



Sustainable technology solutions to support the elderly.

By Tan Hwee Pink

From 1980 to 2017, the global population aged 60 years and above has more than doubled from 382 million to 962 million people, and is expected to double again by 2050 to reach nearly 2.1 billion people.¹ Interestingly, two-thirds of the elderly live in the developing world, where their numbers are growing faster than in the developed world. Asia is predicted to experience more than a twofold increase of persons in this age group, with the population aged 60 years and over projected to increase from 549 million in 2017 to nearly 1.27 billion by 2050—a quarter of the total population in the region.

While a higher life expectancy is testimony to our achievements in modern medicine, this demographic trend has significant implications for labour supply, family and household structure, pension systems, demand for healthcare and welfare services, as well as housing and transportation services. Greater longevity is turning out to be a double-edged sword, especially in Asia, as governments grapple to cover the costs of institutionalised resources and facilities for healthcare and eldercare, as is the case in the West. Private healthcare costs are also rising steeply. Therefore, it is becoming necessary to create living arrangements where seniors can age in place, that is, live in their own home and community independently, comfortably, and safely. While this will greatly reduce the strain on budgetary resources and ease the pressure on healthcare costs, ageing in place creates its own set of challenges for seniors and their caregivers.

Home alone

The household living arrangements of seniors differ markedly across countries and regions, reflecting differences in economic conditions, availability of support systems and infrastructure,

family size, as well as the social and cultural norms that surround inter-generational co-residence. In Asia, 73 percent of those aged above 60 years lived with their children in 1990, this has since declined to 64 percent in 2010. The corresponding numbers in 2010 for North America and Europe were 19 percent and 20 percent respectively.²

The old-age support ratio, defined as the number of residents aged 20 to 64 years to those above 65 years old, has been on a steady decline in Asia. In Singapore, the support ratio has more than halved from 9.0 in 2000 to 4.5 in 2019.³ The proportion of older persons living alone is increasing globally, and with this comes a multitude of risks ranging from their safety and physical health to their psychological well-being. Seniors living alone tend to suffer from frailty, fatigue, and diminished strength, often attributable to malnutrition, lack of exercise, and the presence of chronic diseases. Their limited mobility, combined with a limited network of family and friends, often leads to social isolation, loneliness, and depression.

Between 2007 and 2011, at least 50 seniors who lived alone in Singapore passed away in their own homes, only to be discovered after a prolonged period. In Japan, the number of *Kodokushi* (the Japanese term for people dying alone and remaining undiscovered for a long period) is expected to rise from 30,000 a year in 2016 to 200,000 a year by 2040.⁴

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Cultural differences notwithstanding, these statistics beckon Asian countries to take notice and prepare proactively.

Technology for seniors to age in place

Technology has pervaded all aspects of our lives, and healthcare is no exception. Technology solutions and apps, once seen as primarily targeted at millennials, have expanded their reach and now offer promising options for eldercare. Indeed, 'silver tech' is the new buzzword in tech circles as it defines the wave of innovation across apps and tech-based services for the ageing demographic.

Technologies for seniors living alone have a strong focus on passive in-home monitoring, without the need for active participation by the seniors. Data from unobtrusive devices such as motion sensors and door contact sensors can be analysed to measure levels of activity or identify changes in daily functioning at home. Wearable devices can track health data that can be fed to healthcare professionals, enabling responses to be delivered to the doorstep. Sensors in the home and on mobile devices can track activity levels, and report anomalous events to caregivers, triggering the need for targeted care. Most importantly, the data that is collected can help develop pre-emptive solutions tailored to the senior's health and social needs.

The SHINESeniors project

In Singapore, the seeds for technology-enabled ageing in place solutions were sown through the SHINESeniors project, which was developed jointly by Singapore Management University (SMU); Tata Consultancy Services (TCS); the Agency for Science, Technology and Research; the former Eastern Health Alliance; and various community care partners. The project aimed to address the challenges posed by a rapidly ageing population in Singapore while catering to the diverse needs of stakeholders. It was developed as a collaborative framework involving vulnerable seniors, caregiving organisations, public entities, and technology partners to address the immediate and personal safety needs of the elderly (reactive care), the long-term health and social needs of the elderly (preventive care), and the technology-centric and care-centric challenges for sustainable technology-enabled community eldercare.

