Designing a PDA Interface for Dialysis Patients to Monitor Diet in their Everyday Life

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Abstract

Dialysis patients can only consume one liter of fluid and two grams of sodium each day. If they go over these limits, they can have serious health complications. Since up to 80% of patients do not adhere to their fluid and sodium intake, we are developing a PDA application to assist dialysis patients in monitoring their nutritional allowances. In this paper, we give an overview of the interactive PDA application and describe our user-centered design process to create an interface for dialysis patients with varying visual acuity, literacy skills, and computer experience. Our preliminary studies suggest that dialysis patients can use PDAs, but the interface must not rely on stylus input, writing, or small icons for usability. We will use our results in designing low fidelity paper interface prototypes before implementing the interface on the PDA.

1 Introduction

Dialysis patients are only allowed to consume approximately one liter of fluid and two grams of sodium each day[1] because of their kidney problems. If they exceed this limit they run the risk of hypertension (Agarwal *et al.*, 2003; Lindsay *et al.*, 2003), pulmonary edema (Sacchett *et al.*, 1991), and even death. Therefore, it is critical patients monitor their intake of food and fluids. Currently, many patients try to monitor their nutrition by remembering or writing down their daily fluid and sodium consumption in a food diary. However, studies have shown 80% of patients do not restrict their fluid intake (Betts & Crotty, 1988; Cummings *et al.*, 1982; Welch, 2001, 2003). We are designing an interactive Personal Digital Assistant (PDA) application that provides various kinds of interactive information and feedback to help patients monitor their fluid and dietary intake. The rationale is that patients will carry the PDA around with them in their everyday life and to use it as a cognitive aid whenever they want to eat, drink, or find out more about a particular food item.

Our aim is to enable patients to easily record dietary information and to obtain immediate feedback on their fluid and sodium intake in relationship to their medically prescribed limitations. In this paper, we present the design stages we are following to create the PDA Dietary Intake Monitoring Application (DIMA). We start the paper by reviewing related work and motivation for the creation of DIMA. In Section 3 we give a brief overview of DIMA. Section 4 describes how we are developing DIMA's interface. We conclude the paper with our future goals.

2 Related Work

Patients typically use paper diaries when self-monitoring. However, actual compliance when completing paper diaries is as low as 11% in some instances. When patients use electronic diaries, such as on a PDA, compliance rates are as high as 94% (Stone *et al.*, 2002; Stone *et al.*, 2003) suggesting that electronic self-monitoring is a more accurate and better way for individuals to self-monitor.

A patient's health is not a barrier to technology use as has been shown in some empirical studies (Brennan *et al.*, 1992; Brennan *et al.*, 1995; Gustafson *et al.*, 1999). PDAs have been used for electronic self-

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[1] The amount of fluid and sodium consumption allowed varies among patients.

monitoring to report symptoms in a variety of health contexts (Affleck *et al.*, 1998; Affleck *et al.*, 1996; Broers *et al.*, 2002; Newman *et al.*, 1997), track equipment-generated values such as blood glucose levels in diabetes (Clarke *et al.*, 1997), and assess situational cues and self-efficacy associated with smoking (Shiffman *et al.*, 2000).

Patients must have particular cognitive and behavioral skills to successfully monitor dietary and fluid recommendations, such as the ability to read labels, make conversions, and perform calculations. Our past research found that approximately one-third of dialysis patients had difficulty performing simple calculations (Evans *et al.*, 2004). Patients could use PDAs to successfully self-monitor without the need of reading labels, making conversions, or performing calculations. Although PDAs are being developed to self-monitor dietary intake (Okoboji Software Inc., 2003; Intille *et al.*, 2003), the efficacy of PDA technology in altering intake has not been tested. To our knowledge, DIMA will be the first PDA application to assist dialysis patients' monitor their nutritional intake.

3 Overview of DIMA

The creation of DIMA is a collaborative effort between hemodialysis adherence, computer science and informatics, nutrition, biostatistics, and nephrology researchers. The application will allow patients to input food or fluid items by selecting icons or scanning the barcodes on items. Patients can view their intake in reference to prescribed fluid and sodium levels at any time. In future iterations of DIMA, patients will be able to view their intake levels for potassium, phosphorus, calories, and protein. If a food item is scanned, the scanner will pass the barcode numbers to DIMA's backend where the barcode will be looked up in the barcode/nutritional database. If a food item is inputted via the graphical user interface, DIMA's backend will look up the item in a nutritional database. Once nutritional information is found, DIMA will save the food item inputted and update the participant's current dietary and fluid levels. When the patients come in for dialysis treatment, researchers will download the patient's nutritional intake for analysis. The success of DIMA will be measured by patients' ability to control their fluid and sodium intake.

