



12-4-2014

## Sensor Technology for Supporting Independence Among Cognitively Impaired Elders

Kelsey Wright

Western Michigan University, kelsbwright@gmail.com

Follow this and additional works at: [https://scholarworks.wmich.edu/honors\\_theses](https://scholarworks.wmich.edu/honors_theses)



Part of the Occupational Therapy Commons, and the Other Rehabilitation and Therapy Commons

---

### Recommended Citation

Wright, Kelsey, "Sensor Technology for Supporting Independence Among Cognitively Impaired Elders" (2014). *Honors Theses*. 2526.

[https://scholarworks.wmich.edu/honors\\_theses/2526](https://scholarworks.wmich.edu/honors_theses/2526)

This Honors Thesis-Open Access is brought to you for free and open access by the Lee Honors College at ScholarWorks at WMU. It has been accepted for inclusion in Honors Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact [wmu-scholarworks@wmich.edu](mailto:wmu-scholarworks@wmich.edu).



Sensor Technology for Supporting Independence Among Cognitively Impaired Elders

Kelsey B. Wright

Western Michigan University

Lee Honors College

### Abstract

Dementia is the most expensive disease in the United States and its prevalence is rapidly increasing as the older adult population grows. The number of older adults diagnosed with dementia living alone is also rising, which brings about numerous safety risks. Due to the declining cognitive skills and behavior changes seen with dementia, it is important find approaches for monitoring their safety. This literature review discusses commercially available monitoring systems and empirical studies using sensor technology with older adults. It also describes a current pilot study that is exploring the use of sensor technology in the homes of cognitively impaired elders as a means to monitor the safety of these individuals. **Objectives:** 1) To test the feasibility of sensor technology in the home of cognitively impaired older persons living alone. 2) To evaluate the clinical value of sensor data from participating subjects. **Methods:** Exploratory study with a non-randomized sample of 10 subjects. Subjects will be recruited from a local healthcare organization for frail and vulnerable older adults. Sensors will be installed in the homes of subjects and data will be collected and compared to baseline routine information to detect behavior, cognitive, and condition changes over a six-month period. **Outcomes:** 1) It will provide important data about behavior outside the clinical setting for high-risk elders. 2) The acceptability of the technology and its impact on clinical care will be assessed through a survey administered to CentraCare staff. **Conclusions:** The use of sensor technology in the homes of older adults with cognitive impairments has the potential to decrease healthcare costs and increase quality of life.

### Sensor Technology for Supporting Independence Among Cognitively Impaired Elders

Dementia is the most expensive disease in the United States and its prevalence is rapidly increasing as the older adult population grows. Annual payments for health care for those diagnosed with dementia is projected to increase from \$214 billion in 2014 to \$1.2 trillion in 2050.<sup>1</sup> These costs are affected by the rising number of diagnoses in the United States; 1-in-8 Americans age 65 and older have been diagnosed with this disease and this number is expected to double by 2050 because of the growing older adult population.<sup>1</sup> In 2010, the US Census reported there was over 40.3 million adults aged 65+ in the United States and this number is estimated to more than double to 88.5 million by 2050.<sup>2</sup>

#### **Dementia**

Dementia is an umbrella term for neurodegenerative disorders that are characterized by a decline in memory and other cognitive skills that alter an individual's ability to perform activities of daily living (ADLs). The term "neurodegenerative" means that there is damage to the neurons (nerve cells) in the brain, causing abnormal functioning or death to the cells. This in turn alters an individual's cognitive skills such as memory, behavior, and judgment. The various types of dementia are each progressive diseases and dependent on the how they affect the brain and symptoms they cause in an individual.<sup>1</sup> Symptoms of dementia differ greatly depending on the type, but an individual must have significant impairment in at least *two* of the following areas in order to have dementia: memory, communication, ability to focus and attend, reasoning and judgment, and visual perception.<sup>3</sup> See Appendix A for Table 1, which outlines the different types of dementia, what causes them, and symptoms commonly seen with each type.

