



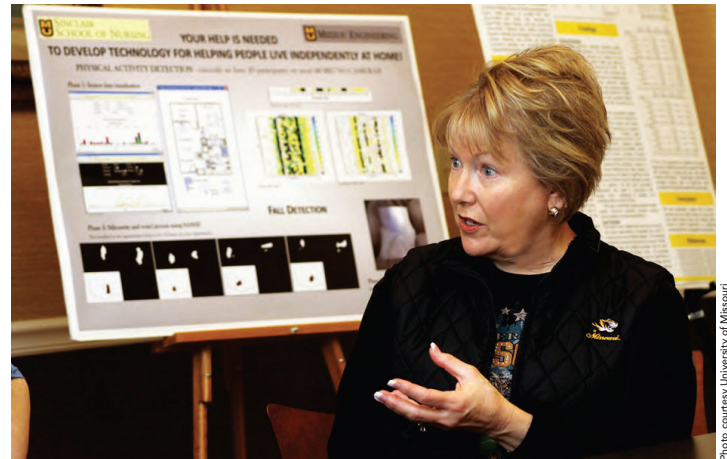
## From Detection to Prevention and Beyond: The Future of Sensor Technology in Senior Living

Christine Kilgore

In an innovative senior living community in Columbia, MO, called TigerPlace, sensor technology that continually monitors the residents and sends alerts when patterns change is helping nurses and other providers prevent falls and detect early signs of illnesses and changes in health status, allowing them to intervene days or weeks earlier than they otherwise might.

The facility — a state-sponsored aging-in-place site that is jointly operated by the University of Missouri (MU) Sinclair School of Nursing and Americare Systems, Inc. — is one of the oldest living laboratories in the country for passive monitoring technology, which aims to slow and prevent functional and cognitive decline and keep people out of nursing homes and hospitals. Today TigerPlace has growing company; experts who are developing and/or tracking the development of elder care technology say that interest in passive monitoring systems is gaining steam both inside and outside academia and across the care continuum.

“It’s the biggest push that we’re seeing [in technology innovation for seniors],”



Marilyn Rantz, PhD, RN, leads research aiming at measuring function with sensors to help residents live healthier lives.

said Justin Smith, innovation and technology manager for Direct Supply, Inc., in Milwaukee, WI. “Facilities traditionally have had an episodic data-gathering approach. But now we’re seeing a move toward more continuous, round-the-clock data — data that can be turned

[into alerts] that tell the clinician ‘Here’s a trend we’re seeing for this resident . . . maybe you need to check in with them.’”

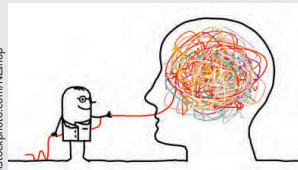
The commercial marketplace for passive sensor systems is still in its infancy.

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## A Person-Centered Approach to Fall Prevention

Barbara Resnick, PhD, CRNP

Fall prevention is a major concern for every community in which older adults live. Approximately 15% to 50% of older adults living in assisted living communities experience a fall over a 6- to 24-month period, and 4% to 22% of nursing home residents fall annually. Only a small percentage of falls result in major adverse outcomes such as a fracture or head trauma, but bruising can still cause pain, and skin tears can result in a

slow healing process that requires significant nursing time. Falls also can have a psychological impact — such as instilling a fear of falling with a subsequent decline in physical activity. The staff may begin to fear a resident’s falling as well and wish to keep that resident immobilized.

The factors that influence falls are many, encompassing issues with both individuals and the environment. The resident-level factors include age, muscle

strength, gait and balance, cognitive function, visual and hearing impairment, depression, and the use of certain medications (antidepressants, anxiolytics, antipsychotics, diuretics, or any medication that can cause orthostatic hypotension). The environmental factors that contribute to falls include tortuosity of paths, cluttered areas, slippery areas,

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## Technology

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Even so, some independent assisted living facilities and full-spectrum corporations are investing and signing on as early adopters, said Mr. Smith and Liz Jensen, RN, MSN, RN-BC, the company's clinical director. Technology companies, in the meantime, seem more willing to invest in the research "that's necessary



to prove the [clinical value and efficacy] of these new ways of providing care and services," said Ms. Jensen.

