Using Sensor Technology to Detect and Monitor Behavioral Symptoms of Dementia

By Christine Kilgore

The use of sensor technology to detect and monitor aggression, agitation, and other behavioral and psychological symptoms of dementia (BPSD) is in early stages of research but holds significant potential for improving care, researchers said in interviews with *Caring*.

Measuring and mapping movement of the human body using wearables and sensors embedded in the environment is a key element of ongoing research on BPSD. "Technology is evolving so rapidly, it's impossible to project out with a great deal of confidence where this will end up [for long-term care and other settings], but I absolutely think this sort of intensive data-guided approach to care is the future," said Ipsit Vahia, MD, medical director of the McLean Institute for Technology in Psychiatry and director of the Technology and Aging Laboratory at McLean Hospital in Belmont, MA.

"We're only barely scratching the surface on how much clinically relevant information can be gleaned from [movement-related] variables," said Dr. Vahia, who is also an assistant professor of psychiatry at Harvard Medical School.

Dr. Vahia and his team are using novel wall-mounted devices that emit radio signals to measure variables such as gait speed and pattern, spatial location and body position, and sleep time and sleep stages. With the use of signal processing, machine learning, and artificial intelligence (AI) more broadly, they aim to train the devices to efficiently process data — understanding everyday patterns and detecting variations in these patterns — and to develop predictive, clinically useful algorithms.

A major end goal, he said, is to "give staff a more moment-by-moment sense of how someone is doing, and more importantly to pick up on changes much earlier than they [otherwise] might have, and to intervene preemptively."

In their monitoring and mapping thus far of approximately 40 residents who have major neurocognitive disorder (MND) and behavior disturbance, the sensor data have helped spur an investigation of suspected paranoia in a resident with MND and a history of paranoid ideation and pacing, and has detected akathisia in a patient who had been hospitalized for severe depression and given haloperidol (Haldol). In the latter case, the patient's daily number of motion episodes had more than doubled.

Their passive motion-sensing technology was also useful in tracking the severity of apathy in a patient with MND and comorbid major depressive disorder characterized by severe psychomotor retardation. For this patient, time spent on her couch was a marker of severity. During a webinar held last year by the American Association of Geriatric Psychiatry on using sensors and AI for dementia care ("Innovations in Dementia Care Using Sensors and Artificial Intelligence," Oct. 7, 2020; https://bit.ly/3ihuYmg), Dr. Vahia said, "It was also helpful to have data to use to track the impact of a [trial of a] stimulant — we wouldn't have had this data otherwise."

Gait speed and patterns not only predict fall risk, but also serve as markers of increased agitation, anxiety, depression, or apathy, and can be used to track medication efficacy and side effects, Dr. Vahia emphasized in the interview. Overall, he said, sensor-driven data are "opening the door to a much more precision-based geriatric psychiatric practice."

Detecting Agitation With Ambient and Wearable Sensors

At the University of Toronto, geriatric psychiatrist Andrea Iaboni, MD, DPhil, is using advances in computer vision and advanced pose-tracking in video images to record and measure changes in movement, specifically in the estimated margin of gait stability — a variable (the "wobble factor") that she and her team found to be associated with a higher risk of imminent falls (*J Gerontol A Biol Sci Med Sci* 2020;75:L1148–1153).

"I want to know if a medication [for BPSD] is having a negative impact on them, if it's increasing the risk of falls," said Dr. Iaboni, medical lead of the Specialized Dementia Unit based at the Toronto Rehabilitation Institute of the University Health Network (UHN), a research and teaching hospital network affiliated with the University of Toronto.

But her research also aims to develop algorithms that link patterns of movement with various neuropsychiatric symptoms of dementia, and that detect "anomalies or unusual behaviors that are happening in the environment," such as aggression or agitation. The amount of data and processing power required "at this moment is challenging," Dr. Iaboni told *Caring*. Algorithms need to distinguish a punch from the act of reaching out to hold a hand, for instance.

