EVALUATING THE USABILITY OF DIABETES MANAGEMENT IPAD APPLICATIONS

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by

Charles Coutu-Nadeau

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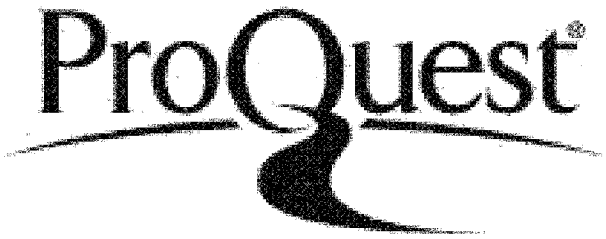

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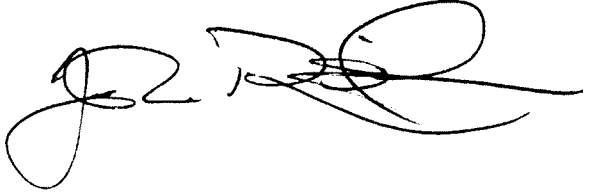

ABSTRACT

Background

Diabetes is a major cause of morbidity and mortality in the United States. In 2012, 29.1 million people were estimated to have the condition, with type 2 diabetes accounting for 95% of all cases [1]. It is currently one of the most costly conditions in the country [2] and forecasts as a heavier burden for the U.S. with the prevalence expected to significantly increase [3]. For those who live with the disease, it is possible to manage diabetes in order to prevent or delay the onset of complications [4]. However the self-management regimen is complex and impacts nearly every important aspect of one's life [5].

The ubiquitous nature of mobile technologies and powerful capabilities of smartphones and tablets has led to a significant increased interest in the development and use of mobile health. Diabetes management is an application area where mobile devices could enhance the quality of life for people living with chronic illnesses [6]–[8], and usability is key to the adoption of such technologies [9], [10]. Past work has evaluated the usability of diabetes management apps for Android, iOS and Blackberry smartphones [11]–[14] despite the fact that no established method to evaluate the usability of mobile

apps has emerged [15]. To our knowledge, this study is the first to evaluate the usability of diabetes management apps on iPad.

Methods

This study introduces a novel usability survey that is designed for mHealth and specific to the iOS operating system. The survey is built on previous usability findings [11]–[14], Nielsen heuristics [16] and the Apple iOS Human Interface Guidelines [17]. The new instrument was evaluated with three evaluators assessing ten iPad apps, selected because they were the most popular diabetes management apps on the Apple AppStore. A focus group was subsequently held to gather more insight on the usability of the apps and the survey itself. Statistical analysis using R and grounded theory were used to analyze the quantitative and qualitative results, respectively.

Results

The survey identified OneTouch Reveal by LifeScan Inc. and TactioHealth by Tactio Health Group as the most usable apps. GlucoMo by Artificial Life, Inc. and Diabetes in Check by Everyday Health, Inc. rated as the least usable apps.

Setting up medication and editing blood glucose were the most problematic tasks. Some apps did not support all functions that were under review. Six main themes emerged from the focus group: the presentation of health information, aesthetic and minimalist design, flexibility and efficiency of data input, task feedback, intuitive design and app stability. These themes suggest important constructs of usability for mHealth apps.

Discussion and Conclusion

Mobile health developers and researchers should focus on the tasks, heuristics and underlying issues that were identified as most problematic throughout the study. Additionally, research should further inquire on the potentially critical relation between the information available on app markets and the usability of apps. Several signs point to the potential of the usability survey that was developed but further adjustments and additional test iterations are warranted to validate its use as a reliable usability evaluation method.

BIOGRAPHICAL SKETCH

Charles Coutu-Nadeau is a graduate student at Weill Cornell Medical College since September 2013. Submitting this thesis marks the completion of his Master of Science in Health Informatics. He obtained a Bachelor of Electrical Engineering from McGill University in 2012.

Charles developed an interest and expertise in mobile health (mHealth) through internships at Tactio Health Group, a Montreal-based startup building app-powered, patient-centered remote patient monitoring solutions. At Tactio, a company founded and owned by his father Michel Nadeau, Charles was involved as an engineer in product development, technical support and sales.

Fascinated by streamlined, user-centric product design, his introduction to the world of electronic health records at Weill Cornell only reinforced his belief that usability is key to the adoption and success of a health technology. He now looks forward to transition from a remarkable year doing his Master's degree to a successful career of improving the world with technology.

To my mother Marie-Josée Coutu and father Michel Nadeau who made this journey possible. I will forever remember this special year spent at Weill Cornell in New York and will always be grateful.

ACKNOWLEDGMENTS

I would first like to thank my research supervisor and mentor throughout this project: Dr. Joshua E. Richardson. I arrived at Cornell with no research experience whatsoever and very lofty goals. Dr. Richardson was highly supportive of my ambitions throughout the year, even helping me obtain an internship at the Clinton Foundation Health Matters Initiative to complement my studies in health informatics. Not only did he generously share his experience in mHealth research but he also provided me council and trust, which I appreciated very much.

