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Assistive Technologies for the Frail Elderly, Chronic Illness Sufferers and People with Disabilities – a Case Study of the Development of a Smart Home

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Abstract

This paper reports on initial stages of a case study of building a consortium to undertake research into advanced technologies and telecommunications that support the notion of an assisted care 'Smart Home'. The aim is to through research and development to provide greater independence, improved quality of life and reduce unnecessary hospital admission for the dependant being cared for in their own homes including the frail elderly, chronic illness sufferers and people with disabilities. The primary outcome is the intent to support families and professional carers, reduce costs and, where possible, identify commercial opportunities for new products and services. Queensland Smart Home Initiative (QSHI) is discussed as a case study together with the Consortium's first Smart Home at an aged care facility in Queensland, Australia.

Keywords

Smart home, assistive technology, healthcare, ICT

Introduction

There has been interest internationally in Smart Homes particularly for the frail elderly (Essen and Conrick, 2007). In 2006 a consortium of stakeholders was established in Queensland Australia with the longer term aim of building a national and potentially international Centre for research, development, commercialisation and adoption of assistive technologies to support independent living, improve quality of life and enable home care particularly for the frail elderly, chronically ill, and people with disabilities. Anticipated outcomes included better access to care for clients, financial savings for care providers and departments of health, national and state economic benefits, export opportunities and commercial benefits to stakeholder organisations.

Background

There are concerns in most developed countries about the impacts of their ageing populations. The concerns include how to support the increasing percentages of retirees and how to resource the anticipated increases in demands for health and other support services. Technology is seen as having significant potential in better equipping societies to addressing these increasing pressures. Applications include assisting aged people in extending active and independent lives, maintaining productivity and in delivering care in home and community settings. Around the world including in Australia there is an increasing level of activities, strategy development, research projects, implementations of assistive technologies by health providers,

Achieving world class aged care is a major national policy direction emphasised in the *National Strategy for An Ageing Australia* (Commonwealth of Australia 2001). The initiative reported on in this paper aims to address a key goal of this Strategy, which is for a care system that provides integrated and coordinated access, assistance and information for older Persons with multiple and significant and diverse care needs.

Increasing availability of advanced telecommunications including fibre-to-the-home provides an opportunity to explore the benefits of technologies in providing support for older people and others requiring support. This potential includes technology as prostheses to support productive ageing, managing activities of daily living,

supporting families as carers and advocates through technology such as remote monitoring, improving access to service delivery information, enabling clinicians to share care plans and better coordinate care. There is potential through technology to support ageing in place and delaying or avoiding moves to institutional care. Savings are anticipated from applying technology to foster prevention and early detection of the onset of disease or disability, when treatment is often cheaper and more effective.

Population Ageing

We live in an environment of population ageing, increasing pressures on hospital services, shortages of carers and increasing consumer demand as well as an increasing availability of assistive technologies to support care deliver, particularly in home settings. This is compounded by the predications that the percentage increases in people with disabilities will dramatically grow between 2006-2031 (Giles *et al* 2003). Further more Giles *et al* claim that "The number of people aged between 75 and 94 years with a profound restriction rises steadily until 2021, and then increases sharply, so that the total numbers of people with a profound restriction in these age categories exceed the number with profound restriction in the age group 0–64 years".

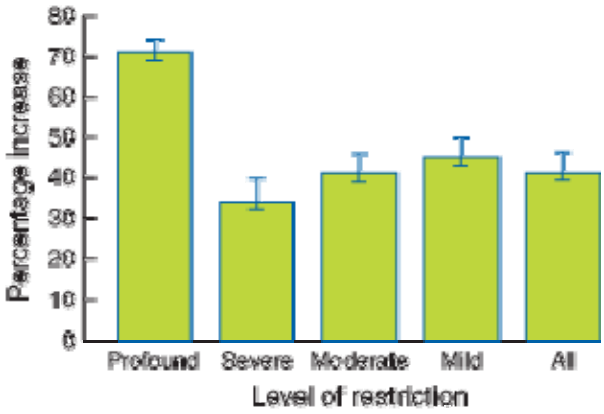

Figure 1: Anticipated increases percentages of people with disabilities between 2006–2031 (Giles et al, 2003)

