Smarter, Safer Homes
Australia’s Ageing Population

1 in every 10 Australian homes is occupied by a person or persons over 65 years and living independently. As our population continues to age, we’ll need new technologies and platforms in the home to support how older Australians live and stay healthy.

The Cloud
When it comes to senior care, the home is much more valuable than the hospital. Smart homes platforms collect and analyse patterns of movement, activity, and consumption. This data, combined with the insights that they use analytics tools to present, becomes the cloud.

Self-Management
Residents can monitor and track their own wellbeing indicators and control data privacy settings through new, no-over tablet apps.

Family
Social interactions translate positively with physical and emotional health. Fraud and reminders ensure people’s rights are being respected and their independence is being maintained, while monitoring their companionship.

Community and Social Care
Central analysis of data from sensors gives carers a comprehensive picture of residents’ habits to live independently and where they could do with some help.

Doctors and Nurses
Doctors and nurses can incorporate data analysis of residents’ wellbeing into their consultations – or intervention if an alert is detected.
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Full Report:

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An Ageing Australia

Australia’s ageing population is steadily increasing. A fertility boom from 1946–65, coupled with advances in healthcare and associated increased life expectancy has seen the proportion of the population aged 65 years and over increase from 8% to 14.7% between 1970 and 2014 (ABS 2014), and is expected to reach 22% in 2050 (Figure 1).

Figure 1: Projected increase in the number of people (per cent of population) aged 65+ in Australia.

Female longevity is apparent in the 85+ group with a ratio of 2:1 females:males and 4:1 in the 100+ group (ABS 2014). Many of these people are still active and independent; however, both activity and independence decrease with age. By the time they reach 85 years or over, some form of aged and/or health care assistance is usually required. As this population subset currently equates to ~456,500 individuals, and is expected to rise to 1.8 million by 2050 (AUIGR 2010), there is a strong incentive to find innovative means of caring for these people.

With an ageing population comes a variety of societal issues. Currently there are five people of working age for every person over 65, but this is expected to drop to 2.7 by 2050 (ACCI 2012). This change is expected to impact economic participation due to a skills void resulting from older people leaving the workplace. There are also ramifications for aged care providers, with a shortage of workers facing a growing number of people requiring aged care services. This in turn puts pressure on families to meet health, social, safety and other daily needs of their elderly members. Many families are time poor and do not have the medical knowledge or the space to take on the health care and residential needs of the elderly.

Health and Wellbeing Challenges for the Elderly

Natural ageing presents challenges for individuals, especially those living alone. Independence and agency are both impacted by the normal processes of ageing which include a decrease in strength, endurance and flexibility; decline in organ function; reduction in bone mass; slowed reflexes and impairment of the senses, particularly vision and hearing. Healthy lifestyles, good nutrition and regular medical care are the most important factors in maintaining health and wellbeing. Even so, the risk of chronic or disabling disease increases with age and the symptoms can sometimes overlap normal ageing processes. For the individual it can be hard to tell the difference between limited flexibility and early signs of arthritis, forgetfulness and early dementia, presbyopia and retinopathy. Almost half of those aged 65–74 have a disability; although only 11% of these experience limitations in their daily activities (AIHW 2012). These figures increase to four of five for 85+ year olds with a disability and more than half of those are limited by it. A similar percentage of people in these age groups have long term health conditions (AIHW 2012).

The most common chronic diseases experienced by the ageing include cancer, cardio- and cerebrovascular disease, respiratory disease and dementia (AIHW 2014a). Heart disease and stroke account for almost a third of all deaths (AIHW 2014b) and are a major cause of disability. Current trends in diet and exercise, and the increase in associated disorders such as diabetes and obesity, could see greater instances of poor health in future aged populations.

Cognitive independence in the elderly is threatened by disorders of brain function. The most prevalent of these is dementia, including Alzheimer’s disease (AD). Dementia affects 24–40% of people aged over 85 (NHMRC 2007), with age of onset ranging from approximately 65 years for AD to ~84 years for other dementias. A higher incidence of dementia in women than men may be partly explained by female longevity. With the increases in the proportion of the population aged 65+, AD is forecasted to affect at least 463,000 people in 2031 (AIHW 2007; NHMRC 2007). The incidence of other neurological conditions also increases with age. Parkinson’s disease (PD) affects 3% of those over 75
years (NHMRC 2007) and the annual risk of stroke is estimated to be 1 in 45 for people between the ages of 75–84, increasing to 1 in 30 for those over 85 years (Anderson et al. 1993). As a result of these neurological conditions, a high percentage of elderly people experience severe or profound limitations.

