

ENGINEERING AND DEMENTIA INTELLIGENT ASSISTIVE TECHNOLOGIES

Institution of
**MECHANICAL
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Dementia currently affects approximately 800,000 people in the UK alone, a figure which is set to double by 2040 as our population ages and with it, a three-fold increase in healthcare costs^[1]. As we see changes in demographics; particularly increasing numbers of elderly citizens, we are presented with opportunities from new technologies that could assist individuals suffering with dementia. In this report the Institution of Mechanical Engineers explores the possibilities of using Intelligent Assistive Technologies (IAT's) as a practical and cost effective means of providing care and supporting dementia sufferers, by promoting both safety and wellbeing.

The Institution calls for the creation of a specific Dementia Technology Advisory Body to define and oversee the specification, development and introduction of ethically sound, and effective technology by 2019. It is proposed that this body should be part of the UK Dementia Research Institute, include all dementia stakeholders and should work with the Medical and Healthcare Products Regulatory Agency (MHRA) to develop an appropriate regulatory framework.^[2] This Advisory Body would be responsible for:

1. The promotion of investment in healthcare infrastructure systems to ensure compatibility with IAT's guaranteeing both social benefits and cost savings.
2. Ensuring that designers and engineers involve all stakeholders in the development of appropriate devices including patients, carers, providers (hospitals, care homes and communities), payers and regulators.
3. Investigating and clarifying the ethical dimensions of these devices and ensure that these issues are addressed at the early stages of product development.

ENGINEERING AND DEMENTIA: THE USE OF INTELLIGENT ASSISTIVE TECHNOLOGIES

DEMENTIA: POLICY, SERVICES AND STATISTICS

In a series of documents starting in 2009, the UK Government laid out its policy for dementia, which culminated in the then Prime Minister's Challenge on Dementia 2020^[3] published in February 2015. This challenge focused on boosting research, improving care and raising public awareness about the condition in England. As part of this challenge, the Government committed to invest over £300m into research and medical innovation, in order to enable the country's science and medical sectors to lead the way in discovering the next big breakthrough in dementia diagnosis and care. It is expected that the annual Government investment in this research will double by 2025.

Government Objectives for 2020

The challenge set out a number of objectives that the Government wished to see by 2020. These included:

- Increased public awareness and understanding of the factors that increase the risk of developing dementia.
- Equal access to dementia diagnosis, as would be expected for other conditions, with a national average for an initial assessment of six weeks following a referral from a GP.
- Every person diagnosed with dementia to have meaningful care following their diagnosis, in accordance with NICE Quality Standards.
- All NHS staff to have training on dementia appropriate to their role.
- All hospitals and care homes to become dementia-friendly health and care settings.
- Alzheimer's Society to deliver an additional three million Dementia Friends in England.
- More than half of people living in areas that are recognised as dementia-friendly communities.
- All businesses encouraged and supported to become dementia-friendly.
- Funding for dementia research on track to be doubled by 2025.
- Cures or disease-modifying therapies on track to exist by 2025.
- Increased numbers of people with dementia participating in research.

International Dementia Research

The UK Dementia Research Institute in England was announced as a key aspiration of the Prime Minister's Challenge and commenced foundational research programmes in the autumn of 2017. At the same time, separately announced by the World Health Organization (WHO) was a Dementia Discovery Fund worth \$100m (approximately £72m).

Globally, to date, research initiatives have focused on the funding of foundational research into dementia, leading to pharmacological solutions and awareness in communities and healthcare providers. This has led to an improvement in diagnosis rate from 42% in 2010/11 to 67% by March 2016.^[4]

However, there has been minimal research investigating the development and deployment of intelligent assistive technologies as a support technology for dementia patients and their carers. The benefit of such technologies, would be in helping to fill the social care gap until fundamental research provides solutions to reduce the incidence of dementia and mitigate its effects.



The introduction of these technologies to support dementia patients and their carers poses some significantly different and potentially unique challenges compared with other healthcare technologies.

Graham Isaac

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DEMENTIA TECHNOLOGY - THE BIG PICTURE

There is growing interest in so-called 'dementia technology' or intelligent assistive technologies. These technologies can promote both safety and wellbeing; supporting patients to either remain in or return to their own homes and in doing so, help reduce the occurrence of delayed transfer of patients in hospitals.^[5]

Table 1: How Assistive Technologies Can Help

Communications	<ul style="list-style-type: none"> • Voice control of communication devices – phones, tablets, etc
Orientation and Memory	<ul style="list-style-type: none"> • Locate missing objects – purse, keys etc • Find the way from A to B • Tell time and date
Safety Monitors	<ul style="list-style-type: none"> • Alert caregivers to dangerous situations • Medication reminder • Find people who become lost – exit sensors, GPS trackers • Cooker cut-off, gas, carbon monoxide, flood and smoke detectors, temperature monitors, etc
Recreation and Leisure	<ul style="list-style-type: none"> • Maintain contact with friends, neighbours and family • Immediately answer repetitive and frequently asked questions accurately, consistently and without irritation • TV, radio and music control, games audio books, etc

