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Government
Office for Science



Developing medical, fitness and well-being environments to maintain health and well-being over the life course

Future of an ageing population: evidence review

Foresight, Government Office for Science

Developing medical, fitness and well-being environments to maintain health and well-being over the life course

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This review has been commissioned as part of the UK government's Foresight Future of an Ageing Population project. The views expressed do not represent policy of any government or organisation.

Contents

| | |
|------------------------------------------------------------------------------------------|-----------|
| Executive summary..... | 4 |
| 1. The question being posed | 5 |
| 2. The policy environment | 6 |
| 3. Health and social care into the future | 8 |
| 3.1 Health and social care infrastructure..... | 8 |
| 3.1.1 Mobile and ICT infrastructure..... | 9 |
| 3.1.2 GP/hospital/path lab infrastructure | 10 |
| 3.1.3 Skills infrastructure..... | 10 |
| 4. Review of current evidence | 11 |
| 4.1 Methods..... | 11 |
| 4.1.1 Review of fitness and well-being interventions | 11 |
| 4.1.2 Reviews of self-management interventions and digitally enabled care services | 11 |
| 4.2 Search strategy | 12 |
| 4.3 Results | 12 |
| 4.3.1 Increasing physical activity..... | 12 |
| 4.3.2 Self-management interventions..... | 13 |
| 4.3.3 Digitally enhanced services..... | 15 |
| 5. The implications of existing evidence | 17 |
| 6. Discussion points..... | 18 |
| 6.1 Agile service commissioning to meet local needs | 18 |
| 6.2 Technology as a ‘moving target’ | 18 |
| 6.3 Need for new evaluation methods..... | 18 |
| 6.4 Gaps in the evidence | 19 |
| 7. Broader technological transformations | 20 |
| 7.1 The move to open-access and publicly available research data..... | 20 |
| 7.2 The rise of ‘big data’ | 20 |
| 8. Visions for the future | 21 |
| 8.1 By 2025 | 21 |
| 8.2 By 2040 | 22 |
| References | 23 |

Executive summary

Background and methods

This report is derived from a review of the research evidence on physical activity interventions and initiatives, interventions to support self-management/ self-care of long-term conditions and digitally enabled care services and technologies. The aim was to use existing evidence to envision future services and associated infrastructure.

The Evidence Review involved scoping the literature for topics researched and to determine the nature of that research. Rapid-scoping review methods were applied to trusted sources, and searches for specific key texts were conducted. A separate search was conducted to identify literature relevant to each domain. A narrative was then produced from the review findings.

Review findings

The evidence base for physical activity interventions is growing. There has been significant recent investment in the development and evaluation of interventions to promote activity and reduce sedentary behaviour at the individual, community and population levels. The evidence to link higher levels of physical activity to positive health outcomes and disease prevention is convincing, both in 'well' populations and in those with long-term health conditions.

Self-management interventions are heterogeneous in nature but common elements exist across the majority of them. The consensus in the literature is that self-management will become increasingly important due to unsustainable demands upon services. Evaluation of self-management interventions reveals a small but varying effect across a wide range of outcomes. However, little is known about the mechanisms by which these interventions work and how these might vary across differing conditions and populations.

Technology is being increasingly used to support service delivery in a wide range of contexts, and for the delivery of a variety of interventions including fitness and self-management. There is strong evidence supporting the use of technology for remote monitoring of people with long-term conditions, but further research is required.

Implications

Digital applications are already altering established patterns of service delivery. The findings presented here reveal varying results of efficacy which do not accord with the optimistic future described in various envisaging reports. Research has yet to consider unwanted and unforeseen effects of moving towards technology-enabled services. It is also important to consider how to effectively harness new health data emerging from the use of eHealth systems, technology-enabled services and health-tracking devices.

There is an ongoing requirement to evaluate new technologies and technology-enabled services in ways that provide both timely and robust answers, particularly as technology development is a continually moving target. These considerations are discussed in this report.

I. The question being posed

What will the health of the population be in one decade from now and what services will be available to support our well-being, health and social care requirements across the life course and within a changing environment? How will this have changed further in 25 years from now? This Evidence Review is about identifying solutions for the future from what we know about what works now in the context of:

- services designed around users;
- the digitalisation of society and the impact of this upon policy direction of travel;
- consequent service reconfiguration across the entire health and social care landscape.

2. The policy environment

Health and social care policy identifies the critical importance of the following in shaping the future design and delivery of services:

- universal recognition of the need for people to look after their own fitness, health and well-being;
- increasing empowerment of the end user of services;
- a culture where self-management of long-term (chronic) health conditions is the norm;
- timely and easy access to sustainable services by all sectors of society and in any setting;
- service innovation through a whole range of providers.

The primary care-led commissioning of health and social care, introduced in 2012 through the Health and Social Care Act (The Stationary Office, 2012), suggested the need for radical changes to how we conceptualise, organise and deliver health and social care. The goal of new UK commissioning arrangements through primary care was to support the new vision for sustainable services. Such services would need to be responsive to current demographic shifts such as population ageing and population migration as well as to other factors such as climate change and demands stemming from the built environment. They would need to be integrated at the point of delivery with distinctions between health and social care becoming increasingly blurred. Naylor *et al.* (2013) identified a series of priorities for the new commissioning arrangements; for example promotion of primary and secondary prevention, increasing support for self-management rather than fostering reliance upon services, coordination across health and social care, and improved ambulatory/emergency and acute care.