There is interest in many countries in better enabling frail older people and the chronically ill to receive care in their own homes and delay or avoid moving into institutional care. In some countries there are projects that go beyond research or demonstration and aim to implement assistive home technologies on a broad scale. In South Australia a system of referrals from hospital admission to home care is in use (Soar J, Yuginovich T and Whittaker F, 2007). Similar initiatives include the HARP programmes in Victoria and in Queensland the Gold Coast Hospital is planning to implement a new system for managing Emergency Department demand.

There is great potential for technology to enhance the safety and independence of frail older people, enable access to quality care services and to extend their ability to remain in their own homes. Intelligent monitors can keep a continuous watch on patients' vital signs, activity patterns, their safety and security. The technology can monitor indicators of their state of health, provide alerts to events such as falls, and give early warnings of potential problems. The technology can notice changes in activities and alert a carer. Monitoring devices can be more accurate guides to the health risks such as a heart attack than are the patient's symptoms, providing advance warnings and reducing unnecessary emergency callouts (Soar J, Conrick M and Barnett M, 2007).

A 2005 report (Philipson and Roberts, 2007) identified four key areas where digital technologies can be used to improve the lives of the aged, disabled and chronically ill. These include self management of healthcare in home settings with enormous potential savings and other benefits. Home automation will enhance security, safety and independence at home. This will help maintain quality of life and decrease the demand for carer support hours. Communication technologies will provide important benefits for people whose mobility is limited, or who live alone. Finally the various home automation and digital technologies can benefit the aged and the disabled, improving their quality of life by enhancing their independence. Technology has the potential to extend their physical independence, so they can stay for longer in their homes. It gives them a more dignified life, and it saves public and private money.

The number and sophistication of available technologies continues to increase. There is a need for research into adoption issues, return on investment, realisation of benefits, integration and interoperability. Indications are there are gaps in the range of technologies and particularly in intelligent software and interfacing.

The Queensland Smart Home Initiative

During 2005-2006 planning work on building a national consortium commenced. Key stakeholders in federal and state government departments, aged care facility owners and operators, national aged care industry associations, and technology suppliers were consulted. The first phase of this project, the Queensland Smart Home Initiative (QSHI), was launched by the Queensland Minister for Health on 23 April 2007.

The QSHI showcases local and international technologies and innovations to support independent living and home care, and to reduce hospital admissions and length of hospital stay. The products are currently being evaluated by the University partners. This research will inform the development of a Business Case for the Australasian Centre that will show the gaps and consequently the R&D and commercialisation opportunities for partner companies, and other benefits to health consumers and the economy.

The QSHI is a consortium of leading companies, government and researchers. It aims to provide R&D platforms in aged care facilities for the review, assessment, selection, development, trialling and evaluation of home care technologies to meet requirements in the diverse Queensland environment. Additional sites will allow for testing of the technologies in metropolitan, rural and remote settings.

The outcome will identify issues associated with the technology including any gaps, ease of installation and use, robustness for challenging environments, user acceptance, costs, benefits and return on investment. The Queensland Smart Home Initiative will provide a basis for building a greater capacity in Australia for research, development, commercialisation and adoption of assistive technologies to support independent living and home care for the frail elderly, chronically ill, and people with disabilities.

Methods

The project arose from a plan for building a consortium in this domain. The first phase of the project involved building the research consortium based upon a high-level vision of the potential ICT and assistive technologies for care in home and community settings. A small number of organisations were selected to be approached to invite expressions of interest in participation. Selection of organisations was based upon an assessment of complimentary skills and interests, and to avoid duplication. The organisations were selected in order to provide a balance of stakeholder interest. The organisations that committed to support the initiative included a department of health, a major aged and community care provider, a home care technology supplier, a smart home environment supplier, an association of owners and operators of aged and community care facilities, an aged care consumer organisation, a multi-national manufacturer of ICT componentary, a telecommunications company and two universities.

