EPSRC Health Technologies Strategy

Convened and facilitated by

UKRI Engineering and Physical Sciences Research Council

Co-chaired by

Healthcare technologies team

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Contents

CONTEXT

EPSRC has published a Strategic Delivery Plan which sets out our strategy, priorities and what we will deliver between 2022 – 2025. This Delivery Plan is structured around UKRI's six strategic objectives.

EPSRC has eight cross cutting priorities, which have been developed to deliver against the UKRI strategy, support research and innovation and address government priorities. These priorities aim to provide a balance across our portfolio, between discovery research, mission-inspired research, and an effective ecosystem to underpin them. Our new health technologies strategy links to many of our priorities for example Net Zero, but specifically aligns to our priority around Transforming Health and Healthcare.

Research delivered through the Health Technologies theme aims to address the priorities we have identified in consultation with our community and will also contribute to the UKRI strategic themes, Ageing and Wellbeing and Tackling Infections. EPSRC will work in partnership with other funders to support collaborative working across communities and deliver the EPSRC contribution to the wider health agenda.

Engineering and physical sciences and our future health

Engineering and physical sciences research can have a huge impact on health, healthcare, and wellbeing, and is critical to successfully tackling many challenges faced by the health service as stated in the NHS Long Term Plan:

As medicine advances, health needs change and society develops, the NHS has to continually move forward so in 10 years' time we have a service fit for the future.

The widely acknowledged challenges of delivering future health services for an ageing society and supporting people to live healthy lives, requires more effective prevention or delay to the onset of illness, improved treatments and more effective interventions for individuals and populations. A future health system also needs to be sustainable and provide support more equitably across society.

Engineering and physical sciences research can play a key role in ensuring health service delivery is suitable for the future. As the COVID-19 Pandemic demonstrated, the engineering and physical sciences community contribute analytical, system thinking and multidisciplinary approaches to solving the challenges faced by the healthcare system, and the rapid implementation of new solutions at scale. With limited skills and resources available, and a growing number of people living with complex health needs, engineering and physical sciences has huge potential to improve efficiency and quality of delivery of future healthcare, including enabling increased automation across the system without compromising patient care, freeing up resources for more bespoke interventions.

Engineering and physical sciences research is also key to the development of new technology including biopharmaceuticals, medical technology, genomics, diagnostics, and digital health technologies and hence a wide range of products including therapeutics, medical technologies, diagnostic devices, and digital tools, as well as products for consumer health. The engineering and physical sciences are therefore critical for the UK life sciences industry (one of the dominant economic and major growth sectors in the UK).

Engineering and physical sciences research can make a significant contribution to the priorities identified in the NHS Long Term Plan such as ageing well, digital transformation and delivering personalised care as well as helping provide new treatments for acute and chronic conditions and enabling the more effective management of multiple, complex long-term conditions. Furthermore, EPSRC supported research can have an important role in the prevention of disease from preparing for pandemics and slowing the spread of infectious diseases to diagnosing diseases such as cancer at a much earlier stage.

Engineering and physical sciences research can create solutions and treatments from the personalised up to the large-scale population level interventions to benefit people's health.

Context

Working with our community, we have refreshed our strategy for health technologies. This refresh provides an ambitious plan for how the engineering and physical sciences will enable a healthy society, building on UK long-standing strengths and unique capabilities in health technologies and develop new creative approaches to realise the potential of new and emerging technologies, for example in neurotechnologies, artificial intelligence, precision medicine and quantum technologies.

Our strategy recognises that we need to achieve a balance between responding to current health priorities and helping to open up possibilities to transform our future health. It stresses the importance of working in partnership and enabling our researchers to tackle complex, and in many cases, global challenges with a focus on translating our research from the laboratory to the real world.

Breakthroughs arising from past research include:

DNA sequencing technology

In 1953 James Watson and Francis Crick published the structure of the DNA-helix. Their discovery was the result of a combination of experimental (x-ray crystallography) and theoretical approaches. We can now sequence the entire human genome and the opportunities this offers include genotyping of specific viruses to direct appropriate treatment; identification of oncogenes and mutations linked to different forms of cancer; the design of medication and more accurate prediction of their effects.

