Scoping study on the emerging use of Artificial Intelligence (AI) and robotics in social care

Final Report

May 2018

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Published by Skills for Care

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Published by Skills for Care, West Gate, 6 Grace Street, Leeds LS1 2RP www.skillsforcare.org.uk

Reference no. WP2.1a6-CON-17001

Skills for Care is the employer-led strategic body for workforce development in social care for adults in England. It is part of the sector skills council, Skills for Care and Development.
This work was researched and compiled by **Consilium Research and Consultancy Ltd.**

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Acknowledgements

Skills for Care and Consilium Ltd would like to thank the range of individuals and organisations within the fields of robotics, local government, academia and social care who supported this scoping study and gave up their time to speak with members of the research team. Their time and support is greatly appreciated.

Executive summary

Introduction

Consilium Research and Consultancy (Consilium) was commissioned in March 2018 by Skills for Care to undertake a scoping study on the emerging use of Artificial Intelligence (AI) and robotics in adult social care. The purpose of the scoping study is to:

- Examine the existing international literature in the context of AI and robotics and their uses in adult social care;
- Explore what is currently happening in the context of AI and robotics and their uses in adult social care focusing on the UK but including international examples; and
- Outline workforce issues that might arise as the use of AI and robotics in adult social care begins to grow.

Overview of research methods

This scoping study has incorporated a rapid evidence review of existing published literature on the potential for and use of AI and robotics within adult social care and engaged a range of individuals and organisations within the fields of robotics, local government, academia and social care.

Context

The adult social care sector in England continues to face a range of challenges with growing unmet care need with estimates showing that showing that 1.2 million people are not receiving the help they need, an increase of 18% on last year. Whilst there is a recognised need to invest more in social care in the coming years technology could also have an important role to play in supporting the care workforce and improving care outcomes. However, there is recognition that technology is not yet being used to its full potential with calls for increased investment in technology to support caring as part of the UK government's industrial strategy.

Presenting a typology of AI and robotic technologies

This rapid evidence review has highlighted a wide range of AI and robotic technologies that have been piloted or are in use within social care either within the UK or, more commonly, internationally. Much of the research focuses on the role of technology in supporting older people, albeit the applications have transferable value for a wider range of people who use care services.

A common theme identified in the review was a lack of information on the extent to which the different AI and robotic technologies had moved beyond the prototype and testing phase. Several authors provide a clear distinction between physically-assistive robots (PARs) and socially assistive robots (SARs), distinguishing between the intellectual and physical needs of people in different phases of late life.

PARs have been developed to perform discreet tasks including lifting and carrying to support people who use care services. Whilst some PARs have been designed to operate independently from the care workforce others have been designed to support the care workforce to undertake physical tasks associated with performing their care role. Given the significant safety challenges and requirements surrounding the design and use of PARs, the evidence review suggests that there are currently a limited number of robots either in development or being used within social care.

Socially assistive robotics aims to endow robots with the ability to help people through individual non-contact assistance in convalescence, rehabilitation, training and education. SARs can be categorised into two operational groups, namely ‘service robots’ which are tasked with aiding activities of daily living and ‘companion robots’ which are more generally associated with improving the psychological status and overall well-being of its users.

Cognitive Assistance Robots (CARs) is another emerging area work in using SARS to support users to perform cognitive tasks with potential to support people with dementia, Alzheimer’s disease and other cognitive impairments.

Some of the AI and robotic technologies are focusing on enabling social care employers to respond more effectively to questions or concerns raised by carers and patients, by using chatbots as part of their customer interface. These have the potential to aid carers and people who use care services to monitor and self-manage their care and identify at an early stage behaviours or symptoms that may require professional intervention and support.

Also, within the field of AI and robotics are technologies, **care coordination aids**, that aim to support social care employers in making logistic and efficiency improvements to the delivery of care services whilst also improving communication between social care employers, carers, the care workforce and people who use care services.

One area which has been highlighted within stakeholder consultations is the future use of AI and ‘**machine learning**’ within social care. Machine learning is the set of techniques and tools that allow computers to ‘think’ by creating mathematical algorithms based on accumulated data.

Machine learning offers the potential for AI and robotic technologies to draw on data collected through sensors and social interaction to learn offline and on the job thus improving the quality of care provided.

Given the predicted growth in data produced by new technologies such as smart sensors in homes and telemedicine robots, machine learning may offer a system of turning data into intelligence which in turn can ensure care plans are regularly updated to enable human care workers or assistive robots to intervene proactively in a range of assistive scenarios, such as medicine adherence, nutrition and rehabilitation support, as well as social engagement.

Evidence of effectiveness

The evidence base demonstrating the effectiveness of AI and robotics in supporting care provision is relatively under-developed and characterised by research that is limited due to methodological issues. This is in part because many of the AI and robotic technologies have yet to move from concept and early prototype stage to wider application within the adult social care sector. Much of the evidence base therefore presents commentary on the future potential for the use of AI and robotics within social care whilst highlighting a need for more in-depth studies. The exception is the use of Cognitive Assistance Robots where there is good evidence of their use in the adult social care sector in the UK.

Current limitations of AI and robotic systems

Acknowledged barriers for growing the use of AI and robotic systems include cost and a lack of understanding or even antipathy within the sector to their introduction, which in turn limits the opportunity to evidence their contribution to supporting the care workforce and improving outcomes for people who use care services.

Gaps in the evidence base

A notable gap in the evidence base relates to any assessment of the routes to market for the range of assistive robots that have been developed and piloted over the last decade. The literature on the development of assistive robots is dominated by technological papers with little consideration of how such devices might be commercialised for a mass market at a price that is affordable for older people and their families as well as public services and care insurers.

The lack of evidence or reports on effective routes to market for AI and robotics highlights a need for greater dialogue between technology companies and robotic developers, social care employers, carers and people who use care services. A lack of effective dialogue is likely to perpetuate challenges in ensuring greater adoption and use of AI and robotic technologies across the social care sector.

Another notable absence in the evidence base relates to achieving a greater understanding of the user experience and user acceptance of AI and robotic technologies. The evidence base highlights a need to better understand older adults' lived experiences with SARs to create the possibility of using an approach that embeds technological innovation into the care practice itself. Further evidence is therefore required from a wider roll-out of SARs to support the develop of models and approaching for better integrating the use of AI and robotics within the everyday process of providing care.

Workforce implications

There is limited published evidence on the current or future role for the social care workforce in using AI and robotics as part of their care provision. This perhaps reflects the lack of involvement of the care workforce in collaborating with technology companies and robotic developers to design and shape AI and robotic systems to fit with the realities and practicalities of providing care.

Some commentators forecast rising unemployment as labour is substituted for AI-enabled robots and machines, whilst others foresee a transformation in the type of employment available with the creation of new jobs compensating for those that were lost and the prospect of robotics and AI augmenting existing roles and enabling humans to achieve more than they could on their own.

The literature around the use of AI and robotics in social care largely mirrors these differing views with some framing the debate as ‘humans versus machines’ whilst others suggest that the implications are likely to be far subtler with AI and robotics providing support for tasks within jobs.

Consultations with AI and robotics sector representatives undertaken for this scoping study have emphasised that the main hurdle to overcome initially is in terms of cultural change and addressing the reluctance and scepticism from the care workforce on the ability of AI and robotics to assist them in their role rather than being a threat to their jobs.

Part of challenge is that few professional learning and training programmes in social care practice, social work or elder care offer students the opportunity to explore and integrate awareness of the technologies currently and in the future deployable in care settings. They do not provide students with sufficient opportunities to develop critical awareness of human robot interaction.

This suggests that staff at all levels, including those in initial training, need greater clarity on the current and potential scope for AI and robotics to add value to their care roles. Further work is required to bring together key stakeholders from robotic developers and social care employers (and through them the care workforce and people who use care services) to explore and promote the use of AI and robotics in social care and the role of the workforce in embracing and using new technologies.

Stakeholders also outlined a range of factors required to support the introduction of AI and robotics in social care including the required protocols and policies to inform commissioning, maintenance, CPD and training, risk management protocols and clarification of the scope of the role of AI and robotics in social care.

Future training needs

Although this study has uncovered little published research, discussions with a range of stakeholders as part of this study have highlighted a range of potential training needs for the social care workforce linked to an increased use of AI and robotics. Unsurprisingly the focus of any training is likely to be influenced by the design and intended purpose of the AI and robotic technology, the needs of the person in receipt of care and the care setting.

A further area likely to require training for the future workforce is in interpreting the data collated by AI and robotic systems. However, not all workforce implications surrounding the increased use of AI and robotics will be technology focused or require digital skills competency with research studies highlight the contribution that AI and robotic technologies can play in freeing up frontline care staff to focus on more human tasks such as providing emotional and social support for people who use care services.

The proliferation of AI and robotic systems over the past decade is likely to continue, however to realise their potential to support the social care sector further work is required to ensure user acceptance and use. As such there is likely to be a future role for the care workforce in encouraging and facilitating people who use care services to use AI and robotic technologies that can support them to live independently and manage their health needs.

Conclusions

Whilst several research studies demonstrate the potential of AI and robotics to support the delivery of care, there is a recognised need to produce stronger evidence through more robust trials and pilots. Where evidence of impact has been presented, to date these have focused mainly on the impacts on people who use care and support services with less attention paid to the impact on the care workforce (including formal and informal carers). Given that a significant proportion of the technology remains at the concept or prototype phase there appears to be little practical evidence of the use of AI and robotics within the social care sector in England.

There is a need to draw together a clearer picture of the existing use of AI and robotic technologies within the social care sector and to review their routes to market. Further work is also required to explore the future potential use of machine learning within adult social care and how this could be built into PAR and SAR technologies.

To date the research suggests there has been an insufficient focus on adopting user-led design within the development process and little opportunity for social care employers and the care workforce to influence the development of new technologies at a concept stage. This needs to be addressed to ensure that new AI and robotic technologies can support the practical, everyday challenges facing the workforce in delivering care.

The lack of research focusing specifically on the workforce implications of an increased use of AI and robotics highlights an area that needs to be addressed. The evidence base highlights a consensus that AI and robotics will not replace the workforce but will likely provide support for tasks within jobs. As such more work is required to map out the future training and development needs of the care workforce to ensure that the opportunities presented by AI and robotic technologies can be realised.

Stronger collaboration can also help to explore how existing smart technologies such as home hubs, smartphones, computer tablets and smart sensors can be used to improve the quality and efficiency of care delivery which may assist the process of adoption within the social care sector. More research is needed to determine whether these everyday technologies can help to challenge and change the perceptions of the care workforce on the contribution and value of AI and robotics in support their care role and improving outcomes for people who use care services.

