

NewMind Research Roadmap

1 Overview

The NewMind Network works with the NIHR MindTech Healthcare Technology Cooperative to explore the potential for technology to transform care for individuals with mental health conditions. Focussing on four broad clinical areas – Serious Mental Illness, Mood and Affective Disorders, Dementia, and Developmental Disorders – it has brought together researchers, healthcare professionals, service users (patients), mental health charities, and industry to co-develop plausible scenarios for technology intervention and identify the research challenges they pose.

This roadmap is one of the outputs of that process – refined over a series of multidisciplinary workshops, but still a work in progress. There are three components: a *Health Outcomes Framework* that provides a structured approach to describing the purposes of intervention; a summary of *EPS Research Challenges* that identifies key advances that will be necessary to deliver a transformation in mental health care; and an outline *Ethical and Responsible Innovation Framework* that sets out core principles which should guide researchers working in this field.

2 Health Outcomes Framework

When considering technologies for mental health, it is helpful to work with scenarios – concrete examples of proposed interventions that bring to life the opportunities and challenges. It is equally important in such exercises to be clear what health outcomes are intended. NewMind has collected and analysed a large number of proposed scenarios, and asked what they seek to achieve. Despite their diversity, we were able to identify a relatively small number of distinct target outcomes that provide a useful framework for thinking about the purposes of interventions – identifying common needs and the technologies required to address them.

The framework considers three broad outcome themes: empowering the individual to take control of their condition and work with others to address it; targeting interventions more intelligently – providing support at the point of need; and helping individuals to live more fulfilling lives. A common thread is making effective use of continuously acquired information to provide timely and personalised support.

2.1 Taking Control

Currently care for individuals with mental health conditions is delivered primarily in the community via intermittent contacts with health and social care services and professionals. This approach is relatively ineffective, resulting in avoidable crises that are damaging to the individual and expensive for society. Technology has the potential to enable a more collaborative, responsive model of care, empowering individuals to manage their own conditions whilst helping them feel safe and supported, leading to a better experience for the individual and fewer calls on expensive emergency services.

Empowering self-management. Giving individuals the tools to help them manage their own condition effectively, assisting them to develop appropriate targets and monitor progress, and providing real-time personalised support relevant to their own experience.

Enabling collaborative care. Supporting a collaborative model of care, where the individual, their family and friends, healthcare professionals and service providers work together in a more joined-up way to maximise support whilst minimising intrusion.

Developing self-awareness of triggers. Helping individuals to understand the external factors or patterns of behaviour that lead to acute episodes or general worsening of their condition, so they can be addressed or avoided.

Managing medication effectively. Helping individuals (in collaboration with healthcare professionals) to keep track of their medication, the impact it has on their condition any side-effects, to improve adherence whilst allowing for more agile adjustment of treatment.

Jim suffers from COPD and depression. During exacerbations of his respiratory condition he has to go to A&E because of difficulty breathing. He also experiences panic attacks which make him breathless. Because it is difficult for him to tell the difference, he often makes unnecessary visits to A&E. He has decided to use a wristwatch which monitors his activity, a range of vital signs and medication adherence, all in real time. When he has an attack of breathlessness, using an app on his phone, he can check whether the data suggest he needs to go to A&E. Longitudinal data from his COPD and mood disorder are also analysed automatically to detect any trends or interactions. This information is used to provide Jim with feedback on what is happening to him, and suggestions for lifestyle changes he might consider. This information is shared with his wife and his mental health nurse, so they can provide support if necessary.

2.2 Smarter Intervention

The current model of mental health care in the community is based on intermittent assessment of the needs of the individual, leading to the prescription of standard interventions. Decisions are typically based on intrinsically unreliable self-reporting, and there is little opportunity to tailor treatments to the individual. Technology has the potential to enable more agile, personalised support, providing the right intervention at the right time and allowing new approaches to therapy.

Early diagnosis and stratification. Detecting mental health conditions as early as possible and recognising subgroups with distinct patterns of disease and response to treatment, enabling timely and effective intervention.