Biomaterials

Another breakthrough in the engineering and physical sciences has been scientific advances in biomaterials which are used every day in dental applications, surgery, and drug delivery. They are the combined product of medicine, biology, chemistry, tissue engineering and materials science.

Joseph Thrush, PhD Student, and John Clarke, DPhil Student, work at the Rosalind Franklin Institute, Harwell Campus, 21 February 2023. Credit: EPSRC-Rosalind-Franklin-Institute.

Vision

The health technologies theme vision is to stimulate advances in transformative engineering and physical sciences research to have a significant impact in health and ultimately enable people to live healthier lives.

Mission

1. We will deliver impact through high quality engineering and physical sciences research which is co-created with end users, stakeholders, and the public in the following challenge and priority areas:
   - improving population health and prevention of ill health
   - transforming prediction and early diagnosis
   - discovering and accelerating the development of new interventions
2. We will encourage and support disruptive and transformative ideas in engineering and physical sciences research with the potential to deliver a step change for health
3. We will support and attract people from a diverse population to build capacity for future skills requirements in health technologies
4. We will support the accelerated translation of engineering and physical sciences research into health applications

Our strategy identifies a number of challenges, important enablers and key outcomes in addition to our aim of supporting world-leading research and skills.

CDT students, credit: King's College London

CHALLENGES

1: Improving population health and prevention of ill health

2: Transforming early prediction and diagnosis

3: Discovering and accelerating the development of new interventions

Challenge one: Improving population health and prevention

Supporting people to live healthier lives and preventing ill health are of key importance for the UK and globally but an area of relative under investment. A recent review of investment in public health interventions found that spending in this area has a long-term return on investment and saves healthcare costs.[1] In the UK, prevention is highlighted as a key priority for the NHS in the long-term plan. Improving prevention across the life course will enable people to live better lives and will save on treatment costs.

This challenge focuses on the need for novel techniques that optimise health, prevent, and ultimately help eliminate disease. Research within this challenge should be co-created with stakeholders including policymakers to ensure real world impact.

Prevention includes promoting wellbeing in a population, addressing the determinants of health [in the physical environment] as well as the causes of disease and enabling people to have a better quality of life.

Identified priorities where we believe engineering and physical sciences will make important advances in improving the health of the population include:

Population models

This priority focuses on the development of new tools and technologies to interpret and analyse population data to provide advice and guidance to communities and health professionals. These tools could be predictive models developed through advancements of machine learning approaches used to understand individual and population scale variation in disease phenotypes, considering physiological and biological mechanisms. These models could also be used for example to forecast and warn of infectious disease spread.

Predictive approaches to a healthy society

This priority focuses on development of novel tools and technologies e.g., digital twins, to understand what normal health looks like and create models of wellness. It includes the development of technology that measures, monitors, and understands disease through data and identifies when deviations occur within an individual. For example, the harnessing of digital technologies and data analytics can lead to the discovery of indicators of susceptibility and risk of disease, and this can help identify at-risk individuals and enable people to stay healthy and avoid medical complications. Tools can also be developed to stratify and identify groups likely to follow a particular path, be particularly vulnerable to a certain risk factor or environment or respond particularly well to a lifestyle change or treatment.

[1] *Masters et al., Return on investment of public health interventions: a systematic review, BMJ, 2017*

Engineering healthier environments

This priority focuses on 'Engineering healthier environments where people live and work'. It will build on UK strengths, transforming support for built environment and infrastructure research. This will include research and enhanced use of health data analytics on:

- smart cities
- assistive technologies
- robotics
- artificial intelligence.

We will transform the built environment into a tool that will:

- enable a step change in our ability to predict and anticipate factors to prevent ill health
- prevent infection spread
- shape the future living and working environment
- enable the re-design and adaptation of existing spaces to promote increased wellbeing.

Challenge two: Transforming early prediction and diagnosis

Early diagnosis, prompt detection of acute and chronic disease recurrence and treatment monitoring is among the key foundations of any healthcare system.

