DEVELOPING A TECHNOLOGY ROADMAP FOR THE AUSTRALIAN AGED CARE SECTOR: **LITERATURE REVIEW SUMMARY**

AUTHORS: DR KATE BARNETT, PROF KAREN REYNOLDS, PROF SUE GORDON, PROF ANTHONY MAEDER, DAVID HOBBS

PREPARED BY THE MEDICAL DEVICE RESEARCH INSTITUTE, FLINDERS UNIVERSITY FOR THE AGED CARE INDUSTRY IT COUNCIL (ACIITC)

FEBRUARY 2017

CONTENTS

TABLES

1. Technology and positive ageing

Technology has the potential to make the experience of ageing more positive and to radically transform the way in which people receive services and supports as they grow older. This reflects the rapid and continuous growth of new technologies which have become integrated into everyday life, shifting from the 'rare' to the' normal' in a matter of a decade or so.

> *Australia is on the cusp of two of the greatest disruptive transformations in history: the ageing of the population and a technological revolution. How the nation manages with both of these prospects will determine its fortune (McKell Institute 2015).*

An array of disruptive technologies are shaping our lives including cloud computing, additive manufacturing (3D printing), wearable technologies, nanotechnologies, 'big data' (achieved through linked large data sets), mobile apps, the sharing economy (Uber, AirBnB), autonomous vehicles, and a range of technologies defined as 'smart' because of their digital solutions (smart homes, smart cities) as well as the Internet of Things (IoT). These have significant potential to increase the capacity for independent living of older people, and to enhance the way in which services for older people are provided.

Technologies are also becoming more accessible to consumers who can choose to adopt them to enhance the quality of their lives, and increasingly, to support independent living - regardless of age or disability related conditions. Aged 'care' is no longer driven by policy makers and service providers – increasingly it is driven by consumers themselves and by technology experts. It is time for all these stakeholders to work together as the boundaries blur between care, technology and living. Co-design and collaboration are critical.

2. Methodology for the Literature Review

The Literature Review has explored both the academic and 'grey' literature and while there are a vast number of published studies, there are few with robust methodologies, and few designed to assess the effectiveness of different technologies on healthy and positive ageing. In part, this reflects the need for developers of technology to determine if their product fulfils its function (and a significant amount of research is devoted to this issue), and address the disconnection between the speed of technological change and the time needed for longitudinal studies that can measure the effectiveness of technologies. Large randomised controlled trials (RCTs) involving control and experimental groups typically require a five year timeframe to collect reliable data and this can be too long in the face of rapid technological change.

A challenge then is to develop sound but nimble methodologies that can meet these competing demands, perhaps by rapid trials, repeated over time with the same subjects or by case studies series based on specific needs.

In reviewing the academic literature, our strategy has been to begin with systematic and meta-reviews that exclude studies of dubious methodology and to interrogate individual studies cited in those reviews. We undertook a search of major research databases and focused on studies confined to the last five years.

3. Technologies that can benefit older people: trends identified

Technologies can be categorised into those specifically designed to assist older people to manage challenges (Assistive Technologies) and those that benefit older people without having been designed specifically for this purpose (for example, Virtual Reality, 'Smart Living' devices). There are hybrid technologies that blur the boundaries between both groups. As a rule, the academic literature focuses on the former group while the grey literature has more information about emerging, disrupting technologies.

Assistive Technologies are the outcome of an evolution from non-technology enabled aids and equipment (eg walking frames) and are themselves beginning to shift to a more advanced stage. Most are not designed to repair or modify an impairment, but as technology advances, the scope for *therapeutic* technologies is increasing. For example, functional electrical stimulation (FES) has significant potential for restoring movement, while robotic exoskeletons enable movement. These advances are dissolving the boundaries between purely assistive and therapeutic technologies (Cowan et al 2012: 3-8).

Sensor technologies and remote monitoring

Sensor-based monitoring of people living at home has immense potential for supporting independent living and there are significant numbers of commercial installations globally. Although research into the use of monitoring technologies is widespread, there is little strong evidence of effectiveness. The research consists mainly of small-scale studies and includes few longitudinal studies (Peetoom et al 2014). Nevertheless, their positive role in supporting telehealth and telecare to manage chronic conditions, and in enhancing community and residential aged care is becoming increasingly apparent. Combined with 'Smart Living' technologies, sensors also have an important role to play in supporting independent living at home.

In 2016, **4.9 million** people worldwide were remotely monitored by health care providers, with the number having increased by *51 percent* from 2015, as acceptance increases of connected medical devices being used as a part of the care process (connected medical devices used for various forms of personal health tracking are not included in this figure). The number of remotely monitored patients is forecast to grow at a compound annual growth rate of **48.9** percent to reach **36.1 million** by 2020. Furthermore, the use of patients' own mobile devices as health hubs is becoming an accepted part of remote patient monitoring (Berg Insight 2016a).

The evolution of sensor technology is apparent in the literature, moving from a reliance on sensors *embedded* in an environment (a home, or a care facility), to sensors that are *wearable*, to sensors that are *implantable or injectable* into the human body. The

development of portable sensors (wearable or implanted) brings significant scope for customisation to individual need and preference. Implantable devices offer the potential of targeted treatments, because they affect a specific organ and avoid the side effects commonly associated with traditional medicine formats and injectable drugs.

As with all technologies, developments in external fields also influence evolution. Key enablers include smartphones, longer lasting batteries, new materials and fabrics (including smart clothing, textiles and jewellery). Nanotechnology makes possible the printing of sensors with very fine features onto flexible rolls of plastic, in large quantities, at low cost. Changing the structure of materials through nanotechnology holds a range of possibilities, for example, creating water-repelling textures, adding coatings that allow materials to repair when damaged and creating textiles which can regulate temperature. All of these developments have significant potential in the future support and care of older people.

While the use of monitoring technologies is driven largely by the health sector as part of the management of chronic health conditions, these could also be used by the aged care sector (in both residential and community services), ideally based on partnerships between both sectors. The range of user-friendly technologies available, especially via mobile phones and tablets, and the emerging array of health promoting apps, means that consumers are able to access information that helps them monitor and self-manage their condition. Research findings indicate that self-management is critical to effective chronic disease management (Pellegrini et al 2014: 344; Morrison et al 2012: 6).