Ham *et al.* (2012) highlight the increasing public engagement in healthcare and promotion of new models of shared and informed patient decision making, drawing attention to how this shift will influence both services and expectations of what is provided. They also highlight the pivotal role of innovation and radical solutions in delivering the nature and scale of change that is necessary if we are to thrive in a changing global environment. The National Information Board (2014) sets out a framework for action for use of information for health by 2020, which includes giving people full access to their care records through a range of digital means, and making real-time information available to those who need it. However these and other changes can only occur if the contribution of mobile and remote health and social care is maximised. This will include the necessary infrastructure for technology-enabled services underpinned by a different philosophy of delivery that both embraces the individual as a consumer of health and social care and relies upon their active engagement with services.

The need for the global population (and particularly those living in Western societies) to increase physical activity levels to protect against prevalent chronic diseases, including diabetes, heart disease, hypertension, obesity, depression and some cancers is at the heart of the international public health agenda (World Health Organization, 2010; Heath *et al.*, 2012). This requirement is supported by an array of policy and scientific guidelines (for example Chief Medical Officers, 2011; Public Health England, 2014), and increasingly there is an imperative on public health bodies to promote community and national interventions across all population segments (Chief Medical Officers, 2011; Heath *et al.*, 2012). It is noted that even within sub-

populations, there is significant variation in the fitness levels and well-being of citizens, and the barriers faced by different groups to engagement in physical activity also differ (Chief Medical Officers, 2011). For example some people aged 60 and over are well and active, others live with a single chronic disease, and others have multiple co-morbidities requiring significant input from health and social care professionals. Living with a range of symptoms can make it difficult to engage in physical activity in or outside the home (Theou *et al.*, 2011; Public Health England, 2014).

3. Health and social care into the future

A host of reports, conferences and blog posts illustrate how the future of health and social care might be envisioned; for example the King's Fund 'time to think differently' blog and associated reports (King's Fund, 2014) and 'people powered health' by Nesta (2014). In contrast, the NHS *Five Year Forward View* (NHS, 2014) presents a relatively conservative view of how services need to be shaped in the next 5 years. This dichotomy is also evident in the mainstreaming agenda for technologies for health monitoring (telehealth) and for promotion of safety and independence by vulnerable people (telecare), which, despite being supported by a renewed policy commitment to transform service provision through technology (Department of Health, 2015), have temporarily stalled due to the reality of incremental embedding of new innovations within the statutory sector (May 2013). Nevertheless there is a clear push to embed existing technologies into health and social care services with projects being supported to look at the facilitators, barriers and market opportunities to achieving this (Taylor *et al.*, 2014), for example the recently completed Assisted Living Innovation Platform funded by Innovate UK.

It is also important to be cognisant of recent policy, which encouraged people to actively select the location of their health interventions (choose and book) and revealed that many patients currently do not want to be active choosers of a health service, instead entrusting their GPs to draw on their clinical experience to decide the best care options for them (Greenhalgh *et al.*, 2014).

The main threads across reports that consider the next decade of health and social care and beyond are the embedding of a consumerist paradigm, the mainstreaming of technology-enabled care services that promote self-management and remote care provision, use of social media to create and sustain online communities with shared health issues and interests, greater responsibility on citizens to adopt healthy behaviours and lifestyles, and increasing use of health data for a myriad of purposes. For example, Loder *et al.* (2013) propose that sharing health data for a range of purposes will be paramount in future decades, with such data having an increasing monetary value. Within this report, the proliferation of resources and online communities to support self-monitoring is illustrated; for example *Tracking for Health* (www.pewinternet.org/2013/01/28/tracking-for-health), Quantified Self (<http://technori.com/2013/04/4281-the-beginners-guide-to-quantified-self-plus-a-list-of-the-best-personal-data-tools-out-there>), and MyFitnessPal (www.myfitnesspal.com) (although it should be noted that the majority of such communities originate from North America). The growing consumer market for medical fitness, including the proliferation of mobile, tablet and internet applications for monitoring and managing emotional and physical fitness; the development of new weight and exercise management programmes; and greater collaboration between private gyms, national sporting organisations and public health interventions, also form part of a developing infrastructure of well-being environments. As society places greater responsibility on its citizens to adopt healthy behaviours and lifestyles, this trend will continue.

3.1 Health and social care infrastructure

How well is the healthcare infrastructure in the UK placed to take advantage of new opportunities and address new challenges arising from this changing landscape? The issues this encompasses are raised below.

3.1.1 Mobile and ICT infrastructure

In the UK, access to broadband internet by the general population has improved over time, with infrastructure being put in place to eventually ensure connectivity in all locations. There has also been a significant expansion in the availability and use of broadband and mobile technologies for work, health and social care, fitness and leisure. The government is taking advantage of this environment by committing to the digitisation of a range of public services. Ongoing improvements to the ICT (information and communications technology) infrastructure offer important opportunities for new models of healthcare delivery, discussed in section 4.3.3 of this report. Additionally connectivity is being seen as a potential means of combatting social isolation and loneliness, even though the relationship between the internet and social connectedness is far from straightforward. However, there are some challenges.