A research project was then undertaken to distil the vision, research needs, priorities and expectations of the stakeholder organisations. The aim was to inform a collective vision on the potential of the Smart Home project and the development of a research program. This involved individual consultation with managers and senior executives of each of the participant organisations. Semi-structured interviews covered vision, what stakeholders would like to see in 3-5 years, desired outputs, desired projects, anticipated benefits and other impacts. This was followed by a facilitated 3-hour focus group workshop involving 16 participants from across the stakeholder organisations. These included care providers with first-hand aged care experience, technologists, e-health researchers, government aged care strategy and policy officials, telecare call centre operators (with first-hand experience of communicating directly with the aged in their homes), and representative of owners and operators.

Comments of a participant that was reflective of others included:
“This offers the opportunity to improve the quality and diversity of care….to overcome tyranny of distance…..better serve indigenous consumers. We can shift to a more pro-active model of care…get a more holistic view of care….intervene earlier; allow people to stay in their own homes” (representative of large aged care provider chain).

The outputs of these activities were compiled into a draft vision, strategy and research program document which was then used as the basis for a further 2-hour focus group with stakeholders. The final draft was then further refined by a smaller group consisting of single representatives of the technology supplier companies and the university researchers before being circulated to the broader group for final comment.

Selection of Participants and Involvement of Carers

The research reported in this paper is very much in the beginning stages involving the first cohort of participants which were the representatives of the partner organisations. Expectations are that a second group will be the residents in the retirement village where the Smart Home is located. Early discussions indicated the residents would be willing to participate and there was early interest by a small number of residents. Since then the

residents committee has decided that the Smart Home is not relevant to them and the researchers should approach others within the same aged care campus or from elsewhere for whom the technologies might be more relevant.

The perception communicated to the researchers was that the residents did not see benefits of the assistive technologies to them but felt they would be of benefit to those elderly who have significant disabilities. Informal advice from providers of assistive technologies is that the elderly do not always immediately identify potential benefits of assistive technologies to them. This may reflect denial of ageing, fear of stigma if they accept assistive technologies, or a determination to maintain independent living without technical aids.

Carers are likely to be very important in the success of adoption of assistive technologies as they may welcome benefits. Agreement has been reached for a group of carers to be invited to participate in the research through the Respite Centre of the aged care campus.

One of the difficulties of this kind of work is the great variation in abilities of the aging and others with disabilities. Currently around the world there are few examples of older people demanding the technologies. The developments and implementations are instead driven by care providers in places like the Montedomini organisation in Florence, Italy, by government authorities in the case of West Lothian, Scotland (Bowes A and McColgan G, 2005, p6).

Findings

The consultations identified and prioritised the following issues:

1. need for technologies to be user friendly
2. need for respect in dealing with older people
3. to provide more consumer choice
4. the technology should address pressures of workforce shortages
5. to enhance the quality, safety and diversity of care, and to reduce risk
6. to provide greater equity in delivering services over distance
7. to allow for installations in new buildings as well as to retrofit into existing
8. to be standards-based
9. to address privacy, security and trust in systems

The first phase of research projects were prioritised as follows:

1. Evaluation of the installed suite of technologies
2. Barriers to adoption of assistive technologies
3. Technology-User-interface using familiar devices such as a client's television set linked to a set-top box as the communications hub
4. Call centre technologies – review of existing to identify gaps and opportunities for improvement
5. Standards – exploring existing standards development work to identify gaps and develop approaches for addressing those
6. Hospital avoidance – providing the intelligent links, client assessment tools and organisational arrangements to divert patients from hospital admission when appropriate.

