Psychosocial Impact of Monitoring Technology in Assisted Living: A Pilot Study

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Abstract

This paper describes a study designed to assess some psychosocial impacts of monitoring technology in assisted living (AL). Monitoring systems were installed in 15 AL units to track the activities of daily living (ADLs) and key alert conditions of residents. Activity reports and alerts were sent to professional caregivers who provided care to residents participating in the study. Residents (N=15) were assessed using the Satisfaction With Life Scales (SWLS) instrument, professional caregivers (N=7) were assessed using modified Caregiver Strain Index (CSI) and Caregiver Burden Interview (CBI) instruments, before and after the installation of the monitoring system. Pre- and post- installation scores of psychosocial assessment instruments were compared using t-test for means. A statistically significant increase was observed on SWLS results (p=0.031). No significant changes in CSI and CBI scores were detected (p=0.771 and 0.386 respectively). The results indicate that monitoring technologies could provide care coordination tools that may have a positive impact on users' quality of life.

Recent advances in sensor, communication, and information technologies have created opportunities to develop novel tools enabling remote management and monitoring of chronic disease, emergency conditions, and the delivery of health care. In-home monitoring has the added benefit of measuring individualized health status and reporting it to the primary care provider and caregivers alike, allowing timelier and targeted preventive interventions.[1] In-home monitoring may be one of the key solutions to the problem of providing care delivery to the world's growing elder population.

Health monitoring in home environments can be accomplished by a) ambulatory monitors that utilize wearable sensors and devices to record physiological signals; b) sensors embedded in the home environment and furnishings to collect behavioral and physiological data unobtrusively; or c) a combination of the two.[2]

In this paper, we present the results of a pilot study conducted in collaboration with Volunteers of America National Services, where In-home Monitoring Systems (IMS) were deployed in an AL setting. The study represented the second step in the development, validation, and evaluation of the IMS. To develop the sensor suite and refine the activity inference algorithms, we initially tested the system for 18 months under an institutional review board (IRB)-approved study in a community home that served as our "living laboratory." The activity data of a normal, healthy middle-

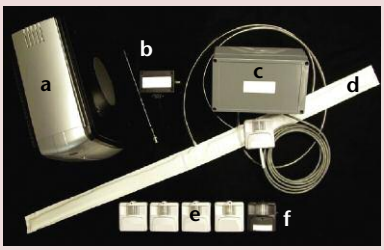
aged participant was logged and analyzed using several data analysis techniques, including clustering,[3] mixture models,[4,5] and a rule-based approach, where spatial-temporal relationships among sensor events are exploited to infer the occurrence of activities. The rule-based approach was validated[6] against 37 days of the subject's self-report,[7] recorded in realtime using a Personal Digital Assistant (PDA)-based electronic diary. The objective of the study was to assess some of the psychosocial impacts of the technology on the target population and on caregivers in a realistic and controlled setting. The hypothesis was that the monitoring technology would impact positively the quality of care provided to the monitored individuals through the on-going and objective health status assessment provided to professional caregivers. The theory also was that the technology plays a role in enabling these caregivers to perform timely interventions, which would in turn reflect positively on the care recipients' quality of life. In what follows, we briefly describe the technical enhancements made to the monitoring system, evaluation approach, statistical methods used, and results of this initial pilot.

Method

Subjects

A set of 22 in-home monitoring systems was assembled and installed in AL units in St. Paul, MN. Total sample size was 22 participants, including 7 males and 15 females. All participants but one were over the age of 65 (mean age 83.78 years, median age 85, minimum age 49, and maximum age 93). All subjects were white. Seven of the participants were memory care unit residents who were not assessed using the self-administered research instruments, and 15 were non-memory care residents (N=15). Inclusion criteria required the subjects to be ambulatory, able to provide for their own hygiene, and able to transition autonomously to meals. Exclusion criteria included subject or guardian refusal to being monitored, inability to get out of bed unaided, and the need for extensive outside assistance in the activities of daily living. Residents interested in participating in the study signed an IRB-approved informed consent. Surrogate consent was obtained from adult children of memory care residents who wished to enroll their parent in the study.

Figure 1. MARC's In-Home Health Status Monitoring System Components:
(a) PC-Based Data Manager,
(b) Radio Receiver,
(c) Bed Sensor System,
(d) Pneumatic Bed Pad,
(e) Wireless Motion Sensors,
(f) Kitchen Motion Sensor with integrated stove-top Temperature Sensor.



