HEALTHY HOMES:
ACCOMMODATING AN AGEING POPULATION.

Institution of MECHANICAL ENGINEERS

Improving the world through engineering

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Creating a home which encourages its occupants to stay mobile and active as they age has the potential to keep them both mentally and physically fit for longer.

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EXECUTIVE SUMMARY

HOMES IN DECLINE

Despite the global perils of famine, accident, violence and infectious disease, most of us will die from a chronic or degenerative disease linked with old age. Today, with advances in acute and palliative health care, most people living in the developed world are expected to live longer than past generations, often well beyond the typical retirement age.

Currently in the UK, a man in good health can expect to live to 75 and women 77, with expectations that by 2039 more than one in 12 of the population will be aged 80 and over. However, increased longevity is often associated with heightened susceptibility to diseases and injury. Falls, as well as chronic diseases such as cancer, diabetes, arthritis, heart disease and chronic pulmonary disease, are common in older adults. For example, it has been predicted that by 2035, the number of people with dementia will have doubled in the UK.

The exact future impact and cost of this ageing population on health and social care services are hard to predict. Although it may well lead to increased costs for the rest of society, it may also create new economic and social opportunities. Either way, it is becoming increasingly difficult for governments worldwide to fully support the health and social care systems and provide appropriate accommodation. Put simply, we are ageing into an environment that is not conducive to old age[1].

It is often the case that with old age comes reduced mobility, with many older adults downscaling their homes as they become less active. This often perpetuates mobility reduction and the onset of frailty, resulting in higher risk of falls or injury and consequently non-elective visits to hospitals.

The annual cost of falls for the NHS in 2015 was £2.3bn. Physical inactivity costs the NHS £10bn a year, with £2.5bn spent on care as a result of poor housing[2].

Both academic research and anecdotal evidence have shown that staying in one's home into old age can improve health and wellbeing and reduce the incidence of visits to hospital. Creating a home which encourages its occupants to stay mobile and active as they age, has the potential to keep them both mentally and physically fit for longer, and reduces the onset of multi-morbidity conditions prevalent in old age. However, the UK's failure to build enough new housing over the last 30 years means there is a severe lack of suitable properties. Savills estate agents estimate that the UK will need to build 78,000 adapted new homes for older people each year over the next decade. If people could remain healthier for longer within their own homes as they age, then this has the potential to reduce both financial and economic pressures on healthcare providers.

The impact on health in old age

It is estimated that in the developed world, of those aged 80 plus:

- One in four will be afflicted with some form of dementia

- One in four will suffer from vision loss

- Four in five will develop hearing problems

Nearly one in eight older people now live with some level of unmet need with vital everyday tasks.[3,4]

INTRODUCING TECHNOLOGY FOR THE FUTURE

RECOMMENDATIONS

The use of smart technologies, including smart homes, could make life better for older people, enabling them to retain their independence and relieve the pressure on health and social care services[1,5].

Research suggests that 78% of global consumers of technology find the idea of living in a smart or cognitive home very attractive; with Chinese and Brazilian customers embracing this idea the most[36]. In contrast, consumers in the UK and Japan, with the highest growth rate of older populations, respectively show only 66% and 59% interest in smart homes. The UK must start to recognise that it needs to change its view of what it is to be older and in doing so address:

1. How being older affects the whole of society

2. How our failing housing infrastructure must be made fit for purpose

3. What our medical technology (MedTech), construction and building services industries can do to provide appropriate technology and housing

We must consider how simple technological adaptions could not only change the way we live, but create economies of scale for age-friendly devices.

To ensure that our ageing population remains fit and well into old age, the Institution of Mechanical Engineers recommends:

- **Establishing financial incentives to build cognitive houses.** Government must change its existing policy on house building and incentivise construction companies to build for older living. A house that enables people to age well will reduce the cost of residential and hospital care in the long-term, saving taxpayers money.

- **Creating a new standard for housing design and construction fit for the 21st century.** Government should commit to modernising the UK building design and construction regulations, and create a kitemark for agile/cognitive housing and its associated technology. This will help stimulate industry to grow the market for age-friendly homes.

- **Initiating new markets for technology to tackle our existing inadequate housing stock.** There is an opportunity for society to create demand for new markets in retro-fit technology, enabling people to live in their own homes for longer. Product suppliers and manufacturers must begin to prepare themselves for this customer-driven demand, or face losing out to more responsive, age-friendly businesses.

- **Investing in nationwide 'healthy living for life' technology programmes.** Our culture encourages downsizing and reduced mobility as we age. This lack of activity is costing the NHS £1–3bn a year in curing preventable illness, not to mention the cost to individuals in residential care or social services. The Department of Health must re-assess the 'personalised health and care 2020' framework, and collaborate with the Academic Health Science Networks to invest in national programmes that focus on technology for prevention of ill health in old age, rather than burdening the NHS when it's too late.

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The UK will need to build 78,000 adapted new homes for older people each year over the next decade.

THE IMPORTANCE
OF THE HOME

The UK has a growing ageing population. Indeed, it is estimated that by 2033[7], nearly two thirds of households will be headed by someone aged 65 or over. However, over 70% of people aged 65+ receive some form of care from their spouse or other family members. With the National Health Service and social services already stretched, the burden of supporting older people in the future will increasingly fall upon family.

Demographic change also affects how housing will operate as a financial asset. Housing assets play a major social role in later life; funding retirement and transferring wealth between generations. It is estimated that the UK's over-65s control nearly £2tn of equity, which is tied up in housing of which over 90% is owned outright.

