Feasibility of Using a Personal Digital Assistant to Self-Monitor Diet and Fluid Intake: A Pilot Study

CNE Continuing Nursing Education

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The feasibility of using an electronic device to self-monitor diet and fluid intake was assessed using the treatment implementation model. The three patients on hemodialysis who participated in this pilot study were asked to self-monitor diet and fluid intake for 12 weeks with a personal digital assistant. The intervention was delivered as intended; however, participants reported problems with usability, and compliance to self-monitoring was lower than desirable. Further adjustments to the intervention will be made before testing efficacy.

Goal
To share information with nurses caring for patients on hemodialysis regarding self-management by the patients using PDA's.

Objectives:
1. Describe the purpose of an investigation examining the effects of self-monitoring by patients on hemodialysis
2. Relate the methods to the results in the investigation of self-monitoring by hemodialysis patients
3. Summarize the conclusions of an effectiveness research activity.

The need for patients receiving hemodialysis to monitor diet and fluid intake in daily living is well known to nephrology professionals. Patients are often provided lists of foods to avoid, alternative cooking strategies, or suggestions on how to improve food flavor, but the day-to-day implementation of the complex diet is the challenging responsibility of all patients.

Few interventions have been tested to promote dietary behavior change among adults receiving hemodialysis (Welch & Thomas-Hawkins, 2005). Self-monitoring, defined as recognizing the occurrence of a behavior and systematically recording it (Kopp, 1988), however, has been tested the most. Paper-and-pencil self-monitoring was bundled with other interventions and tested in four studies for its effects in reducing fluid intake among adults receiving hemodialysis (Christensen, Moran, Wiebe, Ehler, & Lawton, 2002; Sagawa, Oka, Chaboyer, Satoh, & Yamaguchi, 2001; Tsay, 2003; Tucker, 1989). Fluid intake, as measured by interdialytic weight gain, had decreased by the end of the self-monitoring period in 3 studies. Christensen and colleagues (2002) found a nonsignificant decrease in interdialytic weight gain at the end of self-monitoring and other interventions, but a significant decrease 8 weeks after the interventions ended. The independent contribution of self-monitoring in decreasing interdialytic weight gain, however, is unknown (Welch & Thomas-Hawkins, 2005). Furthermore, there are no investigations that examine the effects of self-monitoring on caloric, phosphorus, potassium, protein, or sodium intake.

The use of information technology may be beneficial for patients as they implement diet and fluid prescriptions, and long-term success may be better using a collaborative, patient-centered approach (Glasgow, Goldstein, Ockene, & Pronk, 2004). We propose a self-monitoring intervention based on a theoretical framework of providing continual mastery experiences and feedback to enhance self-efficacy (Bandura, 1986). The capabilities of electronic diaries may provide important resources as patients self-manage diet and fluid intake on a daily basis. Moreover, compliance rates for electronic self-monitoring have been shown to be dramatically higher than

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for those individuals who use paper-and-pencil (Stone, Shiffman, Schwartz, Broderick, & Hufford, 2003).

Systematic evaluation of interventions is essential in intervention research (Sidani & Braden, 1998; Sidani, Epstein, & Moritz, 2003). There are no models to guide evaluation of consumer informatics (Ammenwerth, Graber, Herrmann, Burkle, & Konig, 2003); however, systematic evaluation of an intervention can be guided by the treatment implementation model (Lichstein, Riedel, & Grieve, 1994). This model assesses the implementation of an intervention using the criteria of *delivery, receipt,* and *enactment.* Delivery refers to the specific components included in the intervention that is being tested. Receipt addresses the process of influence and refers to the perception and comprehension of the intervention by the intended recipient. We conceptualized receipt as usability of the informatics intervention with usability referring to the perceived effectiveness, efficiency, and satisfaction of the intervention in relation to achieving tasks in the environment (Folmer & Bosch, 2003). Enactment refers to the extent to which participants use the intervention.