First, there is the issue of ‘digital differentiation’, that is differences in internet access and use associated with factors such as age, material deprivation, ethnicity, gender and geographical location (Longley and Singleton, 2009). For example, a recent National Audit Office publication (National Audit Office, 2013) estimated that 91% of the UK population aged 16 to 64 years are online, while the figure falls to 51% among those aged 64 years and over. Similarly, 91% of people in social classes ABC1 are online, compared with 74% of people in classes C2DE. Hence, without strategies to address digital differentiation, new models of service drawing on ICT technology could become drivers of new health inequalities.

Also, with the Department of Health recently committing to “a digital first health and care system ... thereby encouraging the public, patients and users of services to use digital services” (Department of Health, 2015), the government should (in the view of the authors of this Evidence Review), consider placing this move towards healthcare digitisation within the broader policy context of its drive towards ‘digital by default’ delivery of public services. However, in the view of the authors, our review of the evidence suggests a more nuanced approach is required that takes account of the local context, specific clinical needs and the importance of personalisation of services. Further, that the strategy has to be strongly attuned to unintended consequences such as the impact upon those who are uncomfortable or unable to use online technologies. In addition, it is important to avoid seeing digital technologies as ends in themselves, rather than a means to the ends of improved clinical practice; failure to do so could lead to costly redundant technologies and a two-tier system of access to services.

Over time there will be an increasing number of innovations proposed for health and social care delivery – both ‘disruptive’ (i.e. unexpected), and those introduced as a result of incremental developments. Robotics is one such example. Technology-related projects currently supported by Research Councils UK and international funding agencies illustrate a preoccupation with the potential of robotics for treatment, rehabilitation and care. However to date a limited number of such technologies are available on the market, with funded activity tending to result only in prototypes in many instances. Successful robots with potential for mainstreaming tend to be those that are simpler and have very specific purposes, such as those created to be assistive devices.

As envisioned by Nesta and others, the increasing ability to collect, store, analyse and exchange large data sets presents unbridled opportunities for health and social care delivery but also incorporates a number of threats.

3.1.2 GP/hospital/path lab infrastructure

The rise of chronic healthcare challenges within the population is leading to recognition of the need for a wider array of services to those provided previously, with the recognition that a plurality of providers should be in place in any one locality to achieve this. New providers, both large and small, are consequently seeking to provide health services – for example ten providers including Virgin Care bid for a contract worth between £750 million and £1.1 billion from Cambridgeshire and Peterborough CCG to run services for older people (Dowler, 2013). However, concerns about resultant commissioning complexities and costs are already being expressed, (Iacobucci, 2013, 2014), so robust safeguards are needed. The NHS Future Forum (2011) recommends measures to avoid ‘cherry picking’, service fragmentation and the development of new market monopolies. In a related vein, Glynos *et al.* (2014) warn against the dangers of ‘provider-blind provision’, the notion that the *type* of provider – and the nature of their internal procedures – is irrelevant to purchasing decisions.

3.1.3 Skills infrastructure

The changing landscape of health and healthcare is signalling the need for change to the undergraduate and postgraduate education and training of health and social care practitioners. This includes – but is not limited to – skills in how to enable people to self-manage, use of ICT-enabled services and remote as opposed to ‘hands on’ care. NHS England has sought to meet the challenge of training practitioners to take up new innovations with the formation of new Academic Health Science Networks. These networks will aim to improve clinical practice by spreading new innovations throughout the NHS (NHS England, 2013).

4. Review of current evidence

To provide an evidence-based foundation for future scenarios of well-being, health and social care, underpinned and/or provided through digitised services, we conducted an examination of 'what works now'. This focused upon research literature in the following domains:

- physical activity interventions and initiatives;
- interventions/services to support self-management/self-care of long-term conditions;
- digitally enabled services and interventions.

The domains were examined using a mix of scoping reviews and searches for specific key texts as described below. As would be expected there were significant overlaps across the three domains.

4.1 Methods

4.1.1 Review of fitness and well-being interventions

The evidence base for physical activity interventions is extensive and growing. Therefore a pragmatic approach was adopted that involved creating a narrative out of a number of research reports and articles drawn from trusted sources such as the Cochrane Database of Systematic Reviews and review articles published in trusted journals. This was not a systematic review of the efficacy of interventions in this domain, but instead draws out key evidence that relates to this growing public health agenda.

4.1.2 Reviews of self-management interventions and digitally enabled care services

Rapid-scoping reviews were conducted within these domains, to identify the current evidence base for self-management and digitally enabled services. The intention was to illustrate the nature of existing evidence and provide objective evidence for direction of travel rather than being comprehensive. Therefore the review framework described by Arksey and O'Malley (2005) was employed. This adopts a broad approach while also enabling comprehensive coverage that is replicable. Due to the extent of potentially relevant evidence, we focused upon 'reviews of reviews' rather than being as comprehensive as described by Arksey and O'Malley (2005). This type of strategy has been adopted by other rapid reviews (Ganann *et al.*, 2010), with narrative findings being used to guide policy and clinical practice.