4 Designing DIMA's Interface

DIMA is being developed using a user-centered approach. First, we assessed the users' needs and decided which device to use (the PDA). Next, we asked dialysis patients to complete some common tasks on a PDA to measure the usability of the PDA. Then, we evaluated how patients could use an existing diet application. In this section, we will discuss each step.

4.1 Selecting the Hardware

When we selected the hardware for DIMA, we had to keep in mind that patients had varying visual acuity, literacy skills, and computer experience. We also had to ensure the device could give compliance information to our research team. After evaluating several devices, we chose to use Palm One's Tungsten T3 - a PDA. The PDA has a large screen space to display information and large buttons for patients with poor visual acuity. The high resolution, color display will also allow us to use images to convey information for patients with low literacy skills. Patients who are not familiar with PDAs will not have to worry about maintenance tasks because the PDA is power efficient and will not need recharging between dialysis sessions. Researchers can download compliance information with PDAs via hot sync operations.

In addition, PDAs have several other advantages. First, individuals can enter data in a variety of ways, such as by using voice recordings, touch screens, scanning, and/or a stylus. Second, they are lightweight, portable, easily accessible, and easy to carry in a pocket or purse, but sufficiently obtrusive to trigger clients to remember to record their data (Foster *et al.*, 1999). Third, there is no sick-role stigma associated with a PDA. Fourth, participant time is saved because time data are entered and recorded automatically. Fifth, the automatic recording of time data allows an assessment of time intervals between recordings. Sixth, data from a PDA can be transferred to a personal computer, saving time and reducing errors that might occur with manual entry (Foster et al., 1999). Finally, the age of individuals does not affect PDA use.

Elderly people can use handheld computers (Carmien & Gorman, 2003; Helal *et al.*, 2003) and sometimes use computer interfaces available for people with visual impairment (Jacko *et al.*, 2003).

4.2 Evaluating PDA Usability

We compared how healthy and chronically ill novice PDA users could complete conventional PDA-based tasks (e.g., pressing buttons, viewing icons, voice recording) and non-conventional tasks (i.e., scanning barcodes). All of the tasks were measured quantitatively, such as by the number of incorrect button presses, preferred icon size, or number of incorrect recordings/scannings. We did not enforce any maximum amount of viewing time because we wanted the participants to feel comfortable reading the icons and avoid the stress associated with timed events. Researchers have found placing time constraints on older people increase the number of errors (Laursen *et al.*, 2001).

Thirty participants who were novice PDA users volunteered for the study: 10 healthy participants 25-30 year olds, 10 healthy participants 75-85 years old, and 10 chronically ill participants (mean age 51 years). We were unable to recruit healthy adults who were 45-55 years old for our study. Our first PDA usability study showed that healthy older people (75-85 years old) could physically interact with PDAs with no major differences in performance when compared to healthy younger participants (25-30 years old). Since there were no performance differences between the healthy younger and older groups, we paired the chronically ill group with the age group closest to their own for our comparisons.

We compared the chronically ill participants' success rates with our older group and found chronically ill participants were able to press buttons (T_{17}=2.08, p=0.053), record messages (T_{18}=1.12, p=0.279), and scan bar codes (T_{18}=0.818, p=0.424) just as well as our group without illness. Similar to the older participants, the chronically ill participants chose large icons (18.5mm vs. 19mm) although they could read smaller icons (10.0mm vs. 8.5mm) just as well. Overall, the chronically ill participants found all of the PDA tasks easy to complete suggesting that use of technology to self-monitor dietary and fluid intake would be feasible in this patient population (Moor *et al.*, 2004).