Providing early warning of deterioration. Detecting changes in function and behaviour that provide early warning of deterioration, allowing timely intervention to prevent emergency hospitalisation and irreversible decline.

Altering mood, deploying coping strategies. Responding in real time to challenges facing the individual, providing mood-altering behavioural therapies at the point of need, and supporting them in deploying appropriate coping strategies.

Managing sensory experience. Mediating the audio-visual environment experienced by the individual to reduce sensory overload and avoid triggering acute episodes of confusion or apparently irrational behaviour.

Carole suffers from a mood disorder that is often debilitating. She uses a smartphone app that samples her mood regularly via a short questionnaire and captures information on her physical activity and on her use and the content of voice calls and texts. This information is mined to infer her mental state in real time and this is used by the app to augment her health record, trigger CBT coaching at the point of need, and trigger a call from the mental health nurse if her condition appears to be deteriorating.

2.3 Living Better

The current model of care tends to focus on avoiding the immediate negative consequences of mental health conditions. A more difficult challenge is to tackle the life-limiting effects on sufferers such as loss of independence, social isolation and limited horizons. Technology has the potential to move beyond prevention and treatment to support individuals with mental health conditions in living more fulfilling lives and realising their aspirations.

Living independently. Supporting individuals with mental health conditions in living independently, helping them set realistic targets, assisting them with everyday tasks, and building their confidence whilst keeping them connected.

Reducing isolation. Supporting individuals by providing e-friends and/or helping them to maintain supportive relationships with family, friends and colleagues by providing personalised coaching, and supporting the development and maintenance of social networks.

Supporting challenging activities. Supporting individuals in being more ambitious, by providing them with the tools to assist them in developing more aspirational goals, helping them to break big challenges into small tasks and encouraging a positive approach to risk-taking.

Supporting social interaction. Providing real-time support for effective communication in social situations, explaining the attitudes and intentions of others, identifying potential misunderstandings, and providing tools to help in expressing feelings.

Jean is beginning to show symptoms of cognitive impairment, but wants to live independently for as long as possible. She invests in an electronic personal assistant that she can train to look after her in the way that she wants, before her condition deteriorates. The assistant senses her environment and is able to make informed decisions influenced by how Jean would have acted in various situations acting for her and/or providing prompts as her cognitive ability begins to decline.

Ben has Asperger's Syndrome. He has a wearable device that helps him interact with other people more effectively by inferring their emotional state and intentions in real time, and helping Ben understand them: e.g. "Michael is very busy today so that is why he is frowning."

3 EPS Research Challenges

Driven by our work on scenarios and the Health Outcomes Framework, we have identified key engineering and physical science research challenges that need to be addressed if the full potential of technology to transform the management and treatment of mental health conditions is to be realised. We have considered four broad areas: *Sensing Systems*, *Information Management*, *Data Analytics*, and *Human-centric Systems*.

3.1 Sensing Systems

Sensing systems are fundamental to many technology interventions in mental health. Combinations of mobile devices and wearable, home and environmental sensors have the potential to provide a real-time (or near real-time) picture of what is happening to an individual, enabling a more personalised and responsive approach to care. Specific research challenges include, but are not limited to, the following.

Sensing emotional state and stress. Novel sensors and sensing strategies to infer emotional state and measure stress in real time.

Robust, low-cost sensors. Sensor technologies that are cheap to manufacture and provide reliable measurements over extended periods in real-world conditions.

Sensor platform architectures. Architectures to seamlessly capture, link and upload sensor data from a range of sensing devices.

Intelligent local processing. Algorithms to create compact representations of sensed data close to the point of capture, to minimise transmission power/bandwidth and enhance privacy.

Energy harvesting and power management. Technologies for harvesting energy and for very low power sensing systems, allowing low-maintenance deployment.

Adaptive sampling. Adapting sampling rates, including prompts for user input, based on intelligent assessment of risk and need for additional information.

3.2 Information Management

The use of ubiquitous high-bandwidth data sources and the potential to add value by linking diverse sources of information create important opportunities to enhance care for mental health conditions, but pose significant problems for effective information management. Specific research challenges include, but are not limited to, the following.

