmayı isterim.”

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

55: “Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

56: “Sıra beklemekten kurtulmuş olurum.”

“Kontrol için hastaneye gelip – giderken kaybettiğim zamandan kazanmış olurum.”

57: “Kontrol için hastaneden randevu almaktan kurtulmuş olurum.” [Randevular sürekli dolu oluyor, ve ileri tarihe randevu alınabiliyor.]

“Sıra beklemekten kurtulmuş olurum.”

“Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.”

58: “Sıra beklemekten kurtulmuş olurum.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

“Uygun fiyatlı olması durumunda satın almak isterim.”

“Kontrol için hastaneye gelmek yerine evimden kontrolümü gerçekleştirebilmek çok iyi olur.”

“Eşim vefat ettiği için hastaneye gelirken çok zorlanıyorum.”

“Kontrol için hastaneye gelip - gitmek hem çok zor hem de çok maliyetlidir. Kullanmak isterim.”

59: “Sıra beklemekten kurtulmuş olurum.”

“Akıllı telefonun hafızasına kayıt etmesi çok güzel.”

“Çok unutkan olduğum için herhangi bir yere not etmeden kullanabilmek benim için büyük kolaylık.”

60: “Hastanenin stresinden kurtulmak için bu cihazı kullanmayı isterim.”

“Kağıt-kalem kullanmadan, dokunarak kullanabilmek çok güzel.”

“Sıra beklemekten kurtulmuş olurum.”

“Devletin, mobil sağlık cihazlarının temini için maddi olarak destek olmasını isterim.”

APPENDIX F: GOAL – A: Seven Subgoals’ Task Success and Task Completion Times

Table 23. Total Time (ToT - minutes), Training Time (TrT - seconds), Total Subgoal Time (TsT – seconds), Subgoals’ Task Success (TS), and Task Completion Time (TCT) in seconds of Blood Glucose Level Measurement

Participants	**ToT**	**TrT**	**TsT**	**Subgoals**													
				1 (seconds)		**2 (seconds)**		**3 (seconds)**		**4 (seconds)**		**5 (seconds)**		**6 (seconds)**		**7 (seconds)**	
				TS	**TCT**	**TS**	**TCT**	**TS**	**TCT**	**TS**	**TCT**	**TS**	**TCT**	**TS**	**TCT**	**TS**	**TCT**
1	23 min	1135	245	✓	30	✓	15	✓	15	✓	130	✓	30	✓	5	✓	20
2	10 min	351	249	✓	21	✓	17	✓	15	✓	140	✓	29	✓	5	✓	22
3	30 min	1449	351	✓	28	✓	18	✓	16	✓	160	✗	80	✗	10	✗	39
4	12 min	538	182	✓	20	✓	14	✓	14	✓	100	✓	20	✓	5	✓	9
5	12 min	549	171	✓	19	✓	12	✓	13	✓	95	✓	21	✓	5	✓	6
6	10 min	414	186	✓	19	✓	15	✓	15	✓	103	✓	22	✓	5	✓	7
7	30 min	1422	378	✓	46	✓	37	✓	34	✓	188	✓	28	✓	5	✗	40
8	10 min	403	197	✓	20	✓	16	✓	17	✓	105	✓	24	✓	5	✓	10
9	22 min	1000	320	✓	31	✓	19	✓	20	✓	190	✓	32	✓	5	✓	23
10	15 min	703	197	✓	22	✓	15	✓	16	✓	106	✓	21	✓	5	✓	12
11	27 min	1345	275	✓	27	✓	17	✓	15	✓	157	✓	27	✓	5	✗	27
12	8 min	307	173	✓	18	✓	17	✓	16	✓	92	✓	19	✓	5	✓	6
13	10 min	401	199	✓	21	✓	15	✓	15	✓	109	✓	24	✓	5	✓	10
14	20 min	900	300	✓	29	✓	19	✓	19	✓	155	✓	28	✓	5	✗	45
15	17 min	807	213	✓	23	✓	16	✓	15	✓	115	✓	23	✓	5	✓	16
16	6 min	180	180	✓	19	✓	16	✓	16	✓	98	✓	19	✓	5	✓	7
17	11 min	446	214	✓	20	✓	16	✓	17	✓	118	✓	26	✓	5	✓	12
18	9 min	354	186	✓	18	✓	17	✓	18	✓	96	✓	20	✓	5	✓	12
19	18 min	803	277	✓	27	✓	18	✓	17	✓	162	✓	26	✓	5	✓	22
20	5 min	114	186	✓	19	✓	16	✓	17	✓	101	✓	20	✓	5	✓	8
21	17 min	793	227	✓	24	✓	17	✓	17	✓	125	✓	24	✓	5	✓	15
22	21 min	916	344	✓	28	✓	20	✓	21	✓	157	✗	87	✗	10	✓	21
23	15 min	662	238	✓	23	✓	18	✓	19	✓	115	✓	23	✓	5	✗	35
24	9 min	353	187	✓	17	✓	17	✓	18	✓	99	✓	20	✓	5	✓	11
25	29 min	1368	372	✓	30	✓	20	✓	22	✓	151	✗	102	✗	10	✗	37