4.3 Learning from other applications

We examined the usability of an existing product, DietMate Pro, which uses the USDA database to monitor dietary and fluid intake. The application can monitor sodium, potassium, phosphorus, and protein. Three participants from a university hospital dialysis unit volunteered for the study. Our anecdotal data indicate that participants have difficulty using the stylus to enter data, viewing the small icons and fonts. Participants reported they sometimes have difficulty inputting appropriate food information. These results support what we found in our PDA usability study. Inclusion criteria for the study did not include non-adherence and all 3 patients were reasonably adherent to dietary regimens prior to beginning self-monitoring. Preliminary data analyses indicate that although patterns of intake varied, most of the time patients were within recommended limitations with the exception of substantially reduced protein and calorie intake. Two of the participants increased their nutritional intake and one participant decreased their nutritional intake because of the electronic self-monitoring. The study has helped us identify possible input method problems (avoid stylus input) and interface layouts (less text, larger icons).

5 Future Work

We are in the process of designing low-fidelity interfaces known as picture cards, which are pieces of paper with drawings of interface designs. Using picture cards is a standard technique when creating interfaces because they allow one to quickly change and create interface designs without having to program interfaces. Pictures cards have been successfully used to create interfaces for people with little technical experience and varying literacy levels (Grisedale *et al.*, 1997).

Our picture cards show interface mock-ups, food items, and images displaying quantities (graphical display of how much of a food or fluid item has been consumed). We will test four types of interfaces – food grouped by food group, type of meal, time meal is served, and color of food item. Patients will "navigate" through each interface by selecting icons on the picture card and getting another picture card showing the action of the icon selection (i.e. a new dialog window). The test will assist us in determining the flow of DIMA. Patients will organize the food item picture cards into an order that makes sense to them to give us insight into how to organize food items. We will also show participants a prepared meal (i.e. spaghetti) and ask participants to tell us what individual food items are combined to create the prepared meal to assist us determining whether to present food individually or as prepared meals. Finally, we will show participants examples of display quantities and find out how we should visually display the amount of fluid and nutritional values consumed.

We are also developing short PDA activities/games for patients to use during dialysis sessions. The activities will teach patients skills they will need in order to use DIMA (i.e. scanning bar codes, selecting icons) and help them become more comfortable with using a PDA. Once patients become more comfortable with using the PDA through the activities/games, we will iteratively increase the amount of functionality in the activities until they have the complete version of DIMA.

6 Conclusion

This paper has given an overview of an interactive PDA application to assist dialysis patients monitor their fluid and sodium intake. We are using user-centered design techniques to create an interface for dialysis patients with varying visual acuity, literacy skills, and computer experience. Our preliminary studies suggest that dialysis patients can use PDAs, but the interface must not rely on stylus input, writing, or small icons for usability. We will use our results in designing low fidelity paper interface prototypes before implementing the interface on the PDA.

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References

Affleck, G., Tennen, H., Urrows, S., Higgins, P., Abeles, M., Hall, C., et al. (1998). Fibromyalgia and women's pursuit of personal goals: A daily process analysis. *Health Psychology, 17*(1), 40-47.

Affleck, G., Urrows, S., Tennen, H., Higgins, P., & Abeles, M. (1996). Sequential daily relations of sleep, pain intensity, and attention to pain among women with fibromyalgia. *Pain, 68*, 363-368.

Agarwal, R., Nissenson, A. R., Batlle, D., Coyne, D. W., Trout, J. R., & Warnock, D. G. (2003). Prevalence, treatment, and control of hypertension in chronic hemodialysis patients in the united states. *American Journal of Medicine, 115*, 291-297.

Betts, D. K., & Crotty, G. D. (1988). Response to illness and compliance of long-term hemodialysis patients. *ANNA Journal, 15*, 96-100.

Brennan, P. F., Moore, S. M., & Smyth, K. A. (1992). Alzheimer's disease caregivers' uses of a computer network. *Western Journal of Nursing Research, 14*(5), 662-673.

Brennan, P. F., Overholt, J. L., Casper, G., & Calvitti, A. (1995). Elders using a computer network: Profiles of a champion. *Medinfo, 8*(2), 1545.

Broers, S., Van Vliet, K. P., Everaerd, W., Le Cessie, S., & Radder, J. K. (2002). Modest contribution of psychosocial variables to hypoglycaemic awareness in type 1 diabetes. *Journal of Psychosomatic Research, 52*(2), 97-106.

Carmien, S., & Gorman, A. (2003). *Creating distributed support systems to enhance the quality of life for people with cognitive disabilities.* Paper presented at the UbiHealth 2003, Seattle.