Recommendations

A small number of recommendations are provided below based on the key themes and learning outlined in this scoping report.

Skills for Care

- The findings of this scoping report need to be widely shared with local government, academia and social care employers. Skills for Care should create opportunities for these stakeholders to come together to facilitate better understanding of each other's work and to jointly discuss the implications of this report.
- Skills for Care need to work with organisations and academics piloting the use of AI and robotic technologies to ensure that the future training and development needs of the social care workforce are an integral part of the research and learning is shared with others.
- Where possible, Skills for Care should incorporate a focus on workforce skills needed in this area and potentially perception of using AI and robotics into ongoing consultations with the sector.

Social Care Employers

- Where possible, social care employers should take the opportunity to play an active role in involving their workforce in discussions about opportunities presented by AI and robotic technologies and associated training and development needs.
- There is potential for social care employers to collaborate with academia and robotic developers. If possible, they should seek out or look favourably on requests to assist in the process of designing, developing and testing AI and robotics technologies, and associated workforce issues.

Wider Social Care Stakeholders

- Membership organisations are well placed to undertake research to establish a clearer picture of the existing use of AI and robotic technologies within the social care sector and should be supported in taking these opportunities forward.
- Regulatory bodies could further support the sector by highlighting examples of the use of AI and robotic technologies as part of care inspections and share this learning with the sector.

- Machine learning offers the potential for learning and further AI application in social care based on data collected through new technologies such as smart sensors in homes and telemedicine robots. However, work to establish any potential safeguarding and privacy implications for people who use social care services would need to be investigated further at this stage.

Glossary

Artificial intelligence: Computer software that performs tasks that are normally considered to require intelligence when performed by people, examples are scene and language understanding, planning and learning.

Assistive robot: A robot designed to provide physical or cognitive assistance to a person.

Autonomy: The ability of a machine to make its own decisions.

Autonomous System: An integrated system of machines and devices that share control programs and sensors and make decisions autonomously.

Big data: High-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making.

Chatbot: A chatbot is a computer program or an artificial intelligence which conducts a conversation via auditory or textual methods.

Companion robot: A robot designed to communicate with people using spoken language, and/or non-verbal channels of communication such as expression or touch. A companion robot can provide a form of social interaction that could be reassuring and reduce feelings of loneliness. It could also provide advice, confidence building and promote social engagement by acting as an ice-breaker within social groups or as a social ‘bridge’ to friends and relatives.

Machine Learning: The set of techniques and tools that allow computers to ‘think’ by creating mathematical algorithms based on accumulated data.

RAS:

Social care: Provision of care, protection and support services for people in need or at risk, including those with needs arising from illness, disability, old age or poverty.

Service robot: A robot designed for service industries (i.e. not an industrial robot).

Telecare, telehealth: Remote delivery of health and care services via telecommunications technology.

1. Introduction

This report provides a summary of the recent literature covering developments in and considerations for the use of AI and robotics in adult social care. It provides detail on some of the potential and actual uses of AI and robotics as well as summarising contemporary debates surrounding their impact on people who use care services and the care workforce.

1.1 Consilium Research and Consultancy (Consilium) was commissioned in March 2018 by Skills for Care to undertake a scoping study on the emerging use of Artificial Intelligence (AI) and robotics in adult social care. The purpose of the scoping study is to:

- Examine the existing international literature in the context of AI and robotics and their uses in adult social care;
- Explore what is currently happening in the context of AI and robotics and their uses in adult social care focusing on the UK but including international examples; and
- Outline workforce issues that might arise as the use of AI and robotics in adult social care begins to grow.

1.2 This report provides a summary of the recent literature covering developments in and considerations for the use of AI and robotics in adult social care. It provides detail on some of the potential and actual uses of AI and robotics as well as summarising contemporary debates surrounding their impact on people who use care services and the care workforce. This report also highlights some of the gaps in the published evidence base and issues of relevance to those with responsibilities for preparing the care workforce of tomorrow to fully utilise the contribution of AI and robotics to meeting future care challenges.

2. Overview of research methods

This scoping study has incorporated a rapid evidence review of existing published literature on the potential for and use of AI and robotics within adult social care.

The research team engaged a range of individuals and organisations within the fields of robotics, local government, academia and social care to support the process of identifying current practice examples and to access relevant grey literature. This included consultation with robotics laboratories across a number of HE institutions, robotics and technologies companies and social care employers.

Rapid evidence review

2.1 This scoping study has incorporated a rapid evidence review of existing published literature on the potential for and use of AI and robotics within adult social care. The research team used rapid review methods to search and critically appraise existing research with a view to responding to the key aims of the scoping exercise.

2.2 The search strategy incorporated a number of approaches in order to identify international literature in the context of AI and robotics and their uses in adult social care. Searches were undertaken of a range of web-based knowledge management systems including Social Care Institute for Excellence (SCIE) Social Care Online, Google Scholar, Skills for Care Research Knowledge Base, The British Library Social Welfare Collection, Wiley Online Library, Taylor & Francis Online, The King's Fund and the UKRI Gateway. A full list of references is presented in the Appendices of this report as well as further detail on the parameters of the rapid evidence review.

Sector consultations

2.3 The research team engaged a range of individuals and organisations within the fields of robotics, local government, academia and social care to support the process of identifying current practice examples and to access relevant grey literature. This included consultation with robotics laboratories across a number of HE institutions, robotics and technologies companies and social care employers.

2.4 The research team engaged Skills for Care & Development and the sector skills councils for social care across each of the UK nations as well as consulting the ADASS Digital Technology and Robotics Forum to assist in identifying existing examples of the use of AI and robotics across the social care sector in England.

2.5 To facilitate engagement with key stakeholders the research team also attended two conferences[1] exploring the use of robotics in social care as well as a meeting with staff at Bristol Robotics Laboratory.

2.6 Details of the scoping study were also promoted using social media channels, through Skills for Care's e-bulletin and through the European Social Network. A full list of stakeholders consulted as part of this scoping study is presented in the Appendices of this report.

[1] Includes the CHIRON Robotics in Care Conference organised by Smart Homes and Buildings Association and the Learning Symposium on robots in social care organised by the North London Social Work Teaching Partnership.

3. Context

Delivering adult social care has become more challenging as more and more people need care and funding has not kept pace with a growing population. Whilst there is a recognised need to invest more in social care in the coming years technology could have an important role to play in supporting the care workforce and improving care outcomes.

Although the challenges of keeping pace with the care needs of an ageing population will not be solved through technology alone, innovation including advanced robotic and autonomous systems can aid efforts to meet future care needs by providing support for certain tasks delivered by the care workforce and helping to improve productivity and efficiency.

Whilst there is much commentary on the potential for AI and robotics to transform the delivery of care, to date there has been a lack of focus on the workforce implications arising from the introduction of new technologies.

3.1 The adult social care sector in England continues to face a range of issues. The UK has an ageing population and the total number of years people can expect to live in poorer health continues to rise (Care Quality Commission 2017). Funding and changed models of delivery have not kept pace with a growing population. There is growing unmet care need with estimates showing that showing that 1.2 million people are not receiving the help they need, an increase of 18% on last year.

3.2 The number of people aged 85 or over in England is set to more than double over the next two decades and if the population continues to grow as predicted then the workforce will also need to grow. It is anticipated that over two million new workers will need to be trained and recruited into the health and social care sector between 2012 and 2022.

3.3 Whilst there is a recognised need to invest more in social care in the coming years technology could have an important role to play in supporting the care workforce and improving care outcomes. However, there is recognition that technology is not yet being used to its full potential (HM Government 2012) with previous efforts focused on accelerating the roll-out of assistive technology.

3.4 Carers UK, a charity which represents 6.5 million unpaid carers in the UK, has called for increased investment in technology to support caring as part of the UK government's industrial strategy (Carers UK 2017). The independent think tank, the Institute for Public Policy Research, has also called for a new wave of innovation in social care (Institute for Public Policy Research 2017).

3.5 Although the challenges of keeping pace with the care needs of an ageing population will not be solved through technology alone, publications such as the recent white paper produced by the UK-RAS Network (2017) highlight that innovation, including advanced robotic and autonomous systems, can aid efforts to meet future care needs by providing support for certain tasks delivered by the care workforce and helping to improve productivity and efficiency.

3.6 AI and robotics also have the potential to enable greater self-care and delay or reduce the need for care and support by supporting people to live independently for longer.

3.7 Whilst there is much commentary on the potential for AI and robotics to transform the delivery of care, to date there has been a lack of focus on the workforce implications arising from the introduction of new technologies. This report provides an overview of the existing international literature on the use of AI and robotics in adult social care and outlines workforce issues that might arise as the use of AI and robotics within the sector begins to grow.

4. Key findings from the research

This rapid evidence review has highlighted a wide range of AI and robotic technologies that have been piloted or are in use within social care either within the UK or, more commonly, internationally.

A range of physically assistive robots (PARs) have been developed to perform discreet tasks including lifting and carrying to support people who use care services. Socially assistive robotics (SARs) aims to endow robots with the ability to help people through individual non-contact assistance in convalescence, rehabilitation, training and education. Within the field of robotics there is interest with regards to the potential of Cognitive Assistance Robots (CARs) to support people with dementia, Alzheimer's disease and other cognitive impairments.

One area which has been highlighted within stakeholder consultations is the future use of AI and 'machine learning' within social care. Machine learning may offer a system of turning the data produced by new technologies such as smart sensors in homes and telemedicine robots into intelligence which in turn can ensure care plans are regularly updated to enable human care workers or assistive robots to intervene proactively in a range of assistive scenarios.

One of the main limitations of AI and robotic systems is the lack of application within adult social care with many technologies struggling to move beyond concept and laboratory stage to widespread use with the care sector.

The literature outlines a range of ethical issues highlighted a need for further guidance and protocols to be developed to regulate the use of a diverse range of AI and robotic technologies in social care which, in turn, will require social care employers to deliver training to their respective workforce.

There is limited published evidence on the current or future role for the social care workforce in using AI and robotics as part of their care provision. This perhaps reflects the lack of involvement of the care workforce in collaborating with technology companies and robotic developers to design and shape AI and robotic systems to fit with the realities and practicalities of providing care.

A stronger focus on the use of technology within the inspection regime is likely to create increased interest within social care employers to explore technology solutions, including the use of AI and robotics. What is currently unclear is the extent to which social care employers have considered the short, medium and longer-term workforce implications of integrating technology within their delivery of care.

Presenting a typology of AI and robotic technologies

4.1 This rapid evidence review has highlighted a wide range of AI and robotic technologies that have been piloted or are in use within social care either within the UK or, more commonly, internationally. The evidence base outlines the range of current and potential applications for the use of AI and robotics in adult social care. Much of the research focuses on the role of technology in supporting older people, albeit the applications have transferable value for a wider range of people who use care services including working age adults. A common theme identified in the review was a lack of information on the extent to which the different AI and robotic technologies had moved beyond the prototype and testing phase and how extensively they were being used within the social care sector (UK and internationally).