Discussion

To support the Queensland Smart Home Initiative's objectives a model for research and development has been derived from the initial consultations and focus groups with representatives from a broad range of stakeholder organisations. Although basic technology either exists, or has been adapted, to set up a homecare environment there is also the potential to support a wider community, particularly those in need of higher levels of care which will only be realised through further advances. At the initial stage the main focus will be on the technological improvements of advanced electronic technologies that can be adapted to suit the homecare setting. After implementation and deployment a shift towards understanding the social issues and any perceived barriers will be highly beneficial to ensure widespread take-up and adoption. The initial phase that focuses on applied

research will benefit from commercial spin-off opportunities. A broad Research Program has been developed which has been categorized into the following three streams of research, as follows:

- TECHNOLOGY — electronic and computer-based devices, to include: supportive IT systems, and the testing and evaluation of devices, e.g. usability, acceptance and unit testing, modelling, design and simulations.
- PEOPLE — refers to the frail elderly, chronic illness sufferers and people with disabilities, to include: social and physiological issues, housing, the role and the responsibility of carers, trails and case studies.
- ORGANISATION — refers to government and private funded health, to include: funding, health drivers, efficiencies and cost savings, safety and quality issues, interface with remote and telehealth, standardisation.

Each of these streams has overlapping concerns. For example, technology that does not take into account the people or organisational issues is unlikely to be adopted or particularly beneficial to our healthcare organisations.

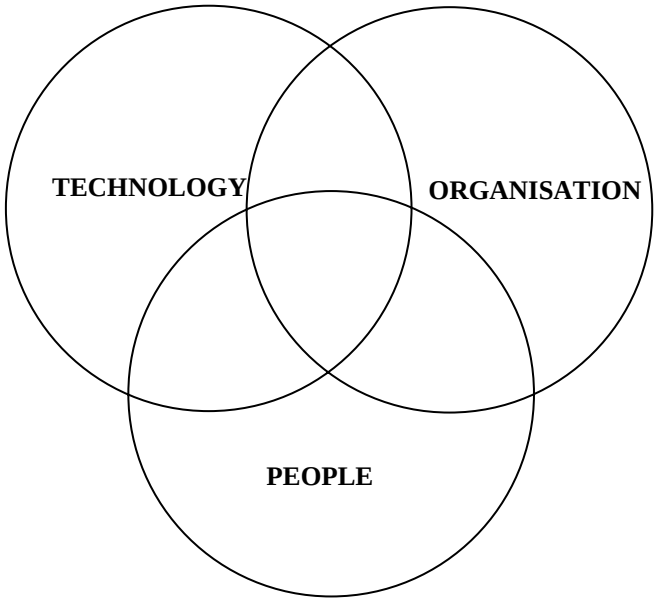

Figure 2: Model for the Smart Home research program

The model above was derived from the consultation and recognises that different priorities and outcomes may prevail depending on the perspectives of the stakeholders involved. To undertake effective research requires that we push the boundaries of knowledge. Hence the determining factor for each research stream is the category where there is the greatest need to advance knowledge to meet the stated aims, i.e. major advances in technology, people or organisational.

The necessity to take this proposed method of approach is derived from the particular constraints that apply to a smart home that can ensure it will be commercially viable and socially acceptable. To appreciate this consider the work that has been done to date on 'assistive technologies' where journals are dedicated to support the associated research, e.g. the Assistive Technology™ Journal supported by the RESNA (www.resna.org). An Assistive Technology Device is claimed to be any item, piece of equipment or product system, whether acquired commercially off the shelf, modified or customized, that is used to increase, maintain or improve functional capabilities of individuals with disabilities. Assistive Technology refers to the devices that can be used by persons with sensory, motor and cognitive limitations to achieve greater independence and self-reliance. Typically assistive technology (AT) refers to those devices that are designed with electronics, microprocessors and high performance materials which allow: powered mobility, augmentative communication, environmental control and the use of microcomputers. These devices usually require training for use and customization to fit it to the individual's needs. Hence, this technology is geared towards the needs of individuals with particular disabilities often requiring more expensive 'bespoke' solutions to give them, as far as possible, an equal quality of life when compared with those currently more able. By contrast the smart home has to provide cost effective solutions that are not only more generic and ubiquitous in nature but conform to the local healthcare regimes. Furthermore, many of the users, particularly the elderly, do not see themselves as in need of specialised support