It is becoming commonplace for those approaching retirement to want to move house; not necessarily to downsize, but to find a property that suits their way of life. It is expected that many family homes will become places of work as well as care, as older people continue to run businesses from home [2]. Yet the English Housing Survey carried out in 2014/15 showed that 93% of homes in England lacked the four basic features that deem them 'visitable' by a mobility-impaired person; level access, a flush threshold, door width and circulation space (for a wheelchair) and a toilet on the entrance-level floor[8]. Additionally, about 53% of over 65 households, approximately three million properties are under-occupied and 20% of older homeowners would be willing to sell their existing home and downsize if the new home was appropriately specified.

It is estimated that the UK will need to build 78,000 adapted new homes for older people each year over the next decade. Additionally, another 71,000 care home spaces will be needed in the next eight years for those unable to care for themselves. Currently it is estimated only 7,000 last-time buyer homes are being delivered each year [9,10,11].

AGEING WELL

It is considered that three things are needed to age well:

- Regular exercise
- Sustained mental stimulation
- Frequent social interaction

Successful ageing is a complex mix of behaviours, emotions and biological states, not just a condition of chronological age. Yet more than one in ten adults are either unable, or find it difficult, to move, walk or stand independently. Furthermore, only about 30% of people aged 55–64 only achieve 30 minutes a day of activity on at least five days a week, with fewer than 10% over 75 meeting the 30 minute target[12,13].

Inactivity across the whole of the population leads to about 37,000 premature deaths in England a year[14]. Often it is a combination of medical conditions (clinical and age-related) and poor home design/layout that restricts daily activities such as washing, cooking and moving between rooms.

Most older people face a combination of long-term conditions with consequences for mobility, vision, hearing, balance etc, and are more likely to reduce their household tasks as they often find these activities difficult or even unachievable.

Some studies suggest these changes occur in a predetermined order and can be represented as a 'curve of functional ability' shown in **Figure 1** below[15], which presents the level of difficulty the very old (85 years plus) have in performing daily tasks of personal care, household chores and mobility.

The Institution of Mechanical Engineers defined a series of criteria for independence at home[15,16], where the needs and applications of technology would vary depending on where a person sits on the curve. An opportunity exists to encourage greater activity through better home design and adaptive and assistive technology for some tasks, such as shopping, using stairs, housework, moving around the house, and transferring from chair, toilet and bed. Automatic assistance could be made to help maintain maximum activity, only providing what is necessary to encourage the older person to maintain muscle exercise as long as possible, based on health and not age[17].

Figure 1: Curve showing decline in functional ability[15]

Healthy Homes: Accommodating an Ageing Population
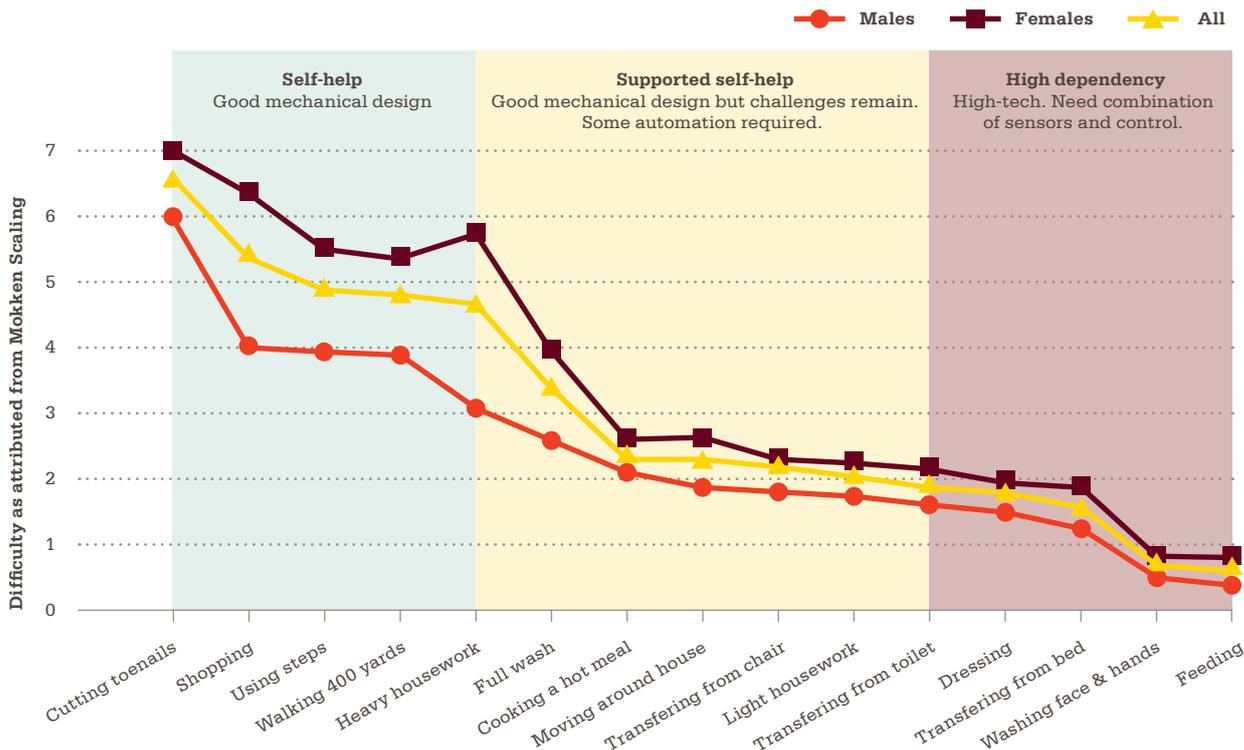
THE COST OF AGEING

In 2016, the UK spent the equivalent of 9.75% of its GDP on health care; approximately £3,251 per capita. This compares to the Netherlands £4,032, Germany £4,177 and £2,519 in Spain[18]. By 2020/21 Age UK estimates that spending on social care for older people would need to increase by £1.65bn to a total of nearly £10bn, if the UK is to provide adequate care for the over-65s[3]. A patient who can be appropriately cared for outside the hospital environment such as in a nursing or residential home, or with additional support in their own home, offers a less costly treatment path than those who are forced to remain in hospital. In 2015 an NHS bed cost an average £1,925 a week, compared to a residential care home at £558 a week or £357 for care at home[19].