4.2 Several authors provide a clear distinction between physically-assistive robots and socially assistive robots. Prescott et al (2012), in their report entitled ‘Robot Companions For Citizens’, focus on the potential for a new generation of safe and human-friendly robots to assist in extending the active independent lives of older people and to help to compensate for the demographic shift in the age of EU populations. The authors distinguish between the needs of people in different phases of late life.

4.3 In the so-called ‘third age’ they highlight that people retain both intellectual and physical function but are facing increasing challenges in maintaining their environments (e.g. difficulty completing household chores) through the gradual decline in these functions. In the final stage of life, the ‘fourth age’, people face additional challenges of acute or chronic illness, and increasing disability and dependency, that can be characterised as involving difficulties in control of their bodies. The authors suggest that the development of robot companions for citizens (RCCs) can be focused towards both categories of need.

4.4 Caleb-Solly (2016) emphasises that the incidence and prevalence of chronic diseases and disabilities are having a profound impact on all aspects of the economy and society. The author states that providing cost-effective and high-quality support for an ageing population, who are likely to be coping with a range of disabling conditions, is a high priority issue for all governments. She proposes that intelligent robots, integrated with smart home sensors and healthcare databases, can provide the ability to realise autonomous assistive care solutions to support independent living.

4.5 Dahl & Kamel Boulos (2013) present an overview of most of the current and potential uses and applications of robotics in health/care and social care. Their report makes a distinction between traditional specialised medical robots, which are used for surgery and rehabilitation, and an emerging class of versatile and less costly robots supporting ‘softer’ human-robot interaction tasks such as the Giraff mobile robot or the Nao small humanoid robot. They outline several examples, including:

- Robots providing assisted logistics in hospital and care home environments;
- Telepresence (video conferencing) and companion robots in home and hospital settings;
- Humanoid robots for entertaining, educating and improving the communication skills of children with special needs;
- Robots as motivational coaches (persuasive robotics);
- Home assistance robots for an ageing society; and
- Human-robot relationships in medical and care situations.

4.6 The authors summarise that robots come in different forms to serve various purposes, tasks and applications in the medical/healthcare and social care domains. The range of robotic applications that are available is vast, diverse and continually growing, from robots used in minimally invasive robot-assisted surgery and rehabilitation, to robots designed to function in hospitals/care homes and personal robots serving as motivational coaches or assisting older people with housework and domestic chores.

4.7 Some of the robotic systems, applications and solutions covered in their review are already commercially available for real-world deployment and everyday use, while others are not yet fully mature and/or commercially viable. The latter remain in the confines of research laboratories at various stages of research prototyping and experimentation.

4.8 The following section presents a brief overview of the different types of AI and robotic technologies including details on their function and main application. Whilst some technologies have been assigned to a specific category progress is being made by robotic developers to produce systems that are multi-functional (i.e. physically and socially assistive) and are able to support for a greater range of tasks for people who use care services.

Physically Assistive Robots (PAR)

4.9 A range of physically assistive robots have been developed to perform discreet tasks including lifting and carrying to support people who use care services. Whilst some PARs have been designed to operate independently from the care workforce (e.g. within a domiciliary care setting) others have been designed to support the care workforce to undertake physical tasks associated with performing their care role.

4.10 Given the significant safety challenges and requirements surrounding the design and use of PARs, the evidence review suggests that there are currently a limited number of robots either in development or being used within social care.

Obi

Obi is a robotic arm that allows people with physical disabilities to feed themselves and restore in the process a sense of dignity that might otherwise risk being lost. Obi resembles a regular kitchen appliance with a simple two-button interface, with one button selecting which food to pick up and the other controlling a spoon that dips into the food and then moves in a fluid motion to the operator's mouth. It can be operated with any part of the body that can activate an accessibility switch. Obi is particularly suitable for those with Motor Neurone Disease, Cerebral Palsy, Muscular Dystrophy, Multiple Sclerosis, Parkinson's Disease and Spinal Cord Injury.

Obi has been an ongoing development project since 2006. The $4,500 robot comes with two interchangeable spoons, a placemat, a customised plate containing four different bowls, and charging cable and documentation. The robot is portable and is currently available for purchase in the UK.

ROBEAR

Robear is an experimental nursing-care robot developed by the RIKEN-SRK Collaboration Center for Human-Interactive Robot Research and Sumitomo Riko Company. The robot can lift patients and transfer them between beds and wheelchairs. Robear has mechanical arms that can carry up to 80kg of weight and also has roller legs that can extend and retract from a base as necessary when bending to lift a patient or when manoeuvring through tight spaces like doorways. The robot weighs 140kg and it is powered by software and advanced actuators (a type of motor that controls mechanisms), as well as three different types of sensors, including Smart Rubber capacitance-type tactile sensors entirely of rubber.

Robear remains a research project for now, as Riken and its partners continue to improve the robot's technology, reduce its weight, and ensure that it will be safe - in this case, through legs that extend while lifting a patient, to ensure Robear does not topple over.

CHIRON (Care at Home using Intelligent Robotic Omni-functional Nodes)

CHIRON was a two-year project funded through Innovate UK's Long-Term Care Revolution SBRI national challenge, which aimed to revolutionise long term care in the UK through business-led innovation. The project was managed by a consortium led by Designability with key technology partners including Bristol Robotics Laboratory and Shadow Robot Company, who have considerable expertise in conducting pioneering research and development in robotics.

The project also included the social enterprise care provider Three Sisters Care who enabled user-centred design to be located at the centre of the development process. Smart Homes & Buildings Association were also part of the project and worked to introduce the range of devices that would create CHIRON within the home.

The project ran from March 2016 to February 2018 and has resulted in a prototype modular robotic system with the brand name of JUVA. This can be located in multiple positions around a home and has the potential to help with a wide range of domestic and self-care tasks independently or enable a care worker to assist an increased number of customers. JUVA is still at the prototype phase with further work being undertaken to take forward further user-testing, to develop a business case and establish a route to market for the system.

Socially Assistive Robots (SAR)

4.11 Socially assistive robotics aims to endow robots with the ability to help people through individual non-contact assistance in convalescence, rehabilitation, training and education. SARs can be categorised into two operational groups, namely 'service robots' which are tasked with aiding activities of daily living (such as providing reminders to take medications or for forthcoming appointments) and 'companion robots' which are more generally associated with improving the psychological status and overall well-being of its users. More recent robotic technologies have looked to perform aspects of both roles thus providing support for a greater range of tasks for people who use care services.

Mobiserv

Mobiserv (An Integrated Intelligent Home Environment for the Provision of Health, Nutrition and Mobility Services to Older Adults) was an EU Framework 7 funded project aimed at creating an intelligent system comprising a robot and smart sensors that can support independent living for older people.

A team of European universities, research institutes, commercial companies and care organisations collaborated on a new type of social carer which could provide assistance for everyday tasks for older people such as reminding them about eating, drinking and taking medicines, offering structure throughout the day and helping people to stay active by suggesting a variety of activities. For example, when a person does not drink for a certain time, which can lead to dehydration, the robot will approach them and encourage him or her to drink, or even suggest a specific drink, based on their preferences or needs. The same holds for food, physical exercises, activities and for social contacts.

The robot is one component of a larger automated system that Mobiserv is developing for elderly people. It includes wearable smart clothes which have the potential to monitor vital signs or sleeping patterns and detect falls. It also includes a smart home environment consisting of smart sensors, optical recognition units, and home automation elements, to detect, among others, eating and drinking patterns, activity patterns, and dangerous situations. Mobiserv began in December 2009 with a prototype for the social companion robot developed in the second year of the project after conducting extensive research with end-users and their formal and informal carers.

Paro

Paro is an advanced interactive robot developed by AIST, a leading Japanese industrial automation pioneer. It allows the documented benefits of animal therapy to be administered to patients in environments such as hospitals and extended care facilities where live animals present treatment or logistical difficulties. Trials of Paro (Robinson, Broadbent & MacDonald 2015), which is commercially available in the UK, have highlighted its contribution to:

- Reducing patient stress and their caregivers;
- Stimulating interaction between patients and caregivers;
- Having a positive psychological effect on patients, improving their relaxation and motivation; and
- Improving the socialisation of patients with each other and with caregivers.

Pepper

Pepper is the first humanoid robot capable of recognising the principal human emotions and adapting his behaviour to the mood of his interlocutor. Pepper was launched in the UK 2016 has been designed to identify emotions and to select the behaviour best suited to the situation. Based on an individual's voice, the expression on their face, body movements and the words they use, Pepper will interpret their emotion and offer appropriate content. He will also respond personally to the mood of the moment, expressing himself through the colour of his eyes, his tablet or his tone of voice.

The robot is currently in use in a range of sectors including hospitality and education. Within the care sector in the UK, Southend-on-Sea borough council purchased Pepper in 2017 initially to be used for community engagement and awareness raising activities but also to facilitate reminiscence work with older people including those with dementia. Pepper has the potential to support and facilitate social interaction within care settings and provide data back to care teams based on these interactions. Although Pepper has yet to be used extensively with people who use care services in England, several research trials are planned to assess the use of Pepper to reduce social isolation and support other care tasks.

Care-O-bot

Care-O-bot is the product vision of a mobile robot assistant to actively support humans in domestic environments. The robot, produced by the Fraunhofer Institute for Manufacturing Engineering and Automation in Germany, is currently in its fourth generation of manufacture and due to its modular system design has the potential to be customised for a range of applications in the home such as providing reminders for appointments or being used as a mobile information point. The robot has not been specifically designed for use within care settings and is currently in use across a range of environments including as a mobile information point.

Dinsow

Dinsow is a service robot developed in Thailand by CT Asia Robotics in 2009. Initially used in the hospitality sector, the Dinsow robot for elderly care was launched in 2015 following partnerships with hospitals in Thailand and Japan. The Dinsow elder care robot acts as a personal assistant of sorts helping people to remember to take their pills, tracking their health and automatically answer incoming calls from family and doctors. The robot is currently on sale in Thailand and Japan but is not yet available within the UK.

HOBBIT

HOBBIT (Mutual Care Robot) is a research project of the EU's 7th Framework Programme to develop a socially assistive robot that helps seniors and old people at home. The goal of the HOBBIT project is to advance towards a robot solution that will enhance wellness and quality of life for older people and enhance their ability to live independently for longer at their homes.

