Psychosocial Impact of Passive Health Status Monitoring on Informal Caregivers and Older Adults Living in Independent Senior Housing

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Abstract

This paper describes a study designed to assess some psychosocial impacts of monitoring technology on seniors living in Independent Senior Housing. Monitoring systems were installed, in 25 independent living units in an apartment complex, to track the activities of daily living (ADLs) and key alert conditions of residents. Activity reports were sent to informal caregivers. Residents (N=25) were assessed using the Satisfaction With Life Scales (SWLS) instrument, informal caregivers (N=26) were assessed using modified Caregiver Strain Index (CSI) and Caregiver Burden Interview (CBI) instruments, before and after the installation of the monitoring system. Paired t-test for means was applied to the pre- and post- monitoring scores of SWLS, CSI, and CBI. The Wilcoxon matched-pairs signed-ranks nonparametric test was applied to compare the number of informal care hours pre- and post- monitoring. No statistically significant increase was observed on SWLS results. No significant changes in CSI and CBI scores were detected. There was a statistically significant increase in the number of informal care hours provided by the informal caregivers of monitored individuals. The results indicate that monitoring technologies could have enabled informal caregivers to provide more care for their loved ones without increasing their burdens, strain levels or negatively affecting their quality of life.

1. Introduction

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 (reviewed in [2]); b) sensors embedded in the home environment and furnishings to unobtrusively collect behavioral and physiological data; or c) a combination of the two [2].

In this paper, we present the results of a pilot study conducted in collaboration with the Evangelical Lutheran Good Samaritan Society, where In-home Monitoring Systems (IMS) were deployed in an independent living senior housing apartment complex. 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 against 37 days of the subject's self-report, recorded in real-time using a Personal Digital Assistant (PDA) based electronic diary [6]. Details are reported in [7]. The objective of the current study was to assess some of the psychosocial impacts of the technology on the target population and their informal caregivers in a realistic and controlled setting. In what follows, we briefly describe the technical enhancements made to the monitoring system, evaluation approach, statistical methods used, and results of this pilot.

2. Method

2.1 Subjects

A set of 25 in-home monitoring systems was assembled and installed in independent living units in Waconia, MN. The total sample size was 25 participants, seven males, and 18 females. All participants were over the age of 65 (mean age 84.04 years, median age 83, minimum age 71, and maximum age 96). All subjects were white. Inclusion criteria required the subjects to be ambulatory, be able to provide for their own hygiene, and be able to transition autonomously to meals, and to have a friend or relative acting as an informal caregiver

who was also willing to participate in the study. Exclusion criteria included subject refusal to being monitored, inability to get out of bed unaided, the requirement for extensive outside assistance in the activities of daily living, and not having an informal caregiver who was willing to participate. The informal caregivers were 26 in total; one of the older adult participants had 2 informal caregivers (six males, and 20 females, mean age 53.54 years, median age 53, minimum age 40, and maximum age 77). All informal caregivers were white. Residents and informal caregivers interested in participating in the study signed an IRB approved informed consent.

2.2 Measurements

The quality of life of the monitored seniors and their informal caregivers was assessed using the Satisfaction With Life Scale (SWLS) instrument [8] before and 4 months after monitoring. The SWLS consists of five statements dealing with general life satisfaction that the participant is asked to agree or disagree with on a 7-point Likert scale raging from Strongly Disagree (1st point) to Strongly Agree (7th point); the five 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; and 5- If I could live my life over, I would change almost nothing.

Caregiver Strain Index (CSI) [9] and Caregiver Burden Interview (CBI) [10] were administered before and 4 months after caregivers started receiving reports and notifications about the health status and care needs of the older adults to whom they provide informal care. 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 Alzheimer patient family caregivers. Questions are answered with a five point Likert scale. All of the original instruments had been shown to have a normal distribution of responses [8, 9, 10].

In addition, informal caregivers were asked to estimate the number of hours per week that they spent providing informal care before and 4 months after they started receiving reports about the health status and care needs of their monitored loved ones.

2.3 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 transmit all data wirelessly to a Personal Computer based Data Manager. The system's components are shown in Figure 1.

The bed sensor detected in-bed presence, pulse, breathing and movement. 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 automatically notify caregivers upon the detection of conditions consistent with possible emergency situations. 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 immediately page a professional caregiver. Alerts were also registered into the data log. During this pilot, alerts were sent to the housing supervisor, who in turn checked on the residents. Data were automatically processed by the activity inference software that detected key ADLs including meal preparation, showering, and bathroom visits. Informal caregivers could access summary reports showing an activity summary with a priority score reflecting the potential care needs of the older adult to whom they provide care.