Apps

Apps have quickly become an integral part of everyday living for many people. In 2014, Apple reported that 75 billion apps had been downloaded from its App Store and half of that number had been downloaded in the previous six months[1]. There has been substantial growth in iPhone sales and there is a direct association between smart phone ownership and App usage.

- Smartphone ownership in Australia increased from 11.1 million in 2013 to 15.3 million in mid-2015. During the same period, tablet ownership increased from 6.3 million to 11.2 million.
- The number of Australians with a smartphone is estimated to increase from an average of 78 % in 2013 to a saturation level of about 81% in 2017. [2]

[1] O'Brien C (2014) Volume of Apple app purchases exploding, *The Age*, Melbourne 25/7/14.

[2] Vision Mobile (2014) The European App Economy 2014 – https://www.visionmobile.com/blog/2014/08/european-app-economy-2014-europe-losing-ground-asia

https://yump.com.au/2016-australian-mobile-statistics-how-digital-is-increasingly-a-mobile-first-experience/ drawing on data from IAB Australia, Google's Consumer Barometer and Think with Google).

Not only do Apps have a role to play in providing services, but the data generated through their use offers significant secondary benefits by providing reliable and real-time data on patterns of service use, needs and preferences.

The Smart Living technologies

The transformative impact of technology on everyday lives and living is most apparent in the developing 'Smart' living market. This involves embedding a range of largely digital technologies that produce greater automation, energy efficiencies and easier management of day to day activities applied to homes (Smart Homes), work (Smart Workplaces) and communities (Smart Cities, Smart Towns, Smart Communities).

As these technologies evolve, they highlight the growing importance of people's homes and local environments to support independent, healthy and positive ageing. Smart Homes must form part of an overall strategy to enable people to live independently in their own homes. The collaboratively developed *Smarter Safer Homes for Older Australians* initiative (Case Study 1, Main Literature Review Report) demonstrates what is possible in supporting positive ageing through the Smart Home (CSIRO 2016).

SMART HOMES: A RAPIDLY EXPANDING MARKET

The Smart Home market is relatively recent but growing rapidly, with consumer awareness and acceptance increasing as major organisations like Target, Apple and Telstra sell home automation products. North America has the most advanced market globally with **9.7 percent** of all households living in a Smart Home. Between 2015 and 2020, a **31** percent compound annual growth rate is forecast for this region, and a **54** per cent growth rate for Europe where 2.4 per cent of households live in a Smart Home. Smartphone apps are the most common user interface for smart home solutions and importantly for older consumers, these are increasingly likely to be voice driven (Berg Insight 2016b).

Across the literature as a whole, where the relationship is explored between technology and its application in aged care, the focus is on community based care and only a handful of studies have involved residential aged care. That said, much of the research evidence associated with telehealth and telemedicine, including monitoring through the use of different types of sensors, has been undertaken in the health sector but is transferable to the residential aged care sector.

4. Evidence for technology's contribution to positive ageing

The research literature provides a small but growing evidence base about the effectiveness of certain technologies in targeting specific needs and enhancing independent living, with or without aged care services. In particular, technology has been found to play a role in:

- ✓ Assessing need, including through automated assessments.
- ✓ Promoting independent living (mainly through monitoring technology).

- ✓ Reducing social isolation and increasing social connection.
- ✓ Reducing the risk of falling.
- ✓ Managing chronic disease.
- ✓ Supporting people with cognitive issues, including dementia.
- ✓ Reducing or managing depression and enhancing well-being.
- ✓ Improving medication management.
- ✓ Supporting family carers.

One systematic review evaluated different technologies against specific care interventions. The authors assigned a score between 1 and 3 (**3** being *Very Effective*; **2** being *Effective*; and **1** being *Not Effective*) and the average scores per technology type across a range of studies on each issue are summarised in *Table 1.*

TABLE 1: AVERAGE EFFECTIVENESS SCORE BY ISSUE ADDRESSED AND BY TYPE OF TECHNOLOGY APPLIED

Type of technology	Issue addressed							
	Chronic disease	Dementia	Depression	Fall risk	Independ living	Medication managemt	Social isolation	Well-being
Robotics			**2**		**2**		**1.8**	**2**
General ITC		**2**	**3**				**2**	**2.4**
Sensor technology		**2**		**2**	**2.4**			
Telemedicine	**2.5**				**2**			
Medication dispenser						**1**		
Video games				**3**				

Source: Khosravi & Ghapanchi 2016: p 23.

4.1 Assessment of need

The current and potential role of technology is not reflected in the aged care system's requirements for assessors. Whether or not new technologies are used in the assessment of consumer needs, and in the development of a service response, is currently a matter of chance, rather than design, and depends on organisational and individual assessors' familiarity with these potential solutions. Employees (assessors and care providers) are currently selected for their clinical knowledge, rather than technology-related training, skills or knowledge.

Furthermore, despite the availability of technology that supports assessment of function and need, such technologies are not an *embedded* feature of assessment processes. These technologies have the capacity to save resources by saving time and improving the capacity to track and maintain client records, and by facilitating more effective assessment and monitoring changes in capacity. Some technologies, for example, sensors, can yield information which a single or even repeated assessment may miss (Sprint 2015: 64).

Automated assessment is likely to be a further feature of technology-driven assessment reform, assuming it can achieve a high utility to cost ratio and support scalable health and aged care (Sprint 2015: 73). It can also empower consumers by supporting *self-administered* assessment – a highly appropriate outcome for aged care reforms that promote consumer choice and control. Smartphones also offer significant promise because of their ability to capture a range of data, making assessment a *portable* activity whose data can be analysed anywhere at any time.

4.2 Managing chronic health conditions

In 2014–15, more than 11 million Australians (50%) reported having at least one of the eight main chronic diseases. This rate is positively associated with age, being higher for those aged 65 and over **(87%)** compared with people aged 0–44 (35%) (AIHW 2016).

Reviewing the literature as a whole, *telemedicine* emerges as very effective in managing chronic health conditions, improving functional status, general health and wellbeing. The systematic review by Khosravi and Ghapanchi (2016: 23) concluded that of all the technologies studied for their effectiveness, telemedicine was the only one applied to assist older people living with a chronic health condition to show significant changes that included improved health conditions, reduced use of general practitioners and reduced hospital readmissions (Tegart et al 2014: 8; Wootton 2012: 213).