The impact of poor housing has a similar effect to that of smoking or alcohol on health and wellbeing. Government estimates poor housing costs the NHS £2.5bn per year across all ages. Allowing vulnerable people to remain in homes with significant hazards is costing the NHS nearly £414 million per year in initial treatment costs alone. This is comparable to the cost of physical inactivity within society (£1bn) and alcohol abuse (£3.2bn)[2,20,21]. 300 older people can be helped by a handyperson for the same cost of one place in a care home for a year (£30,000 vs £100)[22].

A Health Survey carried out in 2011, intimated "that a substantial proportion of older people receiving formal care are funding this themselves". However, the increasing financial burden of residential care is encouraging older people to remain in their own homes for as long as possible, receiving unpaid or social care, rather than move into a care home. Typically a residential care place costs between £50,000 and £90,000 for an average 2½-year stay (£380–£700 a week); varying from 18-56% of the value of a typical house depending on where you live in the UK[23,24].

UK HOUSING & HEALTHCARE POLICY

The ageing population will, over the coming years, challenge existing housing policies. The demographic changes are increasing demand for housing which accommodates the requirements of people as they age. The design and construction of future housing stock will need to consider not just physical accessibility, but also the effect it will have on people's mental wellbeing. Appropriately designed housing that can adapt to people's changing needs will reduce demands on our healthcare services and enable greater flexibility in how individuals manage their lives[2].

Government has recognised for some time that there needs to be significant change to UK housing policy, if the needs of our growing ageing population are to be addressed. The Housing and Planning Act 2016 and the Neighbourhood Planning Act 2017 were established to stimulate the building of up to one million new homes by 2020, speed up the construction process and provide greater opportunities for people (particularly the young) to buy a new home.

While these new regulations paved the way for an acceleration of residential property building, the construction and building services industry has been unable to achieve the Government's aspirations. This is due, in part, to costs and financing facing construction companies and to lack of incentives to transform housing design.

More specifically, the two regulations do not directly tackle the need for suitable housing for our older population, despite the Government wanting to "help deliver outcomes that are best for older people"[2,25]. Without some form of additional statutory legislation or specific financial incentive, the construction and building services industry has no impetus to create dedicated housing for older people. Radical thinking is needed if the UK is to capitalise on its ageing population, such as new housing policies combined with economic schemes to create technological solutions to support older people.

There exists, however, a number of non-statutory policies, developed by housing organisations, ageing charities and other concerned groups, which set out to address the gap in current housing policy pertaining to older people. The Lifetime Homes Standard (LHS), while recognised by Government, remains an option, which local authorities can choose to implement. The LHS sets out 16 design criteria which can be applied to new housing to address accessibility and inclusivity at minimal cost. The purpose of each design feature is to add convenience to the home, to support the changing needs of a family or individual, through life. It is estimated that the additional cost to the building design would be between £545 and £1,615 per dwelling. This of course depends on the size of the building and whether the LHS has been implemented in the early design stages of a new build, or used to modify an existing dwelling. The institution believes that if standards such as these design criteria were incorporated into existing Government policy, further additional cost savings could be made both in construction cost and in long-term healthcare[17].

ASSISTIVE TECHNOLOGY

Today's over 65s are relatively well informed about technology and often want to be engaged in decisions and processes regarding their health and care. Indeed, several health organisations have recommended that digital technology can and should put diagnosis and management of healthcare more firmly into the hands of patients and carers. Yet we are faced with a conundrum. Technology is enabling us to live into very old age. With growing longevity there is a greater need for more technology to support us. While technology is considered to be one of the solutions to the increasing cost of getting older, more technology pushes up the cost of healthcare.

The Institution of Mechanical Engineers believes that there are a number of considerations that need to be addressed if we are to solve this conundrum. First, we need to examine our existing housing stock and assess how we might create low-cost assistive technology that can be used within the home to increase physical activity of our older population today. Second, we need to consider how we can encourage the construction industry to offer adaptive, intelligent homes that cater for the health and wellbeing of future generations of older people.

There are a plethora of businesses providing products and services that can support independent and healthy living in old age. It is predicted that over 130 million smart home devices were shipped in 2017, and by 2020 the average home will have more than 500 connected devices, ranging from washing machines to light bulbs [26,27].

There have been a significant number of studies undertaken to assess the health and cost impact of aids and adaptions such as handrails, grab bars and raised toilets and lowered cabinets, all of which have demonstrated considerable reduction in accident rates, such as falls[1,17]. Fundamental needs such as lighting, security and heat are often held in higher regard than luxury appliances such as dishwashers and coffee makers. Likewise entertainment devices are often seen as important for older people, suggesting people place greater value on warmth, safety and recreation than upgrading their housekeeping equipment.

However, the UK is lagging behind the rest of the world in adopting smart technology for the home[5,28]. Japan, for example, has recognised both the desires of older people and the need to create appropriate technologies to manage those aspirations. Robotic exoskeleton suits to help with mobility and automated nursing care are just a few of the innovative solutions being developed. Fujitsu has recorded sales of over 20 million phones with larger buttons and simplified functions, and Toyota has been developing a range of options for its cars, including collision and parking sensors and rear cameras tailored to older drivers[29,30].