The HOBBIT project set out to study a future robot that will make older persons feel safe at home. The robot can pick up objects from the floor, can learn objects and bring objects and is equipped with easy-to-use entertainment functions. The focus of HOBBIT is the development of the mutual care concept: building a relationship between the human and the robot in which both take care for each other. The purpose of the Mutual Care approach is to increase the acceptance of the home robot.

The main task of the robot is fall prevention and detection. To achieve this, the robot will clean the floor from all objects and thus reduce the risk of falling. It can detect emergency situations and call for help if required. such that help can be called in time.

Following the production of a working prototype, user trials have been conducted in Austria, Greece and Sweden. There is currently no data on whether HOBBIT has been trialled within the UK.

Cognitive Assistance Robots (CAR)

4.12 Within the field of robotics there is emerging work in using SARS to support users to perform cognitive tasks. There is interest with regards to their potential to support people with dementia, Alzheimer's disease and other cognitive impairments with some studies showing early promise (Tapus, Tapus & Mataric 2009; Schneider et al 2014).

4.13 An overview of the use of SARs to offer support as therapists, companions, and educators for people living with dementia by Huschilt & Clune (2012) concluded that SARs should be considered as a viable way to assist people living with dementia to maintain their highest possible level of independence, enhance their quality of life, and provide support to family caregivers. The authors outline that further research is needed to evaluate the merits of this technological approach in the care of adults with dementia.

MARIO (Managing Active and healthy aging with use of caRing servIce robots).

MARIO addresses the challenges of loneliness, isolation and dementia in older persons through multi-faceted inventions delivered by service robots. The main objectives of MARIO are:

- To address and make progress on the challenging problems of loneliness, isolation and dementia in older persons through multi-faceted interventions delivered by service robots;
- To conduct interaction with end users and assisted living environments in order to enable iterative development and preparation for post project uptake;
- To assist caregivers and physicians in the comprehensive geriatric assessment (CGA) of subjects at risk to loneliness, isolation or dementia through the use of service robots;
- The use of near state of the art robotic platforms that are flexible, modular friendly, low cost and close to market ready in order to realise field contributions in the immediate future;
- To make MARIO capable of supporting and receiving “robot applications” similar to the developer and app community for smartphones. This will empower development and creativity, enable the robot to perform new functionalities over time, support discovery and improve usefulness for end users while lowering costs;
- Through novel advances in machine learning techniques and semantic analysis methods to make MARIO more personable, useful, and accepted by end users; and
- To bring MARIO service robot concepts out of the lab and into industry by addressing licensing aspects, the integration of telecommunication aspects and application hosting environment.

The project is still ongoing but reports to have established that companion robots can have a positive impact on older people living with dementia. It has featured in a new European Commission study analysing the impact on society of EU-funded research and innovation in technology for active and healthy ageing. MARIO has recently been tested in a care home in east Galway, Ireland where it is being used to combat loneliness and enable older people to connect with friends and family.

Companionable

The Companionable EU-funded FP7 integrated project, led by a team from the University of Reading, has linked intelligent home systems with Hector, a fully autonomous robot designed to play the role of a companion for elderly people (especially those living alone, or spending many hours of the day alone). The robot aims to help them remain independent, secure fit and happy, through fall detection mechanisms integrated with emergency calls or remote monitoring services, personalised dialogue/interaction displaying emotional intelligence (using both visual, vocal and tactile interfaces, sensor-based movements such as “follow me” and natural language recognition of commands) to avoid feelings of loneliness, provide friendly reminders, store/bring important objects such as keys, wallet, and offer cognitive stimulation/games, as well seamless video connections to family and friends.

Users interact with Hector directly through voice commands and a large touch screen. It can move around a house on its own and respond to commands such as 'follow me' or 'go to the kitchen'. He can help users socialise and provide cognitive stimulation in their daily lives.

Hector functions autonomously, or as part of a larger-scale intelligent-home system designed to support independent living for elderly people. By controlling smart systems around the house, Hector is able to open and close curtains and windows, turn lights on and off, or regulate the central heating.

Hector's integration into smart home systems and remote care and control centres can be adapted to new environments and the care support offered by CompanionAble includes monitoring vital physiological signs and more subtle factors such as moods, as well as diary management, video telephony and reminders to ensure users take the right medicine on time. Hector is currently available for sale in the UK through the robotic solutions provider Robot Center.

Woebot

Woebot is an automated conversational agent (chatbot) who helps people monitor their mood. Drawing from a therapeutic framework known as Cognitive Behaviour Therapy, Woebot asks people how they’re feeling and what is going on in their lives in the format of brief daily conversations. Woebot also talks to them about mental health and wellness and sends them videos and other useful tools depending on their mood and needs at that moment. A study conducted at Stanford University found that using Woebot led to significant reductions in anxiety and depression among people aged 18-28 years old, compared to an information-only control group. 85% of participants used Woebot on a daily or almost daily basis.

Woebot was originally built for young adults in college and school, however it also has potential for supporting anyone at risk of low mood, anxiety and depression. Woebot is currently available for free download on Facebook Messenger and iPhones and iPads, and Android devices.

Carebots

4.14 Some of the AI and robotic technologies are focusing on enabling social care employers to respond more effectively to questions or concerns raised by carers and patients, by using chatbots as part of their customer interface. These have the potential to aid carers and people who use care services to monitor and self-manage their care and identify at an early stage behaviours or symptoms that may require professional intervention and support.

Martha (AI Social Care Bot)

In January 2018 London-based social care start-up Cera launched an AI assistant to help carers and patients answer questions and in future, help spot symptoms of illness. The AI assistant, called Martha, was created by fellow London-based start-up Bloomsbury AI and is designed answer questions from patients and carers during visits. In the near future, the company says, it hopes to use the AI to analyse patients' digital records and provide health alerts to patients or carers based on that data. For example: noting unusual symptoms or behaviours that might indicate pneumonia. Martha will initially be used by Cera's patients and their family members via its website and live chat to advise on specific care needs and respond to questions like “My father has Dementia. What type of care package would you recommend?”

Care coordination aids

4.15 Also, within the field of AI and robotics are technologies that aim to support social care employers in making logistic and efficiency improvements to the delivery of care services whilst also improving communication between social care employers, carers, the care workforce and people who use care services.

RoboCare

The RoboCare Lab based at the heart of the French Tech in Toulouse, have developed and marketed PRESENCE+, a range of services based on all the potential of robotics and IoT. The range of services have a simple interface to help to plan virtual visits to people who user care services and to remotely control telepresence robots, setup in the homes of isolated old people losing autonomy.The telepresence robots are connected to their PRESENCE+ Home platform and they currently have two robots available:

- SAM, available on the French market as a companion robot; and
- SAMY, who was introduced in January 2018.

The SAMY robots is commercially available for €950. The PRESENCE+ Home service requires a 24-month agreement with a monthly subscription charge of €36. It is unclear whether RoboCare products are currently available or used within the UK.

Konnektis

Konnektis is a digital platform that has been developed in the UK to improve care delivery by placing the person at the centre of their care whilst enabling better communication and collaboration among their support network. The platform is designed to enable people to participate in their own health and wellbeing to the fullest extent possible.

The Konnektis 4G-connected tablet stays permanently in the person's home, replacing pen-and-paper records and acting as the central point for the individual and their care network to access, record and share information easily and securely. The system's web-based portal enables live collaboration among the care network with providers better able to communicate with carers, keep care plans up-to-date and send and receive alert notifications. Family members also have the ability to view and visit information in real-time. The Konnektis platform can integrate with other systems so people get the information they need and data can be analysed and learned from. By storing information digitally, it can be mapped out, creating algorithms that can highlight any missed support or clinical interventions and enable quick action.

Machine learning

4.16 One area which has been highlighted within stakeholder consultations is the future use of AI and 'machine learning' within social care. Machine learning is the set of techniques and tools that allow computers to 'think' by creating mathematical algorithms based on accumulated data.

4.17 The UK RAS (2017) white paper on robotics in social care proposes that a key aspect of ensuring the utility of assistive robots will be to develop contextual and social intelligence for robots that will enable them to interact appropriately, safely and reliably in real-time. This will require a more in-depth understanding of both environmental and human user characteristics which could be enhanced by integrating AI and robotic technologies with smart home sensors and external healthcare databases. Machine learning offers the potential for AI and robotic technologies to draw on data collected through sensors and social interaction to learn offline and on the job thus improving the quality of care provided.

4.18 NHS England has highlighted the potential use of AI and machine learning to be used in areas such as radiology, dermatology and pathology to improve clinical care and improve the efficiency of certain tasks. AI within these areas has the potential to interpret clinical data more accurately and more rapidly than medical specialists and the latest technology means the machinery can learn and improve as it progresses.

4.19 The application of machine learning within the social care sector is less clear given that the sector includes over 20,000 organisations providing care in over 40,000 locations. Data on people who use care services is not routinely collated for in-depth analysis and interpretation and is held separately by individual social care employers. There are also no universally agreed data metrics or standards across the network of social care employers.

4.20 What is clear is the need to consider how the growth in data produced by new technologies such as smart sensors in homes and telemedicine robots will be used to support social care employers, care staff and carers in early intervention and prevention activities and risk assessments. In this regard machine learning may offer a system of turning data into intelligence which in turn can ensure care plans are regularly updated to enable human care workers or assistive robots to intervene proactively in a range of assistive scenarios, such as medicine adherence, nutrition and rehabilitation support, as well as social engagement.

4.21 However, there are also ethnical and data security issues to be addressed to ensure sufficient safeguards are in place to prevent misuse of potentially sensitive information. Moves towards greater integration between health and social care, including coordination of data sharing from medical records and care plans, may add a further dimension to the use of AI and machine learning, whilst to requiring consideration of necessary protocols to ensure data protection and confidentiality.

4.22 This review identified no evidence of the use of machine learning within the adult social care sector which may suggest a need for greater dialogue between those involved in the design and manufacture of AI and robotic technologies and social care employers on the future use and coordination and collection of data to improve care outcomes and clarifying issues such as data ownership and consent. There is likely to be merit in understanding how machine learning is being applied to data generated by the growing number of smart home hubs in homes across the UK.

Evidence of effectiveness

4.23 The evidence base demonstrating the effectiveness of AI and robotics in supporting care provision is relatively under-developed and characterised by research that is limited due to methodological issues. This is in part due to the fact that many of the AI and robotic technologies have yet to move from concept and early prototype stage to wider application within the adult social care sector. Much of the evidence base therefore presents commentary on the future potential for the use of AI and robotics within social care whilst highlighting a need for more in-depth studies.

4.24 Bouwhuis at el (2016) report on the current use and possibilities of robots in care and propose that assistive social robots can be useful in eldercare for two reasons, a functional one and an affective one. The authors state that such robots are developed to function as an interface for the elderly with digital technology and to help increase quality of life by providing companionship.

