The digital future of mental healthcare and its workforce:

a report on a mental health stakeholder engagement to inform the Topol Review

Dr Tom Foley and Dr James Woollard

NHS

THE NHS CONSTITUTION
the NHS belongs to us all

Foreword

Every day, most of us use technologies that we couldn't have dreamt of twenty years ago. We see industries reshaped by the internet. We hear of new opportunities to improve every aspect of our lives as well as unprecedented threats to our privacy.

These trends seem unlikely to be reversed or even slowed in the next twenty years. What does this future hold for mental health care?

Good mental health services are now recognised as vital to the NHS and to the health of the nation. With that in mind, the NHS Long Term Plan proposes to significantly increase mental health investment and envisages data and technology as central to transforming services. Stepping forward to 2020/21 sets out the need for continued development of the mental health workforce. We need mental health services that offer the best available care, provided by staff who can work effectively in a culture of continuous improvement. What will result when this policy alignment meets technological progress?

The Topol Review was established to explore how technology will impact on healthcare and its workforce, focusing on the impact of digital health, genomics, robotics and artificial intelligence over the next twenty years. This supplementary report explores these questions within mental health.

Drawing on the broad expertise of patients, clinicians, academics, policy makers and entrepreneurs, the report highlights the potential for emerging technologies to impact on our understanding of mental health and the care that we provide. It assesses the implications for skills and knowledge that our professionals will need.

Good information technology is already critical to good clinical care. Effective, reliable and sustainable ways to record and communicate information between patients, professionals and organisations will be a foundation for further innovation. The Global Digital Exemplar programme and the development of advanced Mental Health data collections are important early steps. The future combination of technologies such as, smartphones, sensors, genomics and artificial intelligence, will build on this foundation to achieve widespread and meaningful impact.

Mental health care will become more personalised. Assessment and intervention will be undertaken with a better understanding of the genetic, behavioural and environmental context of the individual patient. While engaging with services through digital technology will be something that patients can choose to do, it will not be optional for the mental health workforce of the future.

While spending time with patients, empathising, discussing choices and co-producing personalised care plans will continue to be central to the role of a mental health clinician, new knowledge and skills will also be required. Technology will change expectations of the mental health workforce and the way that it is trained, managed and led, for the benefit of patients. Focus will be required to ensure that the same technology is usable and has a positive impact on the wellbeing of the workforce as well as patients.

Predicting the future in fine detail is perhaps a fruitless task, but this report identifies broad trends that are already underway, which are set to transform mental health services and the workforce who deliver them.

Professor Lisa Bayliss-Pratt
Chief Nurse and Interim Regional
Director for London
Health Education England

Professor Tim Kendall
National Clinical Director
for Mental Health
NHS England

Executive summary

This report has been prepared in support of the Topol Review. The findings are based on a series of expert one-to-one interviews, five expert focus groups and purposeful literature searches conducted in summer 2018.

The overarching finding is that new technologies can transform mental healthcare over the next 20 years, but to be successful they must be accompanied by organisational transformation. Together these will have enormous workforce implications.

Key technologies that are poised to impact mental healthcare over the next 20 years include:

1. **Telemedicine (impact timescale: 1-5 years):** Improved technology and greater acceptability can overcome resistance to telemedicine for many patient-professional and professional-professional interactions. Telemedicine can improve access by reducing geographical barriers, travel costs and estates costs. It can also be more convenient for patients.

2. **Sensors/wearables (impact timescale: 2-5 years):** Affordable consumer products are already available. There is significant research showing the usefulness of various measures, such as digital biomarkers of mental states. There are also potential uses in real-time monitoring of patients, allowing the redesign of care pathways.

3. **Smartphones (impact timescale: 2-5 years):** These devices provide an affordable platform for sensors, social media, telemedicine, etc. They could allow more reliable self-reporting of symptoms and self-care. Interaction with the devices may provide useful diagnostic and monitoring information.

4. **Digital therapies (impact timescale: 1-3 years):** Digital therapies can provide standalone self-help or be blended with traditional mental health interventions or online peer support networks. Such interventions are already in use and have a significant evidence base. In the future, artificial intelligence (AI) and natural language processing (NLP)-enabled chatbots may facilitate more advanced automated or semi-automated therapeutic tools.

5. **Social media (impact timescale: 3-7 years):** Studies have shown how phenotypic information can be extracted from social media to aid the prediction and monitoring of mental health disorders.

6. **Genotyping microarrays (impact timescale: 5-10 years):** There is a limited clinical case for whole genome sequencing outside of rare neurodevelopmental disorders. However, there is a potentially transformative role for genotyping microarrays in better understanding the aetiology and classification of mental health disorders. This has already begun to yield polygenic risk scores for the development of disorders, response to treatment and likelihood of side effects in individual patients. These arrays will also provide similar results in other specialties, which have made more progress in employing them. This will result in the generation of predictive mental health data by non-mental health services.

7. **Neuroimaging (impact timescale: 7-10+ years):** Scans are expensive and have had limited success in finding structural or functional markers of mental disorders outside of neurodegenerative conditions. There have been promising developments when combining multiple scanning modalities to predict disease development and response to treatment.

8. **Electronic health records (EHRs) and patient health records (PHRs) (impact timescale: 2-5 years):** All NHS mental healthcare providers employ EHRs and many are planning electronic prescribing, but fewer have patient-accessible health records. Usability, integration and interoperability are often problematic, and data is largely uncoded. Improved EHRs can provide a platform for decision support and predictive tools. They could provide clinicians with useful data for service improvement and researchers with rich data to support trials. PHRs can also improve patient and carer engagement with mental health services, tie in other services, and provide a platform for trusted digital information and interventions.

9. **Healthcare data collections (impact timescale: 1-3 years):** National data sets should contain data on every patient treated in mental healthcare services or in the Improving Access to Psychological Therapies (IAPT) programme. Improved interfaces and visualisations can make this data more useful and accessible to policy makers, commissioners, providers, clinicians and patients. This should also drive up the quality of data submitted. Upgrading the infrastructure supporting these data sets (through NHS Digital's Data Services Platform) will provide more timely and easily linked data that can support decision support, prediction, benchmarking, health surveillance and research.

10. **Natural language processing (NLP) (impact timescale: 2-7 years):** NLP can improve clinical productivity through digital dictation. It can aid the coding of data on entry and retrospectively, making EHR data more useful (see above). NLP can also enable easier patient interactions with the care system, initially to aid administrative processes and eventually to enable limited automated treatment.

11. **Artificial intelligence (impact timescale: 3-10+ years):** AI methods will enable many of the other technologies listed here, such as making sense of data from wearables, smartphones, social media, genomics, neuroimaging, EHRs and data sets to provide decision support or prediction.

12. **Virtual reality (impact timescale: 3-5 years):** Affordable commercial products are already available. There is promising evidence in the management of phobic and psychotic disorders, and the potential to help isolated, hard-to-reach patients.

13. **Augmented reality (impact timescale: 5-10 years):** This is early stage technology in mental health with promising evidence from other industries. There is an opportunity to provide real-time feedback to patients in non-clinical environments as part of psychological therapy interventions. Potential exists for the provision of real-time feedback to clinicians.

In isolation these technologies will have a limited impact on mental health services over the years to come. In many cases, their impact will be multiplied by combining them together. If they are to have a transformative impact on the efficiency and effectiveness of services, releasing time to care while also improving the access and experience of care, then pathways and services must be reimagined around the new technical capabilities. They must also be co-designed with patients and clinicians, rather than imposed. Such a reimagining could enable a mental health system that learns from every patient who is treated, in order to improve the lives of both patients and the clinicians who care for them.

The technologies outlined above are likely to start filling some of the evidence gaps within mental health and may even challenge longstanding diagnostic classifications. This will bring the opportunity for preventative and early intervention strategies, new pharmacological targets, new forms of psychological therapies and a more personalised approach to treatment. The division between systems of direct care, research and the life sciences will become blurred.

There could be more options for self-referral and referral from primary care, with automated or semi-automated interventions able to offer more rapid access to care. Telemedicine and geographically dispersed supervision networks could support each service tier to care for more complex patients.

Some of the monitoring and assessment currently requiring in-patient stays could be conducted in the community. Community clinic space could be released by telemedicine, also reducing the burden on patients. Schools, employers, other services, families and carers could be more closely bound around the care team.

The huge unmet demand for mental health services makes it unlikely that technology will reduce the mental health workforce in the foreseeable future; however, the skills required are likely to change and staff will be focused on higher-value tasks.

The multidisciplinary team will contain new roles. There will be a need for clinicians who can interface with technical staff to ensure that products and services support care. There will also be a need for staff that can support clinicians and patients in their use of technology, as well as analytical support to make use of increasing flows of data.

While technology may provide new interventions for mental health difficulties, patients will continue to seek a human clinician who can empathise and help them to make sense of their experiences.

New technical awareness will be required across the mental health workforce; however, if technology does not become more usable, then it will not be used. Mental health professionals will require the same skill categories as today, but the content of those skills and the context in which they are applied will change in the following ways:

- Communication skills: these will need to extend to online modes.

- Personal and people development: professionalism, teaching, personalised lifelong learning, management and leadership will take on new dimensions.

- Health, safety and security: online issues, cyber security, information governance, the ethics of real-time monitoring and even the ergonomics involved with dispersed working will become more important.

- Service improvement: as services become more digitised, staff will need to gain the skills to optimise these systems.

- Clinical effectiveness: staff will need to understand the theoretical frameworks underpinning clinical assessments, investigations and interventions that utilise technology.

- Equality and diversity: digital inclusion will become central to accessing care.

