Home automation as an everyday living cost

The content of this document is OFFICIAL.

Please note:

The research and literature reviews collated by our TAB Research Team are not to be shared external to the Branch. These are for internal TAB use only and are intended to assist our advisors with their reasonable and necessary decision-making.

Delegates have access to a wide variety of comprehensive guidance material. If Delegates require further information on access or planning matters, they are to call the TAPS line for advice.

The Research Team are unable to ensure that the information listed below provides an accurate & up-to-date snapshot of these matters

Research question: How common is home automation/"smart homes" in Australia?

What is the typical 'scope of works' for a standard 'smart home' vs disability-specific home automation features?

What is the typical cost or price range to setup a 'smart home'?

Are existing homes able to accommodate home automation without needing to upgrade electrical features (e.g. switchboard, wiring)?

Is there a significant difference in outcomes between low cost solutions (e.g. Google Home) and high cost solutions (e.g. Control 4)?

What is the current evidence base regarding home automation and people with disability? Is there evidence home automation is linked to increased independence, or other positive outcomes (e.g. improved quality of life, wellbeing)? Are there any best practice guidelines?

What is the Agency's risk appetite for home automation requests? Do mitigation strategies need to be put in place (e.g. TAB mandatory referral for requests above $20,000)?

Date: 09/05/2022

Requestor: Claire s22(1)(a)(ii) - irrele

Endorsed by (EL1 or above): Sandi s22(1)(a)(ii) - irrelevant material

Researcher: Aaron s22(1)(a)(ii) - irrelevant ma

Cleared by: Stephanie s22(1)(a)(ii) - irrelevant mate

1. Contents

2. Summary

Smart home technology is growing in popularity in Australia. Most people having at least one smart home device in their home. While common, only certain types of automations (eg. entertainment) are ubiquitous in Australian homes. Whether a particular home automation support is more likely an everyday living cost will depend on the type and function of the technology.

With the technology growing and changing, there is inconsistent and outdated information online. Much of the research is still in very early stages and so the evidence base is minimal. There is more research focussing on maintaining independence of older people compared to other disability cohorts.

There is a body of research focussed on using sensors and the Internet of Things (IoT) in the home to monitor and assess people at risk of various harms (for example, trips or falls, burns when cooking etc.). Although home automations are often integrated with IoT, this paper will only discuss IoT technology when it relates to automating processes in the home. Similarly, there is a strong research focus on use of robotics to automate processes in the home (for example, a robot vacuum to clean the floor). There may not be distinct boundaries between home automations and robotics, but this paper will focus on the automation of processes related to structure or fixtures of the house and environment (for example, automated lights, doors or heating/cooling systems).

From the available information it appears that for most common home automations, off-the-shelf control units like Google Home, Apple Home kit or Amazon dot may be sufficient with installation of automated appliances or fixtures. If these mainstream options are not accessible for a user, or if they require a more customised solution, then specialised home automation systems may be required.

Currently, we do not have accurate information about how often home automations are funded and what the average costs that quotes are implemented for. Without this information we cannot accurately determine financial risk to the scheme.

3. What is home automation?

Anything that moves or turns on and off can be automated. In a house, this can include lights, electricity outlets, doors, windows, drawers, blinds, locks, showers, baths, sinks, toilets, air-conditioning, ceiling fans, platform or stair lifts, cameras, intercoms, alarms or other security features, watering or reticulation systems. Any home appliance can be automated including TVs, sound systems, vacuums, fridges, kettles and coffee makers etc.

Home automations, sometimes called domotics, can be linked or integrated via home internet or wireless technology and operated via phones, tablets, computers or dedicated control interfaces, allowing users to control structural or environmental features of their home. A home in which automation is integrated with the Internet of Things is often called a smart home (Choi et al, 2021; Katre & Rojatkar, 2017). The Internet of Things refers to a network of computing devices which can communicate with each other via a system of sensors (Choi et al, 2021). For example, a bedroom light turns on when the bedroom door is opened thanks to a sensor in the door, or a wearable temperature sensor can send information to an air-conditioner to regulate the room temperature. This is an example of an automated system with a passive input. It's called passive because the user does not have to intentionally turn the light on, it is turned on by doing another activity the user would have done anyway (opening the door). This contrasts with active input, in which the user speaks or operates controls on a tablet or phone (Hampton, 2019). Figure 1 illustrates the relationship between inputs and outputs in a home automation system.

