CENTRE FOR WORKFORCE INTELLIGENCE

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# The technology horizon

## Preliminary review on technologies impacting the future health and social care workforce


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# Introduction

## Background

Technology has the potential to be a key enabler in transforming the delivery of health and social care in England: meeting the challenges of managing rising demand from demographic changes, placing the patient or service user at the centre of care, and reducing costs while improving the efficiency and productivity of the workforce. The Department of Health (DH, 2012a) aims for England to be a world leader in health technology, an ambition which is supported by the opening of the London Centre of Innovation Excellence in early 2013.

However, there are uncertainties around what technologies will be developed, the pace at which they will evolve and the stage at which they will be adopted across health and social care. What is more certain is that their implementation will have significant overall implications for the health and social care workforce.

As part of our horizon scanning research, we have worked with experts to develop a list of big picture challenges facing health and social care (see www.horizonscanning.org.uk). One of the findings of our work is that there is considerable uncertainty about how the health and social care system can prepare for changes resulting from innovation and technology, and how the workforce will need to evolve to ensure the successful adoption and diffusion of new devices, techniques and procedures so that workers, patients, service users and citizens can reap the greatest benefit.

To address this, the CfWI are working with a team from the University of Manchester on a study of new and emerging technologies that are likely to impact the health and social care workforce.

## Purpose

The purpose of our research is not to predict technological developments, but to identify possible areas of change, and to consider the implications for the workforce.

The aim of this report is to stimulate thinking around the impact of future technologies on the health and social care workforce. It provides a starting point to consider factors that may influence the requirements, numbers and proportions of the future workforce, which may in turn stimulate changes in education and training, multidisciplinary working or priorities and practices.

Further research will include greater analysis of the trends and drivers identified in this report, and we will work with expert stakeholders to examine the workforce implications in more detail.

## Methodology

The research to date has been produced from an initial web-scanning exercise and documentary analysis to identify the key trends and technology areas in health and social care. This included a literature scan across 28 selected initiatives or agencies from the International Network of Agencies for Health Technology Assessment. From this research, five common themes emerged. Each theme and some related technologies are discussed in greater detail in the following sections of this report:

1. **Therapeutic technology**– technologies used in the treatment of disease and injury, including pharmacological, surgical and psychological therapies. This section discusses regenerative medicine and minimally invasive procedures.
2. **Diagnostic technology** – technologies for identifying diseases and other conditions. This section discusses nanotechnology and point-of-care diagnostics.
3. **Enabling technology** – technologies that mitigate the impact of disease or disability. This section discusses mobile technology, wearable health monitors, and assistive technologies.
4. **Preventive technology** – technologies that reduce the risk or severity of illness and injury. This section discusses genomics and gaming and education.
5. **Organisational technology** – technologies supporting alternative health and social care delivery configurations and organisational design. This section discusses integrated big data.

These briefings are presented as a high-level summary of technology trends, with some ideas of what the future may hold and some workforce considerations. The future-looking sections are expressed in the future tense in order to focus on potential developments; they are based on simple interpretation and extrapolation of trends, and are not intended to be predictions about the future.

# Therapeutic technology: regenerative medicine

## Drivers

**Stem cell research, biomaterials, bioengineering, 3D printing, research funding**

## Description

Regenerative medicine concerns the replacement or repair of human cells, tissues and organs to restore normal function. It has great potential for long-term conditions, surpassing what can already be done through drugs, devices and surgery (Alliance for Regenerative Medicine, 2013). In the future, this technology may help address the issue of donor shortages, as well as ensuring host compatibility.

Research into artificial blood is being carried out by teams from across the world, including the Scottish Centre for Regenerative Medicine, which received licence in May 2013 for human trials of synthetic blood created from stem cells (Buckland, 2013). The proof of principle for transfusion of artificial red blood cells in humans was first demonstrated in 2011 (Giarratana et al, 2011), and further developments in cell engineering are likely to lead to the mass production of infection-free red blood cells, to be used in life-saving transfusions (American Society of Hematology, 2011). This could bring an end to our reliance on volunteer blood donations, where current demand in the UK is estimated at 8000 units per day (NHS Blood and Transplant, 2013).