The SMU-TCS iCity Lab contributed to the development of the Assisted Living Platform (ALP), a technology platform consisting of sensors, a Smart Data Hub to store the data, custom-built Internet of Things (IoT) middleware, and an algorithm layer to dynamically analyse the data collected with a variety of Machine Learning approaches. Using a community-based caregiver network that includes volunteers from GoodLife!, Thye Hua Kwan Moral Charities, the former Eastern Health Alliance and NTUC Health, the ALP combines sensor-enabled homes, personalised home care, and a medicine-adherence care model to keep costs under control, while still enabling the last-mile human touch.

The implementation of a discreet mode of tracking is a key priority in such projects, to enable the elderly to live comfortably and independently while retaining a safety net, and without them feeling they are being monitored. The ALP features unobtrusive sensors that closely map daily activities, and generates system events based on periods of movement, rest, and ingestion of medication. The medicine adherence study uses sensor-based medicine boxes to monitor regularity of medication consumption. In cases of divergent data patterns,

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timely alerts tip off community caregivers, who can step in to provide support. Monitoring is managed through dashboards, a portal for administrators, and a mobile app or over-the-top messaging platform that alerts caregivers when a situation requires intervention.

Based on the data captured by the sensors, a distinctive pattern emerges for each person. A narrative of their daily lives is created, which helps the team understand what is normal and typical, so that it can deliver the right care at the right time. The research team uses Machine Learning algorithms to predict cases of frailty deterioration, nocturia,⁵ and social isolation in the elderly, which can indicate the need for early assistance or intervention.

Social impact

Over a three-year period, the ALP was installed in the homes of 90 ageing Singaporeans living alone. By and large, the initiative was well-received by beneficiaries and caregivers alike. Despite starting on a small scale, the project has shown distinct benefits—the collaborative platform has since become instrumental in saving the elderly from social alienation and emotional and physical decline.

For instance, 89-year-old Madam Lee preferred to stay home and spend her afternoons sleeping. Occasionally, she took bus rides alone to while away her time. The Social Isolation survey flagged Madam Lee as socially isolated with a small social network. Sensor data also showed that she left home less often than her peers in the community, and her outings had shown a downward trend in recent months. These results were shared with the volunteer group, which took steps to encourage Madam Lee to visit the centre located below her home for meals and games. Her neighbour, who visits the centre regularly, also made phone calls to encourage her to join them. Through this intervention, her attendance at the centre jumped from 30 to 80 percent and she started spending more time outdoors. Subsequently, her Social Isolation indicators also showed an improvement.

In another instance, a 79-year-old senior had two falls in his home, leaving him very weak. He was unable to travel in his motorised wheelchair, as it was dangerous for him to get on and off the wheelchair on his own. To get out of the house, he needed someone to wheel him, so he was no longer independent. He had to depend on caregivers to visit him; otherwise, he was quite cut off from the community. One day, the No Activity alert was triggered at 5 am. A volunteer visited him and found the elderly gentleman sitting in the living room, where he had spent the whole night as