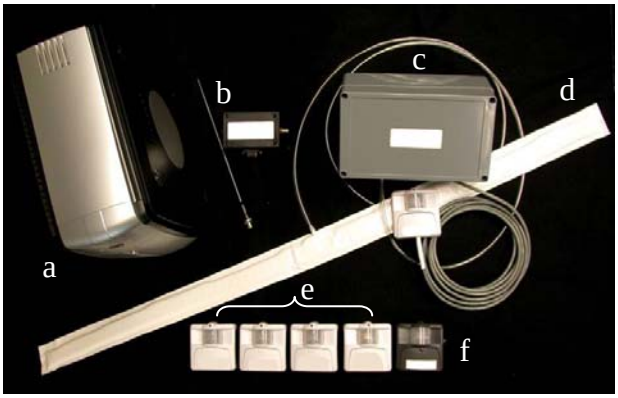

Figure 1. MARC's In-Home Health Status Monitoring System Components: (a) PC-Based Data Manager, (b) Radio Receiver, (c) Bed Sensor System, (d) Pneumatic Bed Pad, (e) Wireless Motion Sensors, (f) Kitchen Motion Sensor with integrated stove-top Temperature Sensor.

The Data Manager monitored four alert conditions that included "possible forgotten stove burner", "possible fall", as well as high or low pulse. In this pilot, the system has been augmented with a passive floor-vibration based gait monitor and fall detector placed underneath the bed (not shown in Figure 1, for more information about this gait monitor and fall detector, see [11, 12]). Such a notification sub-system, unlike many emergency pendants, does not require user activation. The two-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 directly called the facility's pager system and sent the participant's identification code appended with the code for a possible fall to the caregiver. More technical details about the monitoring system, the system's acceptance, case studies emphasizing the systems' utility in care planning, and a detailed analysis of the alerts were reported in [13].

2.4 Statistics

Paired t-test for means was applied to the pre- and post- monitoring scores of SWLS, CSI, and CBI. The Wilcoxon matched-pairs signed-ranks nonparametric test was applied to compare the number of informal care hours pre- and post- monitoring.

3. Results

3.1 Outcome Evaluation

After four months of monitoring, there was no significant difference in the mean of the perceived quality of life score of monitored older adults (Table 1) (mean of 25.04 ± 6.31 pre-monitoring and 23.84 ± 6.40 post-monitoring, p=0.2822 two-tailed).

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

Subject Number	**Pre-Monitoring Score**	**Post-Monitoring Score**
1	22	20
2	24	19
3	26	27
4	31	30
5	26	24
6	26	21
7	32	35
8	32	34
9	22	18
10	7	18
11	28	21
12	34	21
13	15	16
14	31	29
15	23	27
16	27	19
17	27	27
18	24	34
19	12	11
20	30	35
21	21	23
22	28	25
23	27	24
24	28	20
25	23	18
Mean	**25.04**	**23.84**
Standard Deviation	**6.31**	**6.40**
Standard Error	**1.26**	**1.29**

Similarly, there was no change in the scores of informal caregivers on the SWLS (Table 2) quality of life assessment instrument after monitoring (mean of 27.89 ± 6.33 pre-monitoring and 27.39 ± 7.20 post-monitoring, two-tailed p=0.5081).

Table 2. Informal Caregivers' Perceived Quality of Life Scores on Satisfaction With Life Scales (SWLS)

Caregiver Number	**Pre-Monitoring Score**	**Post-Monitoring Score**
1	30	35
2	14	20
3	29	34
4	28	28
5	34	33
6	35	35
7	31	31
8	30	33
9	25	13
10	13	13
10-2	16	16
11	21	19
12	35	34
13	22	25
14	31	31
15	31	32
16	33	30
17	25	25
18	32	32
19	28	25
20	29	30
21	35	34
22	31	30
23	34	33
24	23	14
25	30	27
Mean	**27.89**	**27.39**
Standard Deviation	**6.33**	**7.20**
Standard Error	**1.24**	**1.41**

These results indicate that the use of the technology neither affected the monitored older adults' perceived quality of life nor did it affect the informal caregivers' perceived quality of life.