In this study, preliminary evaluation data were collected about use of a handheld computer, a personal digital assistant (PDA), to self-monitor diet and fluid intake for the purpose of assessing feasibility of the intervention. Specifically, we wanted preliminary answers to the following questions: (1) Can patients on hemodialysis learn to use a PDA? (2) Would a PDA be usable by patients on hemodialysis for monitoring diet and fluid intake?, (3) Would patients record diet and fluid intake as instructed?, and (4) Would recording diet and fluid intake take a long time?

Methods

Sample

A convenience sample of 4 participants was recruited from an outpatient hemodialysis center in a large, Midwestern city. One patient withdrew from the study. The remaining 3 participants had a mean age of 54, were African American, and 2 were male. Further descriptive information about the sample, methods, and procedures is presented elsewhere (Dowell & Welch, 2006).

Intervention

The electronic self-monitoring diaries were Palm PDAs (Zire 31) that came with a protective case and were programmed with software designed for the collection of diet and fluid information (DietMate Pro®). The PDAs presented icons on a screen measuring approximately 160 X 160 with a bright color Super Twisted Nematic (STN) display from which participants could choose food and fluid items and indicate portion size using a stylus. Participants were instructed to carry the PDA on their person during usual daily activities for the 12 weeks of the study and to record fluid or food immediately after consumption. All entries were stamped with time and date. Participants were electronically provided with a daily total of calories, fluid, sodium, phosphorus, potassium, and protein intake.

Data captured by the computer diaries were transferred to a personal computer on a weekly basis. The data were then transferred over the Web to DietMate Pro®, which supplied an Excel spreadsheet containing daily summaries. The electronic computer did not come with the availability of voice recordings, or touch-screen technology. It did come with audible alarms, but all participants requested that these be turned off. The PDAs required recharging every 3 days.

Measurement

Delivery. Field notes were reviewed to ensure that participants had received verbal and written instructions that allowed them to meet the following objectives: (1) identify the steps to follow when entering dietary intake data, and (2) demonstrate the ability to enter diet intake data. The protocol required that participants were trained until they were proficient in use. At the end of the self-monitoring period, participants were asked to respond to the following item, "The PDA was easy to use once I learned how," on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree).

Receipt. Receipt was operationalized in two distinctly different ways. First, weekly field notes were recorded and participants were asked whether they had had any navigation difficulties (yes/no) and about their overall satisfaction (yes/no) with the PDA during the preceding week. Percentages were computed by dividing the total number of weeks each participant reported navigation problems and ranked overall satisfaction with the PDA by the 12 weeks of self-monitoring. An overall mean was obtained for both navigation problems and overall satisfaction. Second, at the end of the self-monitoring period, participants were asked to respond to a 15-item instrument developed and administered at the completion of the study to assess the usability of the electronic diary. The response scale for all items was a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Four items were included to assess effectiveness. The items included statements such as, "The PDA made me think about how to change my diet and fluid intake" and "This was an easy way to monitor my intake." Six items were included to assess efficiency, and sample scale items included "I could clearly see the symbols on the PDA" and "Touching the buttons on the PDA was easy." Five items assessed satisfaction. Sample items included "I enjoyed using the PDA" and "I liked getting personal information about my diet and fluid intake."

Enactment. Enactment was operationalized in three different ways. First, at weekly intervals during intervention delivery, we asked individuals to self-report compliance. Second, to objectively determine whether participants used the intervention as it was designed, we based another level of

Table 1
Effectiveness, Efficiency, and Satisfaction of Electronic Self-Monitoring