#### **Safety Risks**

As individuals progress in age, their vulnerability to and risk of experiencing adverse health events increases. These events include stroke, heart attack, medication complications, and falls. The risk of these events occurring increases even more when an individual has a cognitive impairment such as dementia. Typically when an older adult experiences an adverse health event—especially if he or she lives alone—the individual is hospitalized and moved into a long-term care facility in order to prevent further decline in their health. With the continuous development of health-related technology, life expectancy rates worldwide are increasing, the number of older adults is growing, and the demand for long-term care is rising rapidly.

The number of older adults who live alone and have been diagnosed with a type of dementia is also quickly growing. Of the 70 percent of older adults with dementia who live in the community, 25 percent live alone.<sup>1</sup> A previous study showed that the attitudes of older adults about living permanently in a nursing home are not necessarily positive.

In this study, seriously ill hospitalized adults were asked to rate their willingness to live permanently in a nursing home. These individuals used a 5-point scale ranging from “very willing” to “rather die.” Of the 3262 completed surveys, only 7% were “very willing” to live permanently in a nursing home. A majority of the older adults stated that they were “very unwilling” (26%) or would “rather die” (30%) than live in a nursing home.<sup>10</sup> This data suggests that older adults prefer to remain in their homes and age in place versus moving and permanently living in a nursing home. Allowing an older adult to remain in one location while he or she is aging permits that individual to be in a familiar environment, control the lifestyle he or she chooses to live, and improves his or her quality of life.<sup>4</sup>

Each type of dementia is progressive, meaning that symptoms worsen over time. Behavior changes are seen in all types of dementia because of the altered state of mind that occurs when the brain’s anatomy is changed. Two particular safety risks involve wandering and falls, which are both major concerns for these individuals who are living alone with a dementia diagnosis.

**Wandering.** One commonly observed behavior with dementia is wandering. This occurs when an individual leaves a safe area and walks around aimlessly. Individuals may forget where they are and find themselves in a dangerous situation, such as walking in the street. There are numerous factors that play a part in wandering, including boredom, confusion about the time of day, unfamiliarity of the environment, and absence of others.<sup>11</sup>

Wandering is a large concern for individuals with dementia who live alone. This is because their loved ones do not know that the individual has left their home and cannot assist if their loved one is put in a dangerous situation. This is a major safety risk because wandering is possibly the greatest safety risk in older adults with dementia because other safety issues, such as falls and elopement (wandering *away*), are associated with wandering.<sup>4</sup>

**Falls.** One out of three older adults (aged 65+) fall each year in the United States. Risk factors for falls in all older adults include postural instability, psychotropic medications, neurocardiovascular instability, environmental fall hazards, and visual impairments.<sup>12</sup> Additional

risk factors for falling that are prevalent in older adults with dementia include wandering, agitation, and perceptual difficulties (visuospatial awareness deficits and lack of fear).<sup>12</sup> Falling is a another major safety risk in older adults with dementia because of those who fall, 30 percent experience moderate to severe injuries, which may include lacerations, hip fractures, or head traumas.<sup>6</sup> This can also lead to hospitalization and/or institutionalization of the individual.

### **A Review of Technology Used to Assist Older Adults with Dementia**

The development of technology to combat adverse events in the homes of older adults with dementia is underway. In 2012, the trade publication HomeCare Magazine—which is in wide circulation among providers—ranked the top 10 technology devices to assist older persons in maintaining safety in the home. This article included three monitoring system devices that relate to the technology in the current study being conducted: GrandCare System, Independa, and BeClose.<sup>13</sup> Each of these systems allow caregivers to implement sensor technology into the home of the individual with dementia and monitor their movement and receive alerts of adverse events. Although these monitoring systems are among the top 10 commercial devices recommended for older persons, there are no empirical studies that support the use of them in the homes of these individuals in order to remain safe. Databases used to find research conducted include PubMed, Nursing and Allied Health (ProQuest), Scopus, ArticleFirst, Web of Science, DynaMed, and ComDisDome (Proquest). A review of the literature on the use monitoring technology with older adults in their homes, as it relates to the current study, was then conducted.

One recent longitudinal study was completed on the use of the Safe Home Program with veterans and their caregivers (n=60) to assess the adoption of smart home technology.<sup>14</sup> In this study, various technologies were installed into the homes of the individuals with dementia based on the person's needs in relation to monitoring and safety. It was found that caregivers were overall accepting of technology that was unnoticeable in the home because this decreased the likelihood of the individual with dementia responding negatively to the unfamiliar object in their home. They also expressed a need for user-friendly technology and a combination system of bed occupancy and motion sensors in addition to a portable unit to receive alarms on in the case of an adverse event.<sup>14</sup> The feedback that the caregivers provided from this study is important to note and apply in future studies that also research the use of sensor technology to monitor older adults with dementia.