Passive monitoring technology is not "ready for prime time . . . but the technology is moving in the right direction," said geriatrician Jay Luxenberg, MD, a clinical professor at the University of California at San Francisco and medical director of On Lok, Inc., which operates a PACE program (Programs of All-Inclusive Care for the Elderly). On Lok

*"We [clinicians] tell [the technology developers], this person got dehydrated, this person fell, this person needed to be hospitalized. Over time, the system learns which changes can precipitate — and predict — a significant change in function and health. This is the future."*  
— Jay Luxenberg, MD

has been collaborating with researchers at Stanford University's artificial visual intelligence laboratory on piloting the use of depth and thermal sensors that monitor daily activity patterns and produce corresponding analytics that clinicians can use to identify potentially troubling patterns of activity.

"We tell [the researchers] at Stanford, this person got dehydrated, this person fell, this person needed to be hospitalized with a [urinary tract infection]," Dr. Luxenberg said. Over time, the system learns which changes can precipitate — and predict — a significant change in function and health. "This," he told *Caring*, "is the future."

### Inside TigerPlace

TigerPlace was built as a state-of-the-art independent living facility in which residents could live through the end of life with the support of both care coordination led by registered nurses (RNs) and new technologies to help them improve and maintain their physical and cognitive functions. It was built to nursing home standards but was licensed as an intermediate-care facility with waivers to operate as an aging-in-place facility. Essentially, the 54-apartment facility is run as independent housing, with the facility and service operations managed by Americare and the care component managed by a federally certified home health agency created as a department within the MU Sinclair School of Nursing.

The wireless sensor system, developed at the MU College of Engineering's Center for Eldercare and Rehabilitation Technology (CERT) in consultation with nursing staff and with input from resident focus groups, has several main components. Hydraulic bed sensors measure pulse, respiration, and restlessness. Depth sensors produce three-dimensional silhouettes and collect information on movement and gait (such as stride length, gait symmetry, and speed). And simple passive infrared motion sensors produce data that are processed to convey activity levels and patterns (known at TigerPlace as "motion density" patterns). With the use of Microsoft Kinect, a motion-sensing

device originally designed for gaming consoles, each resident can be accurately differentiated from other residents, family, and caregivers.

From the start, "we set out to find new ways to detect changes in function because we thought that, as health care providers, if we could measure function better, we could help people stay healthier longer," said Marilyn Rantz, PhD, RN, curators' professor emeritus in the MU Sinclair School of Nursing and executive director of the Aging In Place project and Sinclair Home Care.

Iterations of the sensor systems were installed in the apartments of consenting residents starting in 2005. Over time, longitudinal collection of sensor data and analysis of significant health events enabled the researchers to develop and test various health alert algorithms. "We went through a lot of sensors over the years, and we also experimented with various clinical parameters so that we got a handle on what [sensors and data] give us the most bang for your buck — the most clinically relevant information," said Marjorie Skubic, PhD, professor of electrical engineering and computer science and director of CERT.

For instance, "over the years we've learned how to map their average in-home walking speed to a standardized fall risk assessment instrument, the TUG [Timed Up & Go] score," she noted. "So we can tell from our data analysis system whether someone has a low fall risk or a high fall risk." One of the most recently published studies on falls showed that a decline in walking speed of 5.1 centimeters per second over a week is associated with an 86% probability of falling. The CERT clinical teams continue to work on streamlining their intervention process for fall prevention, Dr. Skubic said.

The sensor technology has also alerted providers to early signs of urinary tract infections, pneumonia, upper respiratory infections, pain, delirium, hypoglycemia, and other problems, Dr. Rantz said. She and her colleagues have described the health alerts and what they call a new paradigm of technology-enabled "vital signs" in several published articles.