Progress is also being made in other areas. In the UK, some experiments in ophthalmology have used transplants of photoreceptor cells in blind animal retinas to improve vision (Barber et al, 2013). Increasingly complex organs are also being bioengineered, for example the successful transplantation of a bioengineered rat kidney (Song et al, 2013). In 2013, Organovo, a regenerative medicine company in the US, used bioprinting to produce 3D samples of human liver cells that have some of the same characteristics as a functioning liver (Xconomy, 2013). Research is under way for nearly every type of human tissue and organ, bringing together a number of scientific fields, including nanotechnology, cell transplantation, material science and bioengineering (Olson et al, 2011). This is significant as approximately 1,000 people die every year in the UK while waiting for an organ donation (NHS Blood and Transplant, 2011).

## On the horizon

While many regenerative techniques are still experimental, promising developments are being made. Regenerative medicine has the potential to revolutionise the treatment and management of long-term conditions, extending life expectancies and reducing demand for services that currently account for a significant proportion of NHS resources. As clinical trials progress, synthetic blood transfusions will begin to be adopted, initially in emergency and military operations, but becoming widespread practice. Stem cell organ transplantation will follow, and there may be early attempts at bioprinting basic tissues and organs. With advances in manipulating nanotechnology, nanorobotics will be used in the in situ regeneration of tissues. As insights from regenerative medicine become adopted in other fields, new methods will emerge, for example in cancer treatment, and in using neural stem cells to help manage neurodegenerative disorders.

## Key workforce considerations

- Widely available synthetic blood could replace the need for blood donations. This may reduce the demand for blood collection professionals and healthcare science staff working for the National Blood and Transplant Service. However, what are the impacts likely to be for phlebotomists and other professionals in blood sciences? If blood transfusion becomes a more common service, will it be a basic training requirement for healthcare professionals? Will new healthcare science roles be required for producing adequate supplies of synthetic blood, and if so, what will the training and skill requirements be?
- The increasing availability of organs is likely to increase demand for surgeons to perform transplants. What additional roles may be required to support this, for example, to take samples from the recipient, bioengineer the new organ and ensure that the organ produced is a suitable match?
- Regenerative medicine is likely to mean that people have healthier organs for longer, but what are the impacts on the mental health of the people who are living for longer as a result? Will there be increased demand for social care staff, mental health nurses and other mental health professionals?

# Therapeutic technology: minimally invasive procedures

## Drivers

**Imaging, robotics, public expectations, computing power, nanotechnology**

## Description

Minimally invasive and non-invasive procedures aim to reduce trauma, pain, hospitalisation time, recovery time and post-procedural complications. There is a growing body of evidence demonstrating the safety and efficacy of such techniques, supporting their widespread adoption and integration into mainstream care (Iribarne et al, 2011).

Progress in non-invasive therapies includes new applications of microwave, laser and ultrasound, which are increasingly being used to support the treatment of complex conditions such as cancer, obesity and scoliosis with greater flexibility and precision. Microwave ablation, for example, is an image-guided technique that uses heat from microwave energy to destroy target cells, and can be used to treat lung cancer in patients who are not suitable for traditional surgical interventions (NICE, 2013). This is particularly pertinent as approximately 75 per cent of patients are not suitable surgical candidates because of the late stage of the cancer, metastases, or co-morbidities (Dupuy & Shulman, 2010).

Minimally invasive procedures are operations generally performed through small incisions. Developments in this area have largely been through progress in fibre optics, imaging, and specialised surgical instruments, including robot-assisted surgery, such as the da Vinci Surgical System (Intuitive Surgical, 2013). Developments in these areas, along with improved laparoscopy, may mean that many more surgical procedures in the future will be performed through a single incision.

Minimally invasive treatments can also be used for neurological conditions, for example using implants to help manage treatment-resistant conditions such as Parkinson's disease. In October 2012, the journal Neurosurgery reported on the successful use of electrical stimulation using extradural electrodes placed under the skull as a safe and less invasive alternative to deep brain stimulation and surgical treatment of Parkinson's (Bentivoglio et al. 2012).

## On the horizon

Improvements to equipment and techniques mean that minimally invasive procedures will become quicker and easier. This, along with the benefits of reduced trauma and recovery time, will result in these techniques replacing traditional procedures. As the long-term benefits of minimally invasive procedures become clear, there will be greater demand from patients for such approaches. Increasingly sophisticated techniques, such as combining magnetic resonance imaging (MRI) with ultrasound, will be used to treat previously inaccessible areas. As progress is made in robotics, surgery will increasingly become computer assisted, with human guidance to begin with, but gradually guided by artificial intelligence. Nanorobotics also allow for the possibility of minimally invasive targeted surgery and drug delivery. Improvements in tactile feedback, combined with computer assistance, will enable more remote operations and remote training.