For digitally enabled services, searches were limited to study populations aged 65 years and over. However for self-management interventions, which tend to target condition types as opposed to distinct age groups, reviews were included if the study population included older people or all adults. As the risk of developing long-term conditions increases during the pre-retirement decade, understanding how self-management interventions support those who are working as well as retired is important for future service-delivery scenarios.

4.2 Search strategy

Searches were performed using five key databases: the Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO, Medline, Web of Science and the Cochrane Database of Systematic Reviews (Web of Science was not utilised for the self-management rapid review).

Papers were included if they examined the outcomes of self-management interventions and/or digitally enabled services, were published between 2000 and 2014, were in English and published in a peer-reviewed journal. Papers were excluded if they fell outside these parameters, included child/adolescent populations or specific sub-populations.

A two-stage process was adopted, firstly screening by title to select citations that appeared to meet the identified inclusion criteria and removing duplicates, and then reading abstracts of the remaining results to remove articles that failed to meet the review criteria. The remaining full-text articles were then screened to check their eligibility for inclusion. The findings are discussed narratively, drawing out key points to consider in thinking through the emerging infrastructure of medical, fitness and well-being environments.

4.3 Results

4.3.1 Increasing physical activity

The evidence linking higher physical activity levels to positive health outcomes and disease prevention is convincing (British Heart Foundation, 2012; Lee *et al.*, 2012; Public Health England, 2014). As well as preventing or delaying onset of declining health in older age (Conn *et al.*, 2011), key studies demonstrate the benefits of physical exercise interventions as part of chronic disease management across a range of conditions, including arthritis and balance problems (Gillespie *et al.*, 2012), cognitive impairment (Blondell *et al.*, 2014), dementia (Forbes *et al.*, 2013), coronary heart disease (Heran *et al.*, 2011), pulmonary disease (Wilson *et al.*, 2014), diabetes (Norris *et al.*, 2005; Avery *et al.*, 2012) and mental illness (Josefsson *et al.*, 2014).

The reviewed literature confirmed the investment that has been made in the development and evaluation of interventions to increase physical activity and reduce sedentary behaviour (the latter being an independent risk factor for all-cause mortality – Rezende *et al.*, 2014). Despite this investment, knowing how best to encourage physical activity in the overall population, including those with specific health needs, is an ongoing challenge (Heath *et al.*, 2012). For example, Wilson *et al.* (2014) found significant effects in favour of physical activity interventions for people with chronic obstructive pulmonary disease in only seven of the 16 studies they reviewed. They noted significant variation in the described components of interventions, which made it difficult to draw clear conclusions about clinical effectiveness. A review of studies into the benefits of exercise for cardiac-based rehabilitation (Heran *et al.*, 2011) identified a stronger evidence base, with researchers concluding that this intervention reduced mortality and hospital admissions when compared to usual care. However, there were no reported differences in morbidity, and mortality reductions were only seen in studies with a follow-up of more than 12 months.

A systematic review examining cost-effectiveness of interventions in primary and community care found that most were cost-effective. Group exercise programmes were more cost-effective than those that were instructor-led; interventions by 'prescription' delivered by healthcare professionals were more cost-effective than gym-based or instructor-led programmes (Garrett *et*

al., 2011). However uncertainty remains regarding the optimum mode of intervention delivery. A meta-analysis examining the effects of physical activity interventions for healthy adults revealed a modest effect compared with usual care (Conn *et al.*, 2011). This study also identified certain components that were more effective than others, such as adopting a behavioural versus a cognitive approach, and delivery of the intervention in person rather than by telephone. Yet a systematic review of telephone-delivered interventions for physical activity and dietary behaviour change observed evidence of behaviour change initiation in 20 of 27 included studies, demonstrating the potential for delivery of interventions using new technologies (Goode *et al.*, 2011). Conn *et al.* (2011) also found evidence that interventions targeting individuals were more effective than those for communities. This finding is supported by Baker *et al.* (2011), who failed to identify quality evidence to support the effectiveness of community-wide interventions to increase physical activity among populations.

Environmental and demographic factors are an important consideration (Rosso *et al.*, 2011). Heath *et al.* (2012) found that different approaches can be more or less effective within different geographical and cultural environments, and for individual communities and population segments. A recent systematic review found that fitness levels vary significantly in the population aged 60 years and over, with numbers meeting recommended guidelines ranging from 2.4% to 83% (Sun *et al.*, 2013). The study also found that older old age groups tended to be less active than younger old people, with women engaging less frequently compared to men. However, it is noted that guidelines referred to by studies varied, and the inclusion of different activity types across the studies such as household activities can then suggest that females are more active (Sun *et al.*, 2013).

Theou *et al.* (2011) also considered the impact of interventions on different older populations, examining the effectiveness of exercise interventions for the management of frailty. They concluded that “exercise programmes that optimise the health of frail older adults are different from those recommended for healthy older adults”. Other studies suggest that moderate- to high-intensity exercise, rather than gentle exercise, is required to maximise health benefits (British Heart Foundation, 2012). However, higher-intensity exercise will be problematic for some older people due to their health status (Theou *et al.*, 2011).