In an interview with *Caring*, Dr. Rantz vividly recalled the first time, early in



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### KEY TECHNOLOGY TRENDS

- The commercial marketplace for passive sensor systems is still in its infancy.
- Continuous, around-the-clock data that can translate into alerts or predict changes in health is the biggest trend in technology innovation for seniors.
- The use of monitoring technology — both biometric remote patient monitoring (as in chronic disease management) and activity monitoring — is on the rise.
- User interface and modes of delivery of usable information to residents and families are becoming increasingly important.
- Most facilities willing to invest in technology are drawn to its fall prevention capability while considering its illness-predicting capability too far fetched.
- Technology that helps skilled nursing facility (SNF) providers follow patients home after discharge will emerge in the future.
- As the use of sensors increases, issues related to data security and resident privacy will demand more attention.



Shoshana Herndon

Marylin Rantz talks to a TigerPlace resident.

the research process, that sensor data prompted a valuable intervention. “I was looking over [nighttime bed sensor] data and graphs during a routine morning meeting and knew right away what was going on — that the patient’s [congestive heart failure] was accelerating. We caught it early, and we prevented an [intensive care unit] stay,” she said. “This was the first case of a pattern recognition for us . . . before we’d even gotten to the point of sending out automated alerts” to clinicians.

Not all residents at TigerPlace have lived with sensor technology. On average, about half of the facility’s apartments have had active systems and half haven’t — a breakdown that has enabled the researchers to tease apart the effects of automated alerts versus the effects of RN coordination, the latter of which is the standard at the facility. A study of length of stay over a span of almost 5 years found that residents using the sensor technology lived at TigerPlace for 1.7 years longer than those without the sensors (*Nurs Outlook* 2015;63:650-655). (RN coordination alone added an average of 0.8 years to length of stay compared with the national median of 1.8 years in residential senior housing.)

CERT’s current research on sensor technology aims to further improve the alert algorithms and “back-end processing,” but increasingly it focuses on the user interface — on how best to deliver information to the clinicians who are caring for patients in assisted living or other senior living communities. At TigerPlace, for instance, a clinician might now receive an alert of an “increase in bed restlessness” or “greater use of the bathroom,” with a link to graphs and other data for their interpretation. But the goal is to capture even more in words. With funding from the National Library of Medicine, CERT is trying to achieve “linguistic summarizations” of clinically relevant trends and changes.

And under another 4-year grant from the National Institutes of Health, Dr. Skubic and her team are developing prototype systems for communicating sensor data to seniors who are younger than the population at TigerPlace and to their family members. “Right now we’re asking, What’s the best platform? How should the information be organized so they and their families can use it? What will they use the information for? Could family members get text messages?” she said. Dr. Skubic noted that focus group sessions with seniors and their families have helped shape the prototypes. Later this year, the sensor systems will be deployed in two settings — an upscale senior living community and a government-subsidized senior housing community — to test them out.

### Outside TigerPlace

A more robust, commercialized version of the sensor system used at TigerPlace has been installed in hundreds of rooms in multiple assisted living communities and memory care units in Missouri and other states by Foresite Healthcare, a company formed in 2013 by former MU doctoral student George Chronis, which partnered in 2017 with Stanley Healthcare as a distributor. (Drs. Rantz

and Skubic are involved in Foresite as advisors and researchers.) Thus far, Dr. Chronis said, the main draw for facilities has been the “fall detection and prevention feature of the system.” For many clients, early illness detection still often “sounds like magic,” he said, even though ultimately it has much greater value.

Majd Alwan, PhD, senior vice president of technology and executive director of the LeadingAge Center for Aging Services Technology (CAST), has been tracking technology adoption and developing toolkits for technology selection. He said there has been a recent jump in using monitoring technology — both biometric remote patient monitoring (as in chronic disease management) and activity monitoring (passive or active).