CASE STUDY 1^[6]

Enquiry Assist – Amazon Echo for Dementia

Generally available technology which can be used in dementia applications. Does not purport to replace human touch or real conversation, but voice controls can make it feel like a helpful friend. Highlighted characteristics are:

- Instantly answers questions, like “What day is it?” or “What time is it?” It is a machine, so it will never get annoyed or frustrated!
- Plays music and reads audiobooks and the news – no need to fuss with complicated controls.
- Tells jokes and riddles.
- Looks up information about anything – like, “What’s playing on TV tonight?”
- Reports traffic and weather.

CASE STUDY 2^[7]

The Zora/Alice robot, developed in Europe, has been designed specifically to support caring for the elderly. In its current form it is mainly being promoted to help in activities, such as rehabilitation, motivation, care, fitness.

Pepper is another robot designed for multiple applications, including retail and healthcare. Pepper can help you find what you are looking for and greets you when you come in.

KEY ISSUES IN INTELLIGENT ASSISTIVE TECHNOLOGIES

Healthcare System Compatibility

IATs offer the potential for enormous benefits, not only by improving the quality of life for dementia sufferers and their carers, but also in reducing the economic burden on healthcare systems and individuals. This technology should not be seen as a replacement for personal care, but as an adjunct that replaces some of the repetitive and deeply personal aspects that carers carry out.

Human assistance will become more remote at a higher level, and will involve supervision of many more patients. To maximise the benefits – both social and economic – of IATs, they need to be compatible with, and integrated into, healthcare systems and services. This will require further investment in IT infrastructure to ensure reliable, detailed and semi-automatic remote monitoring of individuals.

Figure 1: IAT Product Development Cycle^[8]



PRODUCT DEVELOPMENT - VOICE OF THE CUSTOMER

The product development diagram below shows the process that new devices designed to support patients should go through, in order to ensure successful application and use. The views and needs of these different stakeholders, should be overseen by an advisory body with a particular interest in the delivery of medical support devices, such as the UK Dementia Research Institute. An advisory body would be able to ensure that a coherent voice of the dementia community is heard and taken into account by the regulator.

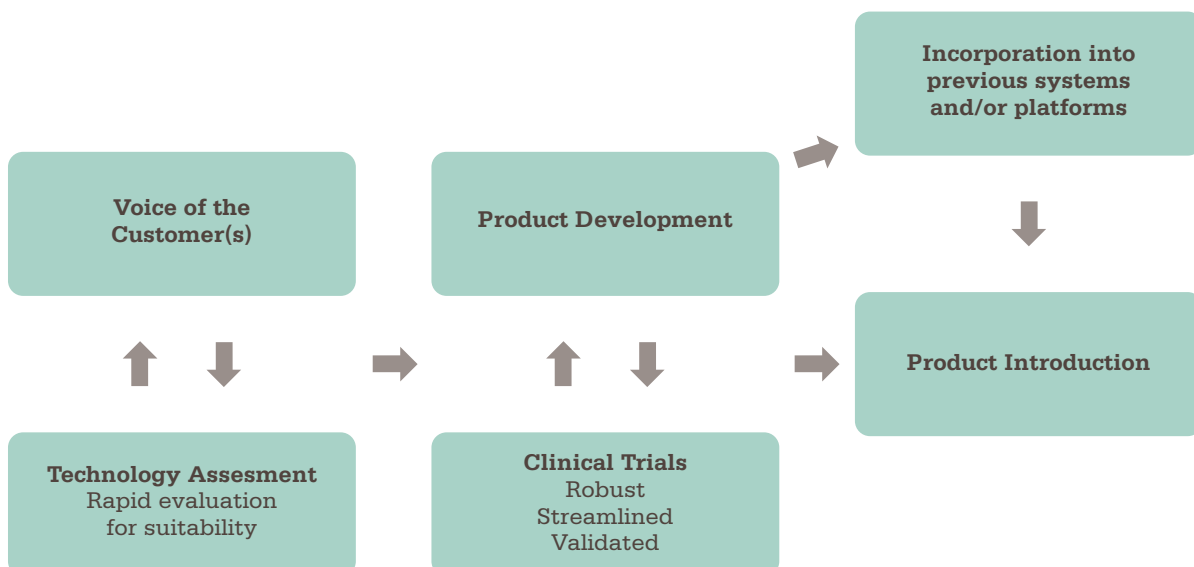
PRODUCT DEVELOPMENT - PRODUCT INTRODUCTION

Two recent reviews highlighted the shortage of clinical trials to validate data from IATs, and a need for more robust medical research.^[9] Furthermore, the speed of research is perpetually outpaced by the technology and associated product development. It is likely that this trend will continue as the volume and pace of technological innovation accelerate. It has been reported that in the period 2011-2015, the IAT sector expanded by a factor of 15^[10].