26	19 min	923	217	✓	22	✓	17	✓	18	✓	122	✓	23	✓	5	✓	10
27	8 min	293	187	✓	19	✓	17	✓	18	✓	100	✓	20	✓	5	✓	8
28	19 min	870	270	✓	27	✓	21	✓	20	✓	161	✓	25	✓	5	✓	11
29	23 min	1104	276	✓	28	✓	20	✓	21	✓	162	✓	22	✓	5	✓	18
30	10 min	386	214	✓	19	✓	17	✓	18	✓	120	✓	23	✓	5	✓	12
31	10 min	389	211	✓	18	✓	17	✓	19	✓	117	✓	25	✓	5	✓	10
32	6 min	176	184	✓	17	✓	18	✓	19	✓	97	✓	20	✓	5	✓	8
33	18 min	817	263	✓	25	✓	21	✓	20	✓	160	✓	19	✓	5	✓	13
34	20 min	924	276	✓	27	✓	22	✓	21	✓	162	✓	23	✓	5	✓	16
35	16 min	703	257	✓	23	✓	20	✓	20	✓	158	✓	19	✓	5	✓	12
36	9 min	351	189	✓	19	✓	18	✓	18	✓	99	✓	21	✓	5	✓	9
37	26 min	1168	392	✓	30	✓	22	✓	23	✓	171	✗	98	✗	10	✗	38
38	8 min	303	177	✓	18	✓	17	✓	18	✓	91	✓	21	✓	5	✓	7
39	27 min	1310	310	✓	29	✓	23	✓	24	✓	174	✓	26	✓	5	✗	29
40	24 min	1182	258	✓	20	✓	19	✓	19	✓	157	✓	24	✓	5	✓	17
41	16 min	704	256	✓	24	✓	19	✓	20	✓	155	✓	21	✓	5	✓	13
42	11 min	460	200	✓	20	✓	19	✓	20	✓	104	✓	22	✓	5	✓	10
43	16 min	697	263	✓	23	✓	20	✓	21	✓	160	✓	22	✓	5	✓	12
44	20 min	901	299	✓	25	✓	22	✓	20	✓	167	✓	23	✓	5	✗	37
45	22 min	1022	298	✓	29	✓	20	✓	24	✓	160	✓	21	✓	5	✗	39
46	21 min	974	286	✓	27	✓	19	✓	19	✓	165	✓	23	✓	5	✗	28
47	10 min	399	201	✓	21	✓	20	✓	21	✓	102	✓	21	✓	5	✓	11
48	23 min	1074	306	✓	30	✓	23	✓	22	✓	165	✓	24	✓	5	✗	37
49	10 min	417	183	✓	18	✓	17	✓	18	✓	94	✓	22	✓	5	✓	9
50	10 min	402	198	✓	20	✓	19	✓	18	✓	101	✓	24	✓	5	✓	11
51	20 min	902	298	✓	30	✓	25	✓	22	✓	165	✓	22	✓	5	✗	29
52	10 min	393	207	✓	25	✓	20	✓	19	✓	107	✓	19	✓	5	✓	12
53	12 min	530	190	✓	24	✓	17	✓	16	✓	101	✓	19	✓	5	✓	8
54	19 min	851	289	✓	28	✓	24	✓	25	✓	168	✓	24	✓	5	✓	15
55	26 min	1255	305	✓	26	✓	23	✓	24	✓	172	✓	25	✓	5	✗	30
56	21 min	970	290	✓	28	✓	20	✓	21	✓	157	✓	23	✓	5	✗	36
57	19 min	881	259	✓	25	✓	19	✓	20	✓	154	✓	22	✓	5	✓	14
58	21 min	977	283	✓	31	✓	20	✓	21	✓	153	✓	23	✓	5	✗	30
59	23 min	1103	277	✓	29	✓	23	✓	22	✓	163	✓	23	✓	5	✓	15
60	18 min	793	287	✓	26	✓	20	✓	21	✓	156	✓	22	✓	5	✗	37
Mean± SD	**16.5 ± 6.7**	**738.6 ± 352.3**	**248.4 ± 57.4**		**24.2 ± 5.2**		**18.9 ± 3.5**		**19.1 ± 3.3**		**134.8± 30.2**		**27.5 ± 17.7**		**5.3 ± 1.3**		**18.7 ± 11.2**