## Key workforce considerations

- Minimally invasive surgery is typically more difficult to perform and may stimulate greater interest in surgery as a speciality. However, will developments in computer-assisted practices gradually enable surgical procedures to be performed by less experienced staff such as technical assistants, gradually reducing the supply of surgeons? Or will subspecialties begin to emerge as more complex surgical techniques are increasingly refined?

- Reduced trauma and improved recovery times may reduce hospital occupation rates, freeing up workforce time and patient beds. However, will specialist facilities for some minimally invasive procedures e.g. radiosurgery, need to be developed, thereby offsetting any economic gain?

- As computer technology is increasingly applied to surgical procedures, will the concept of remote surgery emerge and be integrated into mainstream care, impacting role settings and working patterns?

# Diagnostic technology: nanotechnology

## Drivers

**Nanotechnology, commercial demand**

## Description

Nanotechnology, the science of understanding and manipulating materials on a nanometre or near-molecular scale, offers several developments that can increase the efficacy of disease diagnosis and screening. In 2013, approximately 250 nanomedicine products are being used or undergoing clinical trials worldwide (Wong, 2013). The growth of biocompatible nanotechnologies, which can identify physiological changes at a smaller scale than was previously possible, could lead to earlier and more precise diagnosis.

Versatile nanomaterials offer great potential to increase the speed and ease with which tests are performed, and can be easily integrated into existing sensing platforms (Broza & Haick, 2013). One variation uses embedded carbon nanotubes to detect the presence of universally accepted biomarkers associated with particular a disease or illness, by monitoring changes in electrical resistance. This is then used to identify blood-borne biomarkers that may be indicators of diseases such as breast cancer or HIV, and reduces the cost of a traditional laboratory-based test from 50 USD to approximately 1 USD (Leyden et al 2012). While these biosensors are still under development and are not yet commercially available, the scope exists for them to quantify multiple biomarkers in minutes.

Breath tests using nanoparticles could potentially screen populations for the presence of conditions such as cancers, chronic kidney disease and cardiovascular disorders as well as disease progression. Acting as an early indicator, these breath tests may reduce the frequency of use of traditionally costly and invasive testing, such as endoscopies, biopsies or blood tests (Xu et al, 2013). As an example, a preliminary study involving scientists from Israel and China has produced a breath test for detecting stomach cancer that has proved over 90 per cent effective in clinical trials (Xu, 2013). The test, which produces a chemical profile for the patient, traces tiny particles exuded from tumours and is successful not only at differentiating between stomach cancer and other gastric complaints, but is also able to ascertain how far the cancer has progressed. Whilst large-scale trials will be required to reinforce these findings, this simple non-invasive and cost-effective test could prove critical to improving long-term survival rates.

## On the horizon

Whilst nanomedicine is still at an early stage, it has the potential to make the diagnosis of disease across the developed and developing world affordable and more proficient, enabling treatment to be initiated sooner and with more precision, halting the development of conditions and associated complications. High-throughput techniques which read multiple biomarkers simultaneously will combine with multimodal applications encompassing nanodiagnostics and nanotherapies to create 'theranostics' as an emerging medical field (McCarthy, 2009), enabling diagnosis and therapeutic interventions to be enacted consecutively. Ingestible, tissue-embedded and, later, bloodstream sensors will emerge that can detect highly diluted molecules, enabling earlier diagnosis with greater sensitivity and testing time using minimal clinical samples (Berger, 2011).

## Key workforce considerations

- Ingestible and bloodstream sensors may facilitate real-time and continuous monitoring of patient and service user health and well-being, particularly for those who are susceptible to disease or with long-term conditions. However, what will the impact be of the myriad of data that will emerge? Will new roles in bioinformatics develop as nanotechnology evolves and demand for healthcare scientists increases?

- The emergence of 'theranostics' could revolutionise healthcare models, but what impact will this concept have on traditional training pathways? Will siloed specialist streams merge to produce expert professionals with multiple proficiencies, increasing the scope and duration of postgraduate training?

- Nanoparticle and biosensor chip technology has the potential to reduce the frequency of costly and invasive testing, but what will the scale of the impact be on the endoscopy and diagnostic surgery workforce, as well as related supporting roles? Will this workforce need to be retrained to accommodate alternative diagnostic technologies?

