



Stevie the robot entertains residents and carries out a range of different tasks while at a retirement home.

GREG KAHN PHOTOGRAPHY

The slow rise of the caring robot

Robotics technology is improving, but its routine use in the home, hospital and care settings could be a long way off. **By Neil Savage**

As a teenager in the early 2000s, Conor McGinn worked part-time in the nursing home where his grandmother lived. The employees did all they could to make her and other residents comfortable, but McGinn says her quality of life was never as good as it was before. “The staff were lovely, but looking after people is the most resource-intensive thing you can do, and trying to be happy, good-natured and enthusiastic while you’re under that kind of fierce pressure is just incredibly challenging,” he adds.

Later, as an engineering student at Trinity College Dublin, he wondered why technology wasn’t being used to support caregivers. “Everyone else benefits from this stuff. Why can’t senior living?” he thought. Now a mechanical engineer at Trinity, he builds robots to take on some of the tasks normally done by staff in assisted-living and retirement homes.

Assistive robots have not quite reached the level of *The Jetsons*, the animated 1960s sitcom in which Rosie the robot maid zipped around a futuristic house doing all the chores

people would rather avoid. But in a few years, robotic assistants might routinely feature in older people’s homes, helping them to care for themselves, providing emotional support, and allowing remote access for doctors and nurses. In retirement homes, they could entertain residents or help with cleaning. And in hospitals, they are already taking over some basic tasks, freeing up nurses to focus on patient care.

The need for automated support is growing as the global population ages. There are more than 1 billion people over the age of 60, according to World Health Organization estimates, rising to 1.4 billion by 2030 – that’s one in six people, requiring another 6 million nurses. In Japan, where nearly one-third of the population is over 65 (see page S12), the government has been providing subsidies for care facilities to purchase robots since 2015. These range from exoskeletons that support staff in lifting patients, for example, to a robotic baby seal that helps to soothe people with dementia.

To work out how robots might be used in retirement homes, McGinn and his colleagues built Stevie, a white robot on a rolling base with short, moveable arms and a head that displays

cartoon eyes and a mouth. In 2018 and 2019, they tested Stevie at the Knollwood Military Retirement Community in Washington DC, a facility with 300 older residents. The idea, McGinn says, was not to swoop in with a ready-made piece of technology, but to learn from staff and residents how a robot could improve their experiences.

All-singing all-cleaning

The robot took over some entertainment activities, calling bingo and leading a sing-along, freeing up staff to attend to residents' individual needs. "Stevie could be the novelty at the front of the room," McGinn says. But it can also do other things many caregivers cannot, such as speak in different languages and display subtitles when it talks. "Stevie could do all these things that are normally outside of that core expertise or knowledge that you'd expect caregivers to have," McGinn adds.

Although many of the robot's capabilities already exist in other devices, they are often left unused, McGinn explains. The robot is intended to make the technology more user-friendly. "People would say they were not technology users but spend three hours a day with Stevie." Feedback from small focus groups of staff and residents was generally positive.

The robot needs to be versatile enough to help out around the facility. It might patrol corridors at night to make sure a resident hasn't gone wandering, or it could perform cleaning duties. "It's a force multiplier for care staff," McGinn says. "It's not to replace people, but it's to augment how people care for people."

Stevie was preprogrammed with some actions, such as when it ran a trivia game for residents. But it was mostly controlled by researchers on-site. When asked if it had a girlfriend or about life in Ireland, a researcher typed in answers. Eventually, McGinn would like to give the robot more autonomy. It should be possible for it to navigate around the facility. Giving it Alexa-like abilities to respond to residents is a little trickier, because distinguishing dozens or hundreds of voices in a group setting is more complex than answering three or four people in a family home.

The COVID-19 pandemic derailed plans for a longer-term study to establish whether the robot was making a difference to the emotional and medical health of the residents or reducing staff turnover. McGinn hopes to start that aspect of the research soon as bans on visitors are lifted and group activities resume.