Exercise through assistive technology
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User activity should be intrinsically incorporated and encouraged within the living environment. For example, when a stair lift is installed, the user would need to cycle using hands and/or feet to move up or down the stairs. The stair lift will be electrically powered and uses feedback from the cycling torque and speed of the user through a control strategy; the restraining torque of cycling would be controlled to suit the ability of the user.

RETROFITTING OUR LEGACY

Of the 23.8 million homes in England in 2015/16, about 85% were built before 1990[2,4]. About seven million of those homes are headed by someone aged over 65 years, who will undoubtedly need some form of assistive technology within the coming decade as a result of poor housing provision. Retrofitting adaptive technology will be, in most cases, the only option for most of these households.

The location and height of cupboards, domestic appliances, toilets and bathroom appliances introduce a significant level of difficulty into household activities as we age. Cupboards can be too high or too low to access or too deep to reach items at the back. To encourage physical activity in the kitchen, pull-out storage units that can be accessed at head or chest level, and work surfaces which can be adjusted in height need to be considered. Eye-level appliances such as ovens and dishwashers would encourage older people to maintain activity while providing convenience. The inconvenient siting of sockets and switches that sometimes requires painful bending, crouching or reaching, could easily be addressed by positioning them at waist height[17].

Assistive technology should be designed to assess the needs of the individual and provide just enough assistance to maintain the older person's functional ability. Designers, manufacturers and marketers must pay greater attention to the needs, attitudes and capabilities of older people and develop new strategies and markets now, to satisfy and stimulate imminent demand.

SMART HOMES: BUILDING FOR A SILVER TOMORROW

The smart or cognitive home brings together housing, interactive technology, engineering, and healthcare in a truly unique way. These homes are designed to be flexible living spaces that enable people to maintain a high level of independence and social interaction, activity and wellbeing. They offer the resident greater safety and security than traditional homes, enabling people to live in their own home into later life rather than being hospitalised or institutionalised. A well-designed smart home must include technology that is adaptable, suitable for both young and older adults, easy to use and most of all cost effective[2,30,31].

Home design can cater for changes in physical need by ensuring that maximum activity, by the home occupier, in line with their health ability is maintained through automatic assessment of the user's ability in performing certain tasks. The objective would be to encourage physical activities while performing routine tasks. For example, instead of providing a chair to assist the older adult to stand from a sitting position (using a system which provides the same sit-to-stand motion irrespective of the ability of the user), a chair, which monitors the lifting force with respect to the sit-to-standing pose and provides adequate force to encourage the user to use their own knee muscles to help them stand up would encourage physical activity. A similar system can be used for the bed and the toilet. Sensing of the standing motion and the assistive force can be seamlessly fed to a healthcare monitoring system which constantly adjusts to suit the needs of the occupant.

Connectivity will be the backbone of the smart home. It will provide access to a multitude of technologies and services, both in and outside the home as well as helping us plan travel, work and social engagements. It will also have a major effect on our work, lifestyle and healthcare[2,30].

Conventional wisdom would suggest that older people would prefer to live on the ground floor: benefiting from ease of access and increased safety. Yet it has been suggested that, contrary to popular belief older, people appreciate varied views, natural light, reduced noise and disturbance and greater privacy. These features all lend themselves to above ground floor living and suggest that technology to enable older people to travel between first and upper floors, through the inclusion of well-designed stairs, should be considered as part of designing future healthy homes. The tread, rise, number and orientation of steps as well as positioning of handrails, lighting and landings are of particular importance when considering design for older living[30]. By incorporating relatively simple features into their designs, engineers and designers can enable older people to move more easily between floors, and level changes. This type of design would encourage moderate intensity physical activity without drawing attention to the design changes[30].

Oddly, as we age we often need more space. Not in the conventional sense, for storage or furnishings, but to enable everyday mobility. Sedentary lifestyles where a person is sitting or lying for an extended period of time can be, in part, a result of inconveniently placed appliances and increasing mobility impairments. The typical expectation for older people in the UK is that they will 'downsize' to smaller, more compact properties such as bungalows or flats, once family have left home or physical decline begins to occur. It is often the case that smaller properties and rooms are an impediment to everyday activities, while homes with large open spaces or several rooms where individuals can undertake different tasks, encourage activity and social interactions. A smart home that is adaptive, should future proof against retrofitting, by providing enough space for an individual's functional needs as they age[31].

The location of our smart homes will be just as important as the domiciles themselves. Addressing urban and rural isolation will be an important feature of smart home design and planning. The positioning of smart home communities, the infrastructure and accessibility to amenities, will be key to their success. The Healthy New Towns concept launched in 2015 may provide such opportunities, by creating ten new towns for approximately 170,000 residents, which would be a test bed for innovative technology to address health and wellbeing for all members of society[32].

The smart home can catch the 'little things' before they become major issues for the resident, and ultimately a cost burden on the NHS. For example, increased toilet visits can signal urinary infections or incontinence, deviations in gait over time can be the precursor to an impending fall, all of which could, if left unchecked result in long stays in hospital for treatment. By detecting these signs early, the smart home and its inbuilt technology can warn the resident or a monitoring physician of an imminent episode. With simple interventions such occurrences can be mitigated or even avoided[5,30].

BARRIERS TO ADOPTION OF SMART TECHNOLOGY

COST

The challenge with creating any kind of smart home is to create an environment that provides safety and security by reducing the occurrence of falls and accidents, is accessible to those with disability or chronic illness, while reducing stress, fear or social isolation. Smart home technologies should be designed to function without distracting the user and without causing any pain, inconvenience or movement restrictions[1].