	Item	Mean	SD	Actual Range
Effectiveness	This was an easy way to monitor my intake.	4.00	1.00	3-5
Effectiveness	I learned a lot about my dietary intake.	4.33	.58	4-5
Effectiveness	I learned a lot about my fluid intake.	4.33	.58	4-5
Effectiveness	The PDA made me think about how to change my diet and fluid intake.	4.33	.58	4-5
Efficiency	The PDA was easy to use.	4.00	1.00	3-5
Efficiency	I could clearly see the symbols on the PDA.	4.00	0.00	4
Efficiency	Touching the buttons on the PDA was easy.	3.67	1.53	2-5
Efficiency	The intake monitors on the PDA were helpful.	3.67	1.16	3-5
Efficiency	I could easily find the icons I needed.	4.00	1.00	3-5
Efficiency	The information provided on the PDA was easy to understand.	3.67	1.53	2-5
Satisfaction	I enjoyed using the PDA.	4.00	1.00	3-5
Satisfaction	I was satisfied using the PDA to watch my food and diet intake.	4.33	.58	4-5
Satisfaction	I like the colors used in the PDA.	4.00	1.00	3-5
Satisfaction	I liked getting personal information about my diet and fluid intake.	4.33	.58	4-5
Satisfaction	I liked getting personal information about my diet and fluid intake.	4.33	.58	4-5

evaluation on compliance rates. Compliance was calculated as recording an entry after each meal within an *a priori* window of acceptability (Stone et al., 2003). The PDA recorded the date and time the entry was made by a date and time stamp. The participants were not aware that the PDA recorded their entry time. Wide windows of acceptability were used in an attempt to accommodate different hemodialysis schedules. A participant was considered compliant if the data entry time for breakfast occurred between 5:00 am and 11:00 am, for lunch between 10:00 am and 4:00 pm, and for dinner between 3:00 pm and 10:00 pm. Actual compliance was based on objective measures of when the PDA entry was completed as evidenced by the time-stamp. All measures of compliance were counted and compared against the denominator of total meals for each participant. A total value of compliance was computed for each meal (breakfast, lunch, dinner) over the 3-month intervention period. A weekly overall compliance rate for recording after each meal was also computed. Finally, we operationalized enactment by using subject-level evaluation (Brennan, 1995). This evaluation described individual user behavior and was assessed by describing the number, timing, and duration of PDA accesses. Subject-level evaluation was completed as evidenced by date and time stamp.

Results

Delivery

Field notes indicated that all participants received verbal and written instructions. Each participant required approximately 75 minutes of training. A return demonstration was used to assess proficiency and all were judged to be proficient in use. At the end of the study, participants stated that the PDA was easy to use once they had learned how (M = 4.33; SD .58).

Receipt

Field notes indicated that the participants had navigation difficulties 33% of the time, importantly including the inability to find certain food items in the PDA. In addition, ice was not listed as an item, which was problematic for two of the patients. Self-reported problems included a font that was too small and difficulties using the stylus. Participants also reported that nutritional supplements and many food items were not in the database, requiring participants to make substitutions. Another patient reported the inability to input a recipe into the database in order to obtain nutritional information. On the positive side, one participant reported that the PDA helped her make shopping lists and develop menus for the upcoming week. Our weekly field notes indicated that participants were satisfied with using the PDA only 28% of the time.

When we assessed receipt at the end of 12 weeks of self-monitoring (see Table 1), effectiveness items had mean scores ranging from 4 to 4.33 indicating overall agreement, and the scores ranged from 3-5 for the individual items. Item means for the efficiency scale ranged from 3.67 to 4.00,

Table 2
Overall Compliance Rate for each Meal

Meal	Number compliant	% compliant	95% C.I.
Breakfast	63	24.7%	(4.6%, 69.3%)
Lunch	55	21.6%	(4.0%, 64.2%)
Dinner	79	31.0%	(7.2%, 72.3%)
Overall	197	25.8%	(10.6%, 50.3%)