4.25 Whilst the authors point to a growing attention for these devices in the research literature, they point out that no comprehensive review has yet been performed to investigate the effectiveness of such robots in the care of the elderly and that more work on methods is needed as well as robust, large-scale studies to establish the effects of these devices.

Physically Assistive Robots

4.26 This review identified few studies which reported on the use of effectiveness of physically assistive robots in social care. This may be explained by their current limited use beyond trial phase due to issues relating to safety.

4.27 Prescott et al (2012) state that physically-assistive robots are beginning to enter the market, or are in trials, that can promote mobility and help with personal care. These include wheelchairs with some autonomous steering capability, powered exo-skeletons that can restore legged walking, and various forms of robotic prosthetic limbs. Special-purpose robots are also being evaluated to help in tasks such assisted sit-to-stand.

4.28 Within the field of rehabilitation, Van der Loos, Reinkensmeyer & Guglielmelli (2016) consider robotic systems that provide therapy for persons seeking to recover their physical, social, communication, or cognitive function, and/or that assist persons who have a chronic disability to accomplish activities of daily living. They explore the recent advances in smart prostheses and orthoses that are related to rehabilitation robotics and robotic smart home technologies, which are often considered assistive technologies for persons with disabilities.

There is limited evidence of the use of current use of physically assistive robots in the adult social care sector in the UK

Socially Assistive Robots

4.29 A number of research studies report on the use and impact of socially assistive robots for people who use care services. Kachouie, Sedighadeli, Khosla & Chu (2016) present a mixed-method systematic literature review on the use of socially assistive robots in elderly care. They state that socially assistive robots are being considered as enablers to support the process of care giving or keep elderly people at home longer. Their review covers 86 studies in 37 study groups with the findings implying positive effects of SARs on elderly well-being. The authors conclude that SARs can potentially enhance elderly well-being and decrease the workload on caregivers but emphasise a need for additional research to understand the factors that facilitate the acceptability of SARs by people who use care services and caregivers.

4.30 Pino, Boulay, Jouen & Rigaud (2015) present research which explores attitudes and opinions of older adults toward socially assistive robots. Their research investigated SAR acceptance among three groups of older adults living in the community, namely persons with mild cognitive impairment (MCI), informal caregivers of persons with dementia and healthy older adults. Different technology acceptance questions related to the robot and user characteristics, potential applications, feelings about technology, ethical issues, and barriers and facilitators for SAR adoption, were addressed in a mixed-method study. Results from the study indicated that an accurate insight of influential factors for SAR acceptance could be gained by combining quantitative and qualitative methods.

4.31 Participants acknowledged the potential benefits of SAR for supporting care at home for individuals with cognitive impairment. In all the three groups, intention to use SAR was found to be lower for the present time than that anticipated for the future. However, caregivers and people with MCI had a higher perceived usefulness of, and intention to use SAR, at the present time, than healthy older adults, confirming that current needs are strongly related to technology acceptance and should influence SAR design.

4.32 Another key theme that emerged from their study was the importance of customising SAR appearance, services, and social capabilities to improve user experience and engagement. Mismatches between the needs and solutions offered by the robot, usability factors, and lack of experience with technology, were seen as the most important barriers for SAR adoption.

4.33 Tapus, Tapus & Mataric (2009) explore the use of socially assistive robots in the design of intelligent cognitive therapies for people with dementia. In their paper the authors present a new adaptive robotic system based on the SAR technology that tries to provide a customised help protocol through motivation, encouragements, and companionship to users suffering from cognitive changes related to aging and/or Alzheimer's disease. Their results showed that this approach can engage the patients and keep them interested in interacting with the robot, which, in turn, increases their positive behaviour.

4.34 More recent research on the use of social and assistive robots in dementia care by Ienca, Jotterand, Vică et al (2016) suggests that the integration of robotics into both formal and informal dementia care opens up new possibilities for improving the life of patients and alleviating the workload of caregivers and the healthcare services.

4.35 However, the authors highlight that ethical, legal and social implications need to be considered early in the development of assistive and social robots for dementia to prevent slow adoption, incorrect implementation and inappropriate use. Their paper delineates the ethical landscape and provides recommendations for design and use aimed at protecting users and maximising the benefit in assisting such vulnerable population.

4.36 In their scoping review on the use of socially assistive robot technology in elderly care Abdi, Al-Hindawi & Ng Tet al (2018) identify five roles for SAR technology in meeting rising demand for social care, namely:

- affective therapy;
- cognitive training;
- social facilitation;
- companionship; and
- physiological therapy.

4.37 The review includes a caveat that although SARs have shown potential in elderly care, many studies have methodological issues. Although the size and quality of studies are improving the authors suggest that research needs to be clearer about the precise role any robot intervention intends to serve and use validated measures to assess its effectiveness.

4.38 A similar finding is reached by Broekens & Heerink et al (2009) who report that although there is some qualitative evidence, as well as limited quantitative evidence, of the positive effects of assistive social robots with respect to the elderly, the research designs are not robust enough to establish this and more work on methods is needed as well as robust, large-scale studies to establish the effects of these devices.

4.39 Bemelmans, Gelderblom, Jonker & de Witte (2012) also concur in their systematic review into the effects and effectiveness of socially assistive robots in elderly care. They included 41 publications in their review, describing 17 studies involving 4 robot systems. Whilst most studies reported positive effects of companion-type robots on (socio)psychological (e.g. mood, loneliness, and social connections and communication) and physiological (e.g. stress reduction) parameters, the methodological quality of the studies was mostly low. Although positive effects were reported, the scientific value of the evidence was limited with the authors calling for further effectiveness research in this field given the positive results described.

4.40 Theodore et al (2015) explore whether robots could become authentic companions in nursing care. They highlight that the creation of android humanoid robots to furnish companionship in the nursing care of older people continues to attract substantial development capital and research. They also note however that some people object that machines of this kind furnish human-robot interaction characterised by inauthentic relationships with concerns that AI technologies substitute the real presence of conscious caring offered by humans with the mindless mimicry of human behaviour.

There is limited evidence of the use of current use of socially assistive robots in the adult social care sector in the UK

Cognitive Assistance Robots

4.41 A range of studies present emerging evidence on the use of AI and robotics in social care. Peri et al (2015) investigate whether robots could reduce resident sleeping and stimulate activity in the lounges of an older persons' care facility. They conducted a non-randomised controlled trial over a 12-week period and found that having robots in lounges was mostly a positive experience and the amount of time residents slept during the day was significantly less in low-level care lounges that had a robot.

4.42 Robinson, Broadbent & MacDonald (2015) present research based on observations and interviews at a care home that had introduced the therapeutic robot Paro. They found that some residents engaged on an emotional level with Paro, treating it as both an autonomous agent and an artificial object. Interviews revealed that residents enjoyed sharing, interacting with and talking about Paro which led them to conclude that Paro delivered positive psychosocial benefits.

4.43 Paro is also the subject of earlier research by Wada, Shibata, Musha & Kimura (2008) who assessed the use of robot therapy for older people affected by dementia. They used Paro for therapy of patients suffering from dementia at a cortical neuron clinic and report results from their preliminary experiments which show that robot therapy has a high potential to improve the condition of brain activity in patients suffering from dementia. The authors predict that Paro will be widely used to provide help to people with dementia although no follow-up research is available to determine the extent to which Paro has been used within similar clinics or across wider settings.

4.44 A more recent review by Moyle & Arnautovska et al (2017) on the potential of ‘telepresence robots’ to enhance social connectedness in older adults with dementia concludes that although limited, the current literature suggests that telepresence robots have potential utility for improving social connectedness of people with dementia and their carers. However, the authors call for more systematic feasibility studies to inform the development of telepresence robots followed by clinical trials to establish efficacy within dementia care.

> There is good evidence of the use of current use of cognitive assistive robots in the adult social care sector in the UK

Current limitations of AI and robotic systems

4.45 One of the main limitations of AI and robotic systems is the lack of application within adult social care with many technologies struggling to move beyond concept and laboratory stage to widespread use with the care sector. Acknowledged barriers include cost and a lack of understanding or even antipathy within the sector to their introduction, which in turn limits the opportunity to evidence their contribution to supporting the care workforce and improving outcomes for people who use care services.

4.46 Physical interaction with users is relatively limited in part due to safety concerns and as such there is little evidence of their use within social care. Prescott et al (2012) conclude that the general-purpose household assistive robot is some way off, however there has been a steady advance in, and significant take-up of, robots that perform useful single functions. These tasks can be characterised as:

- requiring limited sensing and actuation capability;
- requiring limited communication with the user; and
- involving relatively low autonomy particular when interacting with users.

4.47 However, this highlights one of the current limitations of AI and robotic systems and a challenge for robotic engineers, namely moving away from robotics that perform single use functions to multi-functional systems that can integrate seamlessly with other smart technologies. Enabling interoperability in the design of AI and robotic systems is major challenge for the sector with the proliferation of single use and standalone systems hampering efforts to achieve greater use of and adoption of technologies within social care.

4.48 Development programmes such as CARESSES (Culturally Aware Robots and Environmental Sensor Systems for Elderly Support[2]) are working to expand the effectiveness of Ai and robotics in social care. Funded by the EUs' Horizons 2020 programme in conjunction with the Ministry of Internal Affairs and Communications of Japan, CARESSES is working to meet the challenges of an ageing population with culturally competent and compassionate robots where 'cultural competence' refers to the ability of a robot to recognise a person's various cultural and personal traits, and to behave accordingly. The aim is for robots to be:

- Aware of factors such as age, education, family structure, religion and heritage (cultural awareness);
- Take into consideration the person's cultural values, beliefs and attitudes about health and illness as well as their self-care practices (cultural knowledge); and
- Be sensitive about the user's attributes like language, accent, interpersonal skills, communication skills, ability to trust others and to be compassionate to others (cultural sensitivity).

4.49 It is envisaged that culturally competent robots will help older people in a variety of tasks including:

- **Companionship** - communicating through speech and gestures, providing entertainment and maintaining contact with family and friends;
- **Health promotion** - providing reminders to take medication, encouraging physical activity, hydration and healthy eating;
- **Care** - assisting with everyday tasks, reminding people about GP and hospital appointments in conjunction with the social care staff; and
- **Safety and prevention** - alerting carers to accidents including falls.

[2] CARESSES has received E2,084,248.75 from the European Union's Horizon 2020 research and innovation programme under grant agreement No 737858, and JPY 60,000,000 from the Ministry of Internal Affairs and Communications of Japan. www.caressesrobot.org The project is set to end in 2020 with target of developing a culturally competent prototype robot.