Approximately 17% of 200 large, nonprofit, multisite senior living organizations that participated in an annual survey conducted by LeadingAge and Ziegler, an underwriter of financing in this sector, had adopted technology for activity monitoring by the end of 2016. Dr. Alwan said, “Within that 17%, almost all of them include some level of [passive] monitoring of activities . . . and some are incorporating

*Continued to next page*

### WHAT ABOUT WEARABLES?

Researchers at the University of Missouri (UM) made a deliberate decision not to use wearable devices — and to focus solely on passive sensor monitoring — when they developed their technology for TigerPlace in the early 2000s. “As nurses with experience in long-term care and older adults, we knew they would not wear stuff when they’re not feeling well,” said Marilyn Rantz, PhD, RN, curators’ professor emeritus in the MU Sinclair School of Nursing and executive director of the Aging in Place project and Sinclair Home Care. “It’s just when they need it most that they wouldn’t have it on.”

By now, TigerPlace and other communities have proven that valuable clinical information can be gleaned from the environment without requiring the elderly to wear anything or handle any buttons or plugs. Still, wearable devices are one of the three main categories of technology — along with passive monitoring and interactive technology — that have a role in addressing and preventing functional decline, experts say.

Certainly, “any technology that can track individuals and encourage them to engage in physical activity (including physical therapy) is the best preventive use of technology,” noted Majd Alwan, PhD, senior vice president of technology and executive director of the LeadingAge Center for Aging Services Technology (CAST).

Today’s wearables aim to do more than track step counts and pulse, however. Some are being marketed for the collection of data on behavior, activity, and movement in seniors with the goal of predicting illnesses early. The challenge, said Marjorie Skubic, PhD, the director of MU’s Center for Eldercare and Rehabilitation Technology, is that “many aren’t carefully validated against clinical outcomes.”

And the question remains of whether these devices can be used reliably in the geriatric population. Dr. Skubic is planning to integrate wearable devices into her upcoming studies of senior living communities outside of TigerPlace. In addition to tracking levels of activity outside the home (where passive monitoring will not be possible), one of the things she wants to know is whether seniors will use them consistently.

Research will tell, but tomorrow’s seniors will be much more comfortable with devices overall. “It makes sense for whomever is looking at solutions for [the aging] to think comprehensively about solutions that support today’s residents with passive technologies as well as tomorrow’s residents who will be moving in with their Fitbits and Apple watches,” Dr. Alwan said.

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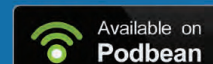
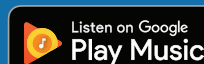
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more comprehensive and advanced functionalities.”

Thus far, most of the use of activity monitoring has been in retirement and assisted living/senior housing communities “where the provider is making the investment and folding it into the rent of the unit or the overall [price] being charged,” Dr. Alwan said. “The value proposition is keeping people as independent as possible for as long as possible . . . delaying a transition into assisted living, for instance, or when they’re in assisted living, delaying a transition to skilled nursing.”

Dr. Alwan said his belief in the power of passive health status monitoring was bolstered years ago when he and his then-colleagues at the University of Virginia’s Medical Automation Research Center conducted a controlled study of their passive monitoring system in assisted living, the same technology that would serve as a basis for the first-generation system used at TigerPlace. Over a 3-month period, they demonstrated a 75% reduction in billable interventions — including hospitalizations, physician visits, and antibiotic prescriptions — in a monitored cohort

in two communities, compared with an unmonitored cohort in a third, similar community in the same region (*Telemed J E Health* 2007;13:279–285).

The technology won’t deliver, however, unless staff have the training and resources to understand the predictive data and to “turn it into preventive action that improves function,” Dr. Alwan said. And at the most basic level, the current payment models and a lack of reimbursement streams are hampering its adoption, Dr. Alwan and other sources said. There are competing priorities, moreover; some facilities are still trying to achieve basic Wi-Fi capability, and others are investing in electronic health record systems.

Mr. Smith of Direct Supply said he expects the passive monitoring market to quickly evolve, given the current attention to fine-tuning the software and decreasing the cost of the systems. “The hardware is ready to go,” he said. “And in the long term, costs may be lower in the scheme of things because the system doesn’t necessarily change with the turnover of a room [or living space].”


