

## My healthy future: the technologies