Ethical considerations

4.50 Several research reports focus on the ethics of introducing AI and assistive technologies into health and social care. Sharkey & Sharkey (2012) explore ethical issues in robot care for the elderly and, whilst acknowledging the possible benefits, discuss six main ethical concerns associated with:

- The potential reduction in the amount of human contact;
- An increase in the feelings of objectification and loss of control;
- A loss of privacy;
- A loss of personal liberty;
- Deception and infantilisation; and
- The circumstances in which elderly people should be allowed to control robots.

4.51 The authors highlight the importance of balancing the care benefits with the ethical costs but conclude that, if introduced with foresight and careful guidelines, robots and robotic technology could improve the lives of the elderly, reduce their dependence and create more opportunities for social interaction.

4.52 Caleb-Solly (2018) highlights a number of ethical concerns regarding the use of robot-supported care. In her presentation at the CHIRON Project Conference 2018 she outlines the following ethical concerns which have been considered as part of the development of robot systems funded through the project:

- The objectification of the people with age-related impairments as ‘problems’ to be solved by technological means;
- The potential for monitoring systems to restrict the capabilities of freedom, privacy, autonomy and/or dignity of people;
- The potential for assistive robots to reduce engagement of people with their surroundings or other people;
- The quality of physical and psychological care robots can realistically be expected to supply;
- The potential of assistive robot relations to be inherently deceptive or infantilising; and
- Perpetuating and encouraging dependency.

4.53 Concerns regarding the replacement of human care with robots is a recurring theme within the evidence base. Coeckelbergh (2010) addresses the issue of ‘replaceability’ and concerns that care provided by AI systems is not as good as human care. His report provides a response to key objections addressing concerns regarding assistive technologies providing only ‘shallow’ care, robots being unable to provide ‘good care’, a lack of privacy and the absence of ‘real’ care.

4.54 With regards to ‘shallow’ care, the author recognises concerns that assistive technologies lack the kind of ‘deep’ feelings that accompany human care. In response, he argues that this level of ‘deep care’ (care as feeling and as reciprocity of feeling) is not always and not necessarily part of ‘low-tech’ human care as it is organised today. In the context of mass care and bureaucratic organisations, human care practices usually lack ‘deep’ care and that much care work is routine work. As such at present there is little time for emotional, intimate, and personal engagement with the people who use care services as the ratio of care recipients to carers is too high.

4.55 For the objection around ‘good care’ the author points out that little work has been done in providing systematic and comprehensive criteria of good care and the place of social and emotional needs in it. He concedes that it may well turn out that for certain care tasks, a particular AI assistive technology is not able to restore, maintain or enhance some capabilities as well as humans can do.

4.56 However, he suggests that this has to be decided on a case by case basis and that the use of AI assistive technology should not be rejected in general. In specific situations and for certain care tasks some AI technologies may be able to replace human care or can assist human care without being able to replace it.

4.57 Ranstad (2017) allay fears about the likelihood of robots replacing the need for humans in the social care sector, suggesting that technology can play an important role in performing everyday tasks like reminding patients to take medication or helping to tackle loneliness, although when it comes to the emotional element of social care only humans can form the important emotional bond between carer and patient. Technology can complement, not replace, the work done by humans to help improve services and alleviate pressures on the NHS.

4.58 The issue of privacy is also raised in several studies. Sharkey & Sharkey (2012) highlight the risk that increased monitoring of people who use care services, as an intentional function of many AI and robotic technologies, could infringe on an individual’s right to privacy. They outline several scenarios such as an individual in receipt of care and support feeling uncomfortable with an operator being able to remote control a robot to peer round their apartment before they are dressed, or when they are taking a bath. They also point out that someone with Alzheimer’s may forget that a robot is monitoring them or that the issue of providing consent would need to be addressed for family members and visitors.

4.59 Coeckelbergh (2010) questions concerns around privacy suggesting that current care practices involve the continuous ‘violation of privacy’ (e.g. personal care). The author suggests that the issue of privacy is not new or unique to the introduction of AI assistive technologies but is also a central consideration of care provided by humans.

4.60 Some authors (Sparrow & Sparrow 2006) have raised concern that the use of AI assistive systems that resemble biological ones run the risk of ‘fooling’ people when they are used to substitute human care. In response Coeckelbergh (2010) suggests that, in practice, people are usually very much aware that a certain AI autonomous system such as a robot is not really human, even if the robot has a human appearance and even if they respond to the robot as if it were human. This does however raise issues around user awareness and user acceptability.

4.61 Research by Wang & Sudhama et al (2017) on the views of older adults with Alzheimer's disease and their caregivers on the use of robots to assist daily activities highlights a potential discrepancy between the views of people in receipt of care and caregivers. They report that few studies have investigated in-depth perspectives of older adults with dementia and their caregivers following direct interaction with an assistive prompting robot. Their research found that whilst older adults expressed opportunities for robots to help in daily activities and were open to the idea of robotic assistance, they did not want a robot. Caregivers identified numerous opportunities and were more open to robots with several wanting a robot, if available.

4.62 This highlights one of the ethical issues facing the introduction of robotic assistance, namely a potential for disagreement between the views of people in receipt of care and care givers for how robotic solutions could or should be used to support the provision of care services. The authors emphasise a need for continued dialogue between users and developers and consideration of robot design and caregiving relationships.

4.63 The regulatory system is however responding, and guidance has been developed to govern the use of robots within the delivery of care. BSI (2014) has produced the standard BS EN ISO 13482 which aims to minimise potential risks posed by robots that come into direct contact with people. Further guidance and protocols will need to be developed to regulate the use of a diverse range of AI and robotic technologies in social care which, in turn, will require social care employers to deliver training to their respective workforce.

Workforce implications

4.64 There is limited published evidence on the current or future role for the social care workforce in using AI and robotics as part of their care provision. This perhaps reflects the lack of involvement of the care workforce in collaborating with technology companies and robotic developers to design and shape AI and robotic systems to fit with the realities and practicalities of providing care. This section of the report outlines some of the debate on the potential workforce issues that might arise as the use of AI and robotics in adult social care begins to grow.

4.65 Although not specifically focused on the adult social care sector, the House of Commons: Science and Technology Committee's (2017a) report on robotics and artificial intelligence points out that whilst improvements in productivity and efficiency, driven by the spread of AI and robotics have been widely predicted, there is no consensus about what this will mean for the UK workforce. Some commentators forecast rising unemployment as labour is substituted for AI-enabled robots and machines, whilst others foresee a transformation in the type of employment available with the creation of new jobs compensating for those that were lost and the prospect of robotics and AI augmenting existing roles and enabling humans to achieve more than they could on their own.

4.66 The literature around the use of AI and robotics in social care largely mirrors these differing views with some framing the debate as ‘humans versus machines’ whilst others suggest that the implications are likely to be far subtler with AI and robotics providing support for tasks within jobs. The House of Commons: Science and Technology Committee (2017a) concluded that learning new skills and adapting our education system would help to ensure that the UK realised the full range of opportunities presented by robotics and AI, while also managing its potential risks.

4.67 Prescott et al (2012) suggest that robots could potentially address the shortage of skilled labour in the caring professions that is expected to arise with the demographic shift with suitably configured robots able to assist carers to be more efficient, to cope with physically demanding tasks such as lifting and allow them to focus more on the human-to-human aspects of their work. However, the authors also stress that no computer, however smart, can intervene to physically assist with many of the daily tasks that are performed by carers to help maintain the health and dignity of older people.

4.68 Coeckelbergh (2010)’s outlines that AI technologies have the potential to contribute to health care in useful and important ways such as helping to lift people, to help people to walk and by monitoring people in their own homes allowing people to stay and feel at home while receiving care.

4.69 In their report on the future of work in the age of automation, AI and robotics, Dellot & Wallace-Stephens (2017) report on the rising public interest in new technologies and their implications for workers. The authors counter what they see as alarmist reporting by news media with several reasons to be optimistic about future work, namely:

- **Technical limitations -** Despite impressive advances in the capability of machines, there are still many things they cannot do;
- **Task vs job automation** - In most cases, AI and robotics will automate individual tasks rather than whole jobs. Because jobs usually encompass a range of functions, the automation of one task means workers will be able to pivot into new roles. No machine can wholly substitute for care workers and such occupations are more likely to evolve than be made obsolete;

- **Technology complements and creates -** AI and robotics will not just substitute for workers. They will also complement them and create new tasks not previously done by humans. Examples include robotic systems used by care workers to help lift patients[3];
- **Demand will be recycled -** Automation must also be looked at through a macro lens that accounts for feedback loops. One of these is the phenomena of shifting or 'recycled' demand. Rising productivity caused by new machines may lead to a lowering of prices (e.g. care costs), thereby freeing consumers (e.g. people who use or purchase care services) to spend money in the same sector or another part of the economy.

4.70 The authors stress that technology is not predetermined to result in a particular outcome and as a society we have a choice in how to apply AI and robotics and manage their effects. There are choices to be made by developers and engineers in terms of the functionality they imbue in machines, social care employers as to which technologies they purchase, HR teams as to whether and how they help staff evolve into new roles and policymakers about the kind of regulatory, welfare and tax system that can maximise the upsides of disruption and minimise the downsides.

4.71 A central argument of their report is that the deployment of AI and robotics could help the UK forge a path towards a better world of work. New technologies could phase out mundane jobs, raise productivity levels, open up the door to higher wages and allow workers to concentrate on more human-centric roles that are beyond the technical reach of machines. Interestingly, this may suggest that the care workforce may need to develop and/or strengthen their soft skills to enable them to provide social and emotional support for people who use care services.

4.72 Consultations with AI and robotics sector representatives undertaken for this scoping study have emphasised that the main hurdle to overcome initially is in terms of cultural change and addressing the reluctance and scepticism from the care workforce on the ability of AI and robotics to assist them in their role rather than being a threat to their jobs.

[3] Japan's Tokai Rubber Industries has developed the RIBA robot, which is being used in health care to lift and move humans up to 175 pounds in weight.

4.73 Part of challenge, as outlined by Share & Pender (2018) is that few professional HEI learning and training programmes in social care practice, social work or elder care offer students the opportunity to explore and integrate awareness of the technologies currently and in the future deployable in care settings. They do not provide students with sufficient opportunities to develop critical awareness of human robot interaction.

4.74 It was suggested that staff at all levels, including those in initial training, needed greater clarity on the current and potential scale and scope of the role for AI and robotics to add value to their roles or service offer in order to underpin this cultural change. This is reinforced by the relative lack of examples of the use of AI and robotics in social care in the UK.

4.75 This would suggest that further work is required to bring together key stakeholders from robotic developers and social care employers (and through them the care workforce and people who use care services) to explore and promote the use of AI and robotics in social care and the role of the workforce in embracing and using new technologies.