Moreover, she and Dr. Vahia said, sensor systems are not yet able to process and monitor the data in real time. "The work we're doing is still quite labor intensive — we have to look at [the data] retroactively ... and pick up on patterns that occur over days or weeks."

In a project using the Empatica E4 wristband in almost 20 patients, Dr. Iaboni had moderate success in identifying a "signature" of various physiological (e.g., heart rate and body temperature) and movement patterns that may signal an active or impending episode of

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insurance claims codes (*J Am Geriatr Soc* 2017;65:1183–1189).

For over 1,800 older adults in long term care, they found that about 65% were taking a CNS medication. However, the falls risk was 1.83 times greater when patients were taking three or more CNS-active medications at daily doses consistent with a geriatric pharmacotherapy handbook. Interestingly, their analysis showed no statistically detectable difference in taking more than zero or less than three CNS-active medications.

Notably, their finding that three or more CNS medications, including opioids, increases the risk of falls is in agreement with the most recent version of the Beers list, the trusted guide developed to give evidence-based support to clinicians assessing medication safety (*J Am Geriatr Soc* 2019;67:674–694). This threshold of three medications enables providers to address the clinically appropriate need for a psychoactive medication while heeding calls for vigilance and frequent monitoring for efficacy and side effects as well as maximizing nonpharmacological interventions.

For CNS-active medications that are no longer effective, evidence-based algorithms are increasingly available for safely decreasing and discontinuing these medications. These include the clinician tools available at the US Deprescribing Network (deprescribingresearch.org) and at the PIMSPlus website (pimsplus.org).

Ongoing efforts are needed to enable tools embedded within our workflow and encourage collaboration among team members to promote safe and judicious use of medications that affect or treat neurologic and/or psychiatric conditions.

Dr. Lee is the Geriatric Pharmacotherapy Fellow at the Peter Lamy Center on Drug Therapy and Aging at University of Maryland Baltimore. Additionally, he works as a clinical pharmacist at the MedStar Center for Successful Aging.

Behavioral Change in Clinical Practice: Hard But Not Hopeless

By Joanne Kaldy

"It's hard to change habits," said Leslie Eber, MD, CMD, at the start of a program on "Changing Provider Behavior: Beyond the 'Just Do It' Mentality" at PALTC21, the Virtual Annual Conference of AMDA – The Society for Post-Acute and Long-Term Care Medicine. She recalled how she would often come back from Society meetings bursting with ideas and plans, and then she was faced with "how challenging it is to change behaviors and habits." But she stressed that there is hope.

Start with System 1 and System 2

To start, Dr. Eber talked about economist Daniel Kahneman's systems of decision-making. System 1 is fast and intuitive, and uses past experiences and immediately available facts. System 2 is a deliberate process that uses questioning and further investigation.

"It feels really good to use System 1. It makes us feel comfortable and secure," she said. "But it also is correlated with predictable mistakes. System 1 decisions are famous for jumping to conclusions if we don't have all the facts." That is, she said, "If it looks like a duck and quacks like a duck, it's a duck." System 1 also relies on expert intuition, the recognition of past patterns. This can be useful, Dr. Eber suggested, "but in medicine, as we learn more and fine-tune best practices, it can be a pitfall." System 1, she said, does not allow for the possibility that evidence critical to our decisions is missing. "We often use heuristics, a shortcut for solving a problem or making a decision." This is where people revert to something they know to do from experience and habit.

System 2 is more time consuming and less comfortable, Dr. Eber explained. However, she said, "When we are measured and deliberate, we divert from our habits and make much better decisions." When we do this, she said, we have to address our cognitive ease — that confidence and trusting of intuition that makes mistakes more likely. At the same time, the focus must be on cognitive strain, which relies on vigilance, suspicion, and an investment of time and effort. This decision-making process may take practitioners out of their comfort zone, but the result is likely to be fewer mistakes.