Table 3
Overall Compliance by Week

Week	Number compliant	Total number	% compliant	95% C.I.
1	15	66	22.7%	(11.4%, 40.2%)
2	17	63	27.0%	(11.6%, 51.0%)
3	14	63	22.2%	(8.8%, 45.8%)
4	18	63	28.6%	(10.4%, 58.0%)
5	20	63	31.7%	(13.1%, 58.9%)
6	20	63	31.7%	(11.6%, 62.2%)
7	18	63	28.6%	(11.3%, 55.6%)
8	17	63	27.0%	(9.1%, 57.8%)
9	16	63	25.4%	(11.1%, 48.2%)
10	17	63	27.0%	(9.1%, 57.8%)
11	15	63	23.8%	(8.0%, 53.0%)
12	10	69	14.5%	(4.7%, 36.7%)

indicating neutral to general agreement. Item scores ranged from 2-5. Satisfaction mean scores for the individual items ranged from 4 to 4.33, indicating overall agreement. Individual item scores ranged from 3-5.

Enactment

Field notes indicated self-reported compliance with recording food and fluid intake. Overall, participants self-reported a compliance rate of 58%.

Using the *a priori* windows established for each meal, the actual compliance rate was calculated for each meal. Generalized estimating equations were used to estimate the standard error and calculate the 95% confidence interval, adjusting for subject and meal (see Table 2). The actual compliance rates for recording each meal after eating ranged from 22% to 31%.

To determine whether compliance with recording after each meal stayed the same or worsened over the 3-month self-monitoring period, the compliance rate was calculated by week. Generalized estimating equations were again used to calculate the 95% confidence interval, adjusting for subject and meal. As shown in Table 3, compliance rates remained steady throughout the study period, ranging from 22%-32%, with the exception of week 12 when compliance decreased to 14%.

As shown in Table 4, there were 483 PDA accesses (63.1% of all 3 meals). Mean duration of data entry was 34.4 seconds (SD 35.4). On average, the majority of meals were entered the following day.

Discussion

Effectiveness research tests the effectiveness of interventions in achieving outcomes in the real-world conditions of clinical practice (Lichstein et al., 1994; Sidani et al., 2003). Three patients on hemodialysis participated in this feasibility study using DietMate Pro® to self-monitor diet and fluid intake for 12 weeks. We evaluated use of DietMate Pro® using the criteria of delivery, receipt, and enactment from the treatment implementation model (Lichstein et al., 1994).

Delivery refers to the specific components included in an intervention (Lichstein et al., 1994) and the criterion for satisfactory delivery was met. Detailed written and verbal instructions were provided to all participants. Written instructions included powering on the PDA, recharging the PDA, use of the stylus, navigation, and the steps required to input information. Patients learned to use the PDA and issues raised by the participants were individually addressed. The amount of time spent teaching the use of the PDA was extensive, however, and it may be useful to consider development of a computerized interactive teaching program. In addition to saving time spent on instruction, the use of such instruction would allow patients to control the amount of time spent in individual learning. By developing an interactive program, touch-screen technology could be incorporated and practice sessions for inputting information could be included. With or without an electronic intervention, it may also be useful to allow time for participants to practice data entry for a few days before beginning the intervention. Our field notes and experiences indicated that patients needed several days to practice.

The focus of *receipt* was on the usability of the PDA to self-monitor diet and fluid (Lichstein et al., 1994). When we met with each participant weekly and in the final evaluation, they reported problems pertaining to usability. The weekly evaluation provided important information, includ-

Table 4
Subject-Level Evaluation of PDA Use

Meal	# of accesses (%)	Mean Duration (sec)	SD Duration (sec)	Mean Entry Time (hr:min)	SD Entry Time (hours)
Breakfast	163 (63.9%)	37.42	38.40	1:09 p.m. the following day	282.26
Lunch	126 (49.4%)	34.98	22.62	11:43 a.m. the following day	182.01
Dinner	194 (76.1%)	31.54	21.98	8:06 p.m. the following day	206.88
All 3 meals	483 (63.1%)	34.42	35.43		