A recent literature review on the use of common sensor technology used in smart homes was also evaluated for the purpose of this paper. This literature review—“Sensor Technology for Smart Homes” (2011)—found that sensor feasibility has been demonstrated, but only in laboratory settings thus far. The author called for studies to be conducted in the communities and homes of older adults as well. Another finding was that the needs of all stakeholders must be considered in order to have conclusive data that the technology does promote safety; these stakeholders include the individual, family, caregivers, clinicians, and therapists and must include the coordination of healthcare. A third finding from the literature review was that there has been inconclusive evidence that shows the use of monitoring technology can predict a change in routine or clinical outcomes such as behavioral, cognition, and condition changes.<sup>15</sup>

The third study reviewed looked at the use of sensory technology in the homes of older adults with dementia is the “Sensor Technology to Support Aging in Place” pilot study (2013). This study focused on the use of monitoring technology in a living lab setting and its correlation with the safety of older adults with dementia who live alone. Clinical data and alerts related to functional independence that were collected through the technology in the homes were received by healthcare providers and used in the healthcare of the participants. Preliminary results suggest sensors can provide important clinical information detecting illness and making earlier assessments.<sup>16</sup>

One limitation of this study is it was conducted in a laboratory setting and not the community; therefore it is not generalizable to the public. A second limitation is that healthcare was provided to the participants through only in-home clinicians. This may have an impact on the health of participants because the provider may not know and understand the individual’s condition and/or needs as well as a general practitioner in the community might. As a result, the measurement of participants’ health and well being at the conclusion of this study may be inaccurate. One recommendation for future is for the data collected from sensor technology to be used not only in the healthcare provided to the older adult, but also have the care be coordinated so the best services can be provided to the individual.

In summary of the literature reviewed, what is left to be explored includes the use of sensor technology in the *homes* of individuals and a combination of bed and motion sensors throughout the home to maximize monitoring. The coordination of care in relation to the data

received by the technology and the use of a portable device for alerting caregivers of adverse events is also to be explored.

### **Current Study Underway**

Providing people with the opportunity to remain in the comfort of their own homes is important for their physical and mental health. This is especially important in patients who have dementia; staying in a familiar and safe setting can make the progressive loss of cognitive abilities easier to manage. A current pilot study is looking at how the use of sensor technology in the homes of cognitively impaired elders who live alone—or are without family caregivers nearby—can maximize their chances of living independently, prevent unnecessary admission to a hospital or nursing home, and provide critical information to healthcare providers about behavior and function that is not evident in the clinical setting. The title of this study is “Sensor Technology for Supporting Independence Among Cognitively Impaired Elders.”

This pilot project is based off of the Great Northern Haven study in Dundalk, Ireland, which uses ambient assisted living technologies to enhance the quality of life of older adults.<sup>9</sup> Technology used includes 100+ sensors and interactive technologies that are installed in an apartment setting in which the adults live. The purpose of the study is to allow older adults to age in place and maintain independent living.<sup>9</sup> On a similar note but smaller scale, the “Sensor Technology for Supporting Independence Among Cognitively Impaired Elders” project is a longitudinal study with continual measurement over a 6-month period of movement within the subjects’ home setting based on sensor data.

The current study’s objectives are to assess the technical feasibility of sensor technology in the homes of cognitively impaired older adults and to evaluate the clinical value of sensor data from participating subjects. It is being conducted in conjunction with CentraCare, a PACE—Program for All Inclusive Care—program that provides comprehensive services and supports Medicaid and Medicare enrollees in Calhoun and Kalamazoo counties (Michigan). It is through the use of Passive Infrared (PIR) motion detectors that CentraCare clinicians will be able to continuously and unobtrusively monitor and assess an aging patient who has been diagnosed with a cognitive disorder, such as Alzheimer’s disease. The information received from the motion detectors will be reviewed and incorporated into care planning/team meetings at Centracare.