A growing body of research is examining the potential benefits of multi-component interventions, for example combining self-management strategies with low-intensity physical exercise (National Voices, 2014), combining social support and physical exercise (Garrett *et al.*, 2011), and offering multi-modal exercise interventions that include cognitive, emotional, social and physical benefits (Han *et al.*, 2004; Wayne *et al.*, 2014). Integrating physical activity interventions within existing self-management interventions, including (i) self-efficacy building, (ii) self-monitoring, (iii) goal setting and action planning, (iv) decision making, (v) problem solving, (vi) self-tailoring, and (vii) partnership between the views of patients and health professionals, offer the potential to maximise the health-related benefits of increased self-care behaviours and physical activity (Du *et al.*, 2011).

4.3.2 Self-management interventions

A search yield of 1,079 records led to 190 papers being screened by abstract; 131 abstracts were excluded during this process. The remaining 59 full-text articles were read in full, with a further 31 then excluded, leaving 28 articles for extraction and narrative synthesis.

Of the 28 articles included, 24 focused on long-term conditions that commonly affect older populations: seven for diabetes (Deakin *et al.*, 2005; Cochran and Conn, 2008; Fan and Sidani,

2009; Minet *et al.*, 2010; Steinsbekk *et al.*, 2012; El-Gayar *et al.*, 2013; Pal *et al.*, 2013), six for arthritis (Warsi *et al.*, 2003; Walsh *et al.*, 2006; Nunez *et al.*, 2009; Iversen *et al.*, 2010; Brand *et al.*, 2013; Kroon *et al.*, 2014), three for chronic obstructive pulmonary disease (Bentsen *et al.*, 2012; Jonsdottir, 2013; Zwerink *et al.*, 2014), two for heart failure (Jovicic *et al.*, 2006; Ditewig *et al.*, 2010), four chronic pain (Du *et al.*, 2011; Carnes *et al.*, 2012; Boyers *et al.*, 2013; Martin *et al.*, 2013), one for angina (McGillion *et al.*, 2014), and one vascular disease (Small *et al.*, 2013). Within this group of studies, there was a combination of broad self-management interventions trialled with the patient population, and condition-specific interventions.

The remaining four studies examined the impact of general self-management interventions for chronic disease (Chodosh *et al.*, 2005; Foster *et al.*, 2007; Nolte and Osborne, 2013; Brady *et al.*, 2013). Only three studies focused specifically on older people (Chodosh *et al.*, 2005; Boyers *et al.*, 2013; Martin *et al.*, 2013); however, the reported mean age of participants across the studies indicate that the majority of interventions were trialled with older patient populations.

Overall, the findings provide evidence of a small to moderate effect across a range of outcomes, including symptom management, general health, healthcare utilisation, quality of life and self-efficacy. There was also a shared consensus across the studies that, although the effects were small to moderate, this is likely to be important going forward, given the increasing number of adults living with at least one chronic condition in older age. Some of the evidence points towards the effectiveness of targeted strategies (Nunez *et al.*, 2009). Although this is supported in a separate review conducted for the Health Foundation in 2011 (de Silva, 2011), which identified the need for a range of different self-management interventions depending upon needs, the strength of evidence in the current review appears to vary by condition.

Some of the strongest evidence came from reviews examining diabetes self-management (Deakin *et al.*, 2005; Minet *et al.*, 2010; Steinsbekk *et al.*, 2012). For example, Steinsbekk *et al.* (2012) and Deakin *et al.* (2005), who examined group-based interventions, found evidence of improved outcomes across a range of measures, with Deakin *et al.* (2005) concluding that “for every five patients attending a group-based education programme we could expect one patient to reduce diabetes medication”. However, the evidence for arthritis self-management was more mixed (Nolte and Osborne, 2013; Kroon *et al.*, 2014). Nolte and Osborne (2013), who examined the efficacy of mainly arthritis-specific self-management interventions, found that while increases in patient knowledge were large, there were only marginal benefits in relation to health-related outcomes. However, they note caution in drawing conclusions because of the difficulty of measuring efficacy of self-management interventions. In their review, the included studies examined over 70 outcome measures mainly relying on patient self-report, which they point out will also differ significantly from outcomes used to measure efficacy of other condition-specific programmes, such as diabetes.

Significant heterogeneity in intervention composition, duration and frequency, as well as modes of delivery and duration, were noted across the identified studies, with no strong evidence supporting one particular approach or design. However, common strands extend across the described interventions; the majority providing people with information and strategies to help them take responsibility for managing their condition, and most including a combination of educational, behavioural and motivational components, with a smaller number adopting just one approach to address a particular symptom or outcome, for example self-monitoring of symptoms. Many were concerned with enhancing self-efficacy, using cognitive behavioural and social behavioural approaches to improve problem solving and coping such as counselling and motivational interviewing. Educational components and strategies for promoting positive behaviour change for overall health and well-being (such as physical exercise or a dietary

component) were also frequently reported, although only two included studies that examined the effects of physical activity-based self-management interventions (Cochran and Conn, 2008; Brand *et al.*, 2013). Both studies showed small positive effects in favour of the intervention over usual care, although Brand *et al.* (2013) observed no difference in effect between self-management alone and self-management with exercise.