Evidence is growing about the effectiveness of monitoring technologies, in Australia and internationally. The *Whole Systems Demonstrator Project* was a two year research project which aimed to create the largest evidence base for tele-healthcare in the United Kingdom. At the time (it began in May 2008), it was the largest randomised control trial of telehealth in the world. By providing a range of telehealth technologies in the home, it achieved a 15% reduction in accident and emergency visits, a 20% reduction in emergency admissions, a 14% reduction in hospital stays and a 45% reduction in mortality (Tegart et al 2014: 8 citing Steventon et al 2012). In Australia, the CSIRO Home Monitoring project also highlights what is possible, finding a **36 per cent** decrease in hospital admission and a **42 per cent** reduction in length of stay if admitted to hospital during the 12-month trial; and a reduced mortality rate of more than **40 per cent** among participants (CSIRO 2016 and see **Case Study 2** in the main Literature Review Report). The table below summarises key literature findings on the effectiveness of telemedicine in managing chronic health conditions.

TABLE 2: EFFECTIVENESS OF TECHNOLOGY IN MANAGING CHRONIC HEALTH CONDITIONS

Technology	Outcomes	Authors
Telemedicine	Increased quality of life	Sicotte et al 2011
Telemedicine	Enhanced health literacy and self-management of health	CSIRO 2016
	Reduced anxiety and depression	
	Improved quality of life	
	Reduced falls	
	36% decrease in hospital admissions; 42% reduction in hospital length of stay; reduced primary health care usage	
	40% reduced mortality rate	

Technology	Outcomes	Authors
Telemedicine	36% decrease in hospital readmissions	Giordano et al 2009
	31% decrease in episodes of hemodynamic instability	
	Heart failure-related readmissions decreased	
Telemedicine	Improved glycaemic control, blood pressure, total & low-density lipoprotein cholesterol levels	Shea et al 2006
Telemedicine	Reduced hospital readmissions + emergency visits.	Pinto et al 2010
	Improved functional status	
Telemedicine	Increased social functioning	Gellis et al 2012
	Improved general health	
	Reduced depression	
Telemedicine	Successful insulin injection	West et al 2010
Telemedicine	Successful foot care	
Telemedicine	No significant change in pulmonary function	Chau et al 2012
	No significant change in health-related quality of life	

Sources: Khosravi & Ghapanchi 2016; CSIRO 2016

4.3 Supporting independent living

Although there is a need for more research on this issue, a range of different technologies are being found to support independent living, as *Table 3* indicates. Monitoring via sensor technologies contributes to this outcome, identifying changing patterns of activity and reducing falls (see also *Section 4.4)* and hospitalisation rates associated with these. Smart Homes using sensor systems can effectively monitor falls, mobility and performance of activities of daily living (ADLs), regulate ambient temperature and operate household appliances and systems. Robotic stride assistance systems are effective in improving walking speed. The effectiveness of virtual reality and gaming cannot be ascertained with confidence, at this stage, although the grey literature indicates that this will become increasingly important in the future. An emerging field is the *'gamification of therapy'*, that is, the use of video games as therapeutic tools.

TABLE 3: EFFECTIVENESS OF TECHNOLOGIES IN SUPPORTING INDEPENDENT LIVING

Technology	Outcomes	Authors
Motion sensor	Delayed entry to long term care for 3 out of 8 participants	Van Hoof et al 2011
Passive sensor system	All users found sensor-data interface useful for identifying changing client activities	Alexander et al 2011
Various sensor technologies	Significant reduction in falls	Rantz et al 2013
	Reduced hospitalisation	
	Reduced emergency visits	
Robot (robotic stride assistance system)	Improved walking speed	Shimada et al 2009
Use of a combination of technologies	Improved care efficiency, reduced health care costs, deferred entry to residential care, enhanced independence	Peetoom et al 2014 reviewing multiple studies
Smart Homes using sensor systems	Effective monitoring of falls, mobility & performance of ADLs; regulating temperature, operating household appliances & home entertainment systems	Morris et al 2013 reviewing multiple studies

Technology	Outcomes	Authors
Virtual reality and gaming e.g. Nintendo Wii; Dance Revolution Dance Mats	No studies evaluated effect on activity or participation, or feasibility regarding safety, training required, costs, or assistance required	Morris et al 2013 reviewing multiple studies

Sources: Khosravi & Ghapanchi 2016; Peetoom et al 2014; Morris et al 2013

Despite advances in sensor technologies, a significant gap in our knowledge involves determining when or how changes in the profile of activity should trigger a call for assistance (Brownsell et al 2011).

4.4 Falls prevention and management

Interventions to minimise fall risk focus on both the individual (building capacity) and their environment (removing factors that enhance the risk of falling), and increasingly, technology has an important role to play in both. In relation to falls, assistive technologies can be further divided into (1) those designed to *prevent* a fall from occurring; and (2) those which aim to *manage* the outcome of a fall after it has occurred. Technologies in the second category are widely known as fall detectors and apart from being important in alerting services and supporters to a fall event, if their detection is timely, they may reduce hospitalisation or shorten hospital stay (Steventon et al 2013: 502).

There is emerging evidence that falls could be prevented with appropriately designed intervention programs, and sensor-based tests hold significant promise for more frequent and accurate assessment of fall risk in clinical and home settings (Ejupi et al 2016). Video games are also being used to prevent falls (Khosravi & Ghapanchi 2016: 20). *Table 4* summarises findings on fall-reducing technologies.

TABLE 4: EFFECTIVENESS OF TECHNOLOGIES IN REDUCING FALLS

Technology	Outcomes	Authors
Fall risk assessment sensor	18% reduction in falls	Lancioni et al 2013
Wireless bed sensor	18% reduction in falls.	Cowan et al 2012
Smart Homes using sensor systems	Effective monitoring of falls	Morris et al 2013 reviewing multiple studies

Source: Khosravi & Ghapanchi 2016; Morris et al 2013

4.5 Reducing isolation and enhancing social connection

Various technology-based interventions exist to reduce social isolation but research demonstrating their effectiveness among older people is scarce. These technologies have been grouped into eight main categories by a recent systematic review: general ICTs, video games, robotics, Personal Reminder Information and Social Management system (PRISMS), asynchronous peer support chat rooms, social network sites (SNSs), Tele-Care, and 3D virtual environments (Khosravi, Rezvani & Wiewiora 2016). On the whole, findings are mixed. The most positive findings are associated with telecare, followed by general ICTs and then by robotics (see *Table 5*).