Subjects for this project will be a non-randomized sample. The Centracare staff will identify 14 potential subjects that meet the eligibility criteria. This criteria requires individuals to: 1) be a Centracare participant; 2) be 60-years of age or older; 3) live alone or is alone for 4 or more hours per day; 4) have a cognitive impairment determined by eligibility for “Door 2” during the Centracare initial assessment. Door 2 relates to:

- A. Short-term memory is okay (seems/appears to recall after 5 minutes);
- B. Cognitive skills for daily decision-making (made decisions regarding tasks of daily life for last 7 days);
- C. Making self-understood (expressing information content, however able).

Of the 14 individuals who meet the above criteria, the 10 subjects at highest risk will be chosen to participate in the study, which is based off of the individuals; hospital utilization frequency. If any of the 10 selected subjects drop out or are unable to complete at least 50% of the study (3 months) then these individuals will be replaced with others who indicated interest in participating and fit the inclusion criteria.

The technology in the pilot project will monitor the function and behavior of a patient to provide a better understanding of the causes and risk factors that contribute to disability and morbidity. In this study, each participant will receive a technology ‘kit’ consisting of a number of ambient sensors. The kit will consist of 2 PIR sensors to detect motion, or lack thereof; 2 door contact sensors to detect front and back door open and closed events; and a bed sensor to detect when/if a person gets out of bed. The combination of these sensors can support powerful alerts to emergency situations within the home, such as night-time wandering, no movement in the morning, and no movement from a room after an extend period of time (i.e. a fall in the shower). Such changes in behavior can indicate a lack of social interaction, depression, increased frailty, or an improved health status.

Baseline recordings will be made of all study subjects, which will include an assessment of typical hours in bed, hours in and out of the home and movement within the home. The sensors will produce a dataset to support the project team in monitoring long term behavioral patterns of older adults with cognitive impairment. Examination of this data allows for identification of behavior over the trial period. (e.g. increased/decreased activity within the home, participant starts to leave the home less often over time, or starts getting up more frequently at night time). Such changes or deviations in behavior might be indicative of lack of

social interaction, depression, increased frailty or indeed might indicate improved health status. Knowledge of such changes can enable more timely interventions for the participant with the aim of avoiding health decline

Because data is continually transmitted by the sensor technology, this project focuses on the extent to which this information is successfully received and also utilized by Centracare staff. Emergency situations detected by the sensors will be transmitted directly to the designated party which is in most cases a family member or an emergency response team (after Centracare business hours) and otherwise in non-emergency cases, to a smart phone and/or email of the appropriate Centracare staff member(s). Except in cases of emergency alerts, sensor information will be reviewed and incorporated into the care planning/team meetings held regularly at Centracare. Staff will be asked to report on data obtained through the sensors and the ease to which this data was accessed. At the end of the project, staff will be asked to complete a survey regarding their acceptability of the technology and impact on clinical care. The results from the sensor technology applications in the study will be useful in the development of low-cost, supportive housing for low-income Centracare participants in the future.

### **Conclusions**

Methods that prevent adverse health events are key to allowing older adults to remain in their homes instead of being moved to long-term care facilities. The use of sensor technology in the homes of older adults with cognitive impairments has the potential to decrease healthcare costs and increase quality of life.