Dad jokes

"The pandemic really showed how important social connectedness is," says Maja Matarić, a computer scientist who runs the Interaction

Lab at the University of Southern California in Los Angeles. "A huge amount of evidence shows that people need social interaction."

That interaction could be with another person, an animal or just with something that "feels alive", Matarić says. She has been studying socially assistive robots since the early 2000s, with the aim of boosting the emotional and cognitive health of older people, those with dementia, and children with autism.

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As people age, their peer groups shrink and they tend to become less mobile, which can lead to boredom and depression, Matarić says. Social robots can help stave off some of those feelings. A 2015 study by robotics researchers at the University of Auckland, New Zealand, found that PARO, a robotic baby seal created in Japan two decades ago, lowered the blood pressure of nursing-home residents who held and petted it (H. Robinson *et al. Austr. J. Ageing* **34**, 27–32; 2015). The results, the researchers said, were similar to those that come from contact with live animals.

Matarić is currently studying robots that encourage older people to read or exercise more. This encouragement could be as simple as offering to tell someone a joke if they'll get out of their chair. "We just downloaded a bunch of dad jokes. They were not great but the users loved it. It was that little bit of regular contact," she says.

"This is not a replacement for human care, but to slightly diminish the care gap that people are experiencing – the extreme loneliness and isolation," she says. "It's always better if you can have a caring human."

Hospital help

Zhi Jane Li, a robotics engineer who runs the Human-Inspired Robotics Lab at Worcester Polytechnic Institute in Massachusetts, is developing control interfaces for telenursing robots that have some level of autonomy for easier tasks, such as cleaning. More complex patient interactions would be run remotely by a human operator.

The idea, which Li initially worked on as a postdoctoral researcher in computer scientist Kris Hauser's Intelligent Motion Lab at Duke University in Durham, North Carolina, grew out of the 2014 Ebola outbreak in West Africa. Researchers wanted to separate caregivers from people who had the highly contagious

disease, a challenge that Li says was reinforced by the COVID-19 pandemic. But it can also help with nurse shortages, which have worsened in the pandemic.

"One person can be taking care of several nursing robots at different locations at the same time," Li says. "You can kind of fan out the capability of a human health-care worker." For some tasks, a trained operator can run the robot. For more complex problems, a nurse or physician could use the machine to interact with the patient remotely.

Li's current work focuses on designing telenursing robots for use in a hospital – a challenging task, but one that should be more straightforward than targeting them for use in a less-structured environment such as a retirement community or private home.

Andrea Thomaz, a roboticist at the University of Texas at Austin, thinks that the semi-structured environment of hospitals makes them an ideal proving ground for assistive robots. Factors such as the widths of corridors and the design of doors are typically fixed, which makes tasks such as navigation not so different from the warehouses and factory floors in which the use of robots is already well established.

But unlike on a car production line, a robot operating in a hospital will come across people or equipment unexpectedly in its path. "They're not completely a Wild West for the robot, but they are a lot more messy and unstructured than a warehouse or manufacturing lab," Thomaz says.

She and her former research assistant, Vivian Chu, co-founded Diligent Robotics in 2017 to sell Moxi, a rolling, white, one-armed robot with LED eyes. Moxi can travel around a hospital, picking up and delivering medicines, equipment, patient samples or linens.

Moxi creates its own internal map during an initial tour of the hospital, after which staff can request deliveries through an app, saving clinicians several hours in a day, according to Thomaz.

In a pilot hospital study using Moxi, nurses were happy to have robots taking over tasks such as carrying laundry and fetching equipment (M. Tietze & S. McBride *Robotics and the Impact on Nursing Practice*; American Nurses Association, 2020). "Nurses love them once they get to experience what they can do," says Mari Tietze, a nursing informaticist at the University of Texas at Arlington, who conducted the study for the American Nurses Association. The robot freed up nurses to spend more one-on-one time with patients, which Tietze says has been shown to lead to better health outcomes and lower rates of readmission, which in turn saves hospitals money.



Hello Robot's Stretch has helped with many tasks since Henry Evans had a brain-stem stroke.