Measurements

The quality of life of the monitored non-memory care residents was assessed using the SWLS instrument[8] before and 3 months after monitoring. The SWLS consists of 5 statements dealing with general life satisfaction with which the participant is asked to agree or disagree on a 7-point Likert scale ranging from Strongly Disagree (1st point) to Strongly Agree (7th point); the 5 SWLS statements are: 1. In most ways my life is close to ideal, 2. The conditions of my life are excellent, 3. I am satisfied with my life, 4. So far I have gotten the important things I want in life, 5. If I could live my life over, I would change almost nothing. CSI[9] and CBI[10] were modified to be administered to professional caregivers, and administered before and 3 months after caregivers started receiving reports and notifications about the monitored individuals. The CSI consists of 13 questions (dichotomous response) and was originally designed to assess various types of strain experienced by live-in informal caregivers; the CBI is a 22-item self-administered inventory originally designed for family caregivers of Alzheimer's patients. Questions are answered with a 5 point Likert scale. All of the original instruments had been shown to have a normal distribution of responses.[8,9,10] Seven professional caregivers, who were involved in providing care for the monitored study participants, were enrolled in the study.

Technical Information

The piloted In-Home Monitoring System is comprised of wireless motion sensors in every room, including the bathroom, and a motion sensor dedicated to the shower area, a stove-top temperature sensor, and a bed sensor system that transmitted their data wirelessly to a personal computer (PC)-based Data Manager. Figure 1 shows the system's components.

The bed sensor detected presence, pulse, and movement in bed. Pulse was computed from a bed pad signal while the monitored individual was quiescent in bed; movement artifacts prevented pulse measurements, but provided information on restlessness. Finally, each system was enhanced with the ability to notify caregivers automatically when conditions consistent with possible emergency situations were detected. The Data Manager collected data from separate sensor modules, processed alert conditions locally, date/time stamped, and logged the collected data. If the pre-determined alert conditions were met, the Data Manager used the phone line to page the caregiver immediately. Alerts also were

registered into the data log.

During this pilot, alerts were sent to the professional caregiver. Data automatically were processed by the activity inference software that detected key ADLs, including meal preparation, showering, and bathroom visits. Professional caregivers could access summary reports listing all the participating residents under their care with a priority score reflecting each monitored individual's potential need for attention.

The Data Manager monitored 4 alert conditions, that included "possible forgotten stove burner," "possible fall," and high or low pulse. Such a notification sub-system, unlike many emergency pendants, does not require user activation. The 2-stage fall notification sub-system was based on lack of activity; it monitored motion reported from motion sensors in every room, as well as bed exit from the bed sensor. A fall "watch" was started whenever the resident exited the bed, and a fall alert was reported if lack of motion persisted for a pre-determined period following bed exit. The fall watch remained active until the participant left the bedroom and bathroom area (indicated by reported motion activity outside the bathroom or bedroom) or returned to bed (indicated by movement followed by detection of the pulse). If no additional motion was detected after exiting the bed, the Data Manager dialed the facility's pager system and sent the participant's identification code appended with the code for a possible fall to the caregiver. The monitoring system was accepted by older adults and case studies have demonstrated the systems' utility in care planning.[11]

Statistics

Paired t-test for means was applied to the pre- and post-monitoring scores of SWLS, CSI, and CBI.

Results

Fifteen of the 22 monitored individuals were capable of completing the SWLS instrument (the remainder were memory care residents and thus incapable of completing these instruments). After 3 months of monitoring, there was an increase in the mean of the perceived quality of life score for the group (Table 1) from 23.53 to 25.87 (p=0.031, N=15, 1 tailed paired t-test for means).

Table 1.
Participants' Perceived Quality of Life Scores on Satisfaction With Life Scales (SWLS)

Subject Number	Pre-Monitoring Score	Post-Monitoring Score
1	18	30
2	27	27
3	22	22
4	30	30
5	25	25
6	10	19
7	30	30
8	30	28
9	29	28
10	30	28
11	26	29
12	30	30
13	13	20
14	20	28
15	13	14
Mean	23.53	25.87
Standard Deviation	7.12	4.90
Standard Error	1.84	1.26

A focal outcome measure was to determine whether or not the use of IMS increased the SWLS score, as predicted by the hypothesis; therefore, one tailed p value was chosen *a priori*. There was a reduction in both the standard deviation and standard error in the collected SWLS data, indicating that after 3 months of monitoring, the perceived quality of life of the non-memory care monitored sample population has become more homogenous. The decrease in variance was statistically significant (one tailed t-test, p=0.0172). Data confirmed a significant negative correlation between pre- scores and score increases (Pearson linear correlation value of 0.73, p=0.0018, with no significant departure from linearity). Note that 5 of the participants had high pre-monitoring scores of 30 and 1 participant had a score of 29, indicating that these 6 participants already were very satisfied with their lives. A score of 30 occurred when all responses were "agree" (to the 5 positive quality of life indicators); no responses of "strongly agree" were chosen.