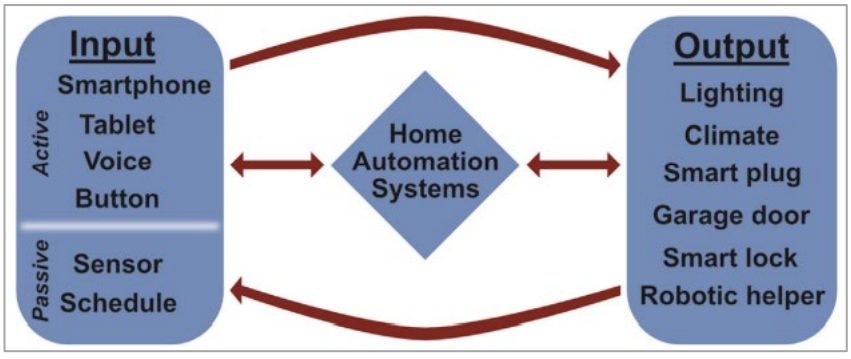

Figure 1: Home automation systems. Source: Hampton, 2019.

4. Home automation in Australia

There is little reliable data on the prevalence of home automations in Australian households. The information that is available was gathered for commercial purposes and may have inherent bias. Data from the Statista Global Consumer survey of 2049 people found 85% had some smart home device in their house. Entertainment devices are the most common (79%), followed by:

- devices for monitoring and automating electricity and lighting (30%)
- safety and security (29%)
- smart appliances (26%)
- smart speakers with virtual assistant (22%)
- energy management (22%) (Statista 2022).

A 2022 Savvy survey of 1000 people found 48% aged over 55 have at least one smart home device and 41% have 5-10 devices. 58% of people 18-44 have at least one smart home device in their home (Chavda, 2022). Due to barriers accessing the full datasets or reports for these surveys, the definitions of ‘smart device’ or ‘smart home device’ are not clear. They may include devices as common as Bluetooth speakers or motion sensor lights. Also, information substantiating the representativeness of the survey group is not available.

5. Home automation as a disability support

There is no standard home automation scope of works in either a mainstream or disability support context. However, based on a review of 20 TAB advice requests from 2021/2022, common automation requests include:

- doors and locks
- windows and blinds
- lighting (ceiling lights or lamps)
- heating/cooling (air-conditioner, ceiling fans)
- intercom / video doorbell
- entertainment (TV, sound systems).

In a mainstream context, the goals of home automation include safety and security, comfort, convenience and energy efficiency (Statista, 2022). Features designed for comfort or convenience in a mainstream context can have significant implications for independent living for people who live with a disability (Hampton, 2019). A 2021 survey of allied health practitioners found commercially available home automation technology has been used to assist people with traumatic brain injury, spinal cord injury, cerebral palsy, amyotrophic lateral sclerosis, multiple sclerosis, stroke, dementia, Alzheimer’s, mild cognitive impairments, autism,

Parkinson's disease, low vision or blindness, and Down syndrome (Ding et al, 2021). Home automation can be useful to:

- remove physical barriers to the use of fixtures or appliances

For example, the automation of doors, windows, and blinds can be used to change the usual physical input (pushing, lifting, reaching, pulling) which a user might have difficulty with to a different input within the user's ability (speaking a voice command, using a touch screen).

- prompt a user to complete daily activities

For example, a user might require prompting to brush their teeth in the morning, so they install a sensor on the bedroom door which triggers a voice prompt when the user first leaves their bedroom in the morning.

- simplify complex process

For example, if a user has difficulty remembering everything they need to do to secure their house when they leave, multiple processes (lock doors, close windows and blinds, turn off all lights and appliances), could be activated via a single input (press a single button on their smartphone).

5.1 Benefits

Research focussing on the use of home automation in a disability, health or ageing context is only a small portion of the research literature on home automation (Li et al, 2022; Choi et al, 2021). Despite this, healthcare was one of the first applications of smart home research represented in the literature. This body of research looks at technology for monitoring health of patients, improving service delivery and promoting ageing in place.