Education and training will need to prepare individuals for new roles and functions. Important areas of change will include:

- selection and recruitment;

- continuing professional development (CPD);

- supervision;

- performance management.

Digital technologies have the potential to improve the working lives of mental health staff. But if they are not carefully designed, they can also lead to an increased administrative burden, increased expectation, burnout and isolation.

An analysis using the Non-adoption, Abandonment, Scale-up, Spread and Sustainability (NASSS) framework[1] highlights that several of the technologies above will have very significant information governance and ethical and regulatory implications that are likely to slow their deployment. Investment in providers will be required to create the capacity to innovate. There will also be implications for the professional identity of clinicians and a change in the expectations placed on patients and their carers. New services must be co-designed with patients and clinicians in order to minimise costly failures. Careful evaluation will be required to ensure the efficacy and cost-effectiveness of technologies.
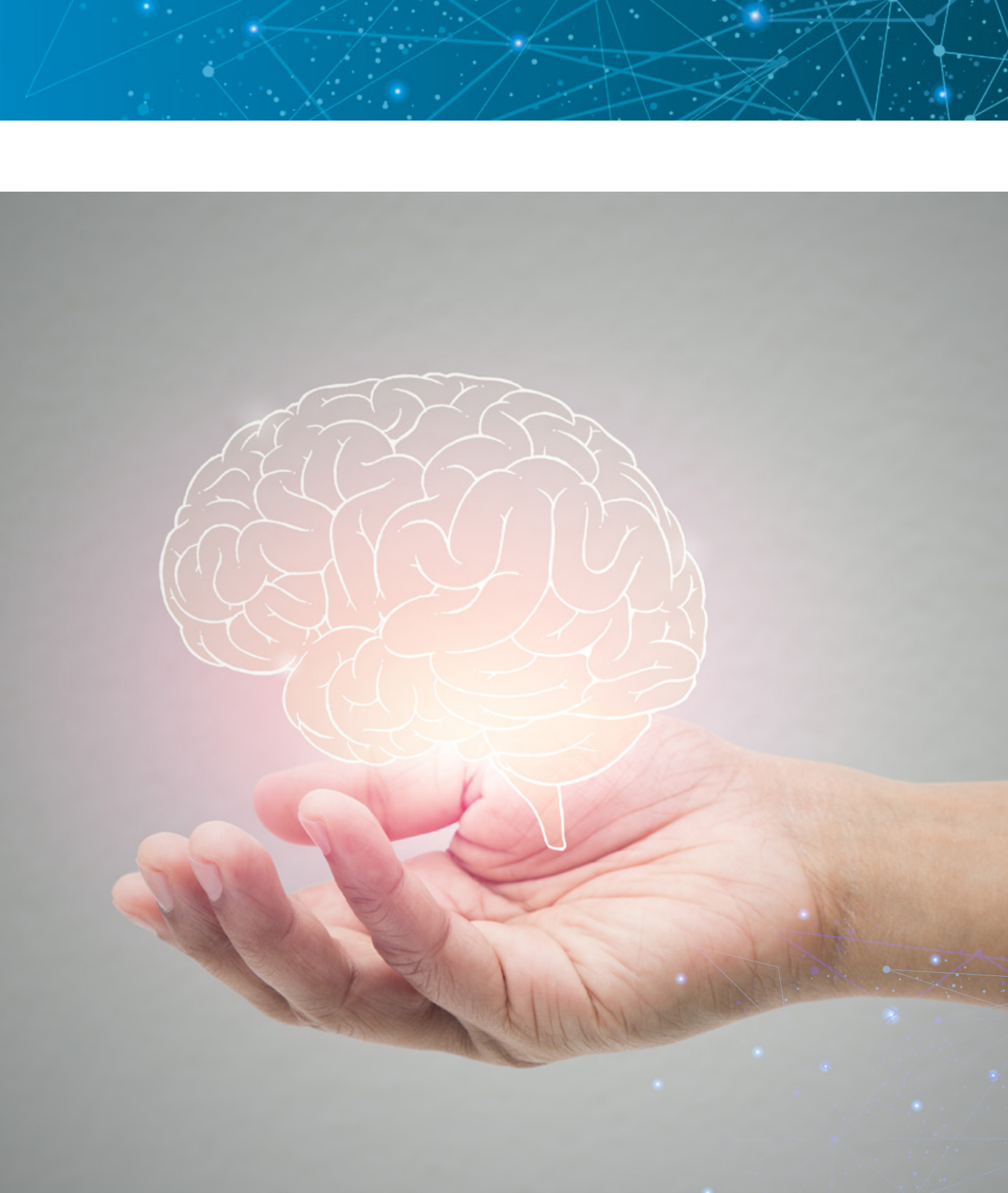
Introduction

Mental health is a complex concept with deeply interrelated biological, psychological and social determinants. Historically, mental health services have been underfunded, stigmatised and fragmented.

Mental health is now a priority in the NHS Long Term Plan.[2] Policy makers have approved increased funding to tackle prevention, access to services and the efficacy of interventions.

Services must become more integrated, with primary, community, ambulance and inpatient care working more effectively together. New community services are planned within schools, colleges and other publicly funded organisations.

There are commitments to provide 24-hour crisis care and liaison services to ensure coverage for those of all ages in acute hospitals. As well as an increased range of services, there will be a single, universal point of access for those in crisis. The NHS Long Term Plan recognises the need to expand access to mental health services for hundreds of thousands of additional people.

The mental health workforce comprises a range of professional groups, each with its own leadership, training and theoretical basis. The NHS Long Term Plan reinforces the six themes outlined in Health Education England's (HEE) Draft Workforce Strategy:[3]

- securing the supply of staff;
- enabling a flexible and adaptive workforce through investment in education and training;
- providing broad pathways for careers in the NHS;
- widening participation;
- ensuring the NHS is an inclusive, modern and model employer;
- ensuring that service, financial and workforce planning are intertwined.

Technology has been identified as critical to the future of the NHS. Digitally enabled care is to become mainstream. This means more online consultations, along with remote monitoring, smart homes, decision support, prediction, and virtual and augmented reality. More comprehensive electronic health records (EHRs) and personal health records (PHRs) and greater linkage of data promise to enable the redesign of care pathways.

Technology that once caused frustration and burnout is now expected to free staff from wasted time and irritating tasks. Systems must be designed with well-trained patients, carers and clinicians to ensure that they are usable and effective.

This report has been produced in support of the Topol Review to assess what impact technology trends are likely to have on mental healthcare and the mental health workforce over the next 20 years.

Methodology

The following methodology was developed to rapidly identify the key technologies that will impact mental healthcare and its workforce in the next five, 10 and 20 years, and to assess that impact by drawing on a wide range of subject matter experts.

1. Technology identification

Ten key technologies were under consideration by the broader Topol Review, as of 15th August 2018. Additional technologies were added to the list if identified as relevant by multiple expert participants.

2. Question formation

A set of three core questions were derived from the interim report:[4]

- How will this technology change the roles and functions of clinical staff?

- What will be the implications for the skills required by staff?

- What will this mean for the selection, education and training of staff?

A set of contextual questions were derived from the Non-adoption, Abandonment, Scale-up, Spread and Sustainability (NASSS) framework:[5]

- What conditions will be impacted (do they have comorbidities and socio-cultural complexity)?

- What technology will be required (feasibility/complexity)?

- What is the value proposition (to developer and patient)?

- What is the scale of expectations on staff, patients and carers who must adopt this?

- What effort is required from the adopting organisations and what is their current readiness to change?

- What are the wider system barriers/facilitators (political, regulatory and professional)?

3. Literature searches

Given the limited time available, purposeful searches were conducted to identify subject matter experts and to triangulate the findings of the expert consultations.

4. Expert one-to-one telephone interviews

These provided an initial overview of the genomics, digital health, artificial intelligence (AI) and robotics fields in relation to mental health. Key subject matter experts and literature were also identified. A list of interviewees is included in the acknowledgements section.

5. Focus groups

One expert focus group was held in Leeds and four in London. They covered genomics, digital health, AI and robotics in mental health. They addressed the technologies identified in (1) and were informed by the questions outlined in (2). They attempted to establish broad timescales for developments. A list of participants is included in the acknowledgements section.

6. Thematic analysis

A deductive thematic analysis attempted to triangulate findings from the literature, expert one-to-ones and focus groups.

7. Report writing

The results of the thematic analysis were compiled into a draft report.

8. Expert review

The draft report was sense-checked by a small number of subject matter experts and updated. A list of expert reviewers is included in the acknowledgements section.

Technologies in mental healthcare and how they will develop over the next 20 years

The Topol Review set out with three broad technology categories – digital medicine, AI and robotics, and genomics. These categories contained 10 more specific key technologies, by August 2018.

These key technologies were tested against the literature and expert opinion within mental health. Some were found to be less relevant to mental health, and some additional technologies were identified. The results are outlined below. For each technology, there is an estimated timescale within which they are likely to start having a significant impact on mental health services (a larger range represents more uncertainty).

Digital medicine

Current mental healthcare is largely concerned with the face-to-face interaction between a person and a professional. Within a 'digital medicine' approach this interaction can be mediated by technology and the human-computer interface becomes increasingly important.

Telemedicine (impact timescale: 1-5 years)

Telemedicine technology has been available for many years, but has not entered widespread use. Reasons have included a lack of acceptability to clinicians or patients, technical challenges and the loss of non-verbal context and cues. It is hoped that increasing familiarity with improving technology and greater integration with other systems will enable greater adoption. In mental health, certain patient groups may find telemedicine more accessible than face-to-face consultations.