The majority of interventions were reportedly delivered face-to-face by multidisciplinary health and social care professionals in the community, with nurses commonly involved (although reporting across the included studies varied significantly). One review examined programmes for adults with long-term conditions delivered by lay leaders (Foster *et al.* 2007); while the review demonstrated short-term improvements in self-confidence and patient perception of health, the reported improvements in pain, disability, fatigue and depression were not significant, and the programmes did not improve quality of life or healthcare utilisation.

The identified literature revealed a trend towards utilising new technologies to deliver self-management interventions, for example, use of remote self-monitoring devices, shared electronic patient records, improved communication between patients and providers, peer support groups and discussion boards, and web-based information. A significant number of the reviewed studies involved interventions that were supplemented with telephone support, with a small number being delivered entirely by phone (Small *et al.*, 2013), or using newer technologies such as telehealth or web-based applications with no face-to-face contact (El-Gayar *et al.*, 2013; Pal *et al.*, 2013). For example, Pal *et al.* (2013) examined the efficacy of computer-based self-management interventions for diabetes, reporting limited effectiveness but small benefits on glycaemic control. The study also found evidence of mobile phone-based interventions being more effective than home-based interventions, although neither was effective in reducing other health-related outcomes.

4.3.3 Digitally enhanced services

The searches returned a total of 581 hits, of which 558 were excluded at title or abstract stage. Eleven of the remaining full-text articles were removed, leaving 13 articles. The majority of identified interventions involved either remote delivery or enhancement of specialist services using mobile and information technologies, or those embedded into the home (smart home). Exceptions included Black *et al.* (2011), who examined eHealth applications for health professionals, and Ghanbarzadeh *et al.* (2014), who examined the applications of 3D virtual worlds in health delivery. Pandor *et al.* (2013) and Marcolino *et al.* (2013) both provided meta-analyses of the impact of home-based monitoring on objective clinical end points.

The identified literature corpus suggests that technology is being increasingly used to support service delivery in a wide variety of clinical contexts. Telemedical approaches provide the strongest evidence base at present, and are increasingly popular in the delivery of care for chronic conditions such as chronic obstructive pulmonary disease, diabetes and heart failure. However, evidence is also emerging on the potential of these approaches for acute care settings. Although the terminology was inconsistent between reviews, three broad approaches can be identified: (i) remote transfer of physiological data measured at home from a patient to a health professional, (ii) educational interventions delivered via a telephone or video-conferencing system, and (iii) substitution/ supplementation of face-to-face clinical consultations with video-conferencing or telephone-based consultations.

Evidence suggests the first two approaches are broadly beneficial, but outcomes for the third approach are more mixed. García-Lizana and Muñoz-Mayorga (2010) and Hilgart *et al.* (2012)

reported professional concerns about video-conferencing consultations for mental health and genetics counselling, respectively, including impact on rapport and capacity to take reliable morphometric measurements remotely. However, with respect to tele-stroke services (rapid triaging following acute stroke), the evidence suggests telemedicine can improve outcomes, including reduced times to triage appropriate treatment, and avoiding the need to transfer patients to distant, specialist neurological units (Johansson and Wild, 2010).

The benefits of telemedicine therefore appear to be context-dependent. In terms of the impact of telemedicine on 'hard' clinical outcomes, two meta-analyses provided estimates. Pandor *et al.* (2013) provided some estimates of reductions in mortality and hospitalisation among trials of remote monitoring for heart failure. Compared with control cohorts, the evidence suggested that remote monitoring approaches were associated with reductions in mortality and hospitalisation. However, the 95% credible intervals for these effects were wide, suggesting considerable uncertainty, possibly due to the heterogeneity of telemonitoring systems and telephone-based interventions. Marcolino *et al.* (2013) found improved status among diabetes patients on two key clinical markers – glycated haemoglobin and low-density lipoprotein cholesterol. The effect sizes and confidence intervals for these outcomes suggested consistent benefits although, again, the systems used in individual studies varied widely.

Three reviews of smart home technologies were identified, but the evidence base is scant. The Cochrane review by Martin *et al.* (2008) suggests that there are plausible mechanisms by which such technologies could enhance independence and quality of life, for instance by making users' homes safer, but also points to the lack of evidence on efficacy. A more recent publication (Morris *et al.*, 2013) revealed some progress. They identified one trial of smart homes conducted with older people with chronic conditions, which found significant benefits in terms of functional status relative to the control group. Privacy was a key concern with these technologies, with nine of 21 included studies reporting this to be an important consideration. In two studies, participants reported they would not have smart home cameras installed, due to worries about being watched.

One review examined the use of eHealth technologies for health professionals (Black *et al.*, 2011). Electronic data storage systems for health records and picture archiving appeared to confer some benefits, although care has to be taken to protect privacy and avoid 'paper persistence'. The evidence for e-prescribing and computerised physician order entry was mixed: although there was some evidence of improved prescribing, the systems were also seen to disrupt professional routines and increase workload.

5. The implications of existing evidence

We conducted evidence reviews as this is the foundation upon which decisions about healthcare are made. The reviews reveal mixed results and varying reports of evidence of efficacy, somewhat at odds with the aspirations expressed in envisioning reports.