Mixed results have been found for technologies' impact on *loneliness* (Chen & Schultz 2016; Morris et al 2014: 147) but this is a much more complex issue to address than isolation. A shared conclusion across all studies reviewed is that there is a need for further research on the role technology can play in reducing isolation and increasing social connectedness.

TABLE 5: EFFECTIVENESS OF TECHNOLOGIES IN REDUCING SOCIAL ISOLATION

Technology	Outcomes	Authors
Internet + social media	Reduced social isolation	Ballantyne et al 2010
General ICT	Increased physical activity.	Blažun et al 2012
	Increased social inclusion	
General ICT	Increased level of satisfaction	Bradley & Poppen 2003
	Decreased social isolation	
Computer training & use	Reduced social isolation	Blažun et al 2011
	Increased quality of life	
Robot (mobile remote presence systems)	Reduced social isolation	Beer et al 2011
	Reduced travel costs	
Robot (pet-type, AIBO)	Decreased stress	Kanamori et al 2002
	Reduced social isolation	
Robot (pet-type)	Reduced social isolation	Wada et al 2007
Robot (relational agents)	No significant differences between groups	Bickmore et al 2005
Interactive online programs	Improved social support, enhanced health related literacy, increased empowerment	Morris et al 2014
Various ICTs	Improved social support Reduced social isolation	Chen & Schultz 2016
Various ICTs, telecare, robot companions	Reduced loneliness Reduced social isolation	Khosravi, Rezvani & Wiewora 2016

Sources: Khosravi & Ghapanchi 2016; Khosravi, Rezvani & Wiewora 2016; Chen & Schultz 2016; Morris et al 2014

4.6 Reducing depression and enhancing wellbeing

Evaluation of the effectiveness of different technologies in reducing depression has found general ICTs to be most effective, with one major study attributing a 20 to 28 per cent reduction in depression to strategic use of this form of technology. Multiple studies of the application of general ICTs and pet-type robots have also emerged as effective in reducing depression, improving wellbeing, mood, life satisfaction and social interaction, as well as enhancing perceived control of health and wellness and a sense of empowerment among users.

TABLE 6: EFFECTIVENESS OF TECHNOLOGIES IN REDUCING DEPRESSION AND ENHANCING WELLBEING

Technology	Outcomes	Authors
Robot (pet-type)	Increased social interaction	Wada et al 2007
Robot (pet-type)	Improved mood	Wada et al 2003
	Reduced depression	
Robot (pet-type)	Improved well-being	Wada et al 2006
Robot (pet-type)	Increased social interaction	Wada et al 2004

Technology	Outcomes	Authors
	Improved well-being	
Robot (pet-type)	Increased demonstrative language	Kanamori et al 2003
	Increased satisfaction	
General ICT	Reduced stress	Salovaara et al 2010
General ICT	Improved well-being	Shapira et al 2007
	Increased sense of empowerment	
General ICT	Improved life satisfaction	Karavidas et al 2005
General ICT	Increased perceived control over health & wellness	Campbell & Nolfi 2005
General ICT	20%-28% reduction in depression	Cotten et al 2012
Telemedicine	Increased quality of life	Chou et al 2013

Source: Khosravi & Ghapanchi 2016

4.7 Supporting people with dementia

The research literature on the role technology can play in supporting people with dementia is as notable for its gaps as it is for its contribution to the evidence base. One systematic review identified that most studies focused on *safety-related* devices (especially falls prevention, tracking or way finding and cooking safety), followed by memory aids, technology to prevent social isolation (with companion robots being an emerging technology) or to support activities of daily living, and clinical devices of various kinds (particularly music therapy and symptom monitoring) (Evans et al 2015: 410).

TABLE 7: EFFECTIVENESS OF TECHNOLOGIES IN SUPPORTING PEOPLE WITH DEMENTIA

Technology	Outcomes	Authors
ePAD artificially intelligent touch screen encouraging interaction	Participants engaged via this technology but further work needed on its prompts	Leuty et al 2013
Non-intrusive sensors	Early detection of deteriorating condition	Aloulou et al 2013
	Increased professional carer satisfaction	
Pictorial instruction program using laptop computer and commercially available, inexpensive video editing software	Successfully supported activity and travel among people with moderate Alzheimer's disease	Lancioni et al 2013

Sources: Khosravi & Ghapanchi 2016; Aloulou et al 2013; Lancioni et al 2013; Leuty et al 2013;

Assessment of the use of monitoring systems is a prominent research topic, reported to have benefits for both the person with dementia (by supporting independent living) and their relatives (by addressing concerns about safety) (Bossen et al 2015: 4-5). There is a trend for research to focus on the outcomes of technology for *family and informal caregivers* rather than people with dementia (Bossen et al 2015: 4-5).

However a systematic review has identified that there is insufficient sound research to be clear about the impact of technology on carers of people with dementia (Godwin et al 2013: 221). This is despite the range of telemedicine technologies providing information, education and support to them.

Furthermore, few devices have been developed with quality of life in mind, few address behavioural issues associated with dementia, and none are available to support recreational activities. A major gap involves the lack of technologies developed using co-design with people with dementia (Evans et al 2014: 415; Bossen et al 2015: 9).

The grey literature identifies an *emerging* role for virtual reality technology in enhancing mood, wellbeing and engagement levels among older people, and in particular, those living with dementia. **Case Study 5** in the main Literature Review report illustrates the application of Virtual Reality technology by Australian provider *BlueCross* while **Case Study 4** overviews a major randomized controlled trial applying the Internet of Things (via a purposively designed connected range of devices) to support people living with dementia.

4.8 Supporting family caregivers

There is a limited amount of reliable research in the current literature on the impact of technology on informal carers. Nevertheless, those that do exist have found that assistive technologies contribute to the support of caregivers of older adults by reducing the amount of time, assistance and energy required in providing care, and by lessening anxiety and fear, task difficulty, safety risk (particularly for activities requiring physical assistance) while increasing the independence of the person in their care (Marasinghe 2016: 357). Telemedicine and monitoring technologies have been found to be effective in reducing carer stress and 'sense of burden', as indicated in *Table 8*.