See Case Study 1: Telemedicine in Oxford Emergency Department Psychiatric Service

Virtual and augmented reality (VR and AR) (impact timescale: 5-10 years)

VR and AR have attracted renewed investment in recent years and many commercial products are now available at affordable prices. VR has been used in the treatment of mental health disorders, most notably phobic disorders and paranoid psychotic states, where patients have been reluctant to engage in real-world interactions.

This technology is likely to improve considerably and become more accessible over the next 10 years. AR has potential uses in providing immediate feedback to patients and clinicians as part of a therapeutic experience.

See Case Study 2: National Institute for Health Research (NIHR) virtual reality trial

Wearables/sensors/Internet of Things/nano-technology (impact timescale: 2-5 years)

Consumer products containing sensors capable of recording location, movement, light and an increasing range of biophysical indicators are becoming more popular and affordable. There remain major issues of accuracy,[6] provenance, quality and access to raw data and information standards, all of which need to be overcome.

See Case Study 3: Sleepsight – research study using wearable and mobile technologies to study links between sleep, activity and symptom levels in psychosis

Ingestible sensor technology that can monitor concordance with medication has also been developed for use in the treatment of mental illness.[7]

Biometric sensors that can be worn on the skin are being developed to measure hormones related to stress.[8] These are in early development, with significant clinical impact likely to be at least five years away.

There is also early stage research into using nano-technology to deliver drugs directly to the brain. Medications used in the treatment of mental illness can cause significant physical side effects that often reduce patients' willingness to continue treatment. There is potential that more direct delivery mechanisms can eventually overcome some of the side effects experienced through systemic administration routes.

Smartphones (impact timescale: 2-5 years)

As smartphones become universal, they will act as a platform for other technologies, including apps, social media, telemedicine, VR and AR. They will contain more of the sensor functionality that is currently found in standalone wearables. They will become a significant channel through which to access mental healthcare and advice.[9] This will be a channel that will not be entirely controlled by recognised and regulated care providers.

Subjective reports of symptom variation over time are central to diagnosis and treatment in mental healthcare. Retrospective reporting is notoriously inaccurate and biased, while mood and other diaries are rarely completed by patients. Ecological momentary assessment (EMA) is an approach that aims to record a person's behaviour and experiences in real time in their natural environment. Smartphones offer the opportunity for regular or event-based experience sampling and recording of patient reported outcomes in keeping with EMA. Such technology exists[10,11] and continues to be developed, and is likely to be more widely used in clinical practice in the years to come.

Interaction with the phone, such as clicks, finger movements, scrolls, locks and unlocks, notifications, charges, app usage, call and SMS frequency, and calendar data, may all provide important indications of the patient's mental state. An understanding of these associations is likely to develop throughout the next 10 years.

Mental health apps/digitally delivered interventions (impact timescale: 1-3 years)

Digitally delivered interventions, including smartphone apps and internet-based therapies can be used alone, supported by a clinician or blended with other traditional mental health interventions. They guide the user through a standardised or personalised intervention based on principles of evidence-based therapies, matched to their personal goals and presenting difficulties. There is already a strong evidence base for these kinds of interventions, and some limited use in clinical practice, eg for depression and anxiety within Improving Access to Psychological Therapies (IAPT) services. Current chatbot systems are rudimentary, but in the future they could utilise AI and natural language processing (NLP, see below) to offer more advanced automated or semi-automated diagnostic or therapeutic tools.

See Case Study 4: NICE national digital IAPT trial with NHS England involving mental health apps and digitally delivered interventions

See Case Study 5: Actissist – mobile phone app for CBT in early intervention in psychosis

We have not included online peer support networks explicitly here, but these are being used as a part of service provision in some areas of mental healthcare. An established example of this is the SHaRON network run by Berkshire NHS Foundation Trust for people experiencing eating disorders Appropriate moderation is critical to these online peer networks.

Social media (impact timescale: 3-7 years)

In recent years, people have shared increasing amounts of personal data on social media platforms. While there have been concerns about the potential mental health harms of social media, it is also widely believed that the data holds important clues to an individual's mental state and can help to track changes over time. Researchers have used such data to extract phenotypic information,[12] but widespread clinical uses have yet to emerge.

Genomics and neuroimaging

In common with many other specialties, mental healthcare is likely to be heavily impacted by genomics within the next 10 to 20 years. The impact of neuroimaging is likely to be more specific to mental health; however, the technologies involved will be related to imaging in other specialties.

Neuroimaging (impact timescale: 7-10+ years)

Despite significant progress, neuroimaging has yet to deliver on the early hope that scans looking at the structure and function of the brain would prove to be diagnostic for the major mental health disorders. The most significant translation into clinical use has been for neurodegenerative disorders in which combinations of scans can be used determine subtypes of dementia. There have also been promising developments in other disorders[13] and in investigating proxies of treatment response.[14]

Costs have decreased, but infrastructure remains expensive and scans require significant clinician, technician and patient time, and do not enjoy the same economies of scale as other technologies[15]. Image analysis algorithms, across various modalities, have advanced in recent years and are now capable of producing useful insights based on large data sets.

Most progress in the next 10-15 years is likely to come from algorithms that combine the results of multiple scanning modalities (eg structural, functional and pharmacological) and from adding deep phenotyping data from health data sets, wearables and surveys. The objectives will be diagnosis, response prediction and prognosis within the framework of stratified medicine.

See Case Study 6: Studying mental health via research domain criteria, neuro-imaging and convolutional neural networks

Whole genome sequencing (impact timescale: 3-7 years)

The cost of whole genome sequencing has decreased rapidly in recent years, but remains slightly beyond what would be acceptable in routine practice. This cost includes analysing and storing the results and is likely to decrease further. The strongest application of whole genome sequencing in mental health is in identifying single mutations of high effect that are responsible for rare neurodevelopmental disorders. The diagnostic yield in psychiatry is relatively low, except in cases that also present with low IQ or physical features known to be indicative of the presence of a rare mutation.

Genotyping microarrays (impact timescale: 5-10 years)

Genotyping microarrays that yield information on ~10 million common variants are viewed as being of more clinical relevance to mental health services in the foreseeable future. Most common mental health disorders have been found to be the result of environmental factors combined with many common genetic variants. They are not usually the result of a single gene mutation. Large-scale research is ongoing to develop a better understanding of these associations.[16,17]

Relatively inexpensive microarrays can detect the presence of many variants and polygenic risk scores can be calculated for individual disorders, including common comorbid disorders such as diabetes and coronary artery disease. This approach is expected to provide information on the likely response to particular treatments, potential prognosis and on the likelihood of side effects. Results from sequencing and microarrays do not change throughout a person's life, so only need to be done once and will not be restricted to variants relevant to mental health.

Storage and processing of microarray data incurs a much lower burden than whole genome sequencing. There is already a network of labs in England capable of processing hundreds of thousands of arrays annually. Although these services are not currently easily available to mental health practitioners, it is thought that capacity could be increased to support routine clinical use within five years.

Although standards exist, there is currently no systematic platform infrastructure for sharing results between providers and embedding them within EHRs. It is hoped that the new NHS Genomic Medicine Service will address these issues.

Genome editing

Due to the polygenic nature of most common mental health disorders, it is not envisaged that genome editing will have a major role to play in the foreseeable future, except perhaps in rare monogenetic neurodevelopmental disorders.

See Case Study 7: Genetic Links to Anxiety and Depression Study (GLAD) Study

Systematic data recording, processing and sharing

Electronic health records (impact timescale: 2-5 years)

The core purpose of EHRs is to enable the recording, organising and sharing of information. All 57 NHS Mental Health Trusts in England already use EHRs. These often suffer from usability issues, and integration with other systems can be challenging. Most of the data recorded is uncoded and there is very limited interoperability, even between providers using the same systems.

Most providers do not currently employ electronic prescribing systems, but the majority plan to do so within five years. Likewise, there is an emerging trend towards allowing patients to have access to their own record. To date, they have rarely been granted the ability to write in their own record. Regional interoperability networks are emerging and are likely to be scaled up by the Local Health and Care Record Exemplars funding programme.

In the next five years, mental health EHRs will follow those in general practice and acute providers in acting as platforms for decision support and predictive systems.[18] Over the next 10 years, health service-controlled EHRs are likely to remain the dominant platforms for bringing together healthcare-related patient information. They will also become increasingly important in mental health surveillance programmes and in supporting clinical trials and observational studies.[19] It will become increasingly important for clinicians to record structured and coded data on which many 'secondary uses' depend. In the longer term, NLP may assist this process.

Healthcare data collections (impact timescale: 1-3 years)

An extensive range of data sets is collected in England.[20] These capture data about the majority of patients who use the NHS. The NHS Digital Mental Health Services Data Set[21] contains clinical and administrative data on the interactions of patients with secondary care services. The Improving Access to Psychological Therapies Data Set records similar data and clinical outcomes on almost one million people who access talking therapy each year. Similar data sets exist for physical health services and multiple data sets can be linked to show how patients interact with the entire NHS. Researchers, policy makers, commissioners, providers and individuals use this data for research and planning.[22]

The infrastructure supporting these data sets is currently being upgraded[23] and they are being organised into an enabling data architecture. It will allow a more timely flow of data with more potential uses, such as prediction, decision support, benchmarking, health surveillance and comparative effectiveness research. In the next five years it will become increasingly common to link NHS data sets with others from outside of healthcare. Increasing the use of EHRs may ease the burden of data submission, but additional steps will be required to improve data quality.[24]

Natural language processing (impact timescale: 2-7 years)

Mental health services depend on language. Patient descriptions of their own symptoms and context are likely to remain the most important source of information for the foreseeable future. Currently, such information is usually typed into EHRs by clinicians in a process that can often take longer than the interaction with the patient. NLP is likely to help in several ways.