4.76 One of the themes highlighted by social care stakeholders engaged through this study was the need to explore the use of existing smart technologies in the home and lower cost AI and robotic systems that are already available on the market (including for example home hubs, the use of smartphones for telemonitoring, use of computer tablets for cognitive support and use of smart sensors for safety). More research is needed to determine whether these everyday technologies can help to challenge and change the perceptions of the care workforce on the contribution and value of AI and robotics in supporting their care role and improving outcomes for people who use care services.

4.77 Stakeholders also outlined a range of factors required to support the introduction of AI and robotics in social care including:

- The required protocols and policies to inform commissioning, maintenance and use etc.
- CPD and training;
- Risk management protocols; and
- Clarification of the scope of the role of AI and robotics in social care.

4.78 Regulatory bodies including the Care Quality Commission (CQC) are beginning to recognise the increasing role that technology can and will play in the delivery of care. In November 2017 CQC's key lines of enquiry were updated to include the following:

> **EFFECTIVE** - How is the technology used to enhance the delivery of care and promote people's independence?
>
> **RESPONSIVE** - How is technology used to support people to receive timely care and support? Is the technology easy to use?
>
> **WELL-LED** - Are technology systems used effectively to monitor and improve the quality of care?
>
> Outstanding services will 'Actively seek out new technology and other solutions to ensure that people live with as few restrictions as possible'.

4.79 As such, the stronger focus on the use of technology within the inspection regime is likely to create increased interest within social care employers to explore technology solutions, including the use of AI and robotics. What is currently unclear is the extent to which social care employers have considered the short, medium and longer-term workforce implications of integrating technology within their delivery of care.

5. Gaps in the evidence base

There is currently a gap in the evidence base relating to any assessment of the routes to market for the range of assistive robots that have been developed and piloted over the last decade. The literature on the development of assistive robots is dominated by technological papers with little consideration of how such devices might be commercialised for a mass market at a price that is affordable for older people and their families as well as public services and care insurers.

The growth of relatively low-cost AI technologies within the domestic market represents a considerable opportunity for the social care sector and has the potential to support a greater level of self-care and promote independent living.

A notable absence in the evidence base relates to achieving a greater understanding of the user experience and user acceptance of AI and robotic technologies. Given the importance of usability and user acceptance in the adoption and roll-out of robotic solutions more research is necessarily to expand the knowledge of how people who use care services, across a range of care settings, experience AI and robotic solutions.

Although this study has uncovered little published research on the future training needs for the social care workforce linked to an increased use of AI and robotics, discussions with a range of stakeholders as part of this study have highlighted a range of potential training needs. Robotic developers will need to fully consider the training requirements and implications of AI and robotic technologies in partnership with wider social care stakeholders and social care employers.

Routes to market

5.1 A notable gap in the evidence base relates to any assessment of the routes to market for the range of assistive robots that have been developed and piloted over the last decade. Blackman (2013) highlights that the literature on the development of assistive robots is dominated by technological papers with little consideration of how such devices might be commercialised for a mass market at a price that is affordable for older people and their families as well as public services and care insurers. He argues that the focus of technical development in this field is too ambitious, neglecting the potential market for an affordable device that is already in the realm of the 'adjacent possible' given current technology capabilities.

5.2 The author also questions on both ethical and marketing grounds the current effort to develop assistive robots with pet-like or human-like features. He suggests that the marketing literature on new products has so far not appeared to inform the development of assistive robots but has some important lessons, which include using analogies with existing products and giving particular attention to the role of early adopters. His paper concludes that what is required is a strategy for enabling mass adoption, which at the time of writing, had so far eluded conventional telecare.

5.3 The lack of evidence or reports on effective routes to market for AI and robotics highlights a need for greater dialogue between technology companies and robotic developers, social care employers, carers and people who use care services. A lack of effective dialogue is likely to perpetuate challenges in ensuring greater adoption and use of AI and robotic technologies across the social care sector.

5.4 There is potential to look to the wider technology sector to understand how AI technologies such as Amazon Echo are being launched into the market place. The voice assisted market has been growing rapidly since Amazon first launched its Alexa device in 2014 and a recent study by Juniper Research has predicted that speakers such as Amazon Echo, Google Home, and the recently released Sonos One will be installed in over 55% of all homes by 2022.

5.5 The growth of relatively low-cost AI technologies within the domestic market represents a considerable opportunity for the social care sector and has the potential to support a greater level of self-care and promote independent living.

5.6 Whilst there is currently no data on the extent to which care social care employers are embracing the use of such technologies, there is evidence that many are piloting the use of voice assisted technologies to support people who use care services. In 2017 Hampshire County Council commenced a pilot to use Amazon Echo technology to support older people needing care. Working with their telehealthcare partner, the PA Consulting Group-led Argenti Telehealthcare Partnership, the pilot trialled a customised version of the Echo device to help support people to live independently in their own homes for longer and reduce social isolation in the elderly.

5.7 A number of other social care employers are following suit. Norfolk Council is looking at ways in which the Amazon Echo and the Amazon Dot could improve the quality of life of older residents. The Digital Line (TDL) is working with Hampton Care Home, Canford Care, Amazon and advanced wireless technology specialists WDSI to begin a four-week case study of voice assistants for residents of the Richmond borough care home. The intention is to assess the suitability of the Amazon devices to manage small tasks such as turning lights on and off for bed-bound residents to potentially calling relatives and care workers from their rooms via the devices.

Understanding user experience

5.8 A notable absence in the evidence base relates to achieving a greater understanding of the user experience and user acceptance of AI and robotic technologies. Vandemeulebroucke & de Casterlé et al (2018) present their systematic review of the qualitative evidence on how older adults experience and perceive socially assistive robots in elderly care.

5.9 The authors conclude that there is a need to better understand older adults' lived experiences with SARs to create the possibility of using an approach that embeds technological innovation into the care practice itself. In other words, further evidence is required from a wider roll-out of SARs to support the develop of models and approaching for better integrating the use of AI and robotics within the everyday process of providing care.

5.10 A presentation by Carers UK at the CHIRON Conference in April 2018 highlighted that although 70% of the public are using technology in their daily lives for work and at home, fewer than 1 in 3 people are using technology to support caring. To realise the benefits from AI and robotics further work is required to understand the barriers for embedding the greater use of technology in social care both from the perspective of the care workforce (including carers) and people who use care services.

5.11 Dahl & Kamel Boulos (2013) emphasise that usability and user acceptance are extremely important for the success of any robotic solution, particularly socially assistive robots that are designed to help older people live longer independently in their homes. The authors state that the ideal robotic solutions must cater for any unique individual user needs and take into consideration users’ socio-demographic profiles.

5.12 Felzmann, Murphy, Casey & Beyan (2015) discuss whether there is potential for genuine end-user empowerment in the use of robot-assisted care for the elderly with dementia. The authors highlight that while the possibility of allowing elderly persons to remain in their communities and empower them to live independent lives for longer than otherwise feasible is frequently mentioned as core rationale behind the development of assistive care robots, the perspective of the elderly end-user is only rarely taken into account in the design of the assistive care robot.

5.13 In this regard further efforts are required. The authors reference the recently funded H2020 MARIO project which aims to address the difficult challenges of loneliness, isolation and dementia in older persons through innovative and multi-faceted inventions delivered by service robots. The project has developed an integrated value-based approach to the design, trial and evaluation of an assistive care robot and aims to integrate the concerns of end-users and their carers and family throughout all stages of the project.

5.14 The authors suggest that this approach can address an essential shortcoming in the field of robotics for the elderly, namely the neglect of user perspectives regarding the development and use of those robots.

5.15 Draper & Sorell (2017) present an international qualitative study which emphasises that values such as respect for autonomy, safety, enablement, independence, privacy and social connectedness should be reflected in the design of social robots. They argue that the same values should affect the process by which robots are introduced into the homes of older people to support independent living but that these values may be in tension. Their study explores what potential users thought about these values and how the tensions between them could be resolved.

5.16 The findings of the study generally supported the priority of autonomy where it conflicts with other values but suggest that safety issues may perhaps be more significant than previously supposed. The authors report that participants' concerns are subtle and the robot itself was not regarded as dangerous, but rather concerns seemed to centre on how safe it was to replace human judgement with robotic programming. The study echoes concerns expressed more widely that robots should not be used to replace human-to-human interaction which may contribute to increased social exclusion. The authors recommend that efforts should be made to use robots to increase the range of interactions of users outside the home to ensure that their introduction facilitate stronger social inclusion.

5.17 Given the importance of usability and user acceptance in the adoption and roll-out of robotic solutions more research is necessarily to expand the knowledge of how people who use care services, across a range of care settings, experience AI and robotic solutions. A number of research studies are planned, for example a collaboration involving the University of Bedfordshire and Middlesex University London who will be part of an international three-year research project to develop and evaluate the world's first culturally aware robots aimed at assisting in caring for the elderly. Such research studies require access to people who use care services and as such social care employers have an essential role in engaging in and facilitating pilot studies involving the use of AI and robotics across different care settings.

Future training needs

5.18 Although this study has uncovered little published research on the future training needs for the social care workforce linked to an increased use of AI and robotics, discussions with a range of stakeholders as part of this study have highlighted a range of potential training needs. Robotic developers will need to fully consider the training requirements and implications of AI and robotic technologies in partnership with wider social care stakeholders and social care employers.

5.19 The growing use of AI and robotics needs to be met by a widening of training and development opportunities for the social care workforce which should cover a range of areas, for example:

- An introduction to robotics including examples of its application;
- Support to develop a change in the workforce's ability to embrace a culture of technological change;
- Work to reduce fears, dispel myths and explore the challenges of integrating AI and robotics into service delivery;
- Examples of the benefits of robotics to people who use care services and the care workforce;
- Identification of forecast skills needs;
- Identification of potential new roles;
- Guidance on regulation;
- Health and safety;
- How to introduce new technology to clients; and
- Confidence building exercises outlining how care staff will contribute to the learning and development process underpinning AI and robotics.

5.20 Unsurprisingly the focus of any training is likely to be influenced by the design and intended purpose of the AI and robotic technology, the needs of the person in receipt of care and the care setting. Whilst there are likely to be a number of common themes across different settings, the training required to use a robotic lifting aid in a residential care home will clearly differ from the training required to programme and interpret data from voice assisted technologies such as Google Home.

5.21 The challenge for robotic developers is to ensure that technologies are user-friendly, intuitive and reliable. For the care workforce the challenge lies in potentially having to become familiar and confident with a range of technologies which may or may not be integrated and whose user interface or operating platform may differ and not yet be interoperable.