Decision-making tasks such as offering medication, or assessing a patient's readiness to be discharged, cannot be handed over to robots for both ethical and legal reasons, says Tietze's co-author Susan McBride, a nursing informaticist at Texas Tech University Health Sciences Center in Lubbock. They could, however, assist in monitoring a patient's vital signs.

The European Union has provided about €1.1 million (US\$1.25 million) to fund a four-year project called ENDORSE, which is due to end in September 2022, for a hospital robot with sensors that can both record patients' vital signs and link them with electronic health records.

Sensors like this are currently available at every intensive-care bed, but in less-urgent care settings and assisted-living facilities, caregivers typically need to hunt for the appropriate equipment, says Nacim Ramdani, a control systems engineer and head of the robotics department at the University of Orleans, France. "Periodic monitoring could be done more cheaply, because you do not necessarily need the nurse running around," he says.

Personal care

Robots that conduct simple tasks or provide social and cognitive support are clearly important, but Charles Kemp is focusing on robots that can help people feed, clean or dress themselves and perform household tasks, an area that Li is also hoping to address.

In 2017, Kemp, a roboticist who runs the

Healthcare Robotics Lab at Georgia Institute of Technology in Atlanta, co-founded Hello Robot in Martinez, California. Its robot, Stretch, looks like a rolling coat-rack with an extendable arm.

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Kemp previously worked on the PR2, a personal-assistance robot manufactured by Willow Garage in Menlo Park, California (the company closed in 2014). The PR2 cost around US\$400,000 and weighed just over 220 kilograms. Stretch costs \$20,000 and weighs just 23 kilograms, making it more like the kind of robot people could one day have in their homes. A video on Hello Robot's website shows Stretch vacuuming, playing with a dog, fetching items and even taking clothes out of the dryer. Some of these tasks are done semi-autonomously by the robot, following programmed instructions, whereas others are controlled by the owner.

These robots are also able to provide more-personal care. A brain-stem stroke in 2002 left Henry Evans able to move only his head and a finger. Evans, who is now 60 and lives in Los Altos, California, has worked with both robots, using them to shave, scratch an itch, flip light switches and play cards. The

robots have given him back some sense of autonomy, he says. "It's very important to me, from a sense of self-worth, to do things for myself independently whenever I want, even if it is slower," he adds. The robots have also relieved Jane, his wife and primary caregiver, from having to do everything for him.

Advances in artificial intelligence are helping robots to better model and understand real-world situations. "As humans, one thing that helps us to help others is a lifetime of experience doing things for ourselves. We have a sense for what things feel like, and what works and what doesn't," Kemp says. Robots don't have this same common sense, and it's a big obstacle to having them autonomously help in more sophisticated ways, he adds.

To help robots provide better assistance, Kemp combined physics-based modelling and machine learning to teach a robot what it feels like for a human to get dressed. Stretch practised virtual simulations, putting a shirt on someone, measuring how pulling the fabric in a particular direction would exert force on the person's arm, for instance, and learning how to shift and tug in different directions to avoid causing discomfort or injury.

Dressing is one of five 'activities of daily life' that roboticists are trying to get machines to help with. Dressing, feeding and washing are areas where Kemp thinks good progress is being made. The other two – helping people use the toilet and moving them from place to place, perhaps from a chair into a bed – are more difficult tasks that he has yet to tackle.

Kemp expected robots to move into settings where they can care for older people faster than they have. Making robots a bigger part of such care requires not just technological development, he says, but a societal shift involving caregivers, older people, the medical community and insurers. It will work best, he thinks, if people build general-purpose robots that can help different kinds of people with a wide variety of tasks. This approach should make them less expensive and able to perform better than if they are specially built to provide just a few services for a limited group of people, he argues.

The main challenge he sees lies in teaching robots how to act around people. "If you want robots to play a more active role and to be more autonomous, how can you give them the common sense to not do something really dumb?" he asks. "If we really want to reach the full potential of robotic caregivers, they have a lot to learn."

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