Aging-in-place with "AT EASE" – Automated Technology for Elder Assessment, Safety, and Environmental monitoring

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***Abstract*—The AT EASE system was designed based on pre-pilot focus groups with endusers to advance the state of the field by testing remote residential monitoring in real time in a real world setting for an eighteen month period. Moreover for the first time information gleaned was converted into notices that were stratified by elders preferences of receipt and tailored to the authorized staff, clinicians, and or family members. Our validity and reliability testing of wireless sensor hardware supported the move from X10 to ZigBee based technology. Recruitment of elders to use the system was difficult even when offered at no cost. Refusers often denied health or safety problems that were confirmed by clinicians. Users were satisfied with the system and outcome results.**

INTRODUCTION

By 2030 the number of Americans aged 65 and older will more than double to 71.5 million older adults or approximately 20% of the U.S. population [1]. Between 2007 and 2015, Americans eighty-five years and older, those considered most at risk for chronic and acute care health problems will increase by 40%[2] . Although vulnerable, research has consistently shown that older adults in America overwhelmingly prefer to remain living in their home and age-in-place as independent as possible. Given the increasing number of older adults and their families seeking new ways of supportive housing, our capitalistic society continues to evolve new types of elderly housing[3]. The latest type is Independent Living facilities (ILFs).

ILFs offer elders a more economical way to live in a senior residential facility. They accomplish this by not only by eliminating an entrance fee but also by limiting the services, not providing professional staff 24/7 and relying on the elders themselves to perform their activities of daily living or manage with help from their families. However helping elders remain independent in the setting of their choice is a complex, multifactor endeavor [4]. Anecdotal evidence is growing that elders' may appear intact during ILF pre-admission interviews but upon relocation become confused. Others as they age-in-place are at risk for physical as well as cognitive impairments. Given the limited staffing in ILFs, residential monitoring technologies may be one way to address oversight concerns.

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BACKGROUND

Previously we determined the feasibility of and receptivity by working family caregivers to using computers at work to link to our remote monitoring system that monitored the health or safety concerns of their elderly relatives alone at home[5,6]. From this three year research project we gained considerable experience in system operations, design, understanding desired features, and how to offer an approach that tailored to the endusers wants and needs. The success of this intervention provided the skill set and experience to address the challenges associated with conducting research in ILFs. The global research question asked: Can we successfully integrate and operate our remote monitoring system in an ILF environment and tailor it to confidentially and reliably address the informational needs of multiple parties 24/7 over a one year period?

STUDY OBJECTIVES

To expand our remote home monitoring system capacity from two way interfacing between a family caregiver and elder alone at home to four way stratified alert communications among family member, ILF building manager, superintendent, and affiliated nurse clinicians. All to be done in a secure HIPAA compliant environment, and without triggering invalid alert notices.

METHODS

We employed a mixed methods approach combining both qualitative and quantitative aspects across three phases of research. In phase 1 eight Focus groups were conducted with 26 participants representing all enduser groups to gain not only their interest areas for monitoring but also their input to the prototype design from the human factors and end users usability perspectives. In phase 2 we conducted formal testing of the signal reliability and validity of the X10 motion sensor technology. This was essential because although we had successfully managed to have the X10 motion sensors work in our community study, they required careful placement to avoid signal interferences. Elderly housing has much more complex HVAC and other electrical systems that can generate signals. So while X10 has the advantage of being low in cost and readily accessible, it does require care in installation and validation of its signaling. We conducted a pilot test in the ILF using an actual residential unit that was available and awaiting a new occupant . In phase 3 we implemented, tested, and conducted outcome analyses with ten sets of elderly residents, their primary family caregiver, and the building and clinical staff. Institutional Review Board (IRB) approval was obtained from both our academic IRB as well as the housing site's affiliated IRB before any subjects participated. Pre and Post interview data with participants were obtained contrasting their ratings on use and satisfaction with the technology, needs met, willingness to pay for similar technology, and subjective impressions including recommendations. Monitoring data was automatically recorded by the system and analyzed by an external evaluator.

RESULTS

The phase 1 focus groups revealed a wealth of information about the residential needs and wants of elders, their families, and staff who live or work in ILFs. This data is reported in depth elsewhere [7]. From the technology perspective, most of the desired areas for remote monitoring we could easily accommodate with minor modifications to our system. The one new area that we had to address came from the building staff who requested a means to address water overflows, primarily from low flow toilets. Consequently we integrated a water detection sensor and placed it on the bathroom floor next to the toilet and in range of the sink and tub. Our pilot testing in an empty residents' apartment identified significant spurious signals (n=149) transmitted by the X10 sensors over a 24 hour period. As a result we converted to using wireless ZigBee sensors and reprogrammed our system accordingly for interface. Retesting of the signal reliability and validity with this approach revealed 100% signal accuracy.