5.22 However, a first step is to raise awareness across the social care workforce of what AI and robotics are, what their potential is, how they can support the workforce and importantly how they contribute to improving outcomes for people who use care services. In this regard learning providers including schools, the FE sector and HEIs can play a role in facilitating engagement, debate and critique around existing and future deployment of AI and robotic technologies with adult social care.

5.23 A further area likely to require training for the future workforce is in interpreting the data collated by AI and robotic systems. Smart sensors, telemedicine robots and companion robots will generate and store data that can be used identify the immediate and longer-term care needs of people who use care services. For frontline staff this may require an ability to review and understand a suite of data sets displayed within a smart home hub and take appropriate action.

5.24 For back office staff this may require more in-depth analysis skills to identify trends within the data and ensure that the package of care is amended accordingly as part of a robust preventative approach (which may in future be aided by AI and machine learning).

5.25 Across the care workforce the future landscape of care is likely to require a range of digital skills and competencies either in the use of AI and robotic technologies to deliver care or the use of digital platforms to update care plans and care records in real time.

5.26 The workforce implications surrounding the increased use of AI and robotics may not all be technology focused or require digital skills competency. Several research studies highlight the contribution that AI and robotic technologies can play in undertaking a range of domestic chores within the home. This has the potential to free up frontline care staff to focus on more human tasks such as providing emotional and social support for people who use care services.

5.27 This is particularly pertinent to the domiciliary care sector where care visits can be as short as 15 minutes leaving little time for social contact and support. Conversely, future training may need to ensure staff have the skills to address and effectively support the social and emotional needs of people who use care services.

5.28 The proliferation of AI and robotic systems over the past decade is likely to continue, however to realise their potential to support the social care sector further work is required to ensure user acceptance and use. As such there is likely to be a future role for the care workforce in encouraging and facilitating people who use care services to use AI and robotic technologies that can support them to live independently and manage their health needs.

6. Conclusions and recommendations

Whilst several research studies demonstrate the potential of AI and robotics to support the delivery of care, there is a recognised need to produce stronger evidence through more robust trials and pilots.

There is also a need to draw together a clearer picture of the existing use of AI and robotic technologies within the social care sector and to review their routes to market. Further work is also required to explore the future potential use of machine learning within adult social care and how this could be built into PAR and SAR technologies.

To date the research suggests there has been an insufficient focus on adopting user-led design within the development process and little opportunity for social care employers and the care workforce to influence the development of new technologies at a concept stage. This needs to be addressed to ensure that new AI and robotic technologies can support the practical, everyday challenges facing the workforce in delivering care.

Conclusions

6.1 The House of Commons: Science and Technology Committee (2017a) laud the recent succession of advances that have recently occurred across the fields of robotics and AI, fuelled by the rise in computer processing power, the profusion of data, and the development of techniques such as ‘deep learning’. They state that such breakthroughs raise a host of social, ethical and legal questions, including a need to:

- Take steps to minimise bias being accidentally built into AI systems;
- Ensure that the decisions they make are transparent; and
- Instigate methods that can verify that AI technology is operating as intended and that unwanted, or unpredictable, behaviours are not produced.

6.2 However, whilst several research studies demonstrate the potential of AI and robotics to support the delivery of care, there is a recognised need to produce stronger evidence through more robust trials and pilots.

6.3 Where evidence of impact has been presented, to date these have focused mainly on the impacts on people who use care and support services with less attention paid to the impact on the care workforce (including formal and informal carers). In addition, given that a significant proportion of the technology remains at the concept or prototype phase there appears to be little practical evidence of the use of AI and robotics within the care sector in England.

6.4 There is also a need to draw together a clearer picture of the existing use of AI and robotic technologies within the social care sector and to review their routes to market. Further work is also required to explore the future potential use of machine learning within adult social care and how this could be built into PAR and SAR technologies.

6.5 There are several challenges facing robotic developers in achieving greater traction and use of AI and robotic systems, one of which is the ability to move away from a proliferation of robots performing single tasks to multi-functional systems that can be integrated with other technologies in a range of social care settings.

6.6 To date the research suggests there has been an insufficient focus on adopting user-led design within the development process and little opportunity for social care employers and the care workforce to influence the development of new technologies at a concept stage. This needs to be addressed to ensure that new AI and robotic technologies can support the practical, everyday challenges facing the workforce in delivering care.

6.7 The lack of research focusing specifically on the workforce implications of an increased use of AI and robotics highlighted an area that needs to be addressed. The evidence base highlights a consensus that AI and robotics will not replace the workforce but will likely provide support for tasks within jobs. More work is required to map out the future training and development needs of the care workforce to ensure that the opportunities presented by AI and robotic technologies can be realised. This can only be achieved through better dialogue and collaboration between technology companies and robotic developers, social care employers, carers and people who use care services.

6.8 Stronger collaboration can also help to explore how existing smart technologies such as home hubs, smartphones, computer tablets and smart sensors can be used to improve the quality and efficiency of care delivery which may assist the process of adoption within the social care sector. More research is needed to determine whether these everyday technologies can help to challenge and change the perceptions of the care workforce on the contribution and value of AI and robotics in support their care role and improving outcomes for people who use care services.

Recommendations

6.9 A small number of recommendations are provided below based on the key themes and learning outlined in this scoping report.

Skills for Care

- The findings of this scoping report need to be widely shared with local government, academia and social care employers. Skills for Care should create opportunities for these stakeholders to come together to facilitate better understanding of each other's work and to jointly discuss the implications of this report.
- Skills for Care need to work with organisations and academics piloting the use of AI and robotic technologies to ensure that the future training and development needs of the social care workforce are an integral part of the research and learning is shared with others.
- Where possible, Skills for Care should incorporate a focus on workforce skills needed in this area and potentially perception of using AI and robotics into ongoing consultations with the sector.

Social Care Employers

- Where possible, social care employers should take the opportunity to play an active role in involving their workforce in discussions about opportunities presented by AI and robotic technologies and associated training and development needs.
- There is potential for social care employers to collaborate with academia and robotic developers. If possible, they should seek out or look favourably on requests to assist in the process of designing, developing and testing AI and robotics technologies, and associated workforce issues.

Wider Social Care Stakeholders

- Membership organisations are well placed to undertake research to establish a clearer picture of the existing use of AI and robotic technologies within the social care sector and should be supported in taking these opportunities forward.
- Regulatory bodies could further support the sector by highlighting examples of the use of AI and robotic technologies as part of care inspections and share this learning with the sector.
- Machine learning offers the potential for learning and further AI application in social care based on data collected through new technologies such as smart sensors in homes and telemedicine robots. However, work to establish any potential safeguarding and privacy implications for people who use social care services would need to be investigated further at this stage.

7. Appendices

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List of stakeholder consultations

Alison Bennett, Director of HR, Sense and Sense International

Brenda Horgan, Manager, Northern Ireland Social Care Council

Chris Melhuish, BRL Director, Bristol Robotics Laboratory

Dr Chris Papadopoulos, Principal Lecturer in Public Health, University of Bedfordshire

Dr Jonathan Synnott, Lecturer in Data Analytics, Ulster University

Dr Praminda Caleb-Solly, Associate Professor in Intelligent Assistive Technologies, University of the West of England

Keith Quinn Learning and Development Manager (Digital Learning), Scottish Social Services Council

Lydia Darragh, Biotechnology & Biological Sciences Research Council (BBSRC)

Martin Rix, Strategic Development Director, NorseCare Ltd

Prof Tony Prescott, Director of Sheffield Robotics, Sheffield Robotics

Professor Nigel Harris, Project Manager, Designability Charity Limited

Proffesor Luc de Witte, Robots for Care project, Centre for Assistive Technology and Connected Healthcare, University of Sheffield

Sharon Houlden, Digital Communications and Assistive Technology, ADASS

Terry Dafter, Service Director (Care and Support - Adults), Bristol City Council

The above list does not include consultations undertaken with delegates at two conferences hosted in London on the use of robotics in social care.

Rapid evidence review approach

The Rapid Evidence Review approach provides an overview of existing research on a (constrained) topic and a synthesis of the evidence provided by these studies to answer the Rapid Evidence Review questions.

The Rapid Evidence Review provides a balanced assessment of what is already known about a policy or practice issue, by using systematic review methods to search and critically appraise existing research. It aims to be rigorous and explicit in method, and thus systematic, but makes concessions to the breadth or depth of the process by limiting particular aspects of the systematic review process.

The key steps to undertaking the evidence review are provided below.

1. Formulate the Rapid Evidence Review questions
2. Design the conceptual framework
3. Set inclusion and exclusion criteria
4. Devise search strategy
5. Begin searching
6. Screening
7. Quality assessment
8. Full data extraction
9. Synthesis of findings

Key aims of the evidence review

The key aims of the review was to explore as much as feasible the following:

- Examine the existing international literature in the context of AI and robotics and their uses in adult social care;
- Explore what is currently happening in the context of AI and robotics and their uses in adult social care focusing on the UK but including international examples; and
- Outline workforce issues that might arise as the use of AI and robotics in adult social care begins to grow.

Scope of the research

The following sets out the keywords used in interrogation of the knowledge management systems:

- Artificial intelligence
- Robotics
- Telerobot
- Socially assistive robot
- Physically assistive robot
- Residential care
- Domiciliary care
- Workforce development
- Companion robot
- Robotics and Autonomous Systems.

Search strategy

The search strategy for the RER involved a search (including citations search) of the following databases:

- Social Care Institute for Excellence (SCIE)
- Social Care Online
- Google Scholar
- Skills for Care Research Knowledge Base
- The British Library Social Welfare Collection
- Wiley Online Library
- Taylor & Francis Online
- The King’s Fund
- UKRI Gateway.

This was supported by searches of the following websites and contact for further information if needed:

- ADASS
- Age UK
- Biotechnology & Biological Sciences Research Council (BBSRC)
- Bristol Robotics Laboratory
- Centre for Assistive Technology and Connected Healthcare, University of Sheffield
- Cera
- Consequential Robotics Limited
- Designability Charity Limited
- Edinburgh Robotics, Heriot-Watt University & University of Edinburgh
- European Social Network
- LGA
- National Care Association
- National Institute for Social Care and Health Research
- Northern Ireland Social Care Council
- Scottish Social Services Council
- Sheffield Robotics
- Social Care Wales
- The Kings Fund
- The Nuffield Trust
- UCL Robotics
- UK Homecare Association

Quality assessment

This RER is transparent in process but is not a systematic review of the evidence therefore we took the following steps to assess quality of studies which match our inclusion criteria:

- Is the study relevant to the review questions?
- Are the methods valid and appropriate (design, sampling, data collection)?
- Is there a strong and appropriate analysis of the data and presentation of the findings?
- Have the findings been interpreted appropriately?
- Have the limitations of the study been considered and amendments made to reflect these?

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