Addressing all aspects of health from physical, mental, and environmental, this challenge focuses on the need for novel techniques that optimise patient-specific illness prediction, early and accurate diagnosis.

The aim includes reducing the incidence of disease, intervening before full symptoms develop, as well as reducing the impacts of multiple long-term illness and strengthening the ability to take exactly the right steps to combat disease at precisely the right time.

Scientific, mathematical, and other techniques, from biomarker identification, research into medical imaging and risk stratification to predictive modelling and real-time, evidence-based decision-making, will all play a role.

Identified priorities where we believe engineering and physical sciences will make important advances include:

Tools to advance earlier diagnosis and detection of disease

This priority focuses on the development of novel tools and technologies such as non-invasive sensors, devices and medical imaging instrumentation, image visualisation and interpretation to enable earlier and more reliable diagnosis of physical and mental health conditions. This priority could include:

- development of low cost, portable technologies which are more accessible to communities such as medical imaging technologies which are delivered in primary care
- development of novel non-invasive sensors and devices to detect disease earlier and more accurately
- complex models and decision-support systems, which use data to support rapid diagnostic decisions including diagnostics which can be used in the home.

Novel techniques for patient specific diagnosis

This priority focuses on:

- New methods of recognising abnormal data patterns and harnessing digital technologies (artificial intelligence, modelling, simulations, and digital twins) and data analytics to predict susceptibility to illness. Working at a person-specific level, these will:
  - analyse physiological and behavioural data collected over time
  - identify causes for concern
  - provide early warnings for the patients themselves, their carers and healthcare professionals.

Detecting infections and antimicrobial resistance

This priority focuses on the earlier detection and prediction of infectious disease. This could include development of novel diagnostics which can deliver rapid and accurate tests at the point of care that will improve patient safety and health outcomes.

Supporting people to manage their own health

This priority focuses on the development of novel digital tools for technology-enabled learning which could support people to make health decisions. These novel technologies will be person-centred and enable the public to better manage their health in their own homes.

For example, individually adaptive, minimally intrusive monitoring technologies enabling individuals to track their own health and have informed interactions regarding healthcare needs. They will also make it easier for patients to interact with healthcare professionals and provide updates on their medical conditions.

Challenge three: Discovering and accelerating the development of new interventions

In a world challenged and changed by the COVID-19 pandemic, the unrelenting drive to tackle existing and emerging diseases by harnessing engineering and physical sciences to develop new and advanced therapies, medicines and other interventions must continue apace. This challenge focuses on the need to produce safer, more targeted treatments and interventions fit for the future. This challenge includes therapies, as well as physical interventions such as provision of prostheses to surgery and radiotherapy, which is fundamental to tackling impairment by restoring function, repairing damage, and eliminating disease.

Developing novel treatments and therapies which could be personalised and designed for the setting in which they are being delivered e.g., home, community or acute care is of key importance.

Identified priorities where we believe engineering and physical sciences will make important advances include:

Resilient Manufacturing

This priority focuses on improving UK capability in developing and manufacturing new medicines, and interventions and delivering these more rapidly and sustainably:

- research to accelerate the time taken from discovery to deployment of new interventions
- scale up technologies that allow future medicines to be manufactured in an affordable way that meets safety and environmental requirements
- research to understand and address the manufacturing challenges for novel therapies from small molecules to cell/regenerative medicine therapies
- processes that will be capable of cost-effective scale up to enable mass production of medicines – for example, to tackle epidemics. It could also include processes that will be capable of scale down to produce personalised medicines, such as regenerative therapies using patients' own cells.

Therapies for chronic conditions

This priority focuses on development of effective treatments for people affected by long term conditions and co-morbidities (related to ageing). Research could include:

- targeted delivery of therapeutics and treatments to specific places in the body, achieve controlled release of their active ingredients or deliver more than one active ingredient at a time
- development of long-lasting therapies
- advances in physics modelling and image-guided treatment planning to increase the precision and targeting of surgical procedures. These advances will ensure fewer side effects, faster recovery times and better overall outcomes in-silico, in-vitro and biomarker technologies for use in drug discovery.