Of consumers surveyed by Data Select, 39% said security and control of the smart environment was important, with 38% wanting connectivity and entertainment and 37% concerned with energy and lighting. Only 30% considered health and domestic appliances to be of importance. In comparison, 36% felt cost of purchasing was a barrier to adoption of smart home technologies, with 22% and 16% saying privacy and home[2].

While the notion yet uptake of such technology is often slow to materialise due to the actual or perceived cost of such technology[5,20].

Tax breaks for older people which could save the country money, such as stamp duty tax relief, for moving and/or future proofing a house, have the potential to increase uptake of technology and smart homes, but would require considerable commitment and fortitude by Government to create policy. A proposal of this kind would take only a significant cultural change within the UK but an extensive overhaul of tax and housing policy[20].

Hip fractures are one of the most common serious injuries arising from a fall. About 70,000–75,000 hip fractures occur in the UK each year, costing about £2bn, or £26,000 per hip fracture in clinical and social care. The charity Care & Repair suggests that very simple adaptations to the home could reduce falls by 25%: the equivalent of 18,000 people. This would result in a cost saving of about £0.5bn each year[33].

Such savings could potentially cover the installation costs of adaptions in just over four years, not even accounting for the annual savings arising from prevention of other minor fall injuries (wrist, knee and foot fracture)[33].

New Zealand Hip Fractures

In 2014, a three year study was carried out in New Zealand based on a sample of over 800 people where a package of relatively low-cost home modifications (including handrails for outside steps and internal stairs, grab rails for bathrooms, outside lighting, edging for outside steps, and slip-resistant surfacing for outside) were installed at an average cost of $850 (£375). The home modifications led to a 26% reduction in injuries attributable to home falls that needed medical treatment. Injuries specific to the home modification intervention were reduced by 39%[33].

SECURITY AND PRIVACY

Global digital transformation is the sole imperative for all of the major digital businesses – Microsoft, Google, Apple and Amazon. Whether that comes in the form of devices, marketing, big data analytics or cloud storage, there is no denying our lives have become digital. They will continue to become even more integrated into cyberspace in the coming decades. Issues about the Amazon and Google digital assistants 'listening in' to our daily conversations, have already begun to raise concern. It is highly likely that these networks of companies will eventually know more about us than we do about ourselves; predicting when we might get ill, suffer a fall or develop dementia, just from analysing how we move around our environments and use our homes and the technology in them. The security of these systems and the control of private information is therefore a crucial factor in the design of future smart homes.

The threat of home-wide hacking grows with every device added to the home's 'Internet of Things', yet few adults, let alone older people, are fully aware of the risks. The feeling of safety within the home and a sense of control is key to enhancing social and emotional wellbeing, and 23% of those aged 55–64 feel they would be less stressed if their home could help them with their healthcare[1,27]. Yet studies indicate that security and privacy issues can be a barrier to older peoples' adoption of smart homes and assistive technology. Their desire for greater connectivity can often blind them to the realities. As smart homes and their associated technologies develop, they will require little or no training to use and virtually no interaction from ourselves; automatically connecting to us directly from the cloud.

Licencing of devices and privacy policies must become a prerequisite of future smart home technologies. All stakeholders across the smart technologies landscape must work with Government and its customer-base to define new legislation regarding smart home technology which involves the transfer, storage and use of personal information. Older people must be mindful of the data they provide to cyberspace and have an opportunity to influence the way in which these regulations are defined. They must be given a choice in the way data is collected; a balance between comprehensive monitoring and the functionality to select how they will be monitored, must be found[1,20,27].

Key to ensuring good connectivity for older people will be addressing barriers to technology use and integrating systems into the built environment. Safety concerns related to malfunctioning of technology highlight the importance of building in redundancy and contingency systems for events such as power outages[1,30,34].

APPEAL

It is estimated that the global spending power of the over 65s will reach $15tn (£10.8tn) by 2020 with Europe already having a 'silver economy' valued at €450bn (£400bn). The 'Grey Pound' accounts for over 50% of consumer spending in the UK, which reached £72bn in 2017[29,35]. Contrary to popular belief, our growing ageing population is becoming more tech-savvy and this will only increase in the decades to come. Many companies have been unsuccessful in bringing products and technologies for older people to the market. Recent research shows that the uptake of equipment and devices, particularly those designed with connectivity in mind, such as smart lights and appliances, has been slow over the last few years, with only 2% of adults owning them. This is often due to a lack of understanding on the part of the manufacturer or retailer as to what the over 65's want from these products and services[36,37].

Charities such as the Centre for Ageing Better believe demand has been slow to materialise as the products that purport to offer aid or adaption to the home are poorly designed and aesthetically unappealing to the older generation and are purchased only when they reach crisis point. Instead of creating products only for older people, creating products that are flexible and span the generations would result in greater uptake[20,29].

All too often, technology aimed at older people emphasises their growing frailty and decline, and is regularly aimed at healthcare providers rather than actual users; rendering the product overly clinical and unappealing. Manufacturers should be mindful of designing products 'for all' which offer self-improvement, stimulation and enhance lifestyle, not focusing on limited specialist use. There are, however, growing negative attitudes towards assistive technology which specifically targets older adults; the so-called 'gerontechnologies' which often contain stigmatising symbolism for many older people; a reminder that they are somehow different[20,34].

Equally, older people do not want to be overwhelmed by the technology they use. They are becoming more discerning when it comes to the technology they surround themselves with. Barriers to use develop if the technology is overly complex and single-use. Technology is more likely to be accepted if it is intuitive and straightforward. There remains disparity between what is being provided and what the customer actually wants.

Creating discreet devices and equipment that can either be worn or built into clothing, or hidden in home furniture and appliances and put away when not in use, must be a priority. Engineers and designers must abandon the notion that older people want devices always on show. On the contrary, older people do not want to be defined by the technology they use. They want technology that supports them while being minimally invasive. Designers must consider the fit, form and function of products that address older people's needs at a price that is accessible to the majority of the population[9].