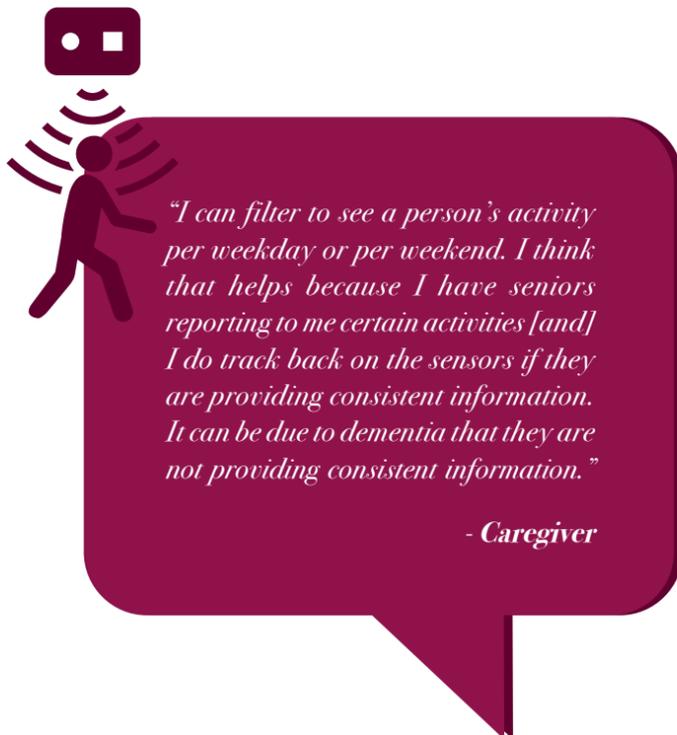


he was too weak to move. He was hospitalised for three days. Post-hospitalisation, the volunteer group engaged with him, took him out for meals and got him to socialise with other seniors at the centre. He also participated in their weekly exercise programme. As a result, his physical health improved and he was even able to walk around his home without any walking aids.

The success of the SHINESeniors project paved the way for several other partnerships in Singapore and beyond, which have leveraged on the ALP framework. As of early 2019, the framework has been successful in collectively benefitting 200 vulnerable seniors and five caregiving organisations through collaborations with three public entities and two technology partners. After participating in one such collaboration, one senior commented, "I feel very safe and can relax with the sensors installed in my home. I also feel it is safe for me to go out when wearing the watch. The sensor gadget does not interfere with my daily activities and it is good for the elderly living alone."

Ensuring scalability and sustainability

'Silver tech' undoubtedly allows for intelligent detection and notification of anomalous events, as well as collaborative decision support for seniors living alone. However, its widespread adoption and deployment remains elusive due to seniors' unfamiliarity with technology and perceptions of privacy invasion. The key obstacle to progress has been securing buy-in for the technology from key stakeholders—the elderly themselves—who are often resistant to embracing it because of privacy concerns, among other issues.



TECHNOLOGICAL LIMITATIONS

Despite the potential value of sensor-enabled homes, there are challenges to scaling up from the current 200 homes (across all projects) to a nationwide level of at least 40,000 homes (the estimated number of seniors living alone in Singapore). These challenges include:



Set-up and operating costs

The programme adopted a Capital Expense (CAPEX) model for the deployment of sensor-enabled homes, where sensor and gateway devices, as well as cloud services and mobile data subscriptions, are procured separately. As the seniors participating in the projects do not have home broadband subscriptions, a monthly recurring cost of about S\$10 (US\$7.20) per home is incurred. Also, the components of z-wave, a proprietary wireless communications protocol, are costly, as it is specifically designed for home automation.



Reliability

The deployment is dependent on the gateway to receive data from each sensor device. The data also needs to be aggregated and transmitted via 3G to the project cloud server. However, as the seniors are mostly in the low/no-income group, they sometimes turn off the gateway to save on electricity (and thus lower their utility bills), resulting in loss of data.



Maintenance needs

The sensor devices are battery-powered as they need to be deployed according to where the senior is likely to be, or at areas that may not have electrical power points. Based on the actual maintenance data from the project, the average lifespan of each motion sensor is about 300 days (10 months), and most of them have a lifespan exceeding 240 days (eight months). When the battery level falls below a certain threshold, the devices need to be replaced—this is costly and may also inconvenience the elderly as access to their homes is needed.

With the maturing and availability of Low Power Wide Area Network (LPWAN) technologies such as Sigfox, Long Range Wide Area Network (LoRaWAN), and NarrowBand-Internet of Things (NB-IoT), it is now possible to address some of the gaps listed above. In particular, with the operator model for Sigfox and NB-IoT, one can potentially achieve savings in cost, as well as for maintenance needs while improving reliability, as there is no longer a need to deploy a mains-powered gateway in each home. Preliminary experimental evaluations suggest that while maintaining a similar battery lifespan, a Sigfox-based system can match the accuracy in detecting at-risk seniors at a fraction of the cost of the incumbent sensor system.