The evidence strongly recommends a multi-stranded approach for increasing population physical activity. Heath *et al.* (2012) distinguish between three types of initiative to increase engagement with physical activity: (i) campaigns and information approaches, (ii) behavioural and social approaches, and (iii) environmental and policy approaches. Behavioural approaches, in other words those that motivate people to engage in physical activity, appear to be more effective than cognitive approaches, however (Conn *et al.*, 2011); this is also supported in the evidence for self-management. The existing evidence to support self-management of health and well-being remains mixed but promising trends are emerging and the knowledge base is rapidly developing (National Voices, 2014).

The proliferation of new technologies and digital applications to monitor and manage health and well-being are beginning to influence service provision, altering the very nature of interactions between patient and provider. Self-management in combination with digital technology is a powerful agent for change, negating the requirement for face-to-face contact for routine diagnosis, rehabilitation, monitoring and treatment, and offering promising solutions. In particular, technology-enhanced interventions can enable the tailoring of interventions to individual requirements, therefore helping to address barriers to engagement, which include social and psychological factors, and also factors relating to the built environment and local community (Rosso *et al.*, 2011).

Furthermore, research has yet to consider the potential unwanted effects of moving towards technology-enabled services. Nevertheless it is evident that technologies such as those embedded within smart homes will continue to be developed and mainstreamed despite the inadequate evidence base, and telemedicine is set to have a far-reaching impact on how NHS services are commissioned and evaluated. As well as providing opportunities to deliver care to people constrained by geography or infirmity, they also present challenges.

6. Discussion points

Given the nature of existing established evidence and also the ways in which services are being conceived, how can we expect services to move forward?

6.1 Agile service commissioning to meet local needs

The evidence underscores the importance of new commissioning arrangements for health and social care which take account of an increasing range of potential providers to meet population needs within a rapidly changing context. One challenge is to ensure the delivery of complex, multi-component interventions to meet long-term health maintenance and emergent needs; for example, the WHO guidance on increasing physical activity by population recommends combining physical activity with complementary interventions targeting related issues, such as smoking, alcohol consumption and stress (World Health Organization, 2010). Moreover such interventions have to be delivered in ways that do not unintentionally increase health inequalities. Questions to be addressed about commissioning include the range and type of providers required to contribute towards a dynamic and responsive healthcare landscape within any locality, how to capitalise upon plurality of, and competition between providers, and how to introduce ethical and legal safeguards to enable the new environment to flourish – including scrutiny of the internal structures of bidding organisations.

6.2 Technology as a ‘moving target’

Technology-enabled services and self-management interventions are complex interventions *par excellence*, made up of multiple, interacting, socially situated and mutually influencing components.

Computerised interventions and services such as telemonitoring systems, health apps, and e-ordering systems, are constantly evolving and newer, more sophisticated devices and interfaces are continually coming to market. Hence any such system that is evaluated in a long-term study such as a randomised controlled trial is outdated by the end of the trial, let alone by the time the results are published. This questions much of the established evidence base concerned with technology-enhanced services, and raises additional questions about the implementation and embedding of new technologies into service provision.

6.3 Need for new evaluation methods

Although the MRC has developed a helpful framework for trialling complex interventions (Craig *et al.*, 2008), evaluating new models of technology-enabled services and self-management will require researchers to draw on innovative methodologies to understand their impact, including the unintended consequences and the ways they transform what it means to be a doctor or a patient.

Evaluation methods will need to evolve in a way that is responsive to ‘moving targets’. It is unlikely that trusted sources of evidence such as guidelines produced by the National Institute for Health and Clinical Excellence will be able to respond rapidly enough to new systems and services. An accreditation system could be developed, with different levels of evidence required depending on the strength of the claims made for a particular product.

In the current drive towards self-directed services and self-management, tension often arises between logics of 'care' and 'choice' in services, both of which may be more or less appropriate in different settings and with different patients (Mol, 2008). Social science methodologies will be as important as more-formal clinical effectiveness appraisals in understanding how new health-related technologies and self-management practices transform the social context of the clinic and the home, as well as the ethical implications of such changes.

6.4 Gaps in the evidence

Although a range of successful self-management programmes were identified in this paper, the evidence to support the increasing numbers of people with a wide range of health challenges and with complex multiple co-morbidities remains limited. Identification of the best ways of promoting self-management is not helped by casual use of terms such as 'empowerment'. Indeed, self-management is a socially embedded practice affected by multiple factors such as culture, gender and the psychosocial realities of individual patients (Gomersall *et al.*, 2011). Understanding how self-management intersects with such phenomena will help identify the most productive ways in which people can be supported to be active in their own healthcare, but more evidence is required on how support can be effectively 'tailored' to meet the needs and perspectives of particular communities and individuals.

There is an ongoing requirement to evaluate new technologies and technology-enabled services, but in ways as indicated above that provide timely answers to stakeholders.

7. Broader technological transformations

Contemporaneously with developments in technology-enabled service delivery and self-management reviewed here, wider technological advances are set to profoundly change the delivery of health services and the relationships between clinicians and patients. Some of these trends include the following.