APPENDIX G: GOAL – B: Four Subgoals’ Task Success and Task Completion Times

Table 24. Total Time (ToT - seconds), Subgoals’ Task Success (TS), and Task Completion Time (TCT) in seconds of Blood Glucose Level Data Expert

Participants											
		Subgoals									
		1 (seconds)		2 (seconds)		3 (seconds)		4 (seconds)		Smart Phone	Information
	ToT	TS	TCT	TS	TCT	TS	TCT	TS	TCT		
1	194	✔	18	✔	8	✔	45	✔	123	✕	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
2	182	✔	16	✔	6	✔	30	✔	130	✕	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
3		✔	17	✔	9	✔	32	✕	0		“E-mail kullanmadığı için gönderim yapamadı. Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
4	177	✔	15	✔	6	✔	28	✔	128	✕	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
5	120	✔	14	✔	5	✔	26	✔	75	✔	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
6		✔	16	✔	9	✔	33	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
7		✔	20	✔	10	✔	42	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
8		✔	17	✔	8	✔	29	✕	0		“E-mail kullanmadığı için gönderim yapamadı. E-mail hesabını açtıktan sonra gönderebileceğini ekledi.

9		✓	19	✓	9	✓	39	✗	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
10	153	✓	14	✓	5	✓	29	✓	105	✗	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
11		✓	18	✓	9	✓	31	✗	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
12	124	✓	14	✓	6	✓	28	✓	76	✓	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
13		✓	18	✓	10	✓	29	✗	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı."
14		✓	20	✓	10	✓	41	✗	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
15		✓	19	✓	11	✓	42	✗	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
16	135	✓	15	✓	6	✓	27	✓	87	✓	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
17	107	✓	14	✓	5	✓	27	✓	61	✓	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
18	121	✓	13	✓	6	✓	28	✓	74	✓	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
19	167	✓	18	✓	7	✓	29	✓	113	✗	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
20	122	✓	15	✓	6	✓	26	✓	75	✓	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
21		✓	20	✓	9	✓	39	✗	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."

22		✔	19	✔	10	✔	40	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
23		✔	21	✔	11	✔	44	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
24	126	✔	14	✔	6	✔	28	✔	78	✔	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
25		✔	20	✔	10	✔	43	✕	0	✕	“E-mail kullandığı halde gönderim yapamadı. Touchscreen kullanarak gönderim yapmanın kendisi için zor olduğunu ekledi.
26	155	✔	17	✔	7	✔	35	✔	96	✔	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
27	140	✔	15	✔	6	✔	31	✔	88	✔	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
28		✔	19	✔	10	✔	42	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
29		✔	20	✔	11	✔	41	✕	0		“E-mail kullanmadığı için gönderim yapamadı. E-mail hesabını açtıktan sonra gönderebileceğini ekledi.
30		✔	15	✔	6	✔	34	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.”
31	150	✔	14	✔	6	✔	28	✔	102	✔	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
32	105	✔	13	✔	6	✔	27	✔	59	✔	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
33		✔	19	✔	12	✔	37	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”