In the city that never sleeps, it was a very busy year. A year of learning and exchanging ideas about clinical informatics, research methods, mHealth, human-computer interactions, health policies and so much more. For this fulfilling year, I must thank Dr. Jessica Ancker, *professeur extraordinaire*, who always made herself available to maximize our learning experience throughout our 3 semesters at Weill Cornell. And of course, I would like to thank Dr. Stephen Johnson and Lyubov Tmanova for their help with my research project throughout the course of the year.

This project could not have been achieved without the generosity of the evaluators who participated in this study: my fellow classmates Baria Hafeez, Dr. Phillip Say and my brother Louis-Philippe Coutu-Nadeau.

I was also helped by Andrew Demidowich, Kevin Lu, Ronald Tamler and Clare Martin. They generously shared in-depth details of their own studies to evaluate the usability of diabetes management apps [11]–[13] so I could build on their findings and methods.

On a final note, I must mention and thank my ex-colleague and friend Dr. André Piccolomini from Tactio Health Group for introducing me to diabetes and for his attention and support launching my research interest.

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LIST OF ABREVIATIONS

ADA	American Diabetes Association
HCI	Human-computer interaction
HIG	Human Interface Guidelines from Apple Inc.
ICC	Intraclass correlation coefficient
ISO	International Standards Organization
mHealth	Mobile health
Apps	Mobile software applications
SMBG	Self-monitoring of blood glucose
WCMC	Weill Cornell Medical College

CHAPTER 1

INTRODUCTION

Diabetes is a major cause of morbidity and mortality in the United States. In 2012, 29.1 million people were estimated to have the condition, with type 2 diabetes accounting for 95% of all cases [1]. The national cost of the disease is currently estimated at $245 billion [18]. With the population rapidly aging and an increasing number of individuals at risk of developing the condition, it is forecasted that 1 out of 3 Americans will have diabetes by 2050, further increasing its burden on the U.S. [3].

Fortunately, it is possible to manage diabetes in order to prevent or delay the onset of complications [4]. In coordination with a professional medical team, people with diabetes must assume self-management responsibilities that include self-monitoring of blood glucose (SMBG), taking anti-diabetic medication, following a diet low in carbohydrates, losing weight, regularly performing physical activity, receiving diabetes self-management education and support, or some combination thereof [19].

The ubiquitous nature of mobile technologies and powerful capabilities of smartphones and tablets has led to a significant increased interest in the development of mobile health. Mobile health (mHealth) appears especially promising for conditions like diabetes that require intense and ongoing

monitoring [20]. In fact, research has consistently shown that diabetes management is an application area where mobile devices could enhance the quality of life for people living with chronic illnesses [6]–[8].

Usability is critically important in the context of systems that help people continuously self-manage complex conditions such as diabetes [9], [10]. Past work has evaluated the usability of diabetes management apps for Android, iOS and Blackberry smartphones [11]–[14]. Also, no established method to evaluate the usability of mobile apps has emerged [15].

To our knowledge, this study is the first to evaluate the usability of diabetes management apps on iPad, a promising device considering its popularity [21] and high satisfaction rate [22] among older adults. The study also introduces a novel usability survey that is designed for mHealth and specific to the iOS operating system that powers iPads and iPhones.

CHAPTER 2

BACKGROUND

Diabetes

Diabetes mellitus is a condition characterized by hyperglycemia resulting from the body's inability to use blood glucose for energy [23]. The three most frequent clinical forms are gestational, type 1 and type 2 diabetes.

Gestational diabetes is a temporary form of diabetes that affects 3 to 8% of pregnant women in the United States [24]. Caused by the hormones of pregnancy or a lack of insulin, it usually disappears after giving birth. Nevertheless, women who have had the disease are more likely to develop type 2 diabetes within 5 to 10 years [24].

Type 1 diabetes accounts for 5 to 10% of cases of diabetes [1]. It is an autoimmune disease that causes the destruction of β-cells, which prevents the pancreas from producing insulin [19]. Although there are several hypotheses, the underlying causes of the disease largely remain unknown. Patient treatment includes insulin therapy, routinely administered via a wearable pump or manual injections [25].

Type 2 diabetes accounts for 90 to 95% of all cases and therefore is by far the most common form of the disease [1]. Type 2 diabetes develops progressively with the body building a resistance to insulin until blood cells

are not able to use blood glucose for energy [26]. Older adults, American Indians, African Americans, Hispanics and people with excess weight are at an increased risk of developing the disease [1]. As opposed to type 1, type 2 diabetes can generally be prevented or delayed by a series of lifestyle changes including weight loss, healthy eating, routine exercise, and using medications as directed [19]. Due to the high prevalence of type 2 diabetes and inherent challenges with effective self-management, this research project narrows its focus on adult patients living with this form of diabetes.

Costs of Diabetes in the U.S.

Diabetes is a leading cause of morbidity and mortality in the United States. In 2012, 29.1 million people, or 9.3% of the U.S. population, were estimated to have the condition [1]. It is currently the seventh leading cause of mortality in the country, with 234,051 certificates in 2010 showing diabetes as a cause of death including 69,071 certificates listing it as the underlying cause [1].

Diabetics are at an increased risk of complications such as heart disease, stroke, hypertension, eye problems, kidney disease, nervous system disease and amputation [27]. Because of the damage to the blood vessels caused by high blood glucose, 60 to 70% of people with diabetes have mild to severe