The final monitoring system design consisted of motion sensors in each room, a water sensor in the bathroom, a system remote to enable/disable the system, a processing unit (with both Ethernet and Modem NICs), a Zigbee computer interface and custom automation software application to operate the processing unit. Each sensor was mounted via a special non-damaging strip of removable adhesive, activated by movement and wirelessly transmitted its signal to a base unit connected to a PC. Time delay between motion events was set at 2 minutes. Motion data was sent to the project server via the Internet every 15 minutes starting at the top of the hour with alerts sent immediately. The server processed and posted the data to our Website reports. The water sensor consisted of a disc attached to the bathroom floor wired to a wireless sensor placed on the side of the vanity. This sensor only transmitted if there was a water overflow event. The system (resident) status, based on level of activity registered, was coded as: Disabled intentionally = yellow, OK = green, Watch = orange, and Attention = red. Algorithms tailored to the participants' concerns and residents functional health status directed whether and when a red posting would be converted into an alert notice and to whom it would be sent.

Our system utilized remote embedded PCs, off the shelf automation components, broadband Internet service, XP/2000 server application and a web based application with secured access for case management of the home monitoring systems. Our Custom XP/2000 service application received incoming alert information from residences, updated the SQL database with alert information, sent priority alerts to appropriate personnel or family members through pagers and emails, downloaded new configuration parameters of the systems and exported reports and data to research staff. The ASP Web site provided a secure interface to family members and research personnel and provided a configuration screen to manage the residential monitoring systems. Secure access to the application was available 24 / 7 over the Internet to all the valid system users, and was easily accessed using the Web Browser (See figure 1).

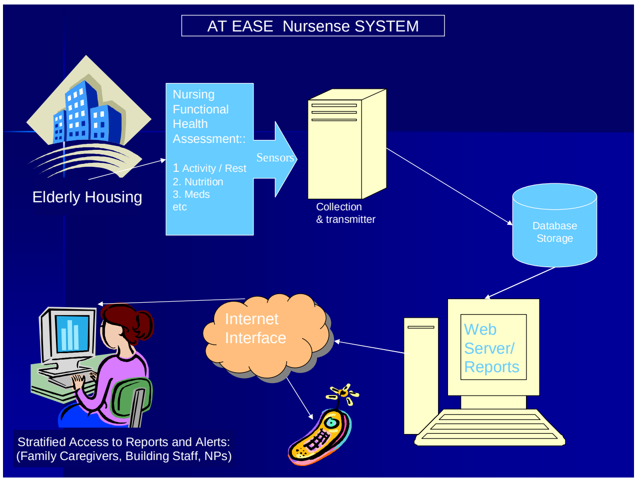

Fig. 1. Final AT EASE system design and architecture. Reprinted with permission D. Mahoney ©

Systems were installed in ten residential units over the course of an 18 month period. We rotated five systems over a five month period per residential unit. In addition we ran one additional system continuously over an 18 month period, that included development and pilot testing phases, for daily reliability and system operations assessment. From the enduser perspectives trend analyses to date indicate positive impressions on main outcome measures relating to number type and utility of alerts, user satisfaction , obtrusiveness of the system and willingness to pay for technology. Notably our alerts were few in number and true. Three alerts correctly related to water overflows and were sent to staff and three related to elders not acting as expected and families were notified. Of the three, all were associated with an elders'episode of illness, one was associated with a needed hospitalization. Formal outcome analyses are in progress and will be reported subsequently. At a clinical level we did find that residents referred to us by the nurse practitioners due to concerns about cognition, universally declined participation. Focus groups and the literature indicated a need for medication monitoring and reminding, yet participating elders did not perceive this need and refused this option. Also, we found we needed approximately six months to recruit 10 dyads of agreeable residents and families to use the monitoring technology. Several of these participants were referred by the ILF's social worker. This leads us to suggest that there is a specific niche point in service delivery that this type of home monitoring technology serves.

CONCLUSION

We demonstrated system feasibility, implementation in ILFs, operability, signal reliability and validity for our system run 24/7 continuously over a 12 month field and 18 month testing period. We also demonstrated that remote monitoring technology is well liked by those who see the need but resistance to technology adoption remains among those who don't perceive that they are in need or vulnerable to mishap in their functional health patterns.

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