and hence the technology must wherever possible fit in with the commodity electronic devices that people are more familiar with. The authors believe it is these constraints that will determine the success and adoption of the advanced technologies employed in the smart home and have included projects that specifically address these issues. This social-technical approach is emphasised in a recent UK report "Time to Care - An overview of home care services for older people in England," (CSCI 2006) which endorses the use of technology to reduce the dissatisfaction of the typical 15 minute home care visit yet emphasises that "Failure to listen to what people really need, and respond to this, results in missed opportunities to promote independence and to help people live full and rewarding lives." Furthermore, "As the numbers of older people grow, councils must reshape services to support people living at home with more personalised care. Doing more of the same will not be enough." That is we need to find new ways of organising services so that people have a better range of choices. Research programs must address these issues and the proposed three stream approach proposed here should provide a more balanced view.

Conclusion

Most people have become familiar with the computer controlled devices increasingly available in motor vehicles. These include central locking, electric windows, climate control, electric adjustments for seats and mirrors, hands-free mobile telephones, GPS, and ease-of-use entertainment systems. It is somewhat surprising that little of that technology has yet made its way into homes where it could be of particular assistance to a range of people.
That may be about to change with increasing numbers of frail elderly people in communities.

This paper reports on a case study of forming a consortium of stakeholder organisations to build Smart Homes for use by frail elderly, chronic illness sufferers and people with disabilities. The consortium members covered a spectrum of entities concerned with this domain. Participants were interviewed individually as well as in focus groups to determine their visions for the concept, needs, expectations and desired projects. This formed the basis of a research program to be undertaken using the homes as a platform.

The Queensland Smart Home Initiative aims to contribute to the national and international agendas for quality care and independent living through assistive technologies based upon the research program developed through stakeholder consultation.

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Appendix 1: Description of technologies deployed in the Smart Home

Smoke detector – upon detection of smoke, the smoke alarm makes an audible sound and also triggers an alert to a main alarm unit. Whereas most detectors are un-monitored, this system provides reassurance that in the event of a fire, the Response Centre will arrange immediate assistance to remove the client from danger, and contact the fire department.

Flood Detector - makes an audible sound and triggers an alert upon contact with water. The alarm can be connected to the water mains and switch off water supply to the residence. This device is useful for minimizing risk to the client and damage to property caused by overflowing water. Suitable for kitchens, bathrooms and laundry areas.

Temperature Extremes Sensor - detects rapid changes in temperature, and hot and cold extremes. An alert is triggered and the Response Centre operator will ascertain the potential risk (hyperthermia, dehydration, heat stroke) and contact a carer.

Gas Detector - makes an audible sound and triggers and alert upon detection of natural gas. The alarm can be connected to the gas mains with an auto shut-off valve. The Response Centre Operator will contact a carer or emergency services to assist as required.

Bed occupancy sensor - Located between the mattress and the base, this device is designed to sense occupancy and/or in-occupancy of a bed. The sensor can also be linked to a lamp/light using an x10 controller to switch the light on for a person who gets out of bed in the night and switch it off when they return to bed. During predetermined times if the client fails to return to bed then an alert will be transmitted to an on-site carer or the Tunstall Response Centre.

Chair Occupancy Sensor - a pad located on the seat or underneath the cushion of a chair can be programmed to send an alert when the chair is vacated, or vacated and a failure to return within a predetermined time. Can be used in stationery wheel chairs to determine if the occupant has fallen from their position.

Client Sensor - the combination of a movement sensor and contacts affixed to a door will detect if a person has passed through the doorway, and send an alert to an onsite carer or the Tunstall Response Monitoring centre.

Radio Output Module (ROM) - enables a range of other commercially available sensors to trigger an alarm to the T400/T4000 alarm units. The sensor is hard-wired to the ROM which in turn transmits a radio frequency 312MHz and triggers the main alarm unit.

Fall Detector - The Fall Detector uses an intelligent two stage detection process in order to identify a genuine fall. The detector wakes up from a sleep state when the impact from a fall is detected. It then looks at the user's orientation through a second sensor. Only if the wearer is in a lying position does the process continue. If this state is unchanged after 15 seconds, the device registers an emergency and sends a radio alarm signal to the home unit, which then initiates a call at the monitoring centre. The device is discretely worn on a belt or a holster.