TABLE 8: EFFECTIVENESS OF TECHNOLOGIES IN SUPPORTING FAMILY CAREGIVERS

Technology	Outcomes	Authors
Various telemedicine technologies	Reduced carer stress Reduced carer workload	Mahoney et al 2011 ; Marasinghe 2016; Mortensen et al 2013, 2012
Intelligent System for Independent Living for people with cognitive impairment	Reduced carer stress Maintenance of carer quality of life	Mitseva et al 2012
Monitoring & alarm technology for people with dementia	Carer stress and workload reduced because they perceived there was less risk & increased safety for the person in their care	Olsson et al 2012
Internet-based education, support and interaction for carers of people with dementia	Reduced carer stress, depression, pain and significantly improved mental health status, self-efficacy, and social support	Lorig et al 2012 Marziali & Garcia 2011

4.9 A role for robotics

There are a number of ways robot technologies can assist older people to live independent lives, with two types featuring in the literature – pet or companion type robots, and lower limb ATs to assist with mobility (most of these being exoskeletons that are fitted to the outside of the limbs). These findings are summarised in *Table 9*.

TABLE 9: EFFECTIVENESS OF ROBOT TECHNOLOGY IN REDUCING DEPRESSION AND SOCIAL ISOLATION

Technology	Outcomes	Authors
Robot (pet type)	Improved mood	Wada et al 2003
	Reduced depression	
Robot (mobile remote presence systems)	Reduced social isolation	Beer et al 2011
	Reduced travel costs	
Robot (pet-type, AIBO)	Decreased stress	Kanamori et al 2002
	Reduced social isolation	
Robot (pet-type)	Reduced social isolation	Wada et al 2007
Robot (relational agent)	No significant differences between groups	Bickmore et al 2005
Robot (relational agent)	Significant improvement in emotional, visual & behavioural engagement of people with dementia	Khosla et al 2016
Lower limb exoskeleton with training & exercise regime	Improved walking speed + increased fitness	Morris et al 2014 citing Shimada et al 2009
Upper limb robotic trainer	Improved motor function	Morris et al 2014 citing Saeki et al 2008

Sources: Khosravi & Ghapanchi 2016; Khosla, Nguyen & Chu 2016; Morris et al 2014

4.10 Smart Homes to support independent living

There is a relatively small amount of robust research testing the effectiveness of Smart Home technologies to support older people to live independently, while the amount of essentially descriptive studies is large (Morris et al 2014: 21; Reeder et al 2013: 574; Demiris & Hensel 2008: 35: Martin et al 2008: 5; Calvaresi et al 2016: 2; Brownsell et al 2012). The literature has been growing rapidly, particularly since 2010, but it has *followed* rather than led this technology sector driven field (Wilson Hargreaves & Hauxwell-Baldwin 2013: 3). This helps to account for the relatively minor focus on testing the effectiveness of Smart Home technologies to support independent living for older people.

Nevertheless, research findings indicate that *multiple* technology components that include activity sensing, and are *tailored* to individual need and preference can support independent living at home (Reeder et al 2013: 574-575). Emerging evidence can be described as promising – see *Table 10*. The CSIRO 'Living at Home Longer' initiative (described in **Case Study 6** of the main Literature Review report) is adding to the evidence about the effectiveness of Smart Homes.[3]

[3] http://www.csiro.au/en/Research/BF/Areas/Digital-health/Improving-access/Smarter-safer-homes

TABLE 10: EFFECTIVENESS OF SMART HOMES IN SUPPORTING INDEPENDENT LIVING AND HEALTHY AGEING

Technology	Outcomes	Authors
Range of smart home technologies	Frail older people in experimental group maintained physical & cognitive capacity while control group deteriorated over 2 yrs	Tomita et al 2007
Range of smart home technologies	Enhanced safety and security	Morris et al 2013
	Enhanced independence	
Multiple technologies, including sensors, tailored to consumer	Enhanced independence	Reeder et al 2013

Sources: Morris et al 2014, 2013; Reeder et al 2013

5. Concluding comments

Regardless of their functional capacity and effectiveness in supporting independent living, technologies that can enhance the quality of life of older people face considerable challenges in being adopted by consumers and integrated into practice by health and aged care professionals. There are impediments to uptake at a number of levels:

- *Individual readiness:* Australian consumers are noted as fast adopters of new technology but among very old people several studies have identified a lack of confidence in using assistive technologies, exacerbated when health and aged care providers share this lack of confidence. The *Digital Divide* is particularly apparent for people aged 65 and older (Thomas, Barraket, Ewing et al 2016). Developing skills to become technology-literate, tailoring solutions to individual capacity and providing support in the use of Assistive Technologies is critical.
- *Workforce readiness:* A key challenge involves building a technology literate aged care workforce. This will require regular training and upskilling so that technologies are known, understood and integrated into care provision.
- *Organisational readiness:* While aged care organisations have integrated a range of technologies, particularly ICTs, into their *operational* processes a similar adoption of technology is not evident in relation to their *provision of care.* However, some individual organisations are leading change in this area.
- *System readiness:* The application of technologies to support the delivery of aged care in Australia is patchy, reflecting the absence of policy and overarching strategies that support the integration of care-supporting technologies into aged care funding, standards and services.

There are a number of issues that must be addressed in applying technologies for the benefit of older people and these include ensuring that ethical standards are addressed, together with issues relating to privacy and cyber security.

There is a need for technologies to be designed, trialled and implemented collaboratively, involving end users, ageing specialists and aged care providers and policy makers, as well

as a range of disciplines. Co-design and co-evaluation must underpin technologies intended to benefit older people. The *Technology Roadmap for Aged Care* could provide the catalyst for the establishment of a national hub to support collaboration between multiple stakeholders.

The review of research literature reveals an embryonic but growing evidence base for the effectiveness of particular technologies in enhancing the provision of health and aged care services, and more broadly, in enabling people to continue to live independently as they grow older. These technologies can support consumer preferences and policy directions that seek to avoid unnecessary entry to long term residential care, and the creation of greater choice and control in the design and delivery of aged care.

In the past, formal care services, and the care and support of significant others, constituted the twin arms of support for older people. It is now evident that technology provides a third arm. The challenge is to ensure that this new trinity works in harmony, as a smoothly functioning team.