# Diagnostic technology: point-of-care (POC) diagnostics

## Drivers

**In-vitro diagnostics, wireless communication, mobile health, microbiology, molecular biology**

## Description

As diagnostic technology evolves, the range of low-cost, easy-to-use methods is enabling more diagnostic testing to take place away from the hospital setting and closer to the site of patient and service user care, such as in GP surgeries, pharmacies and domiciliary settings. The range of devices and clinical tests available for POC diagnostics is continuously expanding, and advances in mobile technology, nanotechnology and genomics are converging to produce self-contained, portable devices that can be operated by non-specialists. These advances are increasing the capacity of the workforce and the resource efficiency of the service. Reducing the timeframe between presenting symptoms and accessing treatment can result in more rapid and effective care, particularly for infectious diseases such as influenza, as well as fewer complications and reduced recovery time. This improves patient outcomes and minimises the costs associated with clinic visits and hospital admissions (Klepser, 2012).

Operating at the intersection of engineering, chemistry and physics, research into microfluidic or 'lab-on-a-chip' devices, which integrate multiple testing functions such as sampling, handling, preparation, mixing and detection on a microbase, has produced promising results. Scientists at an interdisciplinary research institute in Japan have developed a highly practical, self-powered microchip that is capable of detecting minute quantities of biomolecules called microRNAs (which can indicate and classify cancerous cells), from a drop of a patient's blood. The chip, which resembles an integrated circuit and can be mass-produced at low cost, holds great promise for POC application and early-stage cancer diagnosis. It does not yet meet all of the requirements for POC testing, but it is hoped further refinements to the device will improve its sensitivity and make mircoRNA markers visible to the naked eye (Arata et al. 2012). Devices such as these are paving the way for the production of simple diagnostic kits for other complex diseases that can be administered and processed by members of the workforce other than a physician or laboratory technician, reducing demand for highly trained specialists. Using this technology, researchers at the University of California have already developed a test for HIV that is six-to-twelve times faster than current methods (Stybayeva et al. 2010).

## On the horizon

POC devices and test kits will become less complex, more affordable and disposable, gradually becoming integrated into the service delivery model in resource-limited settings as well as the developed world, reducing resource constraints and enabling local healthcare workers to make rapid, evidence-based treatment decisions (American Society for Microbiology, 2012). Devices such as the 'lab-on-a-chip' will be increasingly refined to reflect the quality of lab-based tests and produce parametric measures of patients' health and well-being. Later, encouraged by the familiarity and accessibility of POC tests, patients will begin to take ownership of their own diagnosis, and domiciliary self-testing for a wide range of conditions will become widespread in a move towards a home delivery model.

## Key workforce considerations

- The substitution of laboratory-based testing with handheld biosensors operated in the primary care setting is likely to empower front-line staff such as pharmacists and practice nurses, reducing the demand for skilled physicians and laboratory technicians. In consideration of this, how will education and training evolve sufficiently to ensure that workers are properly trained in the specifics and limitations of POC diagnostics, and appropriately skilled to interpret results accurately, including concepts around sensitivity and specificity? How can the skills of displaced technicians be best utilised?

- Public health initiatives and a growing number of early interventions are likely to result in more effective care. However, how will the generalisation of POC diagnostics and the increased throughput of patients post-diagnosis be managed? Will POC diagnostics necessitate a reorganisation of international healthcare systems to enable the workforce to fully exploit the technology and reduce health inequalities on a broad scale?

# Enabling technology: mobile technology

## Drivers

**Mobile technology, consumer demand, mobile network coverage**

## Description

Mobile technology is one of the most widely available and cost-effective mechanisms through which interventions, self-care and self-management of conditions can be delivered. The concept of an 'app for everything' is rapidly becoming a reality. According to mobile market research company research2guidance (2013), the market for mobile health is moving from the trial phase towards commercialisation, accelerating towards integration with routine care services by 2017.

Monitoring user biodata (e.g. glaucoma parameters) in real time, making doctor's appointments, checking test results, providing information and delivering medication reminders are common functions of mobile apps in the global health marketplace today. Compared to a traditional appointment process, these apps can minimise the inconvenience, time and monetary cost to the patient and service user, whilst maximising the time and productivity of the workforce.

On a broader scale, the proliferation of mobile devices in developing countries can facilitate and augment the supply of health information and services to non-traditional settings. The opportunity to use mobile technology to change attitudes and behaviour towards healthcare is evidenced by a trial undertaken in South Africa using SMS-based initiative SIMpill. The programme, which used a mobile chip embedded in a prescription bottle to communicate with the patient's phone, achieved a 90 per cent success rate in ensuring medication adherence for people with tuberculosis, as opposed to a 22-60 per cent uptake without it (Saran, 2009).