7.1 The move to open-access and publicly available research data

Driven by increased demands for accountability in public expenditure, research outputs are increasingly moving from private subscription journals to open-access models of publishing. Hence, members of the public will have increased access to data from publicly funded research, fundamentally shifting the balance of power/knowledge. In addition, peer-to-peer web-based communities, such as patientslikeme.com, enable lay members of the public to share knowledge and experiences. Patients, in other words, will gain increasing levels of expertise and in some cases, clinical professionals will play more of a supporting role in care decisions (Loder *et al.*, 2013). On the other hand, so-called 'pro-ana' websites (anorexia nervosa promoting), and the potential to spread inaccurate or misleading health information, suggests that these developments will have both positive and negative impacts. Furthermore, being part of this movement is reliant upon internet use, which in the short to medium term will lead to some sectors of society being excluded, thereby adding to existing disparities.

7.2 The rise of 'big data'

The ability to store, manage and analyse large data sets has grown exponentially in recent years. As computing hardware and software become ever-more sophisticated, we will be able to better model the clinical impact of interventions, and the natural history of different illnesses (Bates *et al.*, 2014; Heitmueller *et al.*, 2014; Raghupathi and Raghupathi, 2014). Big data is likely to be as important in the coming decades as the evidence-based medicine movement has been in recent times, and training of all healthcare professionals must reflect this.

Another important aspect of the big data revolution is the potential to capture data in innovative ways. Advances in mobile technology and home-based monitoring are already resulting in rich data that can be used to inform decision making on the part of the individual, by services and by commissioners (Chen *et al.*, 2012; Petersen and DeMuro, 2015). However, to harness the potential of this growing resource, current restrictions on accessing and utilising data within the statutory health and social care system will, with qualification, need to become less stringent.

8. Visions for the future

A timeline for delivery of health and social care envisioned by the King's Fund (2014) provides data on the changes to population demography and health and also proposes dates by which service change will have taken place; for example microchips to monitor medication compliance by 2019 and routine use of robots for health and social care by 2027 (King's Fund, 2014). Nesta are also engaged in the identification of future scenarios for healthcare delivery (Nesta, 2014).

Using the outputs from the reviews we conducted, combined with the policy push, envisioning reports and the authors' awareness of current research activity, the following are proposed.

8.1 By 2025

Health and social care will become an industry in the same way as fitness, with a mixed economy of providers. The distinctions between such services will be dependent upon the provider of services rather than being limited by current boundaries. The distinction between health and lifestyle will also be blurred.

Pervasive technology and in particular internet access will be increasingly embedded into everyday items and into the fabric of buildings (homes and publicly accessed buildings such as supermarkets, pharmacies, libraries, community centres and healthcare facilities). This technology will be freely accessed and adaptable to support lifestyle and health/social care needs as required by the individual user. Universally available internet access will be free at the point of delivery, with the costs being met through taxation.

Activity tracking will be the norm, with people using this data to make lifestyle and health decisions and also to inform business and research, with data analytics behind applications and systems increasingly used to target individual user needs and provide tailored feedback.

Routine health and social care needs will also be increasingly met through a virtual practitioner, be available to citizens 24 hours a day. The virtual practitioner interface will be available through both pervasive and mobile technologies. It will require users to routinely input their vital signs and other health parameters. Tailored self-management will be available through the interface, including motivational support if monitored parameters give cause for concern. Treatment and rehabilitation will be delivered through high-resolution video connections. Triage of health and social care needs and delivery of routine treatment and rehabilitation through this interface in the individual's home or in the community will be the norm rather than a face-to-face encounter with a health/social care practitioner. However, several sectors of society will be marginalised due to lack of access or inability to access the virtual practitioner.

Despite the increasing role of wider infrastructures and services, the predicted increase in the number of older people with three or more long-term conditions will require alternative strategies to ensure that needs are met. Due to the significant technical and environmental challenges that exist, the use of robots in the domestic home for routine care will not yet be a reality, despite considerable research investment. However, in care environments, use of appropriate robots for routine caring tasks will increasingly be made, replacing the need for human carers in some instances.

A shift in expertise from professional to patient, through greater choice and self-monitoring/tracking, with decisions about healthcare utilisation and treatment being increasingly informed by personal health data, will have significant implications for medical encounters and interactions, and require different approaches towards the training and education of health and social care professionals.

Peer-to-peer websites and group-based interventions will proliferate, with both positive and negative impacts, and bring experiential knowledge to the forefront of patient decision making, with consequent impacts upon the balance of power in the clinical consultation. This will include online communities to combat social isolation and loneliness. There will, however, be a return to face-to-face contact to combat isolation in older people, with community-based social and physical activity interventions cutting across the statutory, voluntary and private sectors.

8.2 By 2040

The majority of inanimate objects will have embedded technology, capable of supporting independence and self-management. Activity tracking using technologies within the home and community will be the norm, and this will raise significant ethical dilemmas relating to privacy, surveillance and care provision. For example, some may argue for rationing care by demanding evidence from individuals that they have taken full responsibility for their health and fitness through the results of their data collection before expensive surgery or other forms of service can be accessed. Similarly, technology such as microchips could be embedded within the human body to check compliance with fitness and treatment regimes, monitored by the virtual practitioner. Careful and ethical use of monitoring technologies could help to drive genuine patient empowerment and improved clinical practice, but could alternatively become invasive and disempowering.

A variety of robotic devices will be readily available to provide routine rehabilitation, treatment and care in care and domestic settings. Self-purchase of devices to use at home will be the norm.

Most treatment will be provided remotely – face-to-face encounters with health professionals will only be required for invasive techniques.

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