References

Alexander G, Wakefield B, Rantz M et al (2011) Passive sensor technology interface to assess elder activity in independent living, *Nursing Research,* 60(5): 318-325. DOI: 10.1097/NNR.0b013e318225f3e1

Aloulou H, Mokhtari M, Tiberghien T (2013) Deployment of assistive living technology in a nursing home environment: methods and lessons learned, *BMC Medical Informatics & Decision Making,* 13: 42. DOI: 10.1186/1472-6947-13-42

Australian Institute of Health & Welfare (2016) *Australia's Health* - http://www.aihw.gov.au/australias-health/2016/ill-health/#t4

Ballantyne A, Trenwith L, Zubrinich S & Corlis M (2010) 'I feel less lonely': what older people say about participating in a social networking website, *Qual. Ageing Older Adults,* 11: 25–35. DOI: http://dx.doi.org/10.5042/qiaoa.2010.0526

Beer J & Takayama L (2011) Mobile remote presence systems for older adults: acceptance, benefits, and concerns, in: Proce*edings of the 6th International Conference on Human-robot Interaction,* ACM, pp. 19–26. DOI: 10.1145/1957656.1957665

Berg Insight (2016a) *mHealth and Home Monitoring,* http://www.berginsight.com/ReportPDF/ProductSheet/bi-mhealth7-ps.pdf

Berg Insight (2016b) *Smart Homes and home automation*, 4th report - http://www.berginsight.com/ReportPDF/ProductSheet/bi-sh4-ps.pdf

Bickmore T, Caruso L, Clough-Gorr K & Heeren T (2005) 'It's just like you talk to a friend' relational agents for older adults, *Interact. Comput.* 17(6): 711–735. DOI: http://dx.doi.org/10.1016/j.intcom.2005.09.002

Blažun H, Saranto K, Kokol P & Vo˘sner J (2012) Information and communication technology as a tool for improving physical and social activity of the elderly, *Proceedings of the 11th International Congress on Nursing Informatics*, 2012

Blažun H, Saranto K & Rissanen S (2011) Impact of computer training courses on reduction of loneliness of older people in Finland and Slovenia, *Comput. Hum.Behav*, 28(4):1202–1212. DOI: http://dx.doi.org/10.1016/j.chb.2012.02.004

Bossen A, Kim H, Williams K, Steinhoff A & Strieker M (2015) Emerging roles for telemedicine and smart technologies in dementia care, *Smart Homecare Technol Telehealth*, 3: 49-57. DOI: https://dx.doi.org/10.2147/SHTT.S59500.

Bradley N & Poppen W (2003) Assistive technology, computers and internet may decrease sense of isolation for homebound elderly and disabled persons, *Technol. Disabil.* 15(1): 19–25

Brownsell S, Bradley D, Blackburn S, Cardinaux F & Hawley M (2011) A systematic review of lifestyle monitoring technologies*, Jl of Telemedicine & Telecare*,17(4) 185-189. DOI: 10.1258/jtt.2010.100803J.

Calvaresi D, Cesarini D, Sernani P, Marinoni M, Dragoni A & Sturm A (2016) Exploring the ambient assisted living domain: a systematic review, *Journal of Ambient Intelligence and Humanized Computing,* pp 1–19. DOI:10.1007/s12652-016-0374-3.

Campbell R & Nolfi D (2005) Teaching elderly adults to use the Internet to access health care information: before-after study, *Jl Med Internet Res,* 7(2) e19. DOI: 10.2196/jmir.7.2.e19.

Chau J, Lee D et al (2012) A feasibility study to investigate the acceptability and potential effectiveness of a telecare service for older people with chronic obstructive pulmonary disease, *Int Jl Med Inform,* 81(10) : 674-682. DOI: http://dx.doi.org/10.1016/j.ijmedinf.2012.06.003

Chen YR & Schulz P (2016) The effect of information communication technology interventions on reducing social isolation in the elderly: a systematic review, *Jl Med Internet Res,* 18(1): e18. Published online 2016 Jan 28. DOI:10.2196/jmir.4596

Chou C, Chang C et al (2013) Technology acceptance and quality of life of the elderly in a telecare program, *Comput Inform Nurs,* 31(7): 335-342. DOI: 10.1097/NXN.0b013e318295e5ce

Cotten S, Ford S et al (2012) Internet use and depression among older adults, *Comput Hum Behav,* 28(2): 496-499. DOI: http://dx.doi.org/10.1016/j.chb.2011.10.021

Cowan R, Fregly B, Boninger M et al (2012) Recent trends in assistive technology for mobility, *J.Neuroeng. Rehabil,* 9: 20. DOI: 10.1186/1743-0003-9-20

CSIRO (2016) *Home monitoring of chronic disease for aged care.* Accessed 17/11/16 at http://www.csiro.au/en/Research/BF/Areas/Digital-health/Improving-access/Home-monitoring

Demiris G & Hensel K (2008) Technologies for an aging society: a systematic review of 'Smart Home' applications, IMIA Yearbook of Medical Informatics, 33-40

Ejupi A, Gschwind Y, Valenzuela T et al (2016) A Kinect and inertial sensor-based system for the self-assessment of fall risk: a home-based study in older people, *Human-Computer Interaction,* 31(3-4) 261-293. DOI: http://dx.doi.org/10.1080/07370024.2015.1085309

Evans J, Brown M, Coughlan T, Lawson G & Craven P (2015) A Systematic Review of Dementia Focused Assistive Technology, *Human-Computer Interaction: Interaction Technologies*, Volume 9170 of the series *Lecture Notes in Computer Science* pp 406-417. DOI: 10.1007/978-3-319-20916-6_38.

Gellis Z, Kenaley B et al (2012) Outcomes of a telehealth intervention for homebound older adults with heart or chronic respiratory failure: a randomized controlled trial, *Gerontologist,* 52(4): 541-552. DOI: https://doi.org/10.1093/geront/gnr134.

Giordano A, Scalvini S et al (2009) Multicenter randomised trial on home-based telemanagement to prevent hospital readmission of patients with chronic heart failure, *Int Jl Cardiol,* 131(2): 192-199. DOI: http://dx.doi.org/10.1016/j.ijcard.2007.10.027.