34		✔	20	✔	12	✔	44	✗	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
35		✔	19	✔	11	✔	45	✗	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
36	178	✔	16	✔	7	✔	31	✔	124	✔	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
37		✔	22	✔	13	✔	44	✗	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
38		✔	14	✔	8	✔	33	✗	0		“E-mail kullanmadığı için gönderim yapamadı. E-mail hesabını açtıktan sonra gönderebileceğini ekledi.
39		✔	21	✔	11	✔	47	✗	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
40		✔	18	✔	9	✔	39	✗	0	✔	“E-mail kullandığı halde gönderim yapamadı. Touchscreen kullanarak gönderim yapmanın kendisi için zor olduğunu ekledi.
41		✔	19	✔	9	✔	40	✗	0		“E-mail kullanmadığı için gönderim yapamadı. E-mail hesabını açtıktan sonra gönderebileceğini ekledi.
42	188	✔	16	✔	7	✔	29	✔	136	✗	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”
43		✔	18	✔	9	✔	43	✗	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
44	189	✔	19	✔	8	✔	28	✔	134	✗	“Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı.”

45		✔	20	✔	11	✔	45	✖	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
46		✔	21	✔	12	✔	46	✖	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Eşinin kendisinin yerine e-mail gönderebileceğini ekledi."
47	142	✔	16	✔	7	✔	30	✔	89	✔	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
48		✔	19	✔	10	✔	44	✖	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
49	149	✔	15	✔	6	✔	29	✔	99	✔	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
50	117	✔	15	✔	6	✔	30	✔	66	✔	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
51		✔	20	✔	11	✔	47	✖	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
52	168	✔	19	✔	8	✔	31	✔	110	✔	"Touchscreen kullanarak, hatasız bir şekilde e-mail adresini yazdı ve gönderim yaptı."
53		✔	19	✔	10	✔	45	✖	0	✔	"E-mail kullanmadığı için gönderim yapamadı. E-mail hesabını açtıktan sonra gönderebileceğini ekledi.
54		✔	20	✔	11	✔	48	✖	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."
55		✔	18	✔	10	✔	46	✖	0		"Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı." Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi."

56		✔	19	✔	9	✔	38	✕	0		“E-mail kullanmadığı için gönderim yapamadı. E-mail hesabını açtıktan sonra gönderebileceğini ekledi.
57		✔	18	✔	10	✔	40	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
58		✔	21	✔	12	✔	48	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
59		✔	19	✔	10	✔	47	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı.” Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
60		✔	18	✔	10	✔	45	✕	0		“Bilgisayar ve e-mail kullanmadığı için gönderim yapamadı. Çocuklarının kendisinin yerine e-mail gönderebileceğini ekledi.”
Mean ± SD	**148.2±27.9**		**17.6±2.4**		**8.6±2.2**		**36.5±7.4**		**96.87±24.41**		

APPENDIX H: APPROVAL LETTER OF APPLIED ETHICS RESEARCH CENTER

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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Sayı: B.30.2.ODT.0.AH.00.00/126/147

19th December 2012

To : Prof. Dr. Nazife Baykal
Medical Informatics

From : Prof. Dr. Canan Özgen
Vice Chairperson of Human Research Ethic Committee

Subject : Ethical Approval

The study titled "Usability Evaluation of Mobile Information Communications Technology in Healthcare" was approved by "Human Researches Ethical Committee".