Another opportunity for mobile technology to revolutionise care delivery is the creation of a common data platform or central database which will allow professionals a greater, quicker and cheaper insight into public health trends. Data analysis may, for example, lead to more effective immunisation programmes and reduce the likelihood of epidemics. It may also provide improved understanding of regional and local variance in care needs. Magpi, a surveying application supported by the United Nations Foundation, is just one example of how mobile technology is being used globally to monitor and capture real-time population health data in large and remote communities. To date, Magpi has been deployed in over 170 countries with nearly 20,000 users, generating access to previously unreachable information, and therefore enabling the skills of community workers to be tailored to local need (Datadyne, 2013).

## On the horizon

Mobile technology will become increasingly sophisticated, delivering a more personalised experience to patients and service users, and achieving greater integration into the care delivery model. By 2030, mass uptake among patients, service users and providers will instigate the transformation of service delivery models. Supported by advances in artificial intelligence, mobile apps will become the primary tool for addressing and resolving health issues remotely.

## Key workforce considerations

- Mobile technology is likely to further facilitate the transition from the 'informed' to the 'participative' public. How will the current workforce, including physicians, nurses and carers, therefore be equipped with the skills required to work in a shared partnership with patients? How will they upskill to use and interpret the information provided by apps as a natural extension to their daily activities?

- The replacement of traditional health interventions with mobile technology solutions may reduce costs and increase workforce efficiency, but will patients and service users be given a choice about whether they transfer to a mobile-based system? If not, how will variances in technology literacy be addressed? Will the health and care workforce be expected to facilitate uptake by assuming an educational role? How will we 'train the trainer'?

- Conventional training tools and techniques are likely to be gradually replaced by mobile apps, offering dynamic, blended learning platforms complete with the latest information, video lectures, testing and immediate feedback. This will increase the accessibility, relevance and reach of training, but is it likely to have a significant impact on the duration and scope of medical training?

# Enabling technology: wearable health monitors

## Drivers

**Computer processing power, alternative energies, market pressures, consumer demand**

## Description

Devices which enable users and physicians to track and monitor vital signs have become increasingly portable, shrinking in some cases to the size of a postage stamp and costing less than 0.25 USD to produce (Oregon State University, 2012). Conventional health monitoring technology, which once required patients to be tethered to obtrusive and power-consuming hospital-based machines, is increasingly being replaced by smart gadgets such as watches, bracelets, headsets, sensory clothing and chips, some of which are capable of measuring multiple markers of health and well-being. Worn on or close to the body and fitted with microsensors and actuators, these devices are capable of monitoring, processing and analysing real-time biodata on existing conditions such as cholesterol or blood glucose levels, as well as general health indicators such as heart rate, body fat percentage or sleeping habits (Bohnett, 2012). Powered by body heat, physical movement or even radio frequency signals emitted from a smartphone (Leonov, 2011), these devices ensure that personal health monitoring is becoming more routine and affordable than ever before.

The mass of data yielded from wearable devices can also typically be transmitted to a user's personal health and well-being dashboard stored on a mobile device or secure website, allowing the results to be viewed in context by the patient or service user, as well as by remote third parties such as a physician or care leader (Kolbasuk McGee, 2012). The two-way interaction facilitated by these devices and the aggregated level at which data can be monitored and presented can support early interventions by professionals who can be alerted to abnormal readings in heart rate or blood pressure, for example, by text or email alert. The same devices can also be used to instigate behavioural changes in patients or service users themselves, such as adjusting dietary intake or increasing activity levels.

By serving as an engagement tool, health monitors have profound implications for the management of long-term conditions (Sawant, 2012). Hibbard et al (2013) found that patient activation, defined as 'patients who were more knowledgeable, skilled and confident about managing their day-to-day health and healthcare' had improved outcomes and incurred up to 21 per cent less healthcare costs than those without this confidence and skill. A systematic approach from the workforce and from policy leaders, encouraging patients and service users to take an active role in their care, could take advantage of the opportunities afforded by powerful and discreet monitors.

## On the horizon

Should current trends continue, wearable health monitors will become commonplace in a range of clinical settings, including hospitals, residential care and in people's homes. More discreet or fashionably acceptable monitors will become available, and 'epidermal electronics' – devices that fuse directly with the body in the form of adhesive skin patches, temporary tattoos or implantable chips – will commonly be worn to mitigate and prevent illness and disease (Kim et al, 2011).

## Key workforce considerations

- As wearable health monitors become a popular commodity and uptake increases, how will consumers of this technology be managed in the health and social care system? Whilst wearable devices may promote self-management, mitigate complications and reduce admissions to hospital, how will primary care services be structured to respond to a potential influx of patients concerned about innocuous variations in their readings? Will demand for community-based stewardship increase? How will urgent cases be differentiated and prioritised effectively?