Knee therapies, credit: University of Leeds

Engineering and materials research with therapeutic properties

This priority focuses on:

- Innovative technologies that will:
  - enable development of new materials to promote tissue growth
  - creation of human organs in the lab – avoiding the need to rely on donors when damaged organs need replacement or repair
  - optimisation of the capabilities of donated organs and tissues and maximisation of the benefits they deliver
  - stimuli responsive materials that can respond to a wide range of biomarker triggers.

Innovative technologies for physical intervention

This priority focuses on innovative technologies for physical intervention such as assistive technologies and surgical robotics, for example:

- minimally invasive autonomous technologies for robotic surgery which will reduce recovery times, lower infection rates and lower costs.
- novel, cost-effective technologies for implants, prostheses and assistive devices. Designed to maintain or improve function, novel technologies will adapt to users' changing needs and capabilities, and so encourage more people to use (and keep using) aids that help them overcome impairment
- personalisation of physical intervention technologies. Focusing on digital health or pain management in the home, for example, technologies customisable to individual needs will not only strengthen palliative and other types of patient care but also protect and improve the health of the population at large
- bioelectronic devices providing long-term sensing and control capabilities will help to re-establish function, reduce pain, and assist recovery.

Enablers

Our strategy has also identified a number of enablers, that research within health technologies should address

Responsible approaches to data

Health data should be accessed and used in a trustworthy, ethical, and secure way. We want to ensure that all projects funded by the health technologies theme consider responsible approaches to data gathering, storage and access and to work with other partners to enable researchers to access health data appropriately.

Patient and public involvement and engagement (PPIE)

PPIE aims to deliver better quality research, whether patient focused or accelerating the transfer of evidence into pre-clinical research through effective two-way communication. This can include engagement with patients and other people with lived experience, such as carers, or users of technology including clinical and healthcare professionals. PPIE can offer valuable insights into the reality of facing or living with a disease or condition and can help better characterise the challenges and needs a technology might address. While public engagement is important across all areas of research, it has particular importance for healthcare. People's interactions with health technologies can be amongst the most personal, intimate and invasive of all the interactions with technology that they will experience during their lives. We encourage researchers to engage with PPIE activities at the outset of their research and, where appropriate, draw in from public, patient and user perspectives to inform and shape the next stage of healthcare research.

Sustainable healthcare and health systems

Healthcare's climate footprint is around 4.4% of global net emissions. Healthcare contributes to emissions through energy consumption, transport and product manufacture use and disposal. Sustainability in this context can mean healthcare being delivered more affordably, more resiliently and in a more environmentally friendly way. We aim to scope areas of research opportunity in this space for health technologies researchers and will encourage all applicants to consider sustainable healthcare practices when applying to EPSRC.