ing navigation problems; difficulty in finding food items; the omission of ice, nutritional supplements, and many food items from the database; a font size that was too small; difficulties using the stylus; and the inability to input and then obtain nutritional information from favorite and often-used recipes. The screen size of the PDA we provided was not the largest available on the market. Our earlier preliminary investigations indicated that patients on dialysis had the manual dexterity required in input data and that they had the visual acuity to see the PDA screen (Moor, Connelly, & Rogers, 2004). This study indicated, however, that we needed to consider development and additional testing for feasibility, paying particular attention to font, ability to navigate, and ways to add missing food items. Identifying user needs may be helpful to tailoring an application specific to the hemodialysis population (Gustafson, Robinson, Ansley, Adler, & Brennan, 1999).

Enactment was assessed by weekly self-report of compliance and by objective measures of compliance. Self-reported compliance was considerably higher than actual compliance, which was consistent with the literature (Stone et al., 2003). Overall compliance rates were lower, however, than previously reported, which may have been because of the usability issues described earlier. These feasibility data allow us to better understand patient needs for developing a new product. Once we have addressed user concerns and developed a product that will be useful in the patient population on hemodialysis, we will be able to consider intervention diversity in dosage that will help us interpret effect and reach conclusions about efficacy. Moreover, findings indicate a need for some sort of alarm system to assist patients with integrating electronic self-monitoring into daily living.

Enactment was also assessed using subject-level evaluation. We were particularly interested in whether or not electronic self-monitoring would be a burden to patients. Our findings indicate that mean data entry time is approximately 30 seconds, which probably would not be excessive.

Conclusion

Conducting effectiveness research implies the need to identify and measure factors that may affect implementation of an intervention. We were particularly interested in preliminary evaluation of a consumer informatics intervention to inform our continuing investigations into the use of consumer informatics for self-monitoring diet and fluid intake. The use of consumer informatics may be extremely valuable for patients on hemodialysis because successful implementation of dietary and fluid recommendations depends on many cognitive and behavioral skills, such as the ability to read labels, make conversions, and perform calculations. Our past research found that approximately one third of patients on hemodialysis had difficulty performing simple calculations (Evans, Wagner, & Welch, 2004) and an informatics intervention may help these patients successfully self-monitor.

The use of PDAs has other advantages that may be useful to patients. They are lightweight, portable, easily accessible, easy to carry in a pocket or purse, and there is no sick-role stigma associated with a PDA. This small feasibility project was extremely valuable because we learned that patients on hemodialysis can successfully learn to use a PDA to self-monitor diet and fluid intake. Moreover, electronic self-monitoring did not place an extreme burden on the patients. We determined, however, that the existing market product we selected had several problems related to usability that will need to be corrected for this chronically ill population before proceeding to a formal test of efficacy.

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ANSWER/EVALUATION FORM

Feasibility of Using a Personal Digital Assistant to Self-Monitor Diet and Fluid Intake

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Posttest Instructions

- Answer the open-ended question(s) below.
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_____

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GOAL To share information with nurses caring for patients on hemodialysis regarding self-management by the patients using PDAs.

New Posttest Format

Please note that this continuing education activity does not contain multiple-choice questions. We have introduced a new type of posttest that substitutes the multiple-choice questions with an open-ended question. Simply answer the open-ended question(s) directly above the evaluation portion of the Answer/Evaluation Form and return the form, with payment, to the National Office as usual.

Evaluation	Strongly disagree				Strongly agree
2. By completing this offering, I was able to meet the stated objectives					
a. Decribe the purpose of an investigation examining the effects of self-monitoring by patients on hemodialysis.	1	2	3	4	5
b. Relate the methods to the results in the investigation of self-monitoring by hemodialysis patients.	1	2	3	4	5
c. Summarize the conlusions of an effectiveness research activity.	1	2	3	4	5
3. The content was current and relevant.	1	2	3	4	5
4. This was an effective method to learn this content.	1	2	3	4	5
5. Time required to complete reading assignment: _____ minutes.					

I verify that I have completed this activity _____

(Signature)