Postural instability is common in older people and can arise from inactive lifestyle, weakness, slowed reflexes, arthritis, or degeneration in neural or musculoskeletal systems. A serious consequence of postural instability is an increased propensity for falls. Falls in the elderly have a multitude of repercussions including major injuries with associated costs, decreased confidence in daily activities and progressive social isolation. Unattended falls in the elderly living alone can have serious, even fatal, consequences.

The health and wellbeing challenges facing the elderly can be significant and overwhelming. Males aged 75–84, and 85+ have the second and third highest suicide rates, respectively, of all age by gender groups (ABS 2011). Factors contributing to aged male suicidality are thought to include medication side effects, depression and euthanasia. A study conducted with nursing home residents has found that suicide ideation arises from losses in social status, relationships and health, all of which occur within a short timeframe.

Government expenditure on aged health alone and this figure is expected to increase to over 7% in 2050 (AIHW 2011; ATSE 2010). Together, Federal, state, territories and local Governments fund 70% of health expenditure in Australia, with the remaining 30% primarily provided by individuals and private health or injury insurers.

![Figure 2: Projected increases in the number of Australians requiring aged care support in 2050 and in health care expenditure in 2045 in Australia.](image)

The development of assistive technologies has the potential to realise savings in health expenditure. It has been estimated that avoiding as few as 10% of falls would reduce hospital costs by $85 million (ATSE 2010). Regular medical care, increasing awareness of health and of healthy lifestyles, and monitoring of daily activities, have the potential to further reduce hospital costs through avoidance or early detection of degeneration in health and wellbeing.

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**Implications for Healthcare Expenditure**

Several reports demonstrate the impact of an ageing population on health care expenditure (Productivity Commission, 2005; ATSE 2010; AIHW 2011). These reports indicate that the cost of health care increases with age, doubling between 45 and 65, and doubling again between 65 and 85. The average fee for hospital services for an insured patient of <14 years is $172, compared to $4135 for an insured patient of >85 years. Similarly, average costs in the Pharmaceutical Benefits Scheme (PBS) for an older male (aged 65–74) are more than 18 times greater than those of 15–24 year olds. With such a large percentage of our ageing population facing injury, disabling or chronic disease, and regular medical care, health expenditure is rising faster than economic growth (Figure 2).

In 2010, health costs accounted for over 9% of GDP up from 5.2% in 1998. Of this 9%, 4% represents

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**Infrastructure Challenges of an Ageing Population**

A national study of residential aged care service cost and demand, conducted in 2010, found that the number of residents in residential care exceeded 166,000, a 2.5% increase on the previous year (Ansell et al., 2012). The cost of residential aged care services varied from $33,000–50,000 per bed per annum, a cost subsidised by the government at a similar rate to health care costs. Requirements for residential care are predicted to rise at a greater rate than availability, leaving an estimated shortfall of over a quarter of a million places in 2050. In 2011, there were 85 residential aged care places available per 1,000 persons.

Care places and packages are just two of the challenges posed by an ageing population that were the driving force for a Commission for inquiry into aged care (Productivity Commission 2011). Other challenges include an increase in demand and shift in type of aged care provision, with an increased
preference for independent living, reduced access to carers due to changed socio-economic circumstances and diverse geographical spread. These factors have contributed to high costs for residential care and limits on beds and care packages. Following the Inquiry, a range of reforms were implemented aimed at providing more home care, community care and residential care with funding shifts to improve service delivery. Under the Aged Care Reform Agenda, in 2014 the Government introduced residential care fee caps of $25,000, and home care fee caps of $10,000. A lifetime cap of $60,000 on care fees leaves the Government with an increasing tab (Tegart 2010).

The average per day cost of residential care is $118 (ranging from $100 in remote Tasmania to $163 in remote Northern Territory) (AIHW 2011). Most residents (90%) leave due to death, and of these 20% had length of stays of over five years. The substantial costs associated with residential care also provide an opportunity for substantial savings. ATSE reported (ATSE 2010) that “if only 10% of the current residential care group could stay in the community through application of an ‘ageing-in-place’ policy supported by appropriate technologies and receipt of Home and Community Care rather than residential aged care, this could save the Government about $526 million per year”. Similarly, delaying aged care admission by extending independently living, and thus reducing length of stay, would also result in significant savings.