- The magnitude of data emerging from these devices may facilitate public health monitoring and pre-empt disease outbreaks at the population level, but how will this data be analysed? Will new centralised hubs for biodata specialists operating at the regional or national level need to be developed?

# Enabling technology: assistive technologies

## Drivers

**Shift of care closer to home, cost of production, ethical values, social acceptance, neuroscience**

## Description

Given the ageing population in the UK, real-time home assistive support will prove increasingly important in allowing people to retain their independence and quality of life as they age, by enabling them to adapt to their changing physical and cognitive states in a familiar environment and social network (Tomita et al, 2010). Assistive technologies can reduce pressure on care, health and social support services for older people by helping to address everyday living activities, and progressively monitoring personal care (Morris et al, 2012). This can help reduce costs, whilst increasing workforce availability.

One way in which people are receiving greater assistive support is through the convergence of traditional smart home technology with health and social care applications, for example, through electronic sensors that sound alarms in emergencies (Martin et al, 2009). Smart home devices have progressed from commonplace temperature monitors and stair lifts to door locks that open using fingerprint recognition and integrated infrared sensors, biosensors and smart cameras, complete with fall detection algorithms which can track daily routines and alert carers, relatives or mobile agents to any unexpected behaviour patterns (Tomita et al, 2010). Current trends indicate that assistive technologies are becoming smaller, cheaper, less obtrusive, and more mainstream (Accessible Technology Coalition, 2011). Whilst the main focus of smart home technologies is currently on the support of people with cognitive impairments such as Alzheimer's, these developments are also pertinent for people with physical disabilities, enabling greater autonomy and independence.

Neuroscientists from Brown and Stanford universities in the US have demonstrated the feasibility of mind-controlled assistance through the development of BrainGate, an advanced brain-computer interface. BrainGate aims to restore mobility and independence for people with severe disabilities by translating neural activity into control signals for assistive devices. Whilst in 2006 BrainGate could only control a cursor on a computer screen, by 2012 the technology had advanced to enable a quadriplegic woman to serve herself coffee using a robotic arm which was tethered to the body (Hochberg et al, 2012). Research to transform BrainGate into a wireless device is currently underway.

## On the horizon

Teleconferencing will be used increasingly to address health inequalities and deliver medicinal advice to patients in rural communities, as well as to connect with difficult-to-engage members of the public. Smart home technologies will evolve to allow users to detect the onset of disease, provide increased physical movement to disabled or immobile patients through the use of thought-controlled robotics, or the development of fully automated homes which use artificial intelligence or personal digital assistants to interact with their inhabitants.

## Key workforce considerations

- Biosensors, smart cameras and later brain-computer interfaces which support everyday living may lead to a greater number of people remaining in their own homes for longer, relieving pressures on health and care services, particularly residential homes for older or disabled people. However, to what extent will this necessitate a community-based mobile workforce that is confident and competent in advising and supporting patients and their carers on the use of technology? What level of health or social care expertise should they possess and how will adjustments to education and training be made to reflect this?

- The promotion of self-management and self-care through assistive technologies may support greater choice and control amongst service users, but will it also demand that monitoring initiatives develop to ensure that any early presentation of symptoms is identified and appropriate interventions are instigated? Will the rising demand for remote monitoring eventually increase or decrease workforce productivity?

# Preventive technology: genomics

## Drivers

**Genomics, personalisation, consumer demand**

## Description

Traditional healthcare, which focuses on diagnostics and treatments, is coming together with products and services centred on prevention and well-being, as a result of recent advances in genomics and proteomics (the study of the proteins that genes create or 'express') (PwC, 2009). Whilst historically the transfer of genomic discoveries into real-life applications for prevention has been slow (Johnson, 2008), the field may have far-reaching effects on the understanding and prediction of individuals and communities who are more susceptible to certain diseases such as asthma or cancer.

Developments in genomics may also result in more personalised medicine and treatment for the general population, as well as for those with congenital anomalies (Satava, 2013), and present new opportunities for diagnostics and screening. Already, genetic testing kits are commercially available for purchase over the internet. 23andMe, the world's largest private genomics company, has to date fulfilled over 180,000 consumer orders, assessing each buyer's profile for more than 200 genetic traits and health risks (23andMe, 2012). Whilst the private genomics market remains unregulated and there are concerns around overload of information which may be misleading or unreliable (Sherwell, 2013), the information obtained from appropriate applications of genomic methodologies can be used to target specific individuals or populations for screening. Results that identify the presence of universally accepted biomarkers for diabetes for example, or presymptomatic indicators of conditions such as hemochromatosis (an iron overload disorder), could be used to inform proactive and evidence-based interventions, including personalised treatment, immunisation or lifestyle and behavioural changes (Katz & Ali, 2009).