Capturing and representing context. Building rich descriptions of context, allowing context-sensitive interpretation of data and user feedback.

Managing provenance, relevance and uncertainty. Keeping track of the reliability, relevance and uncertainty of data and derived information.

Managing trust when linking and sharing data. Methods for supporting trustworthy linking, sharing and repurposing of data.

Compression and indexing of longitudinal data. Creating compact, searchable representations of complex longitudinal data for inclusion in health records.

Scalable, adaptable information architectures. Information architectures that can accommodate new and dynamically changing sources of data and scale to very large populations.

Integrating new data sources with health records. Managing and dynamically linking data from a variety of unconventional sources to augment an individual's health record.

3.3 Data Analytics

Collecting large quantities of linked real-time data will provide the foundations for new models of care, but needs to be complemented by methods for making sense of data: recognising patterns, exploiting context, and building predictive models. Specific research challenges include, but are not limited to, the following.

Inferring emotion and intent from faces, speech and text. Combining data from multiple sources to make nuanced inferences of emotional state and intention.

Reliable predictions from unreliable data. Exploiting redundancy to make reliable predictions from data that will typically be noisy, incomplete and partially corrupted.

Predictive models from complex temporal data. Building predictive models from high-dimensional temporal data that displays structure over a broad range of time-scales.

Understanding behaviour using sensed data. Creating rich but compact descriptions of behaviour from sensed data as input to predictive models.

Understanding and exploiting context. Creating rich but compact descriptions of context from sensed and related data/metadata as input to predictive models.

Combining personal & population models. Using population models to 'strengthen' the predictions of personal models, particularly when novel situations are encountered.

3.4 Human-centric Systems

Effective technology interventions will need to fit into everyday life for individuals, and into routine workflows for healthcare professionals. This requires Intelligent user interfaces for service users, informal carers, and healthcare professionals, to support interaction, collaboration and sharing of relevant information. Specific research challenges include, but are not limited to, the following.

Intelligent personal(ised) health advisor. Avatars that understand the history, needs and context of the individual and can provide supportive, personalised advice.

Filtering information for relevance. Avoiding information overload by selecting that which is most relevant to the user (individual, carer, healthcare professional) in a given context.

Decision support for self-care and professionals. Tools to help users (individuals, carers, healthcare professionals) make effective self-care and managed care decisions.

Feedback to influence mental state. Hardware and software to provide personalised feedback designed to influence mood, perception etc.

User-adaptive interfaces. Human-computer interfaces that adapt to the context, needs, knowledge and experience of their users.

Understandable user control of consent. Intuitive user interfaces that allow users to modify their data-sharing consent dynamically, depending on context, competence etc.

4 Ethical and Responsible Innovation Framework

With input from service users and mental health charities we have begun to develop an Ethical and Responsible Innovation Framework for research in technologies for mental health. This is currently less developed than the other elements of the roadmap, but we are keen to prompt debate and receive feedback. The issues we have identified so far, and which should inform researchers are as follows.

Privacy and confidentiality. There are clear issues of privacy and confidentiality for service users and their carers in collecting, sharing and linking real-time data. These need to be addressed.

Co-development. Service users and their carers should be involved directly in developing technology interventions, to ensure that they meet real needs and are acceptable to users.

Choice and personalisation. Service users believe that technology interventions should be offered as a choice, not a prescribed solution, and see this as an issue of personal liberty. They also emphasise the need to be able to personalise interventions to meet their own needs, and to alter their choices over time.

Empowerment and control. Service users see a role for technology in empowering them to take more control, shifting the balance in the doctor-patient relationship. They also see a risk that it could be used to impose boundaries rather than removing them.

Impact on relationships. Service users are concerned that technology interventions might impact on human relationships, substituting for personal interaction and reducing tolerance of diversity.

Fair access and support. Service users are concerned that a market-driven approach to mental health technology might raise issues of affordability and support, leading to increasing health inequalities.