It is likely that new product innovation will be modifications of existing devices, possibly developed for other purposes. The introduction of new technologies into the existing system needs to be overhauled, so that the process allows for key activities to be carried out concurrently. The diagram below shows how the development of products in this sector could be more effective, and not exclude users of older technologies from benefiting from newer, advanced systems.

Figure 2 provides an idea of the flow of information and research, development and diffusion needed for successful product implementation in the IAT sector.

Figure 2: IAT Product Implantation Information Flows^[11]



ETHICAL ISSUES

IATs have the potential to provide new benefits to patients with dementia and their carers, but will, by their very nature, be intrusive. They will have to interact with vulnerable individuals at a physical and psychological level. With this in mind, the ethical dimension of these devices needs to be addressed at the early stages of the product development process.

The ethical concerns surrounding dementia were highlighted by Ienca et al (2017b)^[11]. They categorised the issues into thematic families.

In summary, the ethical issues surrounding replacement of human care with IATs include:

- Unintended consequences of switching from human care
- Appropriate acquisition of informed consent
- Protection of privacy
- Protection of patients from restraint and normative status of 'justifiable benevolent deception' when using socially assistive robots

Ienca et al highlighted the fact that currently nearly 70% of IATs have been developed in the absence of ethical considerations, and this could be a significant limitation in the transition from laboratory to clinical use.

Table 2: The Ethical Concerns Surrounding Dementia Highlighted by Ienca et al (2017b)

Autonomy	The right to independence, ageing in place of choosing.
Privacy	Includes both physical privacy (invasion, intrusion and obstruction of IATs into the private spheres of elders with dementia) and informational privacy (security of information, protection of data).
Beneficence	Technologies which give empathy, dignity, protection of vulnerability and enhancement. Generally leading to improvements in quality of life, as opposed to convenience of care systems.
Non-maleficence	Minimising the likelihood of causing harm.
Interdependence	Considerations of the dialectic between independence and dependence. IATs should enable those with dementia to maintain, restore, reacquire social relations and to improve the capacity to interact with external environments (social, digital and environmental).
Justice	The fair distribution of benefits, risks and costs of technology. In this context these comprise equality and fairness of access to all socio-economic groups and openness of technology, through either free access or licensing of both software and hardware.

SUMMARY OF KEY ISSUES

In many respects, the introduction of IATs to support dementia patients and their carers is similar to that facing the introduction of other healthcare technologies seen to be beneficial, cost-effective and providing safety and risk reduction. However, in several respects, their introduction poses some significantly different and potentially unique challenges:

- The technologies used are likely to be already available but modified for use with dementia patients, and this needs to be reflected in the regulatory pathway.
- The technologies need to be compatible with a wide range of symptoms; from those individuals with Alzheimer's disease to those suffering from mild late-onset forgetfulness as part of the ageing process.
- The technologies need to be adaptable, as the condition will almost inevitably progress over a period of time.
- In light of the rapidly advancing field, technologies need to be upgradable to avoid frequent replacements and associated costs.
- Technologies are unlikely to be standalone and need to be integrated into a healthcare system to maximise the benefits.
- The unique ethical dimension of this technology being used by both vulnerable people and their carers needs to be considered.
- IATs will be needed to help manage the increasing occurrence of dementia in all its forms, due to changes in population demographics.
- Introduction of this technology will require investment in both specific IATs and appropriate wider IT infrastructure. However, it is expected that will quickly be compensated for by reduced hands-on human care, hospital stays and the need for assisted living.

RECOMMENDATIONS AND ACTIONS

The introduction of new IATs should be overhauled to improve both the robustness of research and speed of clinical testing. A specific Dementia Technology Advisory Body should be commissioned, to define and oversee the specification, development and introduction of ethically sound and effective technology by 2019. It is proposed that this body should be part of the UK Dementia Research Institute and include all dementia stakeholders, and should work with the Medicines & Healthcare Products Regulatory Agency (MHRA) to develop an appropriate regulatory framework.^[13]

The following activities should be carried out as actions for the new Dementia Technology Advisory Body:

- Promote investment in healthcare infrastructure systems to ensure compatibility with IATs, ensuring both social benefits and cost savings.
- Ensure that designers and engineers involve all stakeholders in the development of appropriate devices, including patients, carers, providers (hospitals, care homes and communities), payers and regulators, as recommended in our product design diagrams.
- Investigate and clarify the ethical dimensions of these devices and ensure that these issues are addressed at the early stages of the product development process, when dealing with this vulnerable group within our society.

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