Much of the literature on the effectiveness of home automation or Smart home technology focusses on home care for older people (Lee & Kim, 2020; Tural et al, 2021; Astasio-Picado et al, 2022). This literature has shown that smart home technology including sensors, automated lighting, locks and fire detection devices can reduce hospitalisation among older adults, improve feelings of safety and security and promote ageing in place. However, since the focus is on older people, the results may not generalise across disability cohorts.

Research into the use of home automation in a disability context is still developing. As late as 2008, a Cochrane review found no randomised controlled trials, quasi-experimental studies, controlled before and after studies or interrupted time series analyses looking into home automation as a treatment for people with physical disability, cognitive impairment or learning disability. Noting that these technologies are in use, the authors recognise that technology often finds its way into the healthcare industry "without comprehensive evaluation of the health impact or a true understanding of the added value of ICT to health services" (Martin et al,

2008, p.5). Research also often develops slower than technology, so that by the time research is completed, a technology may be obsolete (TAC, n.d).

The evidence base is still minimal though preliminary studies show a positive effect of home automation. A 2021 review into the use of home automation and smart home technology for people with Parkinson's found benefit in improving autonomy and safety, but this is primarily using sensors and data-collection to inform health care providers of risks (Simonet & Noyce, 2021). Two pilot studies into the use of home automation found improvements in social adaptation, activities of daily living and quality of life for people with Parkinson's disease (Latella et al, 2021) and improvements in social and cognitive functioning and autonomy in people with chronic stroke (Maggio et al, 2020). However, both pilot studies measure use of home automation in short sessions rather than as a ubiquitous living environment.

Victoria's Transport Accident Commission has funded a research project looking at smart home technology for supporting memory, planning and organisation. The research is scheduled to be completed in 2022 (TAC, n.d.).

Removing physical barriers. There is some evidence on the usability and accessibility of control systems for operating common home automations (Masina et al, 2020; Conado et al, 2022). For example, Masina et al (2020) found accessibility issues in the use of voice assistants (Siri, Alexa, Cortana etc) for people with cognitive and linguistic impairments. I have found no evidence relating to the effectiveness of common home automations to remove physical barriers. This may be due to the early stages of the evidence base or the typical heterogeneity of new technologies. It may also relate to the fact that home automations straight-forwardly allow people to perform these basic activities (turn lights on and off, open doors and windows) provided the controls are accessible.

Prompting. A 2015 study into prompting technology found an effective prompting system:

> can improve the efficacy of cognitive interventions, minimize the necessity for human assistance, and allow users to feel more independent. Research has shown that prompting technologies can enhance medication adherence, improve the use of external compensatory strategies, reduce caregiver burden, and increase functional independence in those with cognitive impairment (Robertson et al, 2015, p.9).

The authors note prompting is most effective during points of transition (when finishing or starting a different activity) and less effective when the prompt occurs at a specific time of day regardless of what the user is doing (for example, a reminder set for 8:30am every day). Smart home technology can facilitate prompting triggered by certain activities (leaving or entering a room, getting out of bed, turning an appliance on or off) and so may be more targeted than simple time-of-day prompts.

Simplifying complex processes. In a 2019 introduction to home automation, Hampton suggested there was no significant evidence base for the effectiveness of home automation for people with disability. However, he does acknowledge the usefulness of automated lights,

temperature control, video doorbells, locks and other security features for assisting users to simplify complex processes (Hampton, 2019).

6. Risk

6.1 Safety and security

Privacy and data security are major concerns noted in the research (Hampton, 2019; Li & Borycki, 2019; Kang et al, 2021; Ding et al, 2021; Simonet & Noyce, 2021; Luo et al, 2021). Smart home technology often collects usage data and in the context of disability or health related technology would collect personal information about a person's health and capabilities (Kang et al, 2021). In cases where the sensors are intended to monitor the user around the clock, measures to balance privacy and safety may be needed. Eavesdropping is also possible where there are voice activated devices or video cameras (Li & Borycki, 2019). Simonet and Noyce (2021, p.59) offer the following as possibilities for addressing concerns around privacy and data security:

