Usability Evaluation of Home-Use Glucose Meters for Senior Users

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Abstract. Self-monitoring of blood glucose technique provides diabetic mellitus patients a simple and real-time method to monitor their blood sugar at home. In order to understand the interface design problems in home-use glucose meters, the aim of this study was to realize if senior users were able to easily and effectively operate glucose meters via usability evaluation. Five senior users of above 65 years old who never use home-use glucose meters before were recruited to operate typical tasks: a. changing lancet, b. inserting a strip to turn on the meter, c. lancing, d. waiting for the result and e. discarding lancet. The experiment process was recorded for further interview. The results demonstrated that the key factors that caused operation errors were found on lancing device and test strip instead of the glucose meter. Especially for seniors that had memory degradations, they needed side by side assistance to finish the tasks.

Keywords: Senior user, Glucose meter, Usability evaluation.

1 Introduction

According to International Diabetes Federation (IDF), diabetic population in the world has reached 382 million in the end of 2013. It also reported that 10% of the global population will have diabetes by 2035[1]. Self-monitoring of blood glucose techniques provides diabetic mellitus patients a simple and real-time method to monitor their blood sugar at home which helps avoids tiring transportations between home and medical facilities. For seniors with high risk in diabetes mellitus, home-use glucose meters still presence many interface design defects which can easily cause operation errors. In 2005, the United States Food and Drug Administration (FDA) issued a Medical Device Report of Abbott glucose meters to warn users that the Abbott glucose meters provided mg/dL and mmol/L, two different measuring units. When users were setting time and date of the meters, accidentally switching to another measurement could happen. Unknowingly reading the wrong glucose values could subsequently cause wrong dosage of insulin injection or losing control of diet. It resulted in

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multiple incidents of serious high blood sugar or hyperglycemia that endangered lives in the U.S. [2]. Although many seniors are willing to use new technology-applied products, the aging process degenerate the physiological functions. For instance, visual degenerations that common to seniors cause difficulties in seeing the operating interface of the products clearly; decreasing muscle strength and finger sensitivity resulting from motion function degeneration cause difficulty for seniors to operate small buttons [3]. Psychologically, cognitions, comprehensions as well as learning abilities also show signs of degradations through aging. Therefore when senior users are in contact with new products, they may face obstacles in learning that they cannot correctly use them.

In order to compensate the condition of inexperienced seniors using products, related studies shown that usability evaluations are effective methods that can improve the interactions between seniors and medical devices [4,5]. Usability evaluation has been widely implemented in the process of product evaluation and system development [6,7]. Despite that the evaluation methods are not originally developed for medical system, applications on medical devices to evaluate interfaces continue to grow. Users are invited to do typical tasks for researchers to identify the operation flow which errors happen on and users having difficulties with in order to discover design defects [8,9]. The most important issue of medical device usability evaluation is to understand the interactions between users and products. In addition to improve the health of people, it is meant to reduce the probabilities of medical malpractice and ensure the safety of the people as well [10]. Beuscart-Zéphir [11] indicated that many actual cases shown that medical equipment, such as infusion pumps, hand-held electronic prescribing devices and computerized order entry, are in fact prone to human errors. Therefore, the aim of this study is to realize the usability of commercial home-use glucose meters for senior users. And the study results are expected to provide interface design recommendations for new home-use medical devices.

2 Method

2.1 Subjects

Five seniors, 3 females and 2 males, above age of 65 (average 70.9) years old were recruited for this study. All of the test subjects had no upper limb disability, no cognitive impairment, and had no previous experience in using home-use glucose meter independently.

2.2 Instrumentation

Two commercial home-use glucose meters were chosen for the experiments: One-Touch UltraEasy, johnson & Johnson and FreeStyle Freedom Lite, Abbott (Fig.1).

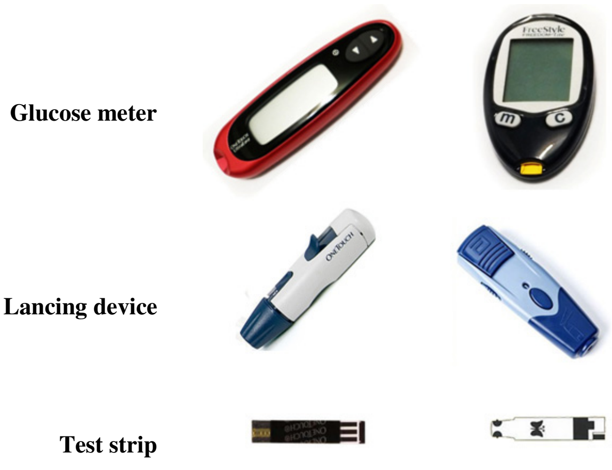

Fig. 1. Two commercial home-use glucose meters, (L)OneTouch; (R)FreeStyle.