Godwin K, Mills W, Anderson J & Kunik M (2013) Technology-driven interventions for caregivers of persons with dementia, *Am Jl of Alzheimer's Disease & Other Dementias*, 28(3) 216-222. DOI: 10.1177/1533317513481091

Kanamori M, Suzuki M, Oshiro H et al (2003) Pilot study on improvement of quality of life among elderly using a pet-type robot, *Computational Intelligence in Robotics and Automation: Proceedings of IEEE International Symposium 2003*, pp 107-112. DOI: 10.1109/CIRA.2003.1222072

Kanamori M, Suzuki M & Tanaka M (2002) Maintenance and improvement of quality of life among elderly patients using a pet-type robot. Nihon Ronen Igakkaizasshi, *Jpn. J. Geriatr*, 39(2): 214–218

Karavidas M, Lim N & Katsikas S (2005) The effects of computers on older adult users, *Comput Hum Behav*, 21(5): 697-711. DOI: http://dx.doi.org/10.1016/j.chb.2004.03.012

Khosla R, Nguyen K & Chu M-T (2016) Socially Assistive Robot Enabled Personalised Care for People with Dementia in Australian Private Homes. In Gołuchowski J, Pańkowska M, Barry C, Lang M, Linger H & Schneider C (Eds.) *Information Systems Development: Complexity in Information Systems Development (ISD2016 Proceedings).*Katowice, Poland: University of Economics in Katowice. ISBN: 978-83-7875-307-0. http://aisel.aisnet.org/isd2014/proceedings2016/CreativitySupport/8 .

Khosravi P, Rezvani A & Wiewiora A (2016) The impact of technology on older adults' social isolation, *Computers in Human Behavior,* 63: 594-603. DOI: 10.1016/j.chb.2016.05.092

Khosravi P & Ghapanchi AH (2016) Investigating the effects of technologies applied to assist seniors, *Int Jl of Medical Informatics,* 85(1): 17-26. DOI: http://dx.doi.org/10.1016/j.ijmedinf.2015.05.014

Lancioni G, Singh N, O'Reilly M et al (2013) Supporting daily activities and indoor travel of persons with moderate Alzheimer's disease through standard technology resources, *Res. Dev. Disabil,* 34(8): 2351–2359. DOI: http://dx.doi.org/10.1016/j.ridd.2013.04.020

Leuty V, Boger J, Young L et al (2013) Engaging older adults with dementia in creative occupations using artificially intelligent assistive technology, *Assist. Technol,* 25(2): 72–79. DOI: http://dx.doi.org/10.1080/10400435.2012.715113

Lorig K, Thompson-Gallagher D, Traylor L et al (2012) Building better caregivers: a pilot online support workshop for family caregivers of cognitively impaired adults. *J Appl Gerontol,* 31(3):5

Marasinghe K (2016) Assistive technologies in reducing caregiver burden among informal caregivers of older adults: a systematic review, *Disability & Rehabilitation: Assistive Technology,* 11(5) 353-360. DOI: http://dx.doi.org/10.3109/17483107.2015.1087061

Martin S, Kelly M, Kernohan W, McCreight B & Nugent C (2008) Smart home technologies for health and social care support (Review), *Cochrane Database of Systematic Reviews,* 4, Article No: CD006412. DOI: 10.1002/14651858.CD006412.pub2

Marziali E & Garcia LJ (2011) Dementia caregivers' responses to two Internet-based intervention programs. *Am J Alzheimers Dis Other Demen*, 26(1): 36–43

McKell Institute (2015) *Positive disruption: healthcare, ageing and participation in the Age of Technology*, The McKell Institute, New South Wales

Mitseva A, Peterson C, Karamberi C et al (2012) Gerontechnology: providing a helping hand when caring for cognitively impaired adults – intermediate results from a randomized controlled trial, *Am Jl Phys Med Rehab,* 92: 297-306. DOI: http://dx.doi.org/10.1155/2012/401705

Morris M, Adair B, Ozanne E et al (2014) Smart technologies to enhance social connectedness in older people who live at home, *Aust Jl on Ageing,* 33(3) 142-152. DOI: 10.1111/ajag.12154

Morris M, Adair B, Miller K et al (2013) Smart-Home technologies to assist older people to live well at home, *Jl of Aging Science*, 1(1) 1-9. DOI: 10.4172/2329-8847.1000101

Morrison L, Yardley L, Powell J et al (2012) What design features are used in effective e-health interventions? A review using techniques from critical interpretive synthesis, *Telemedicine and e-Health*, 18(2) 137-144. DOI: 10.1089/tmj.2011.0062.

Mortensen W, Demers L, Fuhrer M et al (2013) Effects of an assistive technology intervention on older adults with disabilities and their informal caregivers: an exploratory randomized controlled trial, *American Jl Phys Med Rehabilitation,* 92(4): 297-306. DOI: 10.1097/PHM.0b013e31827d65bf

Mortensen W, Demers L, Fuhrer M et al (2012) How assistive technology use by individuals with disabilities impacts their caregivers: a systematic review of the research evidence, *American Jl Phys Med Rehabilitation,* 91(11): 984-998. DOI: 10.1097/PHM.0b013e318269eceb

Olsson A, Engstrom M, Skovdahl K et al (2012) My, your and our needs for safety and security: relatives' reflections on using information and communication technology in dementia care, *Scand Jl Caring Sc*, 26: 104-112. DOI: 10.1111/j.1471-6712.2011.00916.x

Peetoom K, Lexis M, Joore M et al (2014) Literature review on monitoring technologies and their outcomes in independently living elderly people, *Disability & Rehabilitation: Assistive Technology,* 10(4) 271-294. DOI: http://dx.doi.org/10.3109/17483107.2014.961179

Pellegrini C, Steglitz J & Hoffman S (2014) e-Health intervention development: a synopsis and comment on 'What Design Features are used in Effective e-health Interventions?' A review using techniques from critical interpretive synthesis, *Translational Behavioural Medicine*, 4: 342-345. DOI: 10.1007/s13142-014-0283-y.

Pinto A, Almeida J et al (2010) Home telemonitoring of non-invasive ventilation decreases healthcare utilisation in a prospective controlled trial of patients with amyotrophic lateral sclerosis, *Jl Neurol Psychiatry,* 81(11): 1238. DOI: http://dx.doi.org/10.1136/jnnp.2010.206680

Rantz M, Skubic M et al (2013) Automated technology for in-home fall risk assessment and detection sensor system, *Jl Gerontol Nurs*, 39(7) 18-22.