Risk	Mitigation
Intrusive surveillance sensors, unwanted image data, third parties' involvement	• Data encryption (blur, pixelating, silhouettes, skeleton, 3D avatar) to protect identity
Feeling of lack of data control involving private life content	• Written consent after detailed information disclosure • To inform about rights: to view and delete unwanted images, temporarily pause image recording whenever they wish • Cognitively impaired individuals: consent given by people with decision-making authority anticipating benefits and risks • Participants to ask third parties for consent
Security issues: full reliance on technology, sensor failure to detect a dangerous situation, software hacking	• Technology demystification • Glitches detection • Trained investigators
Data ownership: right of self-management of personal data	• Support regulatory bodies. Testable quality standards certification

Other risks relate to networking and remote operation of basic household processes. If a device is connected to a user's Wi-Fi and there is a network failure this may cause be safety issues such as the inability to open or unlock doors. This might be mitigated by systems which connect via Bluetooth or Z-Wave and do not depend on Wi-Fi network. If a smart home system is hacked, all the automated systems may be vulnerable to remote operation. This may be mitigated by appropriate digital security measures. In addition, remote operation of doors and locks raises concerns of restrictive practice. This risk could be mitigated by limiting number of users with access to the systems and identifying if a behaviour support plan involving restrictive practice is required.

6.2 Cost effectiveness

I have not found any research on the cost effectiveness of home automations compared to personal assistance. There is a suggestion in the literature that home automation can increase independence and reduce carer burden, but this is not quantified into reduced hours of support. In theory, a person who only requires monitoring over the day could reduce the amount of on-site care they require. However, for both on and off-site care, reduced hours would depend on the support arrangement in place. There is some evidence that a person only requiring prompting to complete daily activities could rely less on personal assistants and therefore reduce care hours (5.1 Benefits). However, I have not seen any evidence showing that home automations designed for prompting do reduce support hours.

As such, we cannot say that home automations have a track record of reducing support hours and we cannot say in general that home automations are likely to be value for money. Individual requests for funding may be able to demonstrate a likely reduction in support hours or some comparable benefit that would make the request value for money. For example, if a participant can sometimes navigate the community independently and an automated door will enable them to enter or exit their home independently, then the request may increase their independence to an extent that funding would be justified, even if it does not reduce support hours.

There is inconsistent information available when comparing mainstream smart home hubs (Google Home, Amazon Dot, Samsung SmartThings, Apple HomeKit etc) with more specialised control units (C-Bus, Crestron, Mobotix, Control 4). This may be due to the commercial nature of the reviews and the rapid progress of the technology. Most online reviews compare mainstream hubs with each other or specialised control units with each other, but do not compare mainstream with specialised.

Specialised units require more set-up and are more costly but allow for greater customisation. Mainstream hubs are cheaper, fulfill most basic automation needs but their interface is less customisable and may be less accessible. I have not found a home automation technology designed specifically for people with disabilities, though with some specification both mainstream hubs and specialised units can accommodate some accessibility measures. The most cost-effective system will depend on the needs of the individual.

For example, Apple Home is a free app which works with various accessories. It advertises the ability to automate or work with air conditioners, air purifiers, bridges, cameras, doorbells, fans, garage doors, humidifiers, lights, locks, power points, receivers, routers, security, sensors, speakers, sprinklers, switches, taps, thermostats, TVs, and windows. It is compatible with hundreds of products of various brands (Apple Home).

Google Home setups are currently selling for $99 and can automate several processes independently (email, phone, entertain systems) and can link to additional modules (for example, Samsung's SmartThings) to:

> lock and unlock doors, regulate air-con settings, open and close windows blinds, water plants, start robotic vacuum cleaners, and arm and disarm alarm systems, [operate] plug and power outlet, motion sensor, security camera, Honeywell thermostat, garage door opener, washing machine, door bell and garden irrigation controller (Noda, 2018, p.675).

Mainstream smart home hubs are inexpensive but require compatibility with devices or fixtures in the home. This can involve buying new appliances or separately automating household processes, which can sometimes involve substantial costs.

An additional consideration is re-wiring of a home. Mainstream accessories (lights and appliances) and accessories or systems that run on batteries will often not need re-wiring. Many home automation systems or devices need neutral wires and so some older homes may require re-wiring. Some people choose to install deep junction boxes, wiring closets or higher grade ethernet cables (Fritz, 2021; SmartHome, n.d., Tholen, 2021).