Sincerely,

Ethic Committee Approval

Approved

19/12/2012

Prof.Dr. Canan ÖZGEN
Applied Ethics Research Center
(UEAM) Chairperson
ODTÜ 06531 ANKARA

APPENDIX I: CIRRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Akbaşoğlu, Beyza

Nationality: Turkish (TC)

Date and Place of Birth: 16 May 1978, Ankara

Marital Status: Married

Email: bakbasoglu@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
PhD	METU, Medical Informatics	2013
MS	Başkent Unv., MBA	2004
BS	Başkent Unv., Electrical and Electronics Eng.	2002
High School	Ankara Atatürk Anatolian High School	1996

WORK EXPERIENCE

Year	Place	Enrollment
Jan 2013 – Present	Orion Health	Country Manager
Feb 2011 – Present	TEMÇE Co. Ltd.	Managing Partner
Oct 2010 – Present	Acıbadem University	Part-time Lecturer
Sep 2008 – Feb 2011	Birim Bilgi Teknolojileri	Coordinator
Sep 2008 – Jan 2010	Başkent University	Part-time Lecturer
Sep 2004 – Aug 2008	Başkent University	Full-time Lecturer

FOREIGN LANGUAGES

Advanced English, Intermediate German

PUBLICATIONS

1. Kaymakoğlu, B., M. Çolak and E. Öksüz, "Usage of a Family Physician e-Health Service from 2002 to 2008: An Application for Turkey", Medical Informatics and EFMI STC'09, 12-15 November, 2009, Belek-Antalya, Turkey.

2. Kaymakoğlu B., "PACS", Hastane ve Yaşam (Akademik ve Aktüel Tıp Dergisi), 44, 12-13 (April 2009).

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4. Kaymakoğlu, B., A. Barak, M. Çolak and M. O. Çınar, "The Knowledge, Attitude and Behavior Levels of the People Over the Age 65 Related to the Alternative Medicine", 7th International Congress of Informatics in Health, 9-13 February, 2009, Havana, Cuba.

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9. Coşkun, G., B. Kaymakoğlu and E. Gök, “The Internet Usage of Medical School Students and Their Attitudes Towards e-Learning: An Application for Başkent University”, Hastane ve Yaşam (Akademik ve Aktüel Tıp Dergisi), 29, 74-79 (2008).

10. Sunay, A.S., B. Kaymakoğlu and U. Arıöz, “Evaluation of Breast Lession Diagnostic Tests Using Neural Networks”, Medical Informatics’07, 15-18 November, 2007, Belek-Antalya, Turkey.

11. Çolak, M., B. Kaymakoğlu M. Koçak and K. Ersoy, “The Opinions of Patients about Sharing Medical Records”, Medical Informatics’07, 15-18 November, 2007, Belek-Antalya, Turkey.

12. Kaymakoğlu, B., Ö. Yıldız and U. Arıöz, “Assessment of Laboratory and Management Information System Processes of a Hospital According to ISO 15504”, Medical Informatics’07, 15-18 November, 2007, Belek-Antalya, Turkey.

13. Kaymakoğlu, B., U. Arıöz, A. Erkmen and D. Gökçay, “Evaluation of Breast Lesion Diagnostic Tests Using Information Graphs”, International Symposium on Health Informatics and Bioinformatics, Turkey’07, April 30–May 2, 2007, Antalya, Turkey.

14. Kaymakoğlu, B., “Topical Talk on Medical Informatics”, Akademik Bilişim’07, January 31–February 2, 2007, Dumlupınar University, Kütahya, Turkey.

15. Çolak, M., B. Kaymakoğlu, B. and K. Ersoy, "An Evaluation of Web Sites of Private Hospitals in Turkey", Medical Informatics'06, 16-19 December, 2006, Lara-Antalya, Turkey.

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19. Gülkesen, K.H., A. Erdem, B. Kaymakoğlu, U. Arıöz, P. Yıldırım and O. Saka, "Typographic Errors Variants in Pathology Reports", Medical Informatics'05, 17-20 December, 2005, Belek-Antalya, Turkey.

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REWARDS

METU Graduate School of Informatics, 2005 – 2006 Academic Year, METU Graduate Courses Performance Award (CGPA of 3.73/4.00).

Ankara 13th in Anatolian High School entrance examination (1989).

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ■

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı: Akbaşoğlu
Adı: Beyza
Bölümü: Sağlık Bilişimi Eğitim Anabilim Dalı Başkanlığı

TEZİN ADI (İngilizce): USABILITY EVALUATION OF MOBILE INFORMATION AND COMMUNICATIONS TECHNOLOGY IN HEALTH CARE

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ■

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