Residential care admission can only be delayed by extending home stay for those elderly capable of independent living. A recent survey found that respondents felt the most important improvement for aged care in Australia was the provision of services to allow elderly people to live in their own homes longer. Furthermore, quality of life has been shown to decline and psychiatric symptoms worsen following nursing home placement. Many older Australians have their own homes and want to stay in them, but require community or family assistance to do so. As their care needs increase beyond the capacity of current external assistance, residential care is the next option. Dementia is the leading cause of nursing home admission, with more than 50% of residents in aged care having a diagnosis of dementia in 2008–2009 (Van Rensbergen and Nawrot, 2010; Luppa et al., 2010). Common health conditions include circulatory system disorders, arthritis and diabetes (AIHW, 2011).

The provision of assistive technologies and in-home monitoring designed specifically for healthy elderly people and those with mild cognitive impairment and early physical degeneration would provide an intermediary step between family or community-assisted home stay and residential care. With over 22% of the population predicted to be aged 65+ in 2050 (AUIGR 2010), there is a strong imperative to develop innovative assistive technologies to support elderly people to stay safely at home longer and therefore reduce costs associated with health and aged care.

**Implementation of Smart Home Systems**

As longevity of older people increases with advances in medical therapeutics and devices, it is very likely the elderly population will prefer and want to live longer in their homes. Aside from their preferences, the cost and lack of residential care placements are additional factors that will influence families to look adopt assistive technologies to support their parents at home. As health and lifestyle monitoring technologies are becoming embedded in our daily life and internet connectivity is becoming pervasive, the baby boomers who are readily adopting these technologies would warrant their homes to be smart to prolong a healthy lifestyle.

The recent emergence and advances in wireless sensor, monitoring technologies and mobile devices become lifestyle oriented and easily deployable and interoperable, integration towards a smart home becomes more feasible. For smart home integration to be effective in supporting an elderly person at home, it needs to be able to determine if functional ability and independence, together with health, are maintained. A few smart home-like products, such as Just Checking (2016), My Lively (2016), and Tunstall (2012), are emerging in the market place that are employing motion and movement sensors to detect daily activity and the possibly of detecting falls. There are already telehealth products such as Telemedcare (2016) and Intel’s Care Innovations (2016) that support health monitoring. These products, however, are more specialised for those with severe chronic illness and are costly for general health monitoring of elderly who remain functionally independent.

Smarter Safer Homes (SSH) is a recent research and development platform by The Australian eHealth
Research Centre, CSIRO (AEHRC), which took advantage of wireless sensor technology and health home monitoring to provide a smart home integration that aligns with user needs design, engagement of informal (eg. family) support and care services. The design employs analytics that capture an individual’s profile of activities of daily living (ADL) from which personal level functional independence or ability can be determined together with health monitoring assigned.

CSIRO’s research on the SSH platform involves determining how personalised ADL and social inclusion are related to health and psychological wellbeing. The primary outcome is the development of a resident’s profile of these factors over a six or twelve month period together with an estimate of the costs and benefits of the SSH platform. Concurrently, CSIRO is partnering with key service providers of aged care to create a model that will closely align with current service delivery models.

The Smarter Safer Homes Project

The SSH project is led by CSIRO’s Australian eHealth Research Centre with multidisciplinary collaboration including universities, aged care service providers and local clinicians. The CSIRO research team has developed an innovative in-home monitoring and data analytics platform, the SSH platform, that seeks to support and extend independence and improve quality of life for aged residents through the use of cutting edge pervasive communication and wireless sensor and monitoring technology. The potential benefits of these technologies are multiplied where distance separates families and adds substantial costs to delivery of health and other services.

The original ‘Smart Home’ concept was proposed in the 1980s and found its application in health and ageing to support independent living of elderly people. Along with the emergence of new technology in mobile computing, smart sensors and the Internet of Things, smart homes are becoming a hot topic and are poised for strong growth in home automation, assistance and health and wellbeing. However, the wide adoption and deployment of smart homes in the senior community are still elusive. We believe there are two main reasons which have limited smart home initiatives. First, the cumbersome use of technology not particularly tailored to ease of use by seniors together with the perception that technology will compromise their privacy and security. Second, there are no personalised and objective indicators of functional independence that determine the health and wellbeing of senior residents within their own home environment.