Many providers already use digital dictation services. These will increasingly rely on NLP, rather than human typing pools. Where clinicians continue to type notes, predictive text systems will increase the speed of data entry and will enable the data to be coded on entry. In the longer term, NLP applications may be able to first transcribe conversations, then later to understand the sentiment of participants within a conversation, and eventually summarise conversations automatically.

Some existing systems are already able to retrospectively extract structured information from free text clinical notes. This is likely to increase, making vast amounts of information available for research. Improvements in accuracy are likely to open up uses for direct care.

NLP will also enable easier patient interactions with mental health services, first for administrative purposes, then to share information and, ultimately, for limited automated treatment through the advanced chatbot-type systems described above.

Machine learning (impact timescale: 3-10+ years)

Machine learning algorithms will be developed that source data from, and deliver functionality through, the technologies described above. There are already emerging use cases within the following four functional algorithm categories:[25]

Prioritisation:

- tasks in clinician workflow;
- allocation of resources, including workforce management.

Classification:

- clinical decision support for diagnosis;
- clinical decision support for intervention (including sequencing of interventions);
- outcomes evaluation.

Associations:

- phenotyping individuals;
- risk/event prediction.

Filtering:

- isolating digital biomarkers;
- speech elements identification/recognition.

Machine learning has so far had limited clinical impact. This impact is likely to grow over the next five years and to accelerate throughout the next 20 years, as algorithms and the data on which they are trained proliferate.

Robotics

Robotics is likely to have limited application in mental healthcare for the foreseeable future. Robots have been employed as therapeutic companions to help manage mood or psycho-social stress and there have been developments in robots that help maintain independence in older adults.[26] There have been limited trials using robots to manage interpersonal conflict with children.[27] The most widespread current application is within pharmacy and medicines management.[28] This is not unique to mental health care.

Over the next five to 20 years, robotics may have increasing therapeutic uses as the field advances along with developments in AI.

Combining technologies for personalised mental healthcare

The technology categories outlined above are necessarily rooted in current classifications. These distinctions are likely to break down over the next 20 years. For example, smartphones will not disappear, but they may look and function very differently. The most significant advances are likely to come from combining technologies that are currently separate. Whether or not technologies can be packaged together within individual products, the data that they produce and consume will increasingly merge together.

Data from smartphones, sensors, social media, neuroimaging and genomics will be linked with data from EHRs, as well as from health and care data sets. Variables that are predictive of diagnosis, treatment response, side effects and prognosis in mental health disorders have already been identified in each of these data sources. It is hoped that in combination they will enable significantly more powerful predictive models and, ultimately, improvements in care.

A biomarker is an objective indication of medical state observed from outside the patient, which can be measured accurately and reproducibly.[29] In mental health, digital biomarkers are indicators of mental state that can be derived through the patient's use of a digital technology. Commonly cited biomarkers cover physiology (eg heart rate), cognition (eg screen use), behavioural (eg global positioning system) and social (eg call frequency).[30] These can be gathered from smartphones and other sensors, as well as social media interactions and usage of various services.

Some digital biomarkers have been correlated with certain mental states, cognitive abilities or neurodevelopmental deficits.[31] Others remain unvalidated or disputed. The next 10 years will see a development in the evidence base for a wider range of digital biomarkers and a proliferation of low-cost technologies capable of capturing them. The scope of their applicability remains an open question and issues of potential bias, resulting from a lack of digital inclusion (eg smartphone ownership), need to be addressed.[32]

Together, the technologies outlined will have major impacts on the treatment modalities within mental health. They will enable the realisation of personalised or precision psychiatry for individual patients and will collectively amount to a Learning Mental Health System.[33]

See Case Study 8: Digital phenotyping – understanding the biological, lifestyle and environmental risks and outcomes for multimorbidity in psychiatric disorders

How mental healthcare and its workforce will change

Impact on intervention modalities over 5-20 years

Considering the impact of technology on specific care pathways is challenging, because those pathways are themselves predicated on our current understanding of mental health and care. The following section considers how technology will impact on diagnostic classifications and then on intervention modalities.

Diagnostic classifications

Psychiatric disorder classification systems, such as the International Classification of Diseases (ICD) and the Diagnostic and Statistical Manual (DSM), are currently based on symptom clusters. Technology seems likely to change our understanding of mental health. The major psychiatric disorders, like depression and schizophrenia, appear to have many different genetic and environmental causes. A new understanding of mental health/illness aided by digital phenotyping, genotyping and neuro-imaging will challenge current diagnoses and enable a more personalised approach to treatment.

There is also evidence that disturbances of the immune system may also contribute to the aetiology of mental health presentations. Technology that improves our ability to study and evaluate such disturbances may help further distinguish sub-types of clinical presentations, and will add to the personalised nature of care when used in conjunction with the other phenotyping approaches described.

Prevention

These technologies provide the opportunity for automated screening of large at-risk groups. Such approaches must meet the traditional criteria for effective screening.[34] A better understanding of how digital biomarkers correlate with mental state may provide an opportunity to rapidly feed back and adapt the non-healthcare (digital and real-world) environment to promote better mental health. This will require agreement between individuals, commercial services, employers and government organisations about what interventions are appropriate, acceptable and cost effective, and whose responsibility they are.

Other technology-enabled preventative interventions might include mass education or a platform offering care for subclinical individuals. Good Thinking is just such a platform that provides access to mental wellbeing self-help tools for the general population.[35]

Drugs

Drug development is a slow process, generally taking well over 10 years from initial discovery to marketing. It is also enormously expensive, often costing billions of pounds. There is potential for these technologies to increase the speed and reduce the cost of drug development.

Genomics and neuroimaging are expected to offer new targets for basic research and drug discovery. Healthcare data sets will make it easier to identify and recruit potential trial participants. They will also help to identify new uses for old drugs[36] through retrospective observational comparative effectiveness studies. EHRs will act as platforms for collecting trial outcome measures that might flow from smartphones, wearables, social media use or VR tasks. This will make it feasible to run more and larger trials with a broader range of outcome measures (including side effects) and more representative patients.

For existing drugs, it is hoped that these data sources will allow greater differentiation of response and side-effect rates, so that patients can have a more meaningful choice of medications in line with their preferences – precision/personalised psychiatry.

In the longer term, nano-technology may allow for drugs to be delivered directly to the brain, such that they are more effective and people experience less systemic side effects.[37]

Physical health assessment and interventions

Identification of risks based on genetic screening for physical health conditions, such as cardiovascular disease, will allow more targeted physical health monitoring for mental health patients.

Developments in physical health technology will impact on mental healthcare across all settings. Technology that can monitor vital signs from video feeds has already been trialled on inpatient mental health wards[38] and has the potential to reduce risk in challenging settings.

Current medications used in mental health treatment can have significant physical side effects that in some cases require regular investigations, such as blood level monitoring. Electrocardiograms (ECG) are also required to screen for changes to the electrical activity in the heart. In combination with better information sharing between record systems and telehealth approaches, remotely operated, mobile and wearable technology that allows faster access to physical health tests in community settings could improve the quality and safety of care.

Psychological therapies

Psychological therapies within the Improving Access to Psychological Therapies (IAPT) programme are already routinely delivered by telephone, video and text message. VR therapy is available in other settings. The IAPT Data Set allows the monitoring of outcomes for many of these modalities and provides a model for the rest of mental health services.

There is a long history of self-help manuals that deliver elements of psychological therapies in paper form. Many of these have been digitised and are becoming more complex. The addition of AI techniques and NLP is expected to produce systems that are closer to virtual therapists within the next 10 years. These have the potential to greatly increase access, but there is a question mark around the implications for the therapeutic relationship. It is thought that such systems could be adapted to be more culturally appropriate to sections of society that currently find it anxiety provoking to engage.

These technologies are also likely to augment human one-to-one therapy. Online diaries and experience sampling have already been successfully tested, and are likely to enter wider clinical use in the next five years. Wearables may also provide data that can inform therapy sessions and become part of goal setting. In the slightly longer term, such data might be used to provide immediate feedback to patients, helping them to alter behaviour in real time, although this could be unhelpful in some situations. In the next 10 years, NLP and AI systems might be capable of monitoring therapy sessions and providing real-time feedback to the therapist and/or patient. Such conversational analysis technology is already used within some call centres.

There will be new opportunities for group and family centred therapies. Technology may be able to bring fragmented or geographically dispersed groups together. In the next 10 years, NLP technology may be able to analyse general conversations within the home or work environment, then provide feedback to individuals on how they could adapt their communication styles (such as expressed emotion) to help a patient or to promote better general mental wellbeing.

Psychological therapy services are already providing digitally enabled care through internet-based cognitive behavioural therapy (CBT) programmes. The treatments for more severe mental health problems are complex, often relying on multidisciplinary teams providing medical, psychological and social interventions.

Impact on settings of care

The technologies discussed will impact all care settings. They have the potential to change the way that mental health services feel to patients and to make engagement more or less stressful.

Primary care

Most patients with mental health disorders are cared for in primary care. This will continue to be the case, although the borders between services may become blurred as technology enables better integration between services. Primary care may be able to manage more complex patients if they could access technology-mediated support and supervision from more specialist services, without handing care over through traditional referrals. Primary care practitioners will also be supported by the technologies outlined above.