Ms. Jensen, in the meantime, predicted that skilled nursing facilities will increasingly see the potential of

*“SNF providers are now following the resident home after discharge with the hope of avoiding their return to the hospital. I think we’ll see more SNFs invest in technology that supports this process, but who will ultimately pay for it remains the question.”*

— Liz Jensen

the evolving market. “SNF providers are now following the resident after discharge to home with the hope of avoiding their return to the hospital, but many of their processes are staff intensive, like follow-up phone calls or visits,” she said. “I think we’ll see more SNFs invest in technology that supports this process, but questions of who will pay for it remain.” LeadingAge has been advocating that the Centers for Medicare & Medicaid Services ensure that the SNFs using remote monitoring

technologies can support their costs related to infrastructure, hardware, software, and staff training, Dr. Alwan noted.

As monitoring technology evolves and is adopted by more facilities and systems, Ms. Jensen said, it is important that caregivers and clinicians continue to appreciate their roles. Sensor technology “is not replacing who they are — it’s giving them more information to make a good decision. Their role is still to be a good critical thinker,” she pointed out. “But it’s also to be an advocate for the resident. The application of these sensors will create new issues related to privacy and data security . . . and clinicians will probably find themselves being asked by a daughter, for instance, ‘Is this camera or sensor a good idea to put in place for my mom?’” Clinicians will “need to be able to understand what the technology can give [their patients],” Ms. Jensen said. They must know “what they can expect to get out of it,” and they need to listen to and respect their patient’s concerns. 

Christine Kilgore is a freelance writer in Falls Church, VA.

## Performers Put Practitioner Communication in the Footlights

Joanne Kaldy

Communication. It’s something everyone does every day. But sometimes what is said and what is heard are two different things. “Clinicians get frustrated because they think they’re communicating well, but people don’t seem to understand what they’re trying to say,” said Bob Arnold, MD, one of the founders of VitalTalk. Practitioners, he said, often talk to each in “shorthand and words we have a common understanding of, but patients don’t share this understanding.” He added, “It’s hard to shift gears from talking to colleagues to talking to patients and families.” One solution is to help practitioners develop and use different skill sets — such as acting and improvisation — to be better communicators.

### Practice Makes Perfect

Some programs give practitioners an opportunity to tap into their inner actor to be better communicators. For instance, Megan Cole, a stage and screen actor, offers workshops and courses for practitioners on “Balancing Engagement and Objectivity” and “Literature and Medicine.” In her programs, Ms. Cole shares some of her acting skills with participants, such as being aware of the context and subtext of what people are saying and doing. She helps people understand how to break events into goals, actions, and obstacles. Ultimately,



Shoshana Herndon

Megan Cole helps practitioners find balance between engagement and detachment in communicating with patients.

she said, the course is about ways of looking beyond a patient’s condition to see the person inside. It is about finding a balance that allows the practitioner to engage with the patient without becoming personally lost. This balance is essential, she noted, explaining, “We have to learn to trust ourselves and how to balance engagement and detachment.”

Acting is about behaving “as if,” said Ms. Cole. “It’s another way of imagining yourself in the shoes of your character.

If I were this person, how would I feel? How would I behave?” This isn’t so different from what practitioners need to do to communicate effectively with patients and family members, she suggested.

Ms. Cole encourages practitioners to watch movies and plays where actors portray someone struggling with a serious illness or with aging. She said, “If the performer is doing his or her work right and well, [viewers] will get the experience by proxy. They will be drawn into

the situation and feel with the person. They will learn what it’s like to be that person and to have that particular illness. This gives them a safe place to reflect.”

She also encourages practitioners to read literature that addresses aging and illness. She said, “Literature teaches us eternal truths in entertaining ways and reminds us that there is always more than one way to interpret any human experience.” She added, “Literature shows us again and again that different people have a different experience and perspective of the same event.” Reading, she offered, helps us understand and even internalize some of these different views.

### From Improv to Info

Actor Alan Alda came to a realization several years ago that improvisation could help researchers and other practitioners effectively communicate technical scientific information to lay people. As a result, he developed the Alan Alda Center for Communicating Science as part of the Stony Brook University School of Journalism. “Real listening is the willingness to let the other person change you,” Mr. Alda said. The Alda Method taught in his programs uses the improvisational theater techniques

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