Motivated by these limitations, the CSIRO SSH platform was designed as a passive activity monitoring system, without the need of intervention by residents, to capture their requirements for support and services. The platform was designed to be interoperable with commercially available sensors and devices. Furthermore, the design included privacy and security considerations, ensuring informed consent of all monitoring and data collection processes. A study with prospective residents further ensured the design was user-centric and met the stated needs of residents, including that the system be flexible, low maintenance and unobtrusive (Bradford et al., 2013).

The CSIRO SSH platform takes advantage of a provisional patent for a personalised measure of functional independence, indexed through the “Objective Activity of Daily Living” (Karunanithi and Zhang 2015) which reflects their health and wellbeing status.

Smarter Safer Homes Platform

The platform includes a sensor-based in-home monitoring system (data collection), a cloud computing server (data analyses), and a client module (data presentation) with an iPad app, a family/carer portal and a clinical portal. Figure 3 shows the architecture of the SSH platform.

Figure 3: Smarter Safer Homes architecture

The novelty of the SSH platform is its features of providing an objective and personalised measure of ADL components and scoring through non-
wearable and non-intrusive sensors in the home environment; and the ability to correlate this measure with self- or care-reported status of health and wellbeing.

**SSH iPad Application**

To access the progress and summarised information derived from the SSH platform, residents are provided with an iPad and ‘Smarter Safer Homes’ app. The app interface was designed with prospective residents (Bradford et al., 2013), and displays the progress status of their activities of daily living, vital signs and physical activity. It also provides personalised alerts and enables a real-time progress update, when deemed necessary by care provider(s). Residents can connect to their family or care services via a video conferencing services within the app.

An example of the app’s dashboard reflecting the daily status of health and wellbeing is represented by the different coloured rays (Figure 4). A three quarter extension of the ray indicates individuals achieving their expected goal of health or wellbeing measures, whereas a ray below is a decline and full ray is an increased in their state of wellbeing.

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**Family and Clinical Portal**

Family members and friends of the elderly living alone often are anxious about their welfare. The platform includes a family portal that allows significant others to gain an insight into the lives of the elderly resident by communicating some of the information pertaining to their everyday lives via a website. There are four levels of access that the resident can make available to family members or nominated contacts. Figure 6 shows the front page of a family member with full access to the smart home data.

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**Figure 5:** Family portal available through internet browser allows approved family members to view resident data.

The clinical portal provides access for health professionals, such as nursing services or GPs, engaged to monitor the resident’s medical profile and health progress. The clinical portal has the capacity to present an individual’s health progress over various time periods (for example, weekly or monthly). The portal can be accessed by multidisciplinary healthcare teams engaged in an individual’s care.

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**Figure 6:** The dashboard screen of a clinical portal includes a list of smart home residents.
Pilot Studies and Evaluation

Since 2013, the SSH platform has been piloted in three states in Australia, in an independent living setting, a nursing care service, and with home care providers, respectively (Figure 7). The SSH platform was deployed to homes connected to either cable, broadband or mobile network. A brief outline of each study is described below.

Figure 7: SSH clinical trials location, period and number of homes.

Independent Living – Regional, New South Wales

This initial project was instrumental to the design and development of the SSH as a technology platform to take advantage of the National Broadband Network being rolled out at Armidale, regional NSW. The SSH iPad app and user interface was designed with the engagement of the senior community (Bradford et al., 2013). This was followed by a 12-month pilot trial among 17 independent living participants aged 78-92 years, with sensors deployed around their homes in a manner intended to be as unobtrusive as possible. One objective of the study was to explore usability and acceptability of the SSH platform. The study found that after an initial period, residents were unfazed by the technology, and that positive outcomes included increases in family communication, enhanced health autonomy, and advances in technology uptake. This study also demonstrated the capacity to extract the fundamental domains of ADL (such as mobility, transfer, hygiene, meal, and grooming) from a fusion of unobtrusive home-sensor data, using through machine-learning techniques (Zhang et al., 2013, 2014). Although the study was observational and not interventional, a retrospective analysis of an adverse event demonstrated the potential of the sensor data for early detection of health related incidents, which may allow for timely intervention (Bradford and Zhang, 2016).