6.2.1 Reducing financial risk

When a request for home automation is determined to be reasonable and necessary a plan developer includes the line item:

> Environmental Control (ECU)/ Safety-Related Products 05_241303121_0123_1_2.

This is a quotable item in the Assistive Technology category with a benchmark of $17,474. The line item for repair and maintenance is:

> Repairs and Maintenance - Communication Cognitive or ECU AT 05_502200312_0124_1_2

and has a notional value of $500. Home automations are not a mandatory referral to TAB and do not have any mandatory referral rules associated with them.

We do not currently have data on how frequently this line item is included in the plan and whether the benchmark represents to average cost quotes are implemented for. However, this information may be obtained from the Office of the Scheme Actuary. Without this information we don't have a good idea of the financial risk associated with these requests and we don't know if further risk mitigation strategies are required.

However, without an idea of scale, some concerns and strategies are still apparent. It is also possible home automations are being included in plans without the line item or with a different line item, contributing to the lack of clarity about how often this support is being funded. There could be a few reasons for this. Home automations are funded through the Assistive Technology category, though they sometimes blur the line between AT and Home Modifications, requiring rewiring efforts or installation of built-in features like doors and cabinetry. Plan developers may be looking to fund the support through the Home Modifications budget. Environmental control unit is a technical term which may not be widely known. This term may or may not be used in the request, assessment or quote and may not signal to the plan developer to include the correct line item.

Either changing the name of the line-item to include a reference to home automation or publicising the current line item and what it's for could reduce the potential for home automation funding being included via a different route.

Some risk reduction measures are introduced for supports costing above $15,000 such as a full assessments and quotes. Risk of supports being funded that are not value for money could be further reduced by creating a mandatory TAB referral rule (eg. mandatory referral to home automations over $20,000).

Further support for decision makers might include adding a home automation example to the Would We Fund It guide or adding a home automation advice request to the TAB digest.

7. References

Astasio-Picado, Á., Cobos-Moreno, P., Gómez-Martín, B., Verdú-Garcés, L., & Zabala-Baños, M. (2022). Efficacy of Interventions Based on the Use of Information and Communication Technologies for the Promotion of Active Aging. *International journal of environmental research and public health*, *19*(3), 1534. https://doi.org/10.3390/ijerph19031534

Condado, P. A., Lobo, F. G., & Carita, T. (2022). Towards Richer Assisted Living Environments. *SN computer science*, *3*(1), 96. https://doi.org/10.1007/s42979-021-00983-0

Chavda, S. (2022). *Smart home technology adoption rises with more Australians over 60 buying tech devices*. Savvy. Retrieve May 6 2022, from https://www.savvy.com.au/smart-home-technology-adoption-rises-with-more-australians-over-60-buying-tech-devices/

Choi W, Kim J, Lee S, Park E. (2021) Smart home and internet of things: A bibliometric study. *Journal of Cleaner Production*. 301, 126908

Ding, D., Morris, L., Messina, K., & Fairman, A. (2021). Providing mainstream smart home technology as assistive technology for persons with disabilities: a qualitative study with

professionals. *Disability and rehabilitation. Assistive technology*, 1–8. Advance online publication. https://doi.org/10.1080/17483107.2021.1998673

Fritz, R. (2021). How to wire your New House for home automation. Lifewire. Retrieved May 6, 2022, from https://www.lifewire.com/preparing-new-house-for-home-automation-817661

Hampton S. (2019). Internet-Connected Technology in the Home for Adaptive Living. *Physical medicine and rehabilitation clinics of North America*, *30*(2), 451–457. https://doi.org/10.1016/j.pmr.2018.12.004

Katre S and Sojatkar D. (2017). Home automation: past, present and future. *International Research Journal of Engineering and Technology*, *4*(10), 343-346.