A bigger challenge is that technological innovations can become obsolete when incumbent technologies are replaced by newer and better ones. In the case of emergent technologies such as IoT, Artificial Intelligence and crowdsourcing, it is essential to design such technology-based systems with modularity, extensibility and interoperability in mind. In fact, technological innovations thrive on open standards, protocols, and architectures to ensure interoperability.

Another key aspect of collaborative/cooperative technologies is that they should incorporate features that are friendly to the beneficiaries, users and/or operators, to ensure acceptance and sustained usage. For instance, senior-friendly interfaces typically exhibit large fonts and contrasting colours for better visibility. This calls for an iterative approach to interaction design and prototyping, whereby user feedback is continuously sought and incorporated into the final product.

FINANCIAL CONSTRAINTS

To ensure a wider adoption of sensor-enabled homes, we need to address the three-pronged question of “Who will use it?”, “Whose support is needed?” and “Who will pay for it?”. This is pertinent for Singapore as the proportion of one-person households is set to rise. As evidenced by testimonials provided by seniors, as well as those of their caregiving partners, the use of sensor-enabled homes for reactive care is key for the adoption and use of the technology in our projects. While this addresses the first two questions, the answer for “Who will pay for it?” remains unclear. While government schemes for medical care such as MediSave can be used to defray healthcare costs such as medical treatments, and the government’s Home Access Programme provides eligible households with two years of subsidised fibre broadband connectivity and an option to own a tablet, there are no existing schemes to subsidise sensor-enabled homes in Singapore.

PROPOSED EXPANSION INTO SOUTHEAST ASIA

Beyond technological advances, there is a need to expand into Southeast Asia to support other rapidly ageing nations such as Thailand to achieve cost reduction through economies of scale. However, those who wish to export the technology-based SHINESeniors framework to other regional countries to tackle ageing in place need to consider the local context and adapt to it accordingly. Through initial conversations with researchers from Chulalongkorn University, it was discovered that, while cities such as Bangkok face a similar ageing issue, most seniors do not live alone, so they need not rely on a systematic infrastructure of community care to help them age in place. On the flip side though, compared to Singapore, Thai society is more homogeneous in terms of language and culture, which could facilitate widespread smartphone usage even among the elderly.

Leveraging on recent research, which shows that app usage can predict cognitive ability in older adults, we are embarking on a collaborative research study in which we will collect data on how seniors who regularly participate in activities at a Cognition Fitness Centre in Bangkok are using social media, lifestyle and communication apps in a privacy-preserving way. These seniors comprise those who are cognitively healthy, those with mild cognitive impairment, and those with mild dementia. In addition to app usage, it would also be interesting to collect objective data on the out-of-home patterns, as well as activity participation patterns of these seniors. Such research could potentially result in a more cost-sustainable approach towards implementing technology-enabled ageing in place.

It is apparent that the coming of age of sensor technologies and data science allows for continuous and passive monitoring of day-to-day activities of the elderly, both in and out of the home. While the potential for ‘silver tech’ appears vast, it will likely become more palatable for the baby boomer generation who are keen to retain independence in their senior years and have the opportunity to age in place at home or in familiar surroundings.

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References

- ¹ United Nations, Department of Economic and Social Affairs, Population Division, “World Population Ageing 2017”, 2017.
- ² Ibid.
- ³ Singapore Department of Statistics, 2019.
- ⁴ Kawai, “Kodokushi—Dying Alone in Japan”, Hubpages, November 19, 2016.
- ⁵ Nocturia is the medical term for excessive urination at night.



“This sensor monitoring system is good because it is able to detect the lifestyle of the elderly staying in this block. The system will be able to trigger warning signs, and those of us on the ground who are monitoring them will be able to give immediate assistance.”

- Caregiver