The market therefore faces a chicken-and-egg situation. Consumer driven demand will occur only if products are appealing. Suppliers will provide such products only if they see consumer uptake. If smart homes and their associated technologies are to make any impact among the over 65s, then older people must provide incentives to the private sector to bring these products to market, not just by purchasing, but through feedback and endorsement.

URBAN VS. RURAL LOCATION

53.8% of the UK's population lived in a city environment in 2015, with this figure set to rise over the coming decades. However, it is recognised that the rural population is ageing at a faster rate than those in an urban setting. While living in rural Britain has its advantages from a health perspective eg lower cases of cancer and heart disease, low population density and limited access to social, medical and commercial centres can increase social isolation and reduce activity and mobility. These are known to increase occurrence of frailty, falls and dementia. Likewise, urban isolation brought about by obsolete housing stock, inaccessible infrastructure and poor accessibility to amenities can have a similar effect on those growing older in our cities. It is key, that the needs of older people in urban and rural environments must be treated differently to enable them to manage their health in an appropriate manner[38,39].

> Our culture encourages downsizing and reduced mobility as we age. This lack of activity is costing the NHS £1–3bn a year in curing preventable illness, not to mention the cost to individuals in residential care or social services.

INITIATING CHANGE

CHANGING THE VIEW OF BEING OLD: HEALTHY LIVING FOR LIFE

Organisations in the field of health and care for older people agree that more needs to be done to provide access to home adaptations and assisted living technologies which would enable older people to remain in their own homes. The Institution of Mechanical Engineers supports this view but recognises that this is not just a case of installing technology to improve people's health and longevity. A three-pronged approach is required which includes society, industry, and Government to address cultural views of old age, the provision of products and services and the policies that drive innovation and change in our housing market. The Institution recommends that the following areas must be addressed in order for change to occur.

Our culture encourages downsizing and reduced mobility as we age. This lack of activity is costing the NHS £1–3bn a year in curing preventable illness, not to mention the cost to individuals in residential care or social services.

Many older people regard themselves as content and well, even with chronic illness or multiple morbidity conditions. People should be encouraged to build-up and maintain their social activities and networks from a young age, through the provision of both social media and community facilities. Research has shown that having numerous outlets for social activity and relationships can be associated with wellbeing, better health, and longevity. There is then a need for greater awareness from both clinical and technical communities of the perception of what it is to be an older person who has aged well, despite the medical definition[40]. This will enable the NHS and other social care commissioning bodies to make better informed decisions on the provision of assistive and retrofitted technology[15,20,28].

Education is needed to ensure older people understand the benefits of physical activity and how they can utilise technology to assist them in maintaining a healthy lifestyle. The Department of Health must re-assess the 'personalised health and care 2020' framework and look to invest in national programmes that focus on assistive technology for society-wide prevention of ill health rather than burdening the NHS when it's too late. This could be achieved by working with the medical technology (MedTech) industry to develop cost-effective equipment as part of a healthy living for life programme. Training and workshop sessions could be provided by MedTech companies in the community to help older people with any difficulties they might have using home health medical devices. Our view of being old should focus on capability not on age.

The advisory body 'FirstStop', provides independent information and advice service, to help older people make financial decisions about moving, types of care options or remaining in their homes. While Government, namely the Department for Communities and Local Government, has provided significant funding for FirstStop, the organisation continues to rely on grants and 'goodwill' to maintain its services. The demand for this type of service can only increase in coming years. Government must ensure that this service, and others like it, form part of a Government-funded nationwide healthy living for life programme.

GOVERNMENT HOUSING AND SOCIAL CARE POLICY

How a person ages is affected by a range of factors throughout their life. If we are to improve health outcomes for people as they age, then we must ensure that there are appropriate interventions from an early age. It is not within the remit of this report to discuss those interventions, but the Institution recognises that an overhaul of housing and social policy is needed now, if we are to provide society with the appropriate care and habitation in which to age effectively.

Understanding the national and regional requirements of society is key. Ensuring that there are equivalent and maintainable levels of connectivity between urban and rural areas will be necessary. Policy that creates greater flexibility and options for home ownership across the country that accounts for regional differences in older people's finances and health needs must be established. Homes must meet the changing lifestyles of older people and with it financial incentives, such as reduced stamp duty on smart homes, will enable people to move more readily. Without these provisions, more of our older population will be 'stuck' in an unsuitable home until ill health forces them to move[1,9]. Initiating new markets for technology to tackle our existing inadequate housing stock should form the basis of new housing and social care policy.

Research suggests that by focusing housing policy on just a few simple measures, older people would be empowered to lead more active lives at home. Such policy changes could result in considerable long-term savings for the NHS. In the Netherlands, insurers now reimburse users of certain healthcare devices such as sensors. The manufacturers have been proactive in approaching healthcare organisations, including the health ministry, to provide this service. Reimbursements on wearables are also being considered by insurance companies. This is far from being the norm however, and insurance providers are still reluctant to cover the cost of medical devices today that might prevent a hip fracture or stroke tomorrow[5].

There is an opportunity for UK society to create demand for new markets in retro-fit technology, enabling people to live in their own homes for longer. Product suppliers and manufacturers must begin to prepare themselves for this customer-driven demand or face losing out to more responsive age-friendly businesses. Greater understanding of the 'Grey Pound' is needed to ascertain the possibilities of creating a self-funded market for assistive technology[20].