See Case Study 9: Mental Health Foundation survey of GPs on using mental health apps

Hospitals

The number of inpatients in mental health services has decreased enormously in recent decades. Technology could allow some further sub-groups to be cared for in the community by enabling early intervention, better engagement and closer monitoring. For those who need to be admitted, technology can make it a more active and interactive experience.

Technology might reduce length of stays by tackling diagnostic uncertainty and identifying the most appropriate treatments earlier. Patients will have more ways to stay in touch with their community networks. Once discharged, readmissions could be reduced through a combination of improved drug delivery mechanisms, sensor platforms that allow earlier detection of side effects, and better engagement through digitally enabled peer support.

Core electronic records are well established in specialised secondary care mental health services in both community and inpatient settings, but over the next five years, additional functionalities like electronic prescribing, in combination with ubiquitous remote access to relevant systems, will allow further adaptation of clinical workflows, including an increased ability to work remotely.

Community services

Large English mental health providers commonly have over 100 buildings, most of which house community services. As more services are delivered online or through telemedicine, there will be less need for physical clinics. At the same time, large open-plan offices may become less appropriate as clinicians deliver more services from their desks. When patients do have to attend clinics, technology can be used to coordinate the experience, providing reminders to reduce non-attendance, real-time instructions on getting there by public transport or car, information about what to expect and follow-up details.

Home

Technology will allow more services to be delivered to patients in their own home. Telemedicine and virtual services will be available through familiar platforms, such as smartphones and tablets. An increasing range of sensors in the home and on the person will give remote clinicians access to data that would currently not even be available on an inpatient ward. Patients in turn will have access to their medical records and data, which they may choose to use with other online services.

Despite the increasing availability of smartphones, uptake is likely to be lowest in the hard-to-reach groups that also suffer disproportionately from mental health problems.[39]

Work and school

For many patients, work or education can be a source of structure and an aid to mental wellbeing. For others, they can be the source of problems. Technology will bring mental health services into workplaces and educational establishments. It will make it possible for patients to monitor and identify patterns in their mental state in these environments and may enable peers, managers or teachers to become part of a coordinated care network.

Online

As more services move online, human-computer interfaces will need to improve and adapt to the differing needs of patients. Some will prefer frequent, short graphical interactions, while others will seek longer reflective but less frequent sessions. Online services are sometimes believed to be suitable only for less severe or less complex conditions; however, this is unlikely to hold in future. Increasingly, patients with severe disorders that find face-to-face contact difficult will seek online or VR treatment. Current examples include severe anxiety and paranoid disorders.

Online services may also be particularly well suited to mobile populations such as students, who currently receive fragmented care when they move between home and university several times per year.

Impact on the roles, functions and skills of the mental health workforce

Given the huge unmet need that exists for mental health services, it is unlikely that technology will reduce demand for mental health professionals in the foreseeable future. The technologies outlined above and the impacts they will have on investigations, interventions and settings of care will, however, alter the skills required along with the roles and functions of staff.

Releasing time for care

Individually, the technologies above have the potential to reduce the administrative burden, allow treatment in more convenient settings, and empower patients and their carers to take on some of the tasks currently performed in the clinic. Staff at every tier could be supported to care for more complex patients. Throughout the system, time can be released for staff to provide higher value care.

If entire services and pathways are reimagined around technology that is co-designed with clinicians and patients, then significantly greater amounts of time are likely to be released. This is also likely to reduce the risk that technology will create new barriers to care for patients and an administrative burden for clinicians.

Roles and functions

Until now, technology has largely been dropped into mental health services to replace an existing part of the care or administrative process. Increasingly, pathways of care will need to be reimagined around new technological capabilities, such that some functions will be undertaken by other professionals or not at all. Some administrative roles will be automated, and low-value work, such as typing and diary management, will eventually be taken away from highly skilled staff through NLP and intelligent automation.[40]

Despite the development of increasingly advanced sensors, people will continue to be more sensitive than any sensor within mental healthcare. Technology will enable them to more easily and accurately record insights into the mental state of their patients. Effectively, the workforce may become a sensor network, initially recording text, then voice, and eventually, even the staff's physiological indicators could drive predictive algorithms to identify potential high-risk or high-cost events in inpatient or community settings.

It will also become possible for the network of carers (family, friends, school, employer and other agencies) around the patient to become more engaged and even to become part of a broader but more integrated care team. This could aid recovery and help to identify potential relapses earlier. It would involve a complex flow of information between patients, mental health services and carers that will have to be carefully managed by the clinical team in accordance with the patient's wishes.

See Case Study 10: Shared healthcare record for children with ADHD in Greenwich

The multidisciplinary team will contain new roles. There will be a need for clinicians who can interface with technical staff to ensure that products and services support care. There has already been progress at a senior level in appointing national and provider-based Chief Clinical Information Officers (CCIOs). There will increasingly be a need for such skills within individual teams. There will also be a need for staff that can support clinicians and patients in their use of technology, as well as provide analytical support to make use of increasing flows of data. These clinical technologist roles may be a similar role to pharmacists supporting other clinicians and patients with safe and effective use of medicines.

While technology may provide new interventions for mental health difficulties, patients will continue to seek a human clinician who can empathise and help them to make sense of their experiences. Emotional intelligence will therefore continue to be of central importance for clinicians in the digitally enabled mental healthcare of the future.

Knowledge and skills

Technical awareness will be required across the mental health workforce. Training curricula will need to reflect the use of emerging technology classes, just as they have previously reflected new classes of drugs and devices. The rapid evolution of some technologies will make it more practical to provide trainees with broad frameworks or principles, rather than in-depth experience of using particular products.

It is unrealistic to expect large numbers of clinicians to develop skills such as coding or IT support. If technology does not become more usable, then it will not be used. Mental health professionals will require the same skill categories as today, but the content of those skills and the context in which they are applied will change. Using two established frameworks from NHS Employers[41] and HEE,[42] the impact of technology on knowledge and skills is set out across the domains of: communication, personal and people development, health, safety and security, service improvement, quality, equality and diversity.

Over the next five, 10 and 20 years, a multi-system effort will be required to ensure that GPs have the appropriate level of literacy regarding new technological developments. They need to be able to: (1) appraise the quality of products and the evidence related to apps, and (2) signpost effectively to the right tool for the right symptoms. There is a strong case for digital mental health to be added to the mental health training curriculum for GPs.

Communication

There is broad agreement that the core of communication in mental health care is, and should remain, empathy and compassion, regardless of technological change. Managing to sustain these qualities across new digital channels will be a challenge. Staff will need to develop skills to manage this. Underpinned by a technical confidence in the systems they are using, this will be about picking up subtle changes in communication, for example, understanding extended pauses in response to a text-based interface as either a technical issue or part of the communication response.

As communication develops across new modalities, for example, through shared VR, there will be new possibilities for richer communication at a distance, utilising a broader range of senses, such as touch.

Technology that allows analysis of communication may help to support clinicians with this simultaneous breadth and paucity of communication cues. Real-time audio analysis of voice qualities, or NLP of text interaction, along with other contextual data, could mean that clinicians have access to tools that support their assessments and decisions about the nature of the interaction taking place. If this technology is developed, then staff will need to be adept at integrating the information, while sustaining the interaction. While some people (patients and clinicians) may find this more intuitive than others, clinicians will require extensive training and simulation.

Personal and people development

The Health and Care Digital Capabilities Framework[43] identifies teaching, learning and self-development as a key domain, while the Knowledge and Skills Framework[44] incorporates management and leadership more broadly.

Professionalism is important to everyone who works in healthcare. Professionalism will increasingly extend to online behaviour that could be more easily observed by patients and the public. As roles and functions evolve, so too will professional regulation.

Learning will become truly lifelong, but will become more feasible through online systems. A clinician's experience of learning will be increasingly personalised through analysis of learning habits, performance and other contextual factors.

Leadership and management of a potentially remote workforce will require new skills. Leaders and managers will be expected to understand the needs of their teams and to motivate people without regular face-to-face contact (see Performance management and Supervision sections below).

Health, safety and security

Mental health professionals are already expected to interact with a range of computerised systems and this is likely to increase over time. Ability to use these systems is key to safe and productive use. Ergonomics[45] has received much attention within office and clinic spaces, for example, in relation to repetitive strain injury. Staff will require a broader awareness of ergonomics in relation to technologies used in new and remote care settings.

In most cases, it will not be necessary to have an understanding of the detailed technical underpinnings of technology, but rather to understand its capabilities and limitations. As has been recognised in recent years, this includes sufficient knowledge and skills around cybersecurity.

Staff will need to understand and explain to patients the implications of using certain technologies for their privacy and autonomy. An understanding of capacity and informed consent will be essential within this context. An awareness and working knowledge of data regulation laws and guidance will continue to be part of this.

Real-time monitoring will give clinicians and providers more information to predict how risk is changing in real time. With this information will come the responsibility to react. This will require robust systems and staff will need skills to manage the risk and ensure that it does not result in harmful defensive practice.

Service improvement

As services become increasingly digitised, staff will need sufficient knowledge and skills surrounding the development of digital tools and platforms to actively contribute to service improvement. As services are increasingly managed remotely, there may be a greater focus on individual clinicians and teams having the skills to understand how to optimise their technology-enabled workflows through continuous improvement projects. This could be support by the machine learning-based approaches described above.

High-quality, clinically effective care

As technology changes practice, clinicians must continue to develop their evidence-based knowledge and skills. That evidence base will cover theoretical frameworks, clinical assessments, investigations and interventions.

Clinical assessment: Clinical assessments will continue to be centred on history and mental state examinations, but these will be informed by a range of additional inputs and real-time monitoring. It will be necessary for clinicians to understand and integrate these inputs.