Nursing Service – Metropolitan Melbourne

This three month, proof of concept trial tested the feasibility of the SSH platform to deliver remote nursing services to three elderly people living at home. During this trial, an ‘unsupervised’ method was used for discovering daily activities. This method will allow automatic detection of daily routines to further refine indicators of functional decline (Yin et al., 2015). Despite the short period of the study, the three carers/nurses reported that the SSH iPad App was simple and easy to use and the presentation of ADL data was found to be supportive in determining the wellbeing of the resident, facilitating enhanced delivery of the nursing service. Furthermore, feedback also indicated that the real-time surveillance of functional dependence feature of the SSH platform was considered to be a plausible option for family members and nursing services to keep a watch on vulnerable loved ones.

Home Care and Disability Service – Sunshine Coast, Queensland

The purpose of this study, conducted 2014-15, was to explore the viability of the SSH platform for home care providers to enhance their services for aged care residents and people with a disability. This study demonstrated that the platform was able to provide valuable insights to care providers, allowing them to attend to their residents either when their vital signs were abnormal or their functional independence measures were low. The outcome of the studies included the additional feature to the SSH platform for close and real-time monitoring of residents at need and also the value of sleep data to determine the resident’s wellbeing. These additional features both resulted in interventions, either with carers attending through home visits or with residents visiting their GPs. During this study, the SSH platform was tested in a dual occupancy environment where the resident, who had suffered a stroke was assisted and monitored by his partner
who was employed full time. The SSH platform, allowed his partner to closely monitor his ADL and health remotely while at work (Dodd et al. 2015). Furthermore, the analysis of data from the dual occupancy environment was instrumental to CSIRO’s strategic research exploring the tracking of an individual resident’s functional wellbeing in a multi-resident setting (Yin et al. 2016).

Benefits of SSH Platform Technology

As the population ages with people living longer, the Australian government is making some fundamental changes to aged care. In recognition of people wanting to stay at home longer and be connected to family, investments into aged care are moving away from the traditional residential care to a focus on home support and home care packages. These reforms, called Consumer Directed Care, are providing the choice and flexibility to older Australians to age in their home rather than moving to residential care.

The SSH platform is designed to provide the very support at which the Consumer Directed Care (CDC) is aimed. The platform enables consumers (the ageing parent(s)) to engage their family/carer or aged care support through access to their daily status of health and wellbeing. Through a wealth of up-to-date and trending information of resident’s progress, functional measures of independence and health status via the SSH platform, care and support can be enabled in a preventative and timely manner, and in accordance with their individual profile.

The potential savings afforded by the SSH platform can be estimated by applying CDC funding rates to historical data available on residential care 2010–11 (AIHW 2011). This estimate assumes that people 75 years and under could be monitored with the SSH platform for their ADL and subsequently supported through effective engagement of appropriate social and health services. Based on the Aged Care Funding Instrument (ACFI) assessment entry to residential care, 164,000 people were permanent residents of aged residential care as at June 2011. Eligibility for the CDC includes access to Australian government funds of $10,140 per year for home services and support versus $25,500 per year for residential care.

Case 1: As at June 2011, 5246 people aged under 75 years were permanent aged care residents with a

‘low care’ appraisal. If these people could be supported at home with the SSH platform, the cost savings to the government could potentially be up to $80 million each year.

Case 2: If the SSH platform were to be extended to provide medium level ACFI based clinical and assistive care support this would cover an additional 6240 people (as at June 2011), with cost savings could potentially be up to $176 million.

As baby boomers are now entering their retirement age of 65 years, it is very likely that they will take more ownership of managing their assisted living lifestyles, as they are better accustomed to technology advances and use of digital features in everyday life. The improved quality of life, enhanced health outcomes and costs savings afforded by the SSH platform will provide better economic status and longevity and is expected to allow baby boomers to live well beyond the age of 75 years in their own home.

Summary

Over the next few decades, ageing of the population is expected to have large implications for the way in which the lifestyles of older Australians are managed and in particular to the health services sector. The current status of limited residential care placements and aged care staff is a significant problem. The Australian government’s recent aged care reforms are providing flexibility and ownership to the consumers to live longer in their own homes. To better enable this, particularly with the declining numbers of aged and health care staff, recent initiatives are looking at developments in technology based support platforms, such as smart homes. The SSH platform allows for dignified ageing for Australian elders and facilitates efficient and effective service delivery which brings people peace of mind and enhanced quality of life for elders and their families. The system promotes social inclusion and helps to drive down the costs of healthcare to benefit all Australians, every day.

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