Beliefs: Boost or Bust?

Our beliefs help shape our decisions, and in medicine, Dr. Eber said, "our beliefs are deeply engrained." That isn't surprising; human reasoning is belief based, and often it is built on experience. Unfortunately, experience also can lead to inaccurate medical beliefs. Along with our beliefs, Dr. Eber noted, we all have biases. "We need to recognize and address them," she stressed.

Base rate neglect — the gap between statistical evidence and best practices and the practitioner's thinking about an individual patient — is a sort of bias that is common in geriatrics, Dr. Eber suggested. This is when the evidence and clinical knowledge point to one decision, yet the practitioner makes a different one because "I know Mrs. Jones." Compelling statistics, she said, "will not change long-held beliefs or beliefs rooted in personal experience." COVID-19 vaccine hesitancy is an example of this, Dr. Eber offered, as many people dismiss the scientific evidence because of their own personal experience with vaccinations.

So how do we make better decisions? First, Dr. Eber said, "We have to overcome inertia. We have to embrace cognitive strain and consider alternatives and what is possible."

Give a Little Nudge

In recent years, "nudges," described as effective ways to influence behaviors, have become a popular strategy, said Sing Palat, MD, CMD. These, she noted, "are used to alter behavior, but they don't forbid options or remove freedom of choice."

There are different types of nudges. Among them is the *default option*, "which creates a path of least resistance," Dr. Palat said. This type of nudge is designed with the expectation that biases are natural. One popular and common example of a default option is the organ donor opt-out for consent, which has resulted in a high percentage of donors across all states. She said, "Removing small obstacles rather than shoving people in one direction has more impact."

Mapping is a nudge where information about various options is explicitly laid out and made easy to understand

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distress or agitation. She and her team have recently pivoted this research away from a collective analysis of data and toward a personalization of data. "We need to look at how individual patterns [of behavior] are changing over time," Dr. Iaboni said.

Over time, wearables will become less expensive, easier to wear, and easier to charge and transmit data from. With respect to environmental sensors, Dr. Iaboni hopes to use video technologies that nursing homes already employ for wander prevention and location tracking.

Achieving Scalability and Individualization

How to make multimodal sensor technology scalable and adaptable is an overarching goal for Nirmalya Roy, PhD, whose research in the Department of Information Systems at the University of Maryland, Baltimore County, addresses ways to monitor physiological, functional, and behavioral health using a combination of wearable devices and environmental sensors. This could include both ambient sensors attached to walls and ceilings, for instance, and sensors attached to or embedded in objects like laundry baskets or faucets.

"We needed adaptable machine learning methodology and algorithms that will work across multiple devices and environments ... which all have different layouts and artifacts," said Dr. Roy. He is collaborating with the University of Maryland School of Nursing on projects at several retirement community centers and senior homes in the region, each of which aims to control the decline in functional and behavioral health in older adults with and without dementia.

Right now, said Dr. Vahia, the goal of scalability appears to be at odds with one of the other major goals in senior care: the provision of precision, individualized care. But "once technology matures and becomes more affordable and once algorithms can be developed and applied [more universally], it will be possible to have more individual-level data streams," he said. "We'll want to show that we can have a real-world impact on clinical decision-making and on outcomes, and [also, eventually] cost-savings."

Privacy concerns and ethics issues are also on the table. Dr. Iaboni said her patients and their families have had mixed reactions to sensors.

Dr. Vahia said he is optimistic about acceptance over time. In his experience with using off-the-shelf wearable sensors such as fitness monitors to investigate concerns or validate staff observations — or to monitor the effects of a medication change — the patients and their families have been generally cooperative.

While wearables have only been an episodic rather than a continuous part of Dr. Vahia's practice, it is notable, he said, that patients have "almost 100%" accepted the technology after he has "explained that we want to use to the data to make decisions about their care and well-being ... and when we give them the off switch — the ability to discontinue [if desired]."