A similar comparison performed on the responses of the individual questions revealed that the fifth statement (If I could live my life over, I would change almost nothing) was the only statement to show a statistically significant change in the responses after being monitored for 3 months, from a mean score of 4.53 to 5.20 (p= 0.047, N=15, 1 tailed Wilcoxon matched-pairs signed-ranks test);

the Wilcoxon matched-pairs signed-ranks was used since the responses to the individual questions did not have a Gaussian distribution. None of the individual responses to the 4 remaining questions showed any significant change after the monitoring period.

The modified CSI included 10 Yes/No questions covering different areas of strain associated with care. Similarly, the modified CBI included 21 questions pertaining to the different areas of burden associated with providing care. However, the CBI instrument was misadministered by a member of the research team at the pilot site and participants were asked to provide a Yes/No response (as opposed to Likert scale response) to the questions. Yes answers to the questions were assigned a score of 1; No answers were assigned a score of 0. The 2 instruments were self-administered. Many of the questions were left unanswered by the professional caregivers, possibly because they felt that these questions were irrelevant; unanswered questions were assigned a score of 0.5. Table 2 presents the scores of professional caregivers on the CSI instrument.

Table 3 presents the scores of professional caregivers on the CSI instrument.

There was a non-significant change in caregiver strain on the modified CSI from 2.58 to 3.33 (p=0.771, N=6, 2-tailed paired t-test for means). Two-tailed value was chosen *a priori* because monitoring the IMS, false alarm rates, and perceived "technology threats" might cause an increase in strain or burden. One caregiver felt that the pager notifications were burdensome and declined to complete the post instruments; the scores of the mentioned caregiver were excluded from this analysis. The results of the modified CBI showed no statistically significant change in the mean score, from 4.92 to 4.83, (p=0.386, N=6, two-tailed paired t-test for means).

Table 2.
Caregiver Strain Index Scores

Caregiver Number	CSI Pre-Reporting	CSI Post-Reporting
1	2.5	2.5
2	1.0	2.5
3	3.0	2.5
4	5.0	5.0
5	3.0	5.5
6	1.0	2.0
Mean	2.58	3.33
Standard Deviation	1.50	1.51
Standard Error	0.61	0.62

Table 3.
Caregiver Burden Interview Scores

Caregiver Number	CBI Pre-Reporting	CBI Post-Reporting
1	6.5	6.5
2	4.5	3.5
3	5.0	5.0
4	5.5	6.5
5	4.5	4.0
6	3.5	3.5
Mean	4.92	4.83
Standard Deviation	1.02	1.4
Standard Error	0.42	0.57

Discussion

This study indicated that there was a statistically significant positive change in the perceived quality of life (SWLS) of some participants after 3 months of monitoring. Improvement was greatest in individuals with an initial lower perceived quality of life. This observed increase could be attributed to an enhanced sense of security, and appropriate and timely interventions, in addition to possible increase in social interactions with professional caregivers. However, since the perceived quality of life was assessed only twice, pre- and post- monitoring, further investigation of the change in the perceived quality of life is needed on larger samples and over longer periods of monitoring. When quality of life was perceived as high before intervention, intervention had no effect. Finally, the SWLS is very broad in nature; more directed questionnaires would be useful in guiding the IMS development and assessing its impacts in the future.

No significant changes in caregiver strain and burden levels were detected. However, this may be due to a small sample size and/or the suitability and validity of the modified instruments used. A future research aim is to replace the CSI and CBI with instruments that are better suited to professional caregivers. Such instruments may include measure of workload, eg, the Role Workload

Scale from the Michigan Organizational Assessment Questionnaire (MOAQ), and job satisfaction indices. Of interest, there were no statistically significant changes in caregiver burden or strain indexes even with the additional care provided to the participants and increase in duties with the deployment of IMS. Finally, it would be useful to address cost-effectiveness issues, eg, is the cost of the IMS offset by reduced care costs.

Conclusions

The noninvasive monitoring technologies, presented here and piloted in this study, could provide effective care coordination tools that have a positive impact on care recipients' perceived quality of life without negatively affecting the strain or burden levels of professional caregivers reviewing the health status assessment reports and receiving alert notifications. ALC

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How to Create a Resident-Safe Environment

(continued from page 20)

6. Monitoring and implementing changes in federal, state and county guidelines and regulations

Resident safety has become a major concern of the general public as well as policymakers at the State and Federal levels. It is estimated that 44,000 to 98,000 deaths per year are caused by medical errors or other serious adverse events. Elder care facilities must balance the individual residents' right with the need to provide a safe living environment. It is important that all facilities keep up-to-date on all guidelines, regulations, and standards that may assist in improving the quality and safety of resident care. ALC

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