One area in which genomics could play a pivotal role is in the identification of biomarkers associated with Alzheimer's disease. This could initiate appropriate interventions such as anti-inflammatory drugs before symptoms become manifest and irreparable neurological damage is caused (Fulop et al, 2013).By delaying or preventing the progression of disease to the symptomatic stage, the broad application of genomics could ultimately improve patient outcomes and reduce the number of clinic visits and hospital admissions, freeing up beds, workforce time and critically reducing healthcare costs (Satava, 2013).

## On the horizon

As legal and ethical issues surrounding genomics (including privacy, data and security) are addressed, the applications of genomics in preventive medicine will gain greater societal acceptance. Genomic technologies will facilitate the use of genetic tests to inform both practice and policy, and guide public health research into health disparities. Genetic manipulation will become a core focus for preventive medicine, extending high-quality life beyond current upper limits with the absence of illness and chronic disease. From birth, patients will be assessed against a full continuum of risk in attracting illness and disease, using a single chip, and will be assigned a complete profile of risk factors. These genomic profiles will be added to patients' electronic health records and embedded in clinical decision tools, enabling tailored, preventive interventions to be planned, for example, personalised vaccines based on a patient's response to and metabolism of drugs.

## Key workforce considerations

- As genomic technologies become more commercially viable and legal and ethical concerns lessen, demand for preventive health screening may increase. However, how will the complexities of delivering this screening be addressed? Will multidisciplinary working increase as public health teams evolve and expand to incorporate pharmacists, healthcare scientists and dietitians? How will skill requirements for these professions change as more challenging and complex cases emerge? How will these requirements be transferred to education and training curricula in a timely way?

- The application of genomic technologies on a broad scale may increase requirements for highly skilled programmers and analysts to interpret complex data. How can we ensure this quantitative knowledge is converted into effective clinical decisions at the point of care? Will the number of genomic specialists increase markedly? Or will a solid comprehension of genomics and its implications for health and care be required across the entire medical workforce?

# Preventive technology: gaming and education

## Drivers

**Broadband connectivity, virtual technology, social networks, public health, convenience**

## Description

The anonymity, familiarity and economical nature of the internet (Cain, 2010), has facilitated open discussions on health and care. People share common experiences of conditions or services through online forums and websites such as healthtalkonline.org or social media platforms such as Facebook (Wilenius and Kurki, 2012). More recently, technology has evolved through virtual reality (VR), interactive gaming and exercise gaming to provide more realistic and immersive experiences which offer greater interaction and feedback for patients, service users and carers (Ershow et al, 2011 and Talbot, 2011). Games such as *OrderUP!*, *Escape from Diab* and *Nintendo Wii Fit*, use techniques such as self-visualisation with projective physical changes, goal setting, goal review, problem solving and feedback to encourage the self-management of chronic conditions, weight loss and healthier food choices by addressing physical, psychological and social needs and encouraging learning transfer (Thompson et al, 2010). Whilst there is currently limited empirical evidence for the impact of such games on preventive health, positive findings have emerged from trials encouraging medication adherence in children with cancer, and in the teaching of major incident triage (de Freitas and Liarokapis, 2011).

Virtual avatars are also being developed to inform and educate the public. Following the success in 2007 of a Virtual Patient Advocate (VPA) in conveying discharge information to patients with low health literacy (Bickmore, 2009), trials are under way using an avatar named Gabby to influence positive lifestyle behaviours and optimise the pre-conception health of young women from ethnic minority backgrounds (Boston University, 2013). Gabby, who can be accessed through any internet-enabled computer, aims to replicate the role of an empathetic clinician delivering personalised and culturally appropriate information through a combination of verbal and non-verbal behaviour such as gazes and hand gestures. Initial trials show promising results, with 83 per cent of health issues addressed through this process. Whilst there is a need for balance and consideration in deciding the appropriate applications of such innovative promotion, and there remains a need for a level of human support behind these interfaces, early evidence shows that such technology increases access to care, reduces geographical barriers, integrates the patient into the care process, and improves the quality, safety and experience of care (Hempstead et al, 2013).