Improving translation readiness

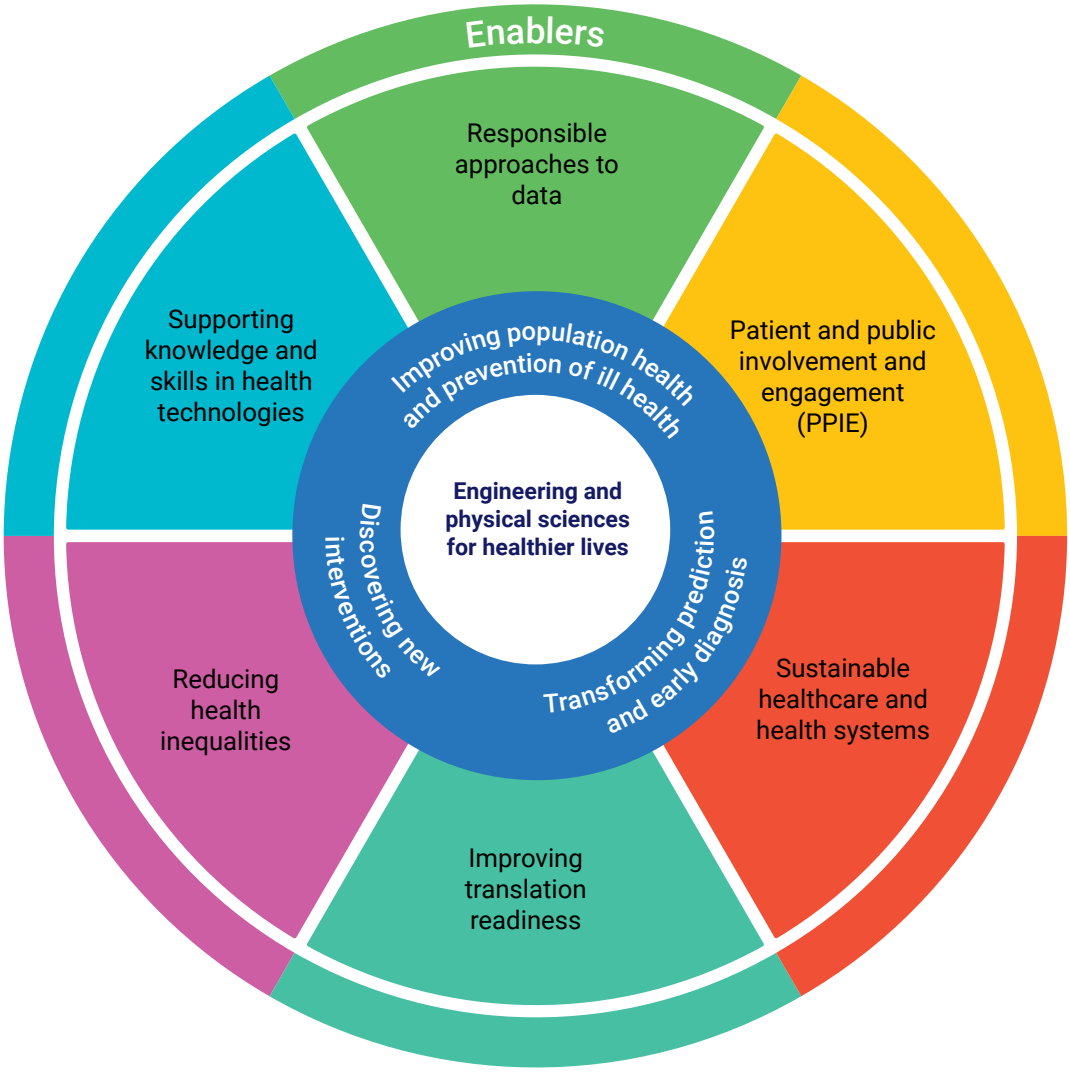
The development landscape for health technologies can be complicated. The journey from bench to end user application can be long and the pitfalls for new technologies are many. Successfully traversing this landscape requires preparation and an understanding of those challenges unique to the healthcare sector. The health technologies theme would like to identify actions where we can help researchers successfully traverse this landscape. For example, working with regulatory organisations to use physical sciences and engineering methods to speed up the regulation process.

Reducing health inequalities

While life expectancy continues to improve for the most affluent 10 per cent of the UK population, it has either stalled or fallen for the most deprived 10 per cent. The NHS and our community workshops highlighted this as a key issue nationally and we would like to embed and explore thinking about this issue in our projects moving forwards.

Supporting knowledge and skills in health technologies

At the centre of excellent health technologies research and innovation are the talented people and teams. Therefore, we need to invest and support the people, skills and careers of the next generation of health technologies leaders.



ANNEX 1

Annex 1- stakeholder group

We would particularly like to thank the following group of experts for their advice and guidance on the strategy.

- Dr Ken Sutherland - President of Canon Medical Research Europe Ltd.
- Professor Lord Ara Darzi - Paul Hamlyn Chair of Surgery at Imperial College London
- Dr Nicola Perrin - CEO of the Association of Medical Research Charities
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- Professor John Girkin – Professor of Biophysics at Durham and Chair of the Healthcare Technologies SAT
- Professor Dame Anne Johnson - Professor of Infectious Disease Epidemiology at UCL
- Dr Andrew Fraser - Director of Public Health Science Public Health Scotland
- Dr Joe de Sousa - Melhor Consulting and EPSRC Council Member
- Professor Alicia El Haj - Interdisciplinary Chair of Cell Engineering at Birmingham


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