BUILDING REGULATIONS AND CUSTOMER-DRIVEN DEMAND

Housing developers recognise that there is huge demand for specialist housing, however the existing design and planning processes actively discourage them from providing or even considering accessible or smart homes. Planning regulations and housing policy only pay lip service to the needs of older people and the optional building regulations do not ensure more homes will be built to the standards needed to suit older people.

Government needs a bolder long-term vision to address the social and medical issues faced by our ageing population if it is to incentivise the construction industry[41]. Creating a new standard for housing design and construction fit for the 21st century must be the priority. Policies which motivate construction companies to build intergenerational houses and mixed home communities that are 'assistive technology-ready' should be created. Standards and recommendations that have been endorsed by leading building authorities and charities representing older people, already exist. These standards should be formally adopted into the UK construction regulations to become mandatory requirements.

To stimulate market demand for smart homes, companies must better understand the needs of older people who, for the most part, do not want to downsize into small, poorly located and inaccessible properties, but who want appropriately sized homes, close to amenities, healthcare and transport links, located near family with flexible adaptive technology built-in[10,31].

The UK has a growing number of retired professional engineers and designers, all with significant experience in their professions and a first-hand understanding of their own conditions. Construction companies should be required to include, wherever possible, a significant proportion of older people in their product design teams. In national infrastructure projects, Government could insist that companies demonstrate their teams have a quota of older people as part of their tendering application[42].

Government should take the opportunity after Brexit to modernise the UK building design and construction regulations, and create a 'kitemark' for agile/cognitive housing and its associated technology. This will help stimulate industry to grow the market for age-friendly homes.

FINANCIAL INCENTIVES
FOR NEW BUILD

Currently there are no financial or tax incentives for construction companies to build healthy homes. The £315m (plus £155m) over five years the Department of Health set aside to build 4,000 specialist homes by 2018 is woeful[20,43]. Government must look to establish financial incentives for construction companies to build smart houses. This could come in the form of tax reimbursement or contracts for maintaining and installing assistive technologies. A house which enables people to age well will reduce the cost of residential and hospital care in the long-term, saving the NHS and taxpayer money.

While the means-tested Disabled Facilities Grants (DFG) provide funding of between £1,000 and £30,000, to older and disabled people to help them make changes to their home, once the adaptation has been installed, maintenance and repair are the homeowner's responsibility. There is an opportunity for Government to work with the insurance industry to offer premium rebates or cash reimbursements to older people installing assistive technology within the home[44].

"The appropriate selection of assistive technology within the home can make a significant difference to a person's activity levels and encourage them to remain in their home for longer.

RECOMMENDATIONS

The Institution of Mechanical Engineers supports Age UK's call for "housing that reflects the changing needs and aspirations of all older people". To achieve this technology and innovation in smart homes will be the key to creating an age-friendly environment. The appropriate selection of assistive technology within the home can make a significant difference to a person's activity levels and encourage them to remain in their home for longer. The Institution recommends:

- **Establishing financial incentives to build cognitive houses.** Government must change its existing policy on house building and incentivise construction companies to build for older living. A house that enables people to age well will reduce the cost of residential and hospital care in the long-term, saving taxpayers money.

- **Creating a new standard for housing design and construction fit for the 21st century.** Government should commit to modernising the UK building design and construction regulations, and create a 'kitemark' for agile/cognitive housing and its associated technology. This will help stimulate industry to grow the market for age-friendly homes.

- **Initiating new markets for technology to tackle our existing inadequate housing stock.** There is an opportunity for society to create demand for new markets in retro-fit technology, enabling people to live in their own homes for longer. Product suppliers and manufacturers must begin to prepare themselves for this customer-driven demand, or face losing out to more responsive age-friendly businesses.

- **Investing in nationwide 'healthy living for life' technology programmes.** Our culture encourages downsizing and reduced mobility as we age. This lack of activity is costing the NHS £1–3bn a year in curing preventable illness, not to mention the cost to individuals in residential care or social services. The Department of Health must re-assess the 'personalised health and care 2020' framework and collaborate with the Academic Health Science Networks to invest in national programmes that focus on technology for prevention of ill health in old age, rather than burdening the NHS when it's too late.

REFERENCES

1. Smart-Home Technologies to Assist Older People to Live Well at Home; www.omicsonline.org/open-access/smarthome-technologies-to-assist-older-people-to-live-well-athome-jasc.1000101.pdf

2. Future of an ageing population, Government Office for Science; www.gov.uk/government/uploads/system/uploads/ attachment_data/file/535187/gs-16-10-future-of-an-ageingpopulation.pdf

3. Briefing: Health and Care of Older People in England 2017; Age UK; www.ageuk.org.uk/Documents/EN-GB/Forprofessionals/Research/The_Health_and_Care_of_Older_ People_in_England_2016.pdf?dtrk=true

4. English housing stock age. IHBC; www.designingbuildings.co.uk/wiki/English_housing_stock_age

5. New technology for old age; www.economist.com/news/ special-report/21724747-latest-technology-even-morebeneficial-old-young-new

6. UK Smart Home Statistics; www.dataselect.com/uk-smart-home-statistics/

7. Laying the Foundations: A Housing Strategy for England; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7532/2033676.pdf

8. English Housing Survey Adaptations and Accessibility Report, 2014-15; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539541/Adaptations_and_ Accessibility_Report.pdf

9. Housing and ageing population 2015; Savills Estate Agents; www.savills.co.uk/research_articles/205506/193071-0

10. Generations apart: The Growth of Age Segregation in England & Wales; www.if.org.uk/wpcontent/uploads/2016/09/Generations-Apart-Brochure.pdf

11. Is late-life dependency increasing or not? A comparison of the Cognitive Function and Ageing Studies; The Lancet; www.thelancet.com/journals/lancet/article/PIIS01406736(17)31575-1/fulltext?elsca1=tlpr%20