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

Table 3. Informal Caregivers' Strain Index Scores

Caregiver Number	**CSI Pre-Reporting**	**CSI Post-Reporting**
1	0.00	0.00
2	0.00	1.00
3	0.00	1.00
4	1.00	0.00
5	3.00	0.00
6	2.00	0.00
7	0.00	0.00
8	0.00	0.00
9	11.00	13.00
10	8.00	1.00
11	10.00	5.00
12	6.00	5.00
13	1.00	0.00
14	6.00	6.00
15	2.00	0.00
16	3.00	1.00
17	5.00	2.00
18	2.00	4.00
19	1.00	1.00
20	4.00	5.00
21	1.00	3.00
22	1.00	1.00
23	0.00	2.00
24	2.00	0.00
25	6.00	9.00
26	1.00	4.00
Mean	**2.92**	**2.46**
Standard Deviation	**3.17**	**3.22**
Standard Error	**0.62**	**0.63**

Table 4 presents the scores of professional caregivers on the CBI instrument.

There was no change in the caregiver strain on the CSI instrument (mean of 2.92 ± 3.17 pre-monitoring and 2.46 ± 3.22 post-monitoring, two-tailed p=0.3336). Similarly, the results of the CBI showed no change in the mean score (mean of 19.12 ± 14.08 pre-monitoring and 18.89 ± 18.01 post-monitoring, two-tailed p=0.8674).

This indicates that the use of the technology did not have a significant effect on either the burden or the strain levels of informal caregivers.

Table 4. Informal Caregivers' Burden Interview Scores

Caregiver Number	**CBI Pre-Reporting**	**CBI Post-Reporting**
1	0.00	0.00
2	15.00	10.00
3	15.00	12.00
4	2.00	4.00
5	23.00	14.00
6	4.00	2.00
7	0.00	0.00
8	4.00	1.00
9	49.00	68.00
10	42.00	41.00
11	27.00	27.00
12	36.00	40.00
13	3.00	1.00
14	28.00	29.00
15	8.00	3.00
16	11.00	5.00
17	22.00	13.00
18	15.00	25.00
19	20.00	8.00
20	28.00	34.00
21	30.00	23.00
22	10.00	7.00
23	24.00	25.00
24	10.00	17.00
25	45.00	58.00
26	26.00	24.00
Mean	**19.12**	**18.89**
Standard Deviation	**14.08**	**18.05**
Standard Error	**2.76**	**3.54**

Table 5 shows the number of hours of care provided by the informal caregivers, pre and post-monitoring. The table shows a significant increase in the number of hours of care from 5.16 to 8.10 (mean of 5.16 ± 4.41 pre-monitoring and 8.10 ± 8.82 post-monitoring, two-tailed p=0.0401, N=25); informal care hours data from one of the informal caregivers were excluded from the analysis because the post-monitoring number of hours worked was not provided. The Wilcoxon matched-pairs signed-ranks nonparametric test was used because the data did not have a Gaussian distribution.

The results indicate that the use of the technology and the availability of wellness and activity reports to informal caregivers may have made the informal caregivers more involved in caring for their loved ones.

Table 5. Number of Care Hours Provided by Informal Caregivers

Caregiver Number	**Hours Pre-Reporting**	**Hours Post-Reporting**
1	7	40
2	2.5	5
3	0.5	1
4	10	10
5	4.5	4
6	0	0
7	0	0
8	5	20
9	9	8
10	10	10
11	8	8
12	2	2.5
13	4	5
14	3	4
15	4	3
16	2	6
17	6	20
18	4.5	3.5
19	13.5	15
20	3	2
21	1	3
22	2	3
23	18	15
24	7.5	12.5
25	2	2
Mean	**5.16**	**8.10**
Standard Deviation	**4.41**	**8.82**
Standard Error	**0.88**	**1.76**

3.2 Diagnostic Use of Collected Health Status Data- Case Studies

One of the monitored older adults was hospitalized on 03/16/05 for Gastro-Intestinal (GI) bleeding. Retrospective inspection of his wellness reports revealed three abnormalities indicative of a possible health issue and that could have been detected; these abnormalities included reduced overall activity level, especially in the evening, compared to the same day in the week preceding his hospitalization and his weekly average activity levels, increased restlessness in bed compared the night before he was hospitalized compared to the night before that, and a much longer stay in bed (until the afternoon, which is unusual for this gentleman, as revealed from the in-bed pulse graph); Figure 2 illustrates the stay in bed comparison, based on the in-bed pulse graphs.