Kang, H. J., Han, J., & Kwon, G. H. (2021). Determining the Intellectual Structure and Academic Trends of Smart Home Health Care Research: Coword and Topic Analyses. *Journal of medical Internet research*, *23*(1), e19625. https://doi.org/10.2196/19625

Latella, D., Maggio, M. G., Maresca, G., Andaloro, A., Anchesi, S., Pajno, V., De Luca, R., Di Lorenzo, G., Manuli, A., & Calabrò, R. S. (2021). Effects of domotics on cognitive, social and personal functioning in patients with Parkinson's disease: A pilot study. *Assistive technology : the official journal of RESNA*, 1–6. Advance online publication. https://doi.org/10.1080/10400435.2020.1846095

Lee LN and Kim MJ (2020) A Critical Review of Smart Residential Environments for Older Adults With a Focus on Pleasurable Experience. *Front. Psychol*. 10:3080. doi: 10.3389/fpsyg.2019.03080

Li, C. Z., & Borycki, E. M. (2019). Smart Homes for Healthcare. *Studies in health technology and informatics*, *257*, 283–287.

Li, W., Yigitcanlar, T., Liu, A., & Erol, I. (2022). Mapping two decades of smart home research: A systematic scientometric analysis. *Technological Forecasting and Social Change*, *179*(121676), 121676. https://doi.org/10.1016/j.techfore.2022.121676

Luo, H., Liu, X., & Wang, P. (2021). Safety risk analysis of Home Automation products. *Journal of Physics. Conference Series*, *1986*(1), 012103. https://doi.org/10.1088/1742-6596/1986/1/012103

Maggio, M. G., Maresca, G., Russo, M., Stagnitti, M. C., Anchesi, S., Casella, C., Zichitella, C., Manuli, A., De Cola, M. C., De Luca, R., & Calabrò, R. S. (2020). Effects of domotics on cognitive, social and personal functioning in patients with chronic stroke: A pilot study. *Disability and health journal*, *13*(1), 100838. https://doi.org/10.1016/j.dhjo.2019.100838

Martin S, Kelly G, Kernohan WG, McCreight B, Nugent C. Smart home technologies for health and social care support. Cochrane Database of Systematic Reviews 2008, Issue 4. Art. No.: CD006412. DOI: 10.1002/14651858.CD006412.pub2.

Masina, F., Orso, V., Pluchino, P., Dainese, G., Volpato, S., Nelini, C., Mapelli, D., Spagnolli, A., & Gamberini, L. (2020). Investigating the Accessibility of Voice Assistants With

Impaired Users: Mixed Methods Study. *Journal of medical Internet research*, *22*(9), e18431. https://doi.org/10.2196/18431

Noda K. (2018). Google Home: smart speaker as environmental control unit. Disability and rehabilitation. Assistive technology, 13(7), 674–675. https://doi.org/10.1080/17483107.2017.1369589

Robertson, K., Rosasco, C., Feuz, K., Schmitter-Edgecombe, M., & Cook, D. (2015). Prompting technologies: A comparison of time-based and context-aware transition-based prompting. *Technology and health care : official journal of the European Society for Engineering and Medicine*, *23*(6), 745–756. https://doi.org/10.3233/THC-151033

Simonet, C., & Noyce, A. J. (2021). Domotics, Smart Homes, and Parkinson's Disease. *Journal of Parkinson's disease*, *11*(s1), S55–S63. https://doi.org/10.3233/JPD-202398

SmartHome. (n.d) *Solutions how to wire your home for automation*. Retrieved May 6, 2022, from https://www.smarthome.com/pages/sh-solutions-how-to-wire-your-home-for-automation

Statista. (n.d.) *Smart home device ownership in Australia 2021*. Retrieved May 6, 2022, from https://www.statista.com/forecasts/1004198/smart-home-device-ownership-in-australia

TAC. (n.d.). *Highlighted research projects.* Transport Accident Commission: Victoria. Retrieved May 9, 2022, from http://www.tac.vic.gov.au/about-the-tac/research/research/highlighted-research-projects?msclkid=db2ad270cf3911ec8bd2dad1822532e

Tholen, C. (2021). *What wiring do I need for a home automation system?* SafeWise. https://www.safewise.com/faq/home-automation/home-automation-wiring/

Tural, E., Lu, D., & Austin Cole, D. (2021). Safely and Actively Aging in Place: Older Adults' Attitudes and Intentions Toward Smart Home Technologies. *Gerontology & geriatric medicine*, *7*, 23337214211017340. https://doi.org/10.1177/23337214211017340

8. Version control

Version	Amended by	Brief Description of Change	Status	Date
1.0	AHR908	Research paper addressing ubiquity and function of home automations	Cleared	09/05/2022