12. The Disabled Facilities Grant Before and after the introduction of the Better Care Fund; http://www.foundations.uk.com/media/4665/dfg-report-final-interactive-converted-draft-6-small.pdf

13. Centre for Ageing Better Annual review 2016-17; https://www.ageing-better.org.uk/publications/centre-ageing-better-annual-review-2016-17

14. What is preventing progress?; https://richmondgroupofcharities.org.uk/sites/default/files/pdfswhat-is-preventing-progress-2014.pdf

15. Losing the Ability in Activities of Daily Living in the Oldest Old: A Hierarchic Disability Scale from the Newcastle 85+ Study; PLOS One; journals.plos.org/plosone/ article?id=10.1371/journal.pone.0031665

16. 21st Century Engineering for an Ageing Population; http://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/21st-century-engineering-for-an-ageing-profession998fa38d54216d0c8310ff0100d05193.pdf?sfvrsn=0

17. The home as enabler of more active lifestyles among older people; www.tandfonline.com/doi/full/10.1080/09613218.2015.1045702

18. NHS Stats and Figures; NHS Confederation; www.nhsconfed.org/resources/key-statistics-on-the-nhs

19. Remote Health Management: Reducing Bed Blocking in the NHS; IMechE; www.imeche.org/docs/default-source/1-oscar/Press-Office/imeche-ps-nhs-bed-blocking.pdf?sfvrsn=0

20. Living in a suitable home and neighbourhood - deliberative workshops findings; Centre for Ageing Better; www.ageingbetter.org.uk/publications/deliberative-workshops-findingsliving-suitable-home-and-neighbourhood

21. The cost-benefit to the NHS arising from preventative housing interventions; BRE; www.viva-access.com/wpcontent/uploads/2016/05/bre_summary_report.pdf

22. Later Life UK factsheet, Age UK; https://www.ageuk.org.uk/Documents/EN-GB/ Factsheets/Later_Life_UK_factsheet.pdf?dtrk=true

23. Health Survey for England – 2012; http://digital.nhs.uk/catalogue/PUB13218

24. Changes in the Older Resident Care Home Population between 2001 and 2011; https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/ageing/articles/changesintheolderresidentcarehome populationbetween2001and2011/2014-08-01

25. Fixing our broken housing market; DCLG; www.gov.uk/government/uploads/system/uploads/attachment_data/file/590464/Fixing_our_broken_housing_market_-_print_ready_ version.pdf

26. Why 2017 will finally be the year of the smart home: Consumers figure it out; CNBC; https://www.cnbc.com/2017/01/04/why-2017-will-finally-be-the-year-of-thesmart-home-consumers-figure-it-out.html

27. The future of connected home health; Plextek; www.plextek.com/wp-content/uploads/2016/07/The-future-of-connectedhome-health.pdf

28. What role can local and national supportive services play in supporting independent and healthy living in individuals 65 and over?; Government Office for Science; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/460109/gs-15-24-future-ageing-supportive-services-roleer14.pdf

29. Embracing the silver economy; bruegel.org/2017/04/ embracing-the-silver-economy/

30. Neighbourhoods of the Future better homes for older adults – improving health, care, design and technology; https://www.agileageing.org/site_files/5944/upload_files/Preview_of_NOF2.pdf?dl=1

31. HQM spotlight – Access and Space, BRE; http://brebuzz.net/2017/07/20/hqm-spotlight-access-and-space

32. Healthy New Towns; NHS England; www.england.nhs.uk/ourwork/innovation/healthy-new-towns/

33. Cost benefits of adapting homes to reduce falls by older people. Applying the findings of international studies to the UK; Care & Repair England; careandrepair-england.org.uk/ wp-content/uploads/2014/12/The-cost-benefits-of-homeadaptations-in-reducing-falls-July-15.pdf

34. End User Security & Privacy Concerns with Smart Homes; Eric Zeng, Shrirang Mare, Franziska Roesner; University of Washington; www.franziroesner.com/pdf/ZengSmarthomes-SOUPS17.pdf

35. Growing the European Silver Economy; http://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/silvereco.pdf

36. Did baby boomers lift Britain out of recession? Grey pound accounts for almost 50% of consumer spending, claims survey; http://www.thisismoney.co.uk/money/news/article-2553921/Baby-boomers-helped-lift-Britain-recession-grey-pound-accounts-50-consumer-spending.html

37. Millennials v Grey Pound - Who holds the key to future retail success?; https://home.kpmg.com/uk/en/home/media/press-releases/2016/05/millennials-v-grey-pound-who-holds-the-key-to-future-retail-succ.html

38. Later life in rural England, AgeUK; https://www.ageuk.org.uk/brandpartnerglobal/bedfordshirevpp/later_life_in_rural_england_report_lr.pdf

39. Ageing and the city: making urban spaces work for older people, HelpAge International; http://www.helpage.org/silo/files/ageing-and-the-city-making-urban-spaces-work-for-older-people.pdf

40. What is successful ageing and who should define it?; The BMJ; http://www.bmj.com/content/331/7531/1548

41. Better homes and bungalows for Britain's older people; DCLG; www.gov.uk/government/news/better-homes-andbungalows-for-britains-older-people

42. Homes for our old age Independent living by design; CABE; webarchive.nationalarchives.gov.uk/20110118111654/http://www.cabe.org.uk/files/homes-for-our-old-age.pdf

43. Sajid Javid: a housing market that works for everyone; DCLG; www.gov.uk/government/news/sajid-javid-a-housingmarket-that-works-for-everyone

44. Home adaptations - help with costs; Independent Age; https://www.independentage.org/information/housingoptions/home-adaptations/home-adaptations-help-costs

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