Understanding the evidence base: This will become about more than just reading and understanding research. Clinicians will have access to large quantities of patient data and will be expected to interrogate it, perhaps with assistance, to gain insights about their practice. They will also have to help their own patients to run personal experiments, using technology, to understand what works best for them.

Understanding of pathology: An enhanced understanding of underlying pathology will become possible through technologies such as genomics and neuroimaging. It will be necessary for clinicians to understand these mechanisms, but also to have access to more detailed up-to-date knowledge.

Investigations: A range of new investigations and monitoring technologies will become available. Clinicians will need to know, and help patients choose, when each is appropriate, how to interpret the results and how to counsel patients on the implications (eg genomics) and risks. They will be assisted by decision-support technology.

Interventions: Additional pharmaceutical and psychological interventions are likely to become available and technology will help to identify when each might be more appropriate for a given patient. It will be important for clinicians to understand patient preferences and to ensure that they are integrated with decision making.

Equality and diversity

While the core tenets of equality and diversity will not change, challenges and opportunities will present in unfamiliar ways. It will become important for staff to understand how patients manage and communicate their identity through digital channels.

Digital inclusion will become more important. Individuals will have different values, beliefs, skills and confidence with technology and this should not negatively impact their access to care.
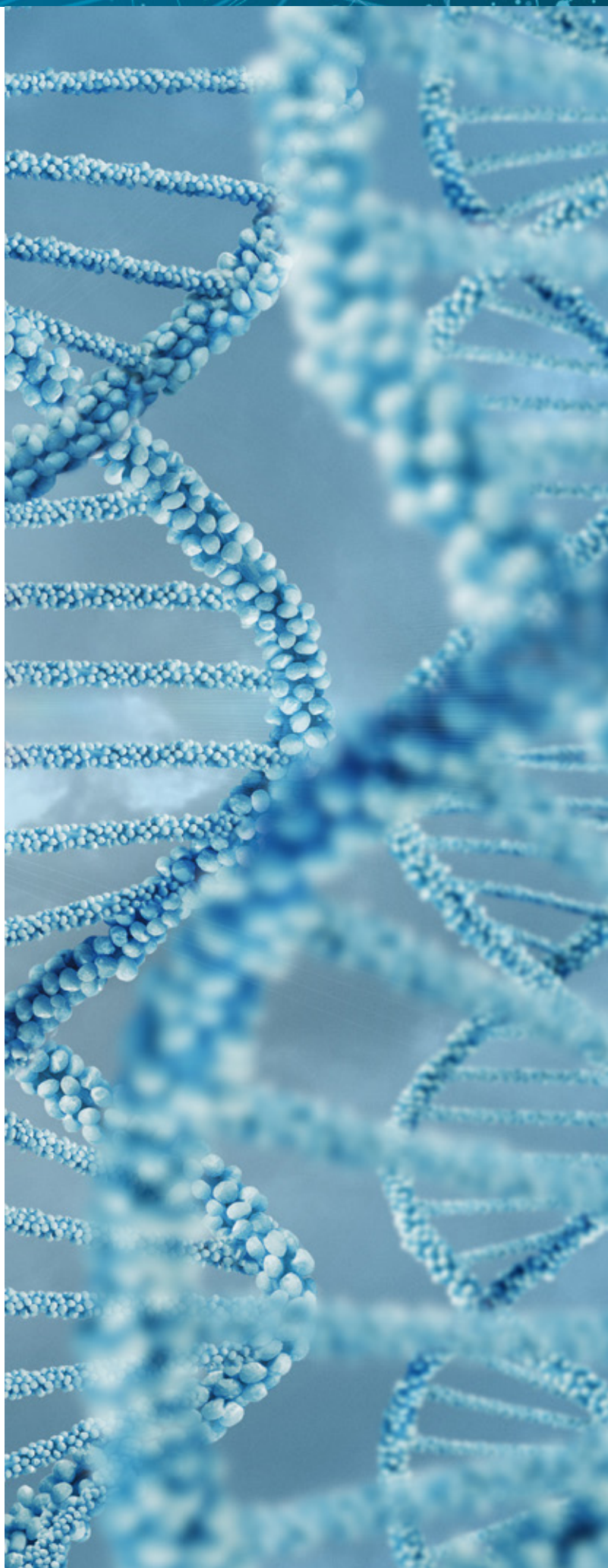
Education and training

The long time that it takes to train most mental health professionals means that staff entering clinical education in the next five years will be working in the system well beyond the 20-year timeframe considered in this report. While it is unreasonable to expect those developing education and training programmes to predict long-term product innovations, they will need to teach the skills outlined above in order to prepare individuals for the new roles and functions that are expected.

Selection and recruitment

Many of the technologies described above could also be applied to monitoring and assessing potential recruits to the mental health workforce. For legal, regulatory and ethical reasons, the use of such technologies could be restricted, but applications and assessment centres are likely to become more advanced in their use of technology. This is likely to follow general trends in recruitment practice, while selecting for the skills and knowledge outlined above.

Continuous professional development

There is currently a shortage of individuals who can teach the new clinical-digital skills that will be required. The traditional model of learning clinical skills from senior colleagues will not apply. In many cases, more junior staff will be early adopters and champions. Digital education platforms such as Massive Open Online Courses (MOOCs) offer an opportunity to scale up education and training. Rapidly evolving technologies will lend themselves to modular, just-in-time learning opportunities rather than the pre-loading of knowledge during education and training.

Supervision

The process of clinicians meeting regularly with a supervisor or peer to discuss cases and general approaches to practice has a special place in mental healthcare compared to other specialties. Supervision, at all levels of seniority, is an opportunity for learning and is generally accepted to promote safer and more effective care.

Technology will change the process of supervision. More data relating to care, including clinical outcomes and digital biomarkers, will enrich the supervision discussion. Teleconferencing and better clinical networks are likely to enable specialised supervision. For example, a clinician with a challenging case could consult a geographically distant expert in that condition.

Elements of supervision could be automated. Algorithms can be developed that monitor data relating to a patient and could make suggestions to optimise treatment. Initially, such systems would monitor compliance with guidelines, but in the longer term they could optimise treatment based on response and the evidence base. Eventually, data from EHRs, genomics, imaging, sensors and non-health data will be combined to enable personalised or precision psychiatry. This will enable clinicians to manage cases more effectively.

Performance management

Staff that deliver IAPT services are already performance managed on patient outcome measures. Increasing use of outcomes in mental health, as well as the development of more objective digital biomarkers, will enable this approach throughout mental healthcare. Clinicians may be offered targeted training to address identified weaknesses. Clinicians shown to have relative strengths in particular conditions or treatment modalities may choose or be directed to specialise. Eventually, algorithms may be able to predict which clinician will most effectively treat a given patient.

Organisational and systemic change

Executive leadership training: In keeping with the Wachter Review, senior leaders within healthcare organisations need the knowledge and skills to support effective adoption and improvement of technologies in an organisation. Appointment to executive roles should be dependent on the demonstration of these skills. Opportunities for emerging leaders, like the NHS Digital Academy, should be sustained and expanded.

Professional Bodies: Professional bodies, particularly regulatory organisations, are important in supporting clinicians' safe and effective adoption of technology. This is particularly true where decision-making is mediated through increasingly complex technology. Such bodies will need to work together to address training and set standards.

Health of the workforce

Technology can result in a negative impact on the workforce. Experience with EHRs has shown that technology can sometimes reduce productivity and lead to staff burnout.[47] The technologies discussed here could result in the liberation of the workforce or could reduce autonomy and job satisfaction. These technologies have the potential to impact the following issues under consideration by the Pearson Commission on the mental wellbeing of NHS staff and learners:[48]

- Need for interventions to support good mental health for all, rather than just focusing on those in most need. – the new services made possible by technology can improve access for staff and learners, as well as their patients.

- Isolation, lack of support and reluctance to ask for help – work is a social activity, but isolation could be exacerbated by technologies that promote geographically dispersed working and reduce face-to-face time. Measures will therefore need to be built in to reduce these issues.

- High societal expectations on staff and learners – citizens now expect to be able to access all sorts of services at the touch of a button, 24-hours-a-day. Healthcare will not escape this trend. Technology can help staff to meet this expectation, but it can also create pressure to always be at work, at least virtually. New performance management data may help to recognise success, but it may also place additional stress on staff.

- Generational differences between learners and teachers – in some cases learners may be more expert in the use of technology than more senior clinical teachers.

- Use technology to improve the learning experience – broad-based online training programmes may help to scale learning quickly across the healthcare hierarchy, but this may create an additional source of stress for some.

Technology is likely to improve the way people feel about their work if it helps them to achieve their goals more easily and to realise their vision of improving the care and experience of their patients. It is equally likely to damage morale and mental wellbeing if it makes their life more difficult or threatens their professional identity.

Non-technology, wider system and organisational developments

Many of the technologies described above are already available, but research into the adoption and spread of innovation has shown that often technology is not the rate-limiting factor.[49] Most of these issues are addressed in the overarching Topol Review, so are not addressed in detail here.

Information governance

The Data Protection Act 1998 has recently been replaced by the Data Protection Act 2018, based on the EU General Data Protection Regulation (GDPR). This legislation is likely to influence how identifiable data is used for much of the 20-year timeframe of this report. This will have implications for many of the technologies outlined above. Changing public attitudes to data sharing will represent a more fluid challenge to some technologies. An approach that engages with patients and the public, is transparent about how data is used and is clear about accountability for the results will be more likely to carry support.