## On the horizon

The range of technologies used to communicate and promote health and care information will expand in scale and scope, integrating further with social media and obscuring the boundary between professional and peer-led information (Crounse, 2011). Later, services will link with patients' electronic health records to track and visualise user data from gaming platforms, producing interactive, preventive health records which send personalised recommendations and alerts to patients, service users and the workforce to communicate preventive practices and to increase the probability of action (Krist et al. 2012). Eventually, broadband capabilities, serious gaming and digital services will converge to offer a multimedia platform capable of delivering on-demand information, instructions and preventive services into people's homes in an accessible and actionable fashion.

## Key workforce considerations

- Social media is likely to increase service user expectations of health and social care, as well as the demand for greater choice and involvement in decision making. Could this new era of partnership working between the workforce and the public be better supported through joint health and well-being strategies developed by cross-functional teams comprising health and care workers, community voluntary groups and local authorities?

- The partial transfer of the delivery of health and care information from the workforce to virtual avatars and gaming could provide new opportunities to connect with difficult-to-engage patients and service users, as well as freeing up workforce time and improving productivity. However, how will the population be educated to escalate critical symptoms and concerns? And what infrastructure will be in place to facilitate this? Will the potential convergence of broadband, serious gaming and digital services simply be treated as an entertainment commodity?

# Organisational technology: integrated big data

## Drivers

**Rich internet technology, paperless systems, big data, person-centred care**

## Description

Data and information, both for and about patients and service users, are crucial components of high-quality care, and the volume of information used and generated is increasing. This information is also migrating to electronic and online outlets following the Government's mandate (Department of Health, 2012b) to the NHS Commissioning Board for everyone to have online access to electronic records of their care by 2015.

There is a wealth of other information available, as people leave digital footprints through their online, mobile and other digital activities. Effective management and analysis of the available data could result in drastic organisational changes, by integrating the range of devices and applications available to create a seamless network of information, facilitating the shift towards more person-centred care. There are indications of early steps towards this: in 2012, St Helens and Knowsley Teaching Hospitals NHS Trust moved to a paperless system by transferring all patient records to an online system. This required an initial outlay of £1.2 million, but is expected to produce savings of more than £3.2 million by 2018 (Andalo, 2013). The Government announced in May 2013 a £280 million fund to be used by hospitals in replacing their paper-based systems (Department of Health, 2013a). According to the Centre for Economics and Business Research (2012), the use of big data analytics across the healthcare sector could deliver benefits of £14 billion from 2012 to 2017.

Virtualised integration of knowledge management systems, taking advantage of developments in a rich internet environment, could allow for greater clinical decision support. Work in this area is already ongoing, for example, trialling IBM's supercomputer, Watson, to provide evidence-based recommendations which support decision making in oncology (IBM, 2013).

The wealth of data available also has implications for public access to health information. Research by London South Bank University (2012) shows that health information is too complicated and is a barrier for the public, as 43 per cent of people aged between 16 and 65 are unable to effectively understand and use everyday health information. Improved presentation of data is crucial to help support the 'informed public'.

## On the horizon

Traditional separations between acute, primary, community and home settings will become more joined up as a result of integrated information management, using the internet as a platform to store and easily share information. Modern mobile and computing technology will become normal interfaces for people to interact with care services. Sophisticated data collection and analysis, using a wide range of biomarkers, combined with increasing computer processing capabilities and developments in artificial intelligence, will enable individualised evidence-based care. Sophisticated decision support tools, taking advantage of integrated big data, will begin to be introduced across care settings by 2030.

## Key workforce considerations

- As the number of systems implemented in health and care organisations expands, how will up-to-date training for professionals be maintained? Will electronic and mobile-based interaction gradually replace face-to-face discussions between workers?
- As the concept of 'big data' evolves, will it encourage greater inter-professional collaboration and learning, drawing workers from different organisations and disciplines? Will these teams operate across geographical regions, further facilitating the shift of care into the community?
- As the availability of patient and service-user-facing data grows, will new roles need to be created to interpret and visualise this data to make it readily accessible?

# Next steps

We are working with the University of Manchester to scan for technologies likely to impact the future health and social care workforce. This document provides a preliminary review of some key trends and technology areas. It outlines current emerging technologies, and gives a sense of what the future might hold.

This report is being published to provide a summary of some interesting areas of likely developments, and to promote discussion. Following engagement with stakeholders, we will further explore the trends and driving forces, understanding the possible implications for the workforce, to inform better evidence-based decision-making.

If you would like to be involved with the ongoing engagement, or the development of our work in this area, please email horizonscanning@cfwi.org.uk. For more on horizon scanning, please visit www.horizonscanning.org.uk.

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