## References

1. Alzheimer's Association. (2014). *2014 Alzheimer's Disease facts and figures*. [Data file]. Available from [http://www.alz.org/alzheimers\\_disease\\_facts\\_and\\_figures.asp](http://www.alz.org/alzheimers_disease_facts_and_figures.asp)
2. Department of Health & Human Services. (2014). *Projected future growth of the older population: By age: 1900-2050: Persons 60 and older*. [Data file]. Available from [http://www.aoa.acl.gov/Aging\\_Statistics/future\\_growth/future\\_growth.aspx](http://www.aoa.acl.gov/Aging_Statistics/future_growth/future_growth.aspx)
3. Alzheimer's Association. (2014). *What is dementia?* Retrieved from <http://www.alz.org/what-is-dementia.asp>
4. Aud, M. A. (2004). Dangerous wandering: Elopements of older adults with dementia from long-term care facilities. *American Journal of Alzheimer's Disease and Other Dementias*, 19(6), 361-368.
5. Tromp AM, Pluijm SMF, Smit JH, et al. Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly. *J Clin Epidemiol* 2001;54(8):837–844.
6. Sterling DA, O'Connor JA, Bonadies J. Geriatric falls: injury severity is high and disproportionate to mechanism. *Journal of Trauma–Injury, Infection and Critical Care* 2001;50(1):116–9.
7. Ding, D., Cooper, R. A., Pasquina, P. F., & Fici-Pasquina, L. (2011). Sensor technology for smart homes. *Maturitas*, 69, 131-136.
8. Rantz, M. J., Skubic, M., Miller, S. J., Galambos, C., Alexander, G., Keller, J., & Popescu, M. (2013). Sensory technology to support aging in place. *Jamda*, 14, 386-391.
9. Netwell Centre (2013). Great northern haven. Retrieved from <http://www.netwellcentre.org/great-northern-haven.html>
10. Mattimore, T. J., Wenger, N. S., Desbiens, N. A., Teno, J. M., Harnel, M. B., Liu, H.,...Oye, R. K. (1997, July). Surrogate and physician understanding of patients' preferences for living permanently in a nursing home. *Journal of the American Geriatrics Society*, 45(7), 818-824.
11. Algase, D. L., Beattie, E. R. A., Antonakos, C., Beel-Bates, C., & Yao, L. (2010). Wandering and the physical environment. *American Journal of Alzheimer's Disease & Other Dementias*, 25(4), 340-346.
12. Shaw, F. E. (2003). Falls in older people with dementia. *Geriatrics & Aging*, 6(7), 37-40.
13. Orlov, L. M. (2012, March). Top 10 technology devices for seniors. *HomeCare Magazine*. Retrieved from <http://www.homecaremag.com/top-10-technology-devices-seniors>
14. McKenzie, B., Bowen, M. E., Keys, K., & Bulat, T. (2013, May 15). Safe home program: A suite of technologies to support extended home care of person with dementia. *American Journal of Alzheimer's Disease and Other Dementias*, 28(4), 348-354.
15. Ding, D., Cooper, R. A., Pasquina, P. F., & Fici-Pasquina, L. (2011). Sensor technology for smart homes. *Maturitas*, 69, 131-136.
16. Rantz, M. J., Skubic, M., Miller, S. J., Galambos, C., Alexander, G., Keller, J., & Popescu, M. (2013). Sensory technology to support aging in place. *Jamda*, 14, 386-391.

**Appendix A**

<b>Type of Dementia</b>	<b>Cause</b>	<b>Common Symptoms</b>
Alzheimer’s Disease	Protein build-up, or plaques, on neurons in the brain that eventually cause damage and death to these nerve cells	Progressive memory loss; apathy and depression; impaired communication; disorientation; confusion; poor judgment; behavior changes; and eventually difficulty with speaking, swallowing, and walking
Vascular dementia	Blockage of blood vessels in the brain that causes bleeding in the brain (strokes)	Impaired judgment, decision-making, and planning
Dementia with Lewy bodies (DLB)	Clumps of protein that collect on neurons in the cortex	Sleep disturbances, visual hallucinations, slowness, and gait imbalance
Frontotemporal lobar degeneration (FTLD)	Neurons in the frontal and temporal lobes shrink in size, protein build-up in cortex	Apparent changes in personality and behavior, difficulty with expressing and understanding speech
Mixed Dementia	A mixture of brain abnormalities seen in more than one type of dementia	A mixture of symptoms seen in more than one type of dementia
Parkinson’s disease (PD) dementia	Degeneration of neurons that produce dopamine (PD) that progresses into accumulation of Lewy bodies in cortex or plaques on neurons	Issues with movement; symptoms seen in dementia that is accompanied with PD (typically DLB or Alzheimer’s Disease)
Creutzfeldt-Jakob disease	Misfolded protein in the brain causes other proteins to misfold and malfunction	Memory and coordination impairment, behavior changes
Normal pressure hydrocephalus	Pressure of the brain caused by reabsorption of cerebrospinal fluid and build-up of fluid in the brain	Difficulty walking, memory loss, decrease in bladder control

Table 1 – Alzheimer’s Association, 2014 *Alzheimer’s Disease Facts and Figures*