Ethical framework

Issues of capacity make ethical considerations in mental healthcare particularly challenging. Some of the technologies identified above have profound implications in terms of the level of surveillance that they place on the patient. This must be weighed against the alternative restrictive options. It is not clear whether current medical ethical frameworks are sufficient or whether a new values-based approach will emerge.

Regulation

Medical device regulation is changing at an EU level, but it is unclear whether the new systems will be capable of effectively regulating emerging technologies, such as AI. The regulatory environment will evolve due to socio-political changes as well as the emergence of new technologies. It could be a crucial enabler as well as a significant barrier.

Evaluation

Randomised control trials are often impractical in evaluating emerging technologies, but there is limited agreement on alternative approaches to determining effectiveness and cost effectiveness. The vacuum is sometimes filled by spurious claims and overhyped technologies that fail to deliver for patients.

Financial constraint

The NHS is under severe financial strain and, even in comparison to other specialties, mental health has been underfunded for many years. Provider and commissioning organisations must have sufficient readiness to change in order to successfully adopt new technologies. This includes financial slack, some appetite for risk and a tolerance of failure.

Behaviour and behaviour change

Improvement in clinical practice and often improvement in a patient's mental state require a change in behaviour. The behaviour of clinicians and patients does not often change because they are told that it should change or even because they are presented with data showing why it should change. Effective behaviour change requires a theoretical framework for understanding the reasons why a behaviour exists in the first place. It then requires evidence-based interventions targeted on those reasons. Such frameworks exist[50] and must be baked into new technologies and the systems within which they are deployed.

Conclusion

This report has presented a rapid review of the technologies that might help to transform mental healthcare over the next 20 years. The findings have been based on interviews and focus groups held with a wide range of subject matter experts, and an attempt has been made to triangulate with the literature. While obvious requirements have been highlighted, a set of recommendations has not been developed.

It seems likely that technologies, for which there is currently an evidence base, will be more widely deployed in the next five years. This will allow the mental health workforce to become incrementally more effective and efficient, without a substantial challenge to their roles and functions. Over the next 5 to 10 years, as pathways of care and entire organisations are reorganised, work will be reimagined around new technological capabilities. This will involve significant disruption to the roles and functions of staff and the skills required will evolve.

Beyond 10 years, firm predictions cannot be made, but it seems likely that technologies within genomics and digital medicine will be widely and routinely used in mental healthcare. The combination of these technologies will transform our understanding of mental health and the ability of clinicians to work in partnership with patients. Together they will be better able to monitor changes in mental state and to choose the right interventions, at the right time, in the right setting. This will involve major disruption to the workforce and will require a commitment to lifelong learning.

This report has used a framework of Non-adoption, Abandonment, and Challenges to the Scale-up, Spread, and Sustainability (NASSS) of Health Technology Interventions[51] to test predictions. It has become clear that the development of technology will not be the rate-limiting factor in the transformation of mental healthcare. The complexity of mental health conditions, system incentives, organisational capacity for change, as well as political and regulatory issues will all determine progress. As has always been the case, the most important determinant will be how the mental health workforce and patients engage with the transformation, how it impacts on their roles and functions, and whether it improves their lives.

Acknowledgements

This report is primarily based on input from subject matter experts who attended our focus group events and who we interviewed. It would not have been possible without their help.

The final report was shaped by thoughtful comments from our expert reviewers.

List of event participants

Participant	Role	Organisation
Ms Alicia Ridout	Deputy Programmes Director	mHabitat
Mr Anthony Kenny	Clinical Fellow	NHS Digital
Dr Adrian James	Registrar	Royal College of Psychiatrists
Dr Amjed Hossain	Chief Clinical Information Officer	North East London NHS Foundation Trust
Dr Camillia Kong	Senior Researcher	University of Oxford
Dr Elvira Perez Vallejos	Associate Professor	University of Nottingham
Dr Hashim Reza	Chair, Informatics Committee	Royal College of Psychiatrists
Dr Jonathan Scott	Consultant Psychiatrist	West London Mental Health Trust
Dr Kate Cavanagh	Senior Lecturer	University of Sussex
Dr Laurine Hanna	Consultant Psychiatrist	Camden and Islington NHS Foundation Trust
Dr Lucia Valmaggia	Reader	King's College London
Dr Mirco Musolesi	Turing Fellow	Turing Institute
Dr Myooran Canagaratnam	Consultant Psychiatrist	Tavistock and Portman NHS Foundation Trust
Dr Nick Meyer	Academic Psychiatrist	Institute of Psychiatry, Psychology and Neuroscience
Dr Nicola Byrne	Chief Clinical Information Officer	South London and the Maudsley NHS Foundation Trust
Dr Owen Johnson	Senior Fellow	University of Leeds
Dr Pauline Whelan	Co-Director CAMHS.Digital	University of Manchester
Ms Eva Woelbert	Senior Portfolio Manager, Data Science	MQ Mental Health
Mr Ian Binns	Head of Information Analysis (Community and Mental Health)	NHS Digital
Mr Joseph Connor	NHS Innovation Associate ML & AI	NHS Digital
Mr Matthew Bennion	PhD Student	University of Sheffield
Mr Phil Hough	Board Member / Carer Consultant	NHS Confederation
Prof David Clark	Chair of Experimental Psychology	University of Oxford
Prof Wendy Burn	President	Royal College of Psychiatrists

Mr Richard Andrews	**Founder and Chairman**	Healios
Mr Richard Gurney	**Digital Exemplar Lead**	mHabitat
Mr Rob Brougham	**Managing Director**	Ieso Digital Health
Ms Tina Davies-Taylor	**Business Development**	NHS Digital
Mr Valentin Tablan	**Senior Vice President**	Ieso Digital Health

List of interviewees

Prof Andrew MacIntosh	**Chair of Biological Psychiatry**	University of Edinburgh
Dr Ben Wright	**Associate Medical Director for Clinical Information**	East London NHS Foundation Trust
Dr David Cousins	**MRC Clinician Scientist**	Newcastle University
Ms Eva Woelbert	**Senior Portfolio Manager, Data Science**	MQ Mental Health
Dr Gerome Breen	**Reader of Neuropsychiatric & Translational Genetics**	King's College London
Ms Liberty Dixon	**FORUM Policy Manager**	Academy of Medical Sciences
Ms Racheal Panizzo	**Programme Manager, Mental Health and Addiction**	Medical Research Council

List of expert reviewers

Ms Alicia Ridout	**Deputy Programmes Director**	mHabitat
Dr David Cousins	**MRC Clinician Scientist**	Newcastle University
Dr Gerome Breen	**Reader of Neuropsychiatric & Translational Genetics**	King's College London
Mr Ian Binns	**Head of Information Analysis (Community and Mental Health)**	NHS Digital
Dr John Torous	**Director, Digital Psychiatry Division**	Beth Israel Deaconess Medical Center
Dr Kate Cavanagh	**Senior Lecturer**	University of Sussex
Dr Victoria Betton	**Founder and Director**	mHabitat
Dr Jan Smeddinck	**Assistant Professor in Digital Health**	Newcastle University

Appendix

Mental health case studies

Case Study 1: Telemedicine in Oxford Emergency Department Psychiatric Service

The Emergency Department (ED) Psychiatric Service in Oxford Health NHS Foundation Trust introduced videolink-delivered assessments and follow-up appointments. The aim was to reduce waiting times in the ED so that more patients are assessed, and to increase access to the self-harm follow-up clinics. An initial evaluation showed high levels of acceptability to staff and patients.

http://positivepracticemhdirectory.org/adults/emergency-department-psychiatric-service-oxford/

Case Study 2: National Institute for Health Research (NIHR) virtual reality trial

In 2017, NIHR awarded a £4m i4i Mental Health Challenge Award to a collaboration including Oxford University, the McPin Foundation, the Royal College of Art, NIHR MindTech, Oxford VR and several Mental Health Trusts. The study involved developing and evaluating VR interventions for people experiencing psychosis. The study built on the pilot work of Professor Daniel Freeman and colleagues using VR experiences to help people manage paranoia. They used an automated avatar as a guide for users, so that the intervention could be considered automated.

The study has three stages: the first is the development of the VR interventions; the second is a multi-centre trial; and the third is the development of a roadmap for rollout.

www.nihr.ac.uk/blogs/virtual-benefits-for-the-real-world/7844

www.nihr.ac.uk/news/4-million-project-to-make-virtual-reality-treatment-available-in-nhs-mental-health-services/7852

Case Study 3: Sleepsight – research study using wearable and mobile technologies to study links between sleep, activity and symptom levels in psychosis

Sleepsight is a Medical Research Council Funded study, currently underway to look at sleep and activity patterns in people with psychosis. The study is using a wrist watch to collect activity and sleep data. Participants are being supplied with a mobile phone that they are encouraged to use as their main phone for calls and internet browsing, whilst also being asked to complete a sleep and symptom questionnaire once a day. The study is being run Dr Nick Meyer, and is a collaboration between King's College London, University of Oxford, University of Surrey, South London and Maudsley NHS Foundation Trust, and Audacious Software.

https://sleepsight.org/#

Case Study 4: NICE national digital IAPT trial with NHS England involving mental health apps and digitally delivered interventions

The National Institute for Health and Care Excellence (NICE) and NHS England are running a real-world evaluation pilot of evidence-based internet-delivered therapies for common mental health disorders. The pilot is looking specifically at internet interventions that are designed to be used by the patient in conjunction with periodic facilitation by a healthcare professional. The pilot is not looking at other forms of interventions, such as automated self-help platforms.