Reeder B, Meyer E, Lazar A et al (2013) Framing the evidence for health smart homes and home-based consumer health technologies as a public health intervention, *International Journal of Medical Informatics,* 82(7) 565–579. http://dx.doi.org/10.1016/j.ijmedinf.2013.03.007

Saeki S, Matsushima Y & Hachisuka K (2008) Cortical activation during robotic therapy for a severely affected arm in a chronic stroke patient: a case report*, Jl of UOEH*, 30(2) 159–165

Salovaara A, Lehmuskallio A et al (2010) Information technologies and transitions in the lives of 55-65 year olds: the case of colliding life interests, *Int Jl Hum Comput Stud,* 68(11): 803-821. DOI: http://dx.doi.org/10.1016/j.ijhcs.2010.06.007

Shapira N, Barak A et al (2007) Promoting older adults' wellbeing through Internet training and use, *Aging Mental Health*, 11(5): 477-484. DOI: http://dx.doi.org/10.1080/13607860601086546

Shea S, Weinstock R et al (2006) A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus, *Jl Amer Med Inform Assoc*, 13(1): 40-51. DOI: https://doi.org/10.1197/jamia.M1917

Shimada H, Hirata T et al (2009) Effects of a robotic walking exercise on walking performance in community-dwelling elderly adults, *Geriatrics & Gerontology International*, 9(4) 372–381. DOI: 10.1111/j.1447-0594.2009.00546.x

Sicotte C, Pare G et al (2011) Effects of home telemonitoring to support improved care for chronic obstructive pulmonary diseases, *Telemed e-Health*, 17(2): 95-103. DOI: 10.1089/tmj.2010.0142.

Sprint G, Cook D & Weeks D (2015) Toward automating clinical assessments: a survey of the Timed Up and Go, *IEEE Reviews in Biomedical Engineering*, 8, 64-77. DOI: 10.1109/RBME.2015.2390646

Steventon A, Bardsley M, Billings J et al (2013) Effect of telecare on use of health and social care services: findings from the Whole Systems Demonstrator cluster randomised trial, *Age & Ageing,* 42, 501-508. DOI: 10.1093/ageing/aft008.

Steventon A, Bardsley M, Billings J et al (2012) Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomized trial, *BMJ,* 2012, 344:e3874. DOI:10.1136/bmj.e3874.

Tegart G, Harvey E, Livingstone A, Martin C, Ozanne E & Soar J (2014) *Assistive technologies for independent living,* Report for the Australian Council of Learned Academies. www.acola.org.au

Thomas J, Barraket J, Ewing S et al (2016) *Measuring Australia's Digital Divide: the Australian Digital Inclusion Index 2016*, Roy Morgan Research, Centre for Social Impact and Swinburne University of Technology, Melbourne

Tomita M, Mann W, Stanton K et al (2007) Use of currently available smart home technology by frail elders: process and outcomes, *Topics in Geriatric Rehabilitation*, 23(1) 24-34

Van Hoof J, Kort H et al (2011) Ageing-in-place with the use of ambient intelligence technology: perspectives of older users, *Int Jl Med Inform,* 80(5): 310-331. DOI: http://dx.doi.org/10.1016/j.ijmedinf.2011.02.010

Wada K & Shibata T (2007) Living with seal robots—its socio-psychological and physiological influences on the elderly at a care house, *Robot. IEEE Trans.* 23(5): 972–980. DOI: 10.1109/TRO.2007.906261

Wada K, Shibata T et al (2006) Robot therapy in a care house – its sociopsychological and physiological effects on the residents, *Robotics & Automation, ICRA 2006 Proceedings, IEEE International Conference,* pp 3966-3971. DOI: 10.1109/ROBOT.2006.1642310

Wada K, Shibata T et al (2004) Effects of robot assisted activity for elderly people and nurses at a day service center, *Proceedings IEEE/RSJ International Conference,* pp 1780-1788.

Wada K, Shibata T et al (2003) Effects of robot assisted activity to elderly people who stay at a health service facility for the aged, *Intelligent Robots & Systems, 2003. Proceedings IEEE/RSJ International Conference* pp 2847-2852. DOI: 10.1109/IROS.2003.1249302

West S, Lagua C et al (2010) Goal setting using telemedicine in rural underserved older adults with diabetes: experiences from the Information for Diabetes Education and Telemedicine Project, *Telemed e-Health*, 16(4): 405-416. DOI: 10.1089/tmj.2009.0136.

Wilson C, Hargreaves T & Hauxwell-Baldwin R (2013) *Using Smart homes: themes, linkages, and disconnects in research on Smart Homes and their users*, 3S Science Society & Sustainability, 3S Working Paper 2013-23 -

Wootton R (2012) Twenty years of telemedicine in chronic disease management – an evidence synthesis, *Jl of Telemedicine and Telecare,* 2012, 18: 211-220 – DOI: 10.1258/jtt.2012.120219.

About Flinders University and the Medical Device research Institute

Flinders University has built a reputation for world-class research, clinical and educational expertise in health technologies, with capabilities spanning medicine, engineering, science and social sciences. Flinders University programs engage widely with industry and other partners to drive innovation and deliver improved health outcomes to the global community.

The University's Medical Device Research Institute, is well known for its collaborative and accessible approach to engagement with industry and community. The Institutes research is driven by real-world problems that are explored through multidisciplinary partnership across established networks. It is also home to the nationally-acclaimed Medical Device Partnering Program (MDPP). The MDPP has been successfully bringing together partners from across industry, research and the clinical community since 2008 to drive new medical innovations and encourage industry growth.

CONTACT US AT:
MEDICAL DEVICE RESEARCH INSTITUTE
FLINDERS UNIVERSITY
EMAIL: MDRI@FLINDERS.EDU.AU
WEBSITE: WWW.FLINDERS.EDU.AU/MDRI

Project Team developing the Technology Roadmap

- **Project Lead:** Professor Karen Reynolds, Matthew Flinders Distinguished Professor, Director, Medical Device Research Institute, Director, Medical Device Partnering Program
- **Strategic Advisor - Restorative Care:** Professor Sue Gordon, Strategic Professor, Chair of Restorative Care
- **Strategic Advisor – Digital Health:** Professor Anthony Maeder, Professor of Digital Health Systems
- **Strategic Advisor & Lead Writer – Ageing and Aged Care Policy**: Dr Kate Barnett, Visiting Research Fellow (Ageing and Aged Care), Medical Device Research Institute
- **Strategic Advisor – Rehabilitation and Assistive Technology:** Mr David Hobbs, Lecturer and Rehabilitation Engineer, School of Computer Sciences, Engineering and Mathematics and the Medical Device Research Institute
- **Project Manager**: Ms Carmela Sergi, Institute Manager, Medical Device Research Institute
- **Workshop Facilitator:** Ms Jo Close, Director, Research Innovations.