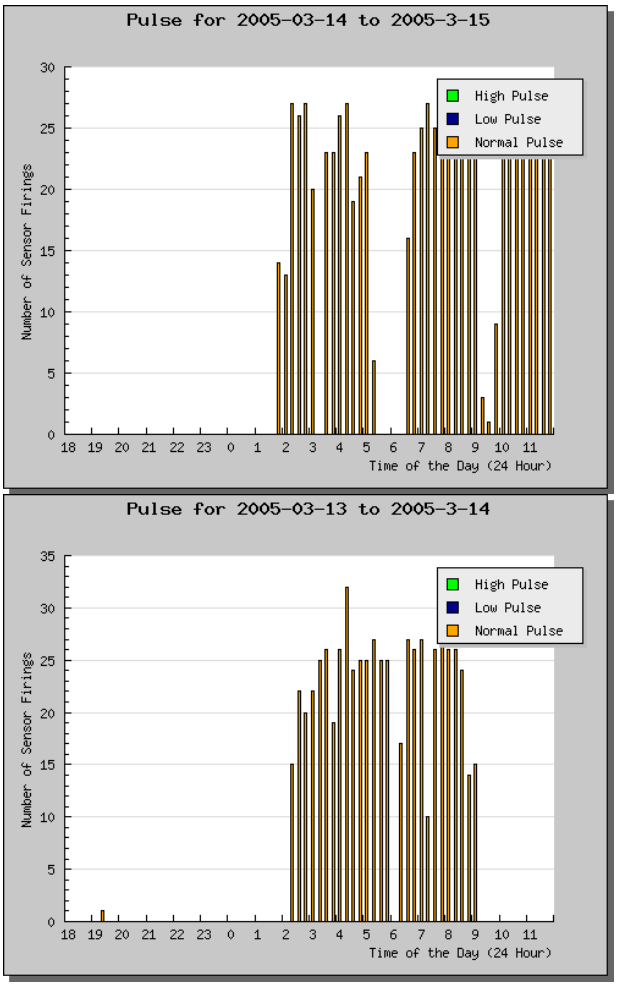

Figure 2. Stay in Bed on the Day Preceding Hospitalization (Upper) compared to the Day Before (Lower), which represent this person's Norm, as revealed by the In-Bed Pulse Graph.

Another resident was admitted into the hospital's emergency department on 04/8, on 04/13, and on 4/15. Retrospective inspection of the report data revealed that there was an increase in restlessness starting on the 04/05 compared to the preceding nights. On the night of the 12th, the subject spent less than 5 hours in bed, and had an increase of bathroom visits on the 12th from an average of 11 to 19. On the 14th, the subject also had increased restlessness.

These two case studies highlight the potential utility of the system in identifying health issues early, allowing informal caregivers, such as adult children, to act based on the health status and wellness by engaging a professional caregiver/ health care provider to provide appropriate and timely care before problems escalate.

4. Discussion

This study showed that there was an increase in the number of informal care hours provided by the informal caregivers of monitored individuals after monitoring without any increase in their burden or strain levels, or any decrease in their perceived quality of life. The change was statistically significant, indicating that the use of the technology, and the availability of wellness reports to informal caregivers, may have effectively enabled them to engage more actively in caring for their loved ones. There were no appreciable impacts on the quality of life of monitored individuals, possibly due to absence of professional intervention based on the reports (unlike the case of assisted living [13] or home health [14] where the monitoring technology has shown a positive impact on the older adult's perceived quality of life; no formal care is provided to the residents of this independent living senior housing apartments).

This study clearly highlights the important role a professional caregiver, health care or eldercare service provider plays when aided by the monitoring technology. The case studies presented highlighted the potential utility of this monitoring technology in identifying health issues early, allowing informal caregivers, such as adult children, to act based on the health status and wellness by engaging a professional caregiver/ health care provider to provide appropriate and timely care before problems escalate.

5. Conclusions

The noninvasive monitoring technologies, presented here and piloted in this pioneering outcome study, could provide effective care coordination tools that have a positive impact on quality of informal care provided by informal caregivers, evidenced by the statistically significant increase in the number of weekly informal care hours, without negatively affecting Strain (CSI), the Caregiver Burden (CBI), or the perceived quality of life levels (as measured by the SWLS instrument) of informal caregivers reviewing the health status assessment reports.

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