Clarke, W. L., Cox, D. J., Gonder-Frederick, L. A., Julian, D., Schlundt, D., & Polonsky, W. (1997). The relationship between nonroutine use of insulin, food, and exercise and the occurrence of

hypoglycemia in adults with iddm and varying degrees of hypoglycemic awareness and metabolic control. *Diabetes Educator, 23*(1), 55-58.
Cummings, K. M., Becker, M. H., Kirscht, J. P., & Levin, N. W. (1982). Psychosocial factors affecting adherence to medical regiments in a group of hemodialysis patients. *Medical Care, 20*, 567-580.
Evans, J. D., Wagner, C. D., & Welch, J. L. (2004). Cognitive status in hemodialysis patients as a function of fluid adherence. *Renal Failure, 26*(5), 575-581.
Foster, S. L., Laverty-Finch, C., Gizzo, D., & Osantowski, J. (1999). Practical issues in self-observation. *Psychological Assessment, 11*(4), 426-438.
Grisedale, S., Graves, M., & Grunsteidl, A. (1997). *Designing a graphical user interface for healthcare workers in rural india.* Paper presented at the Conference on Human Factors in Computing Systems, Atlanta, GA.
Gustafson, D. H., McTavish, F. M., Boberg, E., Owens, B. H., Sherbeck, C., Wise, M., et al. (1999). Empowering patients using compute based health support systems. *Quality in Health Care, 8*(1), 49-56.
Helal, S., Giraldo, C., Kaddoura, Y., & Lee, C. (2003). *Smart phone based cognitive assistant.* Paper presented at the UbiHealth 2003, Seattle.
Intille, S. S., Kukla, C., Farzanfar, R., & Bakr, W. (2003). *Just-in-time technology to encourage incremental, dietary behavior change.* Paper presented at the AMIA Annual Symposium Proceedings.
Jacko, J., Scott, I., Sainfort, F., Barnard, L., Edwards, P., Emery, V., et al. (2003). *Older adults and visual impairment: What do exposure times and accuracy tell us about performance gains associated with multimodal feedback?* Paper presented at the SIGCHI 2003.
Laursen, B., Jensen, B., & Ratkevicius, A. (2001). Performance and muscle activity during computer mouse tasks in young and elderly adults. *European Journal of Applied Physiology, 25*, 167-183.
Lindsay, R. M., Shulman, T., Prakash, S., Nesrallah, G., & Kiaii, M. (2003). Hemodynamic and volume changes during hemodialysis. *Hemodialysis International, 7*, 204-208.
Moor, K. A., Connelly, K. H., & Rogers, Y. (2004). *A comparative study of elderly, younger, and chronically ill novice pda users*. Bloomington: Indiana University.
Newman, M. G., Kenardy, J., Herman, S., & Taylor, C. B. (1997). Comparison of palmtop-computer-assisted brief cognitive-behavioral treatment to cognitive-behavioral treatment for panic disorder. *Journal of Consulting and Clinical Psychology, 65*(1), 178-183.
Okoboji Software Inc. (2003). Nutrifinder.
Sacchett, A., Harris, R., Patel, K., & Attewell, R. (1991). Emergency department presentation of renal dialysis patients: Indications for ems transport directly to dialysis centers. *Journal of Emergency Medicine, 9*, 141-144.
Shiffman, S., Balabanis, M. H., Paty, J. A., Engberg, J., Gwaltney, C. J., Liu, K. S., et al. (2000). Dynamic effects of self-efficacy on smoking lapse and relapse. *Health Psychology, 19*(4), 315-323.
Stone, A. A., Shiffman, S., Schwartz, J. E., Broderick, J. E., & Hufford, M. R. (2002). Patient non-compliance with paper diaries. *British Medical Journal, 324*(7347), 1193-1194.
Stone, A. A., Shiffman, S., Schwartz, J. E., Broderick, J. E., & Hufford, M. R. (2003). Patient compliance with paper and electronic diaries. *Controlled Clinical Trials, 24*(2), 182-199.
Welch, J. L. (2001). Fluid management beliefs by stage of fluid adherence. *Research in Nursing and Health, 24*, 105-112.
Welch, J. L. (2003). Differences in perceptions by stage of fluid adherence. *Journal of Renal Nutrition, 13*(4), 275-281.