Intelligent home unit – the intelligent home unit has feature additional to the traditional community alarm. It can be used with a wide range of personal alarms, Talk-Back speech triggers, cordless telephone handsets and Fall Detectors. It can be used to detect intruders, inactivity, carbon monoxide, smoke and even temperature changes. Dialling options allow individuals to be called with alerts from some alarms, and response centres with others.

Alarm -The device can be used to raise an alarm call from anywhere in the home by pressing the radio trigger, or the illuminated red button on the unit. Calls are received at the response centre, where the appropriate action can be taken. The device can monitor a range of events through the use of one hard wired and 12 radio sensor inputs.

Pendants - Pendants can be worn either around the neck, on the wrist or clipped to clothing. The pendants have a range of 25-50 metres within the home and can extend out in to the garden. They are water proof for clients to wear their pendants while bathing as this is a high risk activity. Adapters are available for clients with limited hand mobility.

Puffer Switches and Pressure Actuators - purpose built devices enable a trigger to be made for people who have extremely restricted movement such as quadriplegics, MS and other mobility limiting conditions. A trigger may be made by blowing into a mouth piece or by the light touch of a body part onto a pressure pad.

Enuresis Sensor - A thin, waterproof and durable mat, which is positioned between the mattress and top sheet of a bed, therefore not affecting user comfort.

Epilepsy Sensor - This state of the art sensor is placed underneath the bed sheet and monitors the user's vital signs including heart rate and toxic-clonic shakings. The sensor may detect a range of epileptic seizures. Upon detection of such a situation, an alarm call will be raised to the monitoring centre or carer to ensure the appropriate action can be taken

Medication Dispenser – The medication dispenser can be used to automatically provide access to medication over a 28 day period, providing audible and visual alerts to the user each time the medication is required to be taken. If the medication is failed to be taken then an alert is raised to the monitoring centre or carer.

The Radio Pull Cord -can be strategically placed around the home, in order to provide a user with a convenient means of summoning help in an emergency. The Radio Pull Cord is used in areas where personal triggers are unlikely to be worn e.g. positioned next to the bed, in a bathroom or toilet. A hard-wired version is also available.

Passive Infra Red Monitor (PIR) - The PIR is a wireless movement detector that can be used for both activity and inactivity monitoring.

Pressure Mat - Monitors movement in specific area and is activated in the normal course of walking through the home. If the sensor has not been activated (walked upon) within a set period of time an alert is sent through to the monitoring centre. Conversely an alert can be sent through to the monitoring centre when it is walked upon, at any time, such as in the case of a wandering patient.

Key safe - holds up to five keys and attaches securely to any wall or flat surface with mounting hardware included. The Strongbox design has a solid track record for unmatched quality and security. Enables safe and secure storage of a spare key conveniently located for emergency access.

Telehealth System – capture and communication of vital signs.

Bracelet – Featuring global positioning system (GPS), hands free portable telephone and an intelligent alert system in a watch size bracelet. In an emergency, when the person requires help, or is wandering or straying, the bracelet is able to locate the carrier but also speak to them on the hands-free system integrated into the bracelet. The Response Centre can contact the family or other carer in order to co-ordinate assistance.

Bedside patient entertainment and information services device - Device to deliver Patient Entertainment and Information Services to the bedside, including a broad range of Patient Entertainment services such as IP Telephony and IPTV as well as Patient Information services such as Medical Records and Heath Education to be delivered via a unified software portal interface on a bedside touch screen unit.

LCD TV - A high resolution large-screen Television set can be both an entertainment device as well as linked to other home care devices for better readability and interaction with a client.

Intelligent Keyless Entry - When a client leaves their house, a swipe of their finger can turn off all lights, lock the doors, close the blinds, and turn off the air conditioning. Similarly when a client returns to their house a finger swipe will similarly turn on devices.

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