The interventions will be selected following an appraisal process overseen by a panel of experts hosted by NICE. The interventions will be deployed in IAPT services in England and effectiveness data collected through the established, routine IAPT data set.

It is expected that there will be sufficient evidence within two years to evaluate internet-based interventions for approval and widescale use in IAPT services.

www.nice.org.uk/about/what-we-do/our-programmes/nice-advice/iapt

Case Study 5: Actissist – mobile phone app for CBT in early intervention in psychosis

The Actissist project is developing a mobile phone app to deliver cognitive behavioural therapy (CBT)-informed strategies in early psychosis. The app was tested in an initial pilot trial in 2015/16 and the results were promising in terms of acceptability, feasibility and impact. The project has now received funding to conduct a larger-scale randomised controlled trial over thre years (until October 2020).

http://research.bmh.manchester.ac.uk/actissist/

Case Study 6: Studying mental health via research domain criteria, neuro-imaging and convolutional neural networks

This study, at the University of Berlin, represents the trend for research combining large data resources, including, Biobank, neuro-imaging, and machine learning. It aims to use convolutional neural networks, a form of machine learning, to analysis MRI brain imaging data in a novel way to explore whether there are as yet unidentified structural differences that link to presentation with mental health disorders.

https://www.ukbiobank.ac.uk/2018/04/dr-kerstin-ritter/

Case Study 7: Genetic Links to Anxiety and Depression Study (GLAD) Study

The GLAD Study, led by the National Institute of Health Research (NIHR) BioResource and researchers at King's College London, is a project set up to support studies exploring risk factors for depression and/or anxiety.

The project is currently recruiting participants aged over 16 years, who are asked to complete a series of health questionnaires and submit a saliva DNA sample for genetic testing. The aim is to create a bank of genetic and phenotyping data that allows further exploration of genetic links to anxiety and depression.

https://gladstudy.org.uk/

Case Study 8: Digital phenotyping – understanding the biological, lifestyle and environmental risks and outcomes for multimorbidity in psychiatric disorders

This study has been approved by Biobank to look at the links between experience of mental health disorders, such as depression and anxiety, and the risk of physical health conditions. The three-year study will use machine-learning approaches to look for these links.

www.ukbiobank.ac.uk/2018/08/understanding-the-biological-lifestyle-and-environmental-risks-and-outcomes-for-multimorbidity-in-psychiatric-disorders/

https://psychiatrie-psychotherapie.charite.de/en/research/neuroimaging_and_neurotechnology/machine_learning/

Case Study 9: Mental Health Foundation survey of GPs on using mental health apps

In November 2017, the Mental Health Foundation surveyed more than 1,000 GPs to assess their views on digital mentalhealth in primary care and its role in the treatment of depression. Two out of three GPs reported using at least one type of digital mental health intervention for depression in their practice and most anticipated that the use of digital mental healthtechnologies would increase in the future.

The survey also identified challenges to embedding digital mental health interventions for depression. Of the GPs surveyed, 92% indicated that neither they nor the staff in their practice had received any training in digital mental health interventions,or they were unsure if anyone had received training.

This work is available online with the current reference below:

Breedvelt, JJF, Zamperoni, V, Kessler, D, Riper, H, Kleiboer, AM, Elliott, I, Abel, KM, Gilbody, S and Bockting, CLH. (2018). Attitudes of GPs toward digital technologies for depression: an online survey in primary care. The British Journal of General Practice.

doi: https://doi.org/10.3399/bjgp18X700721

Case Study 10: Shared healthcare record for children with ADHD in Greenwich

Attention deficit hyperactivity disorder (ADHD) is one of the most common disorders in childhood and leads to difficulties in social, emotional and academic functioning. ADHD often persists into adulthood and so it is important that children, young people and their families find ways to self-manage the condition.

There is a large population of children with ADHD in Greenwich and local health services needed to explore alternative models of service delivery to meet the demand.

This project by Oxleas NHS Foundation Trust aimed to reduce unmet need in these children and their families, improve access to self-management resources, and improve communication and collaboration between families, schools and the ADHD care team.

The project involved the development of a web-based platform called Headspace Focus, which brings together children and young people, their families, the care team, schools and other professionals, in a secure online environment. It provides self-management resources, and allows the sharing of information with care teams and communication via instant messaging.

The platform was launched in December 2017 and, as of April 2018, there were 20 families and five schools signed up. There have been 300 messages exchanged, including advice around sleep and managing difficult behaviour. The platform has helped improve the timeliness of communication between the care team and families. The number of families and schools using the platform continues to grow.

References

1. www.jmir.org/2017/11/e367/

2. www.longtermplan.nhs.uk/

3. www.hee.nhs.uk/sites/default/files/documents/Facing%20the%20
Facts%2C%20Shaping%20the%20Future%20%E2%80%93%20
a%20draft%20health%20and%20care%20workforce%20
strategy%20for%20England%20to%202027.pdf

4. www.hee.nhs.uk/sites/default/files/documents/Topol%20
Review%20interim%20report_0.pdf

5. www.jmir.org/2017/11/e367/

6. Wen D, Zhang X, Liu X, Lei J: Evaluating the consistency of current
mainstream wearable devices in health monitoring: a comparison
under free-living conditions. *Journal of Medical Internet Research*
(2017) 19(3):e68.

7. www.abilifymycite.com/

8. http://advances.sciencemag.org/content/4/7/eaar2904

9. www.ncbi.nlm.nih.gov/pmc/articles/PMC5583042/

10. http://techhub.ichom.org/

11. www.nationalelfservice.net/treatment/digital-health/ecological-
momentary-interventions-smartphones-have-changed-everything-
and-heres-how-digital-mental-health-might-begin-to-catch-up/

12. https://arxiv.org/ftp/arxiv/papers/1608/1608.03282.pdf

13. www.nature.com/articles/nature21369

14. https://eprint.ncl.ac.uk/file_store/production/246054/ECD45FF3-
4BD1-4D1B-9529-D6E5901EA388.pdf

15. www.nesta.org.uk/blog/precision-precision-how-will-predictive-
analytics-change-mental-health-care/

16. https://ajp.psychiatryonline.org/doi/10.1176/appi.
ajp.2017.17030283

17. https://gladstudy.org.uk/about/

18. www.learninghealthcareproject.org/section/use-cases/decision-
support

19. www.learninghealthcareproject.org/section/use-cases/comparative-
effectiveness-research

20. https://digital.nhs.uk/data-and-information/data-insights-and-
statistics

21. https://digital.nhs.uk/data-and-information/data-insights-and-
statistics/mental-health-team

22. https://digital.nhs.uk/data-and-information/data-insights-and-
statistics/data-insights-and-statistics-overview

23. https://digital.nhs.uk/data-and-information/data-insights-and-
statistics/the-future-of-data-insights-and-statistics

24. https://digital.nhs.uk/data-and-information/data-insights-and-
statistics/data-quality-team

25. Based on classification in *Hello World: How to be Human In the
Age of the Machine,* Hannah Fry, 2018, Penguin

26. www.parorobots.com/index.asp

27. www.researchgate.net/publication/323106227_Stop_I_See_a_
Conflict_Happening_A_Robot_Mediator_for_Young_Children's_
Interpersonal_Conflict_Resolution

28. www.omnicell.co.uk/new-technology-reduces-medication-errors-
northumberland-tyne-wear-mental-health-nhs-foundation-trust-
ewan-maule-deputy-chief-pharmacist-northumberland-tyne-wear-
mental-health-nhs-foundati/

29. www.ncbi.nlm.nih.gov/pmc/articles/PMC3078627/

30. www.karger.com/Article/FullText/477382

31. www.jmir.org/2017/3/e75/

32. www.ncbi.nlm.nih.gov/pmc/articles/PMC5665386/

33. www.learninghealthcareproject.org/section/background/learning-
healthcare-system

34. https://onlinelibrary.wiley.com/doi/full/10.1002/lrh2.10025

35. www.good-thinking.uk/

36. www.ncbi.nlm.nih.gov/pubmed/23299882

37. www.ncbi.nlm.nih.gov/pubmed/23183130

38. www.oxehealth.com/news/broadmoor-secure-hospital-completes-
successful-trial-oxecam-patient-safety-monitoring-software

39. www.learninghealthcareproject.org/section/evidence/29/61/dr-
david-w-bates-interview-

40. www.learninghealthcareproject.org/section/use-cases/automation

41. NHS Employers Simplified Knowledge and Skills Framework www.
nhsemployers.org/SimplifiedKSF

42. Health and Care Digital Capabilities Framework https://hee.nhs.uk/
sites/default/files/documents/Digital%20Literacy%20Capability%20
Framework%202018.pdf

43. Health and Care Digital Capabilities Framework https://hee.nhs.uk/
sites/default/files/documents/Digital%20Literacy%20Capability%20
Framework%202018.pdf

44. NHS Employers Simplified Knowledge and Skills Framework www.
nhsemployers.org/SimplifiedKSF

45. www.ergonomics.org.uk/Public/Resources/What_is_Ergonomics_.
aspx

46. www.gov.uk/government/publications/using-information-
technology-to-improve-the-nhs

47. www.rand.org/pubs/research_reports/RR439.html

48. www.hee.nhs.uk/our-work/mental-wellbeing-review

49. www.jmir.org/2017/11/e367/

50. www.learninghealthcareproject.org/section/building-blocks/
behaviour-change

51. www.jmir.org/2017/11/e367/

Follow the ongoing work of the Topol Review

🖥 **https://topol.hee.nhs.uk/**

✉ **Topol.Review@hee.nhs.uk**

🐦 **@NHS_HealthEdEng**

f **Health Education England NHS**