2.3 Experiment Protocols

The experiment protocols were described as followed:

1. First, the researchers would explain the glucose meter operation instructions to the subjects, and allowed them to have 10 minutes to practice using the two meters.
2. The researchers would then explain the test procedures, operation tasks and things to be aware of during experiments.
3. Next, subjects operated five operation tasks in orders, which started from task a to task e, and they should achieve the default target of all the tasks with no time limit.

a. changing lancet
- a.1 open the lancing device cap.
- a.2 insert the lancet.
- a.3 replace the lancing device cap.
- a.4 adjust the lancing depth.
- a.5 cock the lancing device.

b. inserting a strip to turn on the meter
- b.1 open the test strip vial lid.
- b.2 remove a test strip.
- b.3 close the test strip vial lid.
- b.4 insert a test strip into the meter.

c. lancing
- c.1 wipe the lancing area with an alcohol pad.
- c.2 hold the lancing device against the finger and press the release button.
- c.3 apply the correct solution to the test strip.

d. waiting for the result
- d.1 read the result from the meter screen.
- d.2 dispose the test strip.

e. discarding lancet
- e.1 open the lancing device cap.
- e.2 remove the lancet.
- e.3 replace the lancing device cap.

4. The experiment process were recorded using a digital camera to record the actions of subjects using the glucose meters for further analysis and reference of video/ audio retrospection.

In order to avoid learning effects, glucose meters were chosen randomly by subjects. A five-minute break was taken between each experiment.

Fig. 2. One of the subjects was operating OneTouch glucose meter.

3 Results and Discussion

From our observation and interview, we found that users spent more operation time in task a and task b, than other three tasks. The lacing device and test strip were the major parts involved in the above two tasks, the discussion of this study focuses on those two items.

3.1 Lacing Device

The sub-task of task was a.1 open the lancing device cap. Both lacing devices both had different shapes and colors to distinguish the devices and its cap which provided information that the lancing device and the cap were detachable. However, the information of how to detach the cap was not clear. Users would try to unscrew or pull the cap. Use error occurred when the users were unable to realize that the lancing cap should be snapped open. Additionally, for those subjects who had weakened hand muscle strength it was difficult to pull open. It required greater effort and repeat attempts to achieve.

Sub-task “a.5 adjusts the lancing depth” was the bottleneck for the novice user. If those users adjusted lancing depth too deep might increase the pain they felt during lancing. On the contrary, if the lancing depth was not enough, it might cause test failure because of insufficient in blood sample. OneTouch lancing device was designed to adjust lancing depth by twisting the device, which could cause confusion with pulling open the cap. Subjects tended to mistakenly adjust lancing depth by trying to unscrew the device cap.

3.2 Test Strips

Test strips used usually differentiate the side of inserting into the meters and the sampling side by graphics. This study discovered that most of the subjects did not carefully observe the differences of the graphics before use. They inserted the strip without confirming the correct insertion side and thus leaded to use error. The possible explanation could be that the graphic on the test strip was not specific and also due to impaired vision that happed to most seniors participants. For instance, errors usually happened when most of the users did not notice the arrow instruction or failed to understand the meaning of the arrow.

Most of the commercial glucose meters can automatically turned on by inserting the test strip. Although it supposed to be a considering and convenient design, this study shown that OneTouch could still turn on even the test strip was not properly placed in (wrong insertion direction or not fully inserted). The meter could be turned on just because the test port was disturbed. When the subjects realized they made mistakes and tried to give second attempt, it required to reboot the device or the test strip was contaminated by blood even further caused lancing failure. Therefore, the test strip should design with a clear graphic to let users realize that it is set up correctly.

3.3 Glucose Meter Operation Procedures

Most of the subjects could not remember all the operation procedures after the researchers explained the process. They usually required researchers gave step-by-step reminders to finish all the tasks. It proved that the operation procedures of commercial glucoses meters were burdensome for novice senior. Most subjects failed to remember correct procedures because the tasks were too complicated to memorize. This study found that even the subject had performed the same task more than twice they still forgot, hesitated, paused or made mistakes. Aging accompanies with short-term memory degeneration. It is hard for seniors to remember the instructions they read orderly [12]. Most of the home-care medical products use new technologies and consist of multiple functions. However, senior users usually lack for experience in using technological products for which it is hard for them to understand various functions and complicated operating interface [13]. We found that when senior subjects operating complicated devices, such as glucose meter, the concerns of being unfamiliar with the products may result in operation errors.

4 Conclusion

This study recruited seniors to operate two types of home-use glucose meters to evaluation usability. Results revealed many operation problems in practical use. The crucial factors that caused use errors involved lancing devices and test strips rather than glucose meters. If the above two parts can be further designed more thoroughly, the usability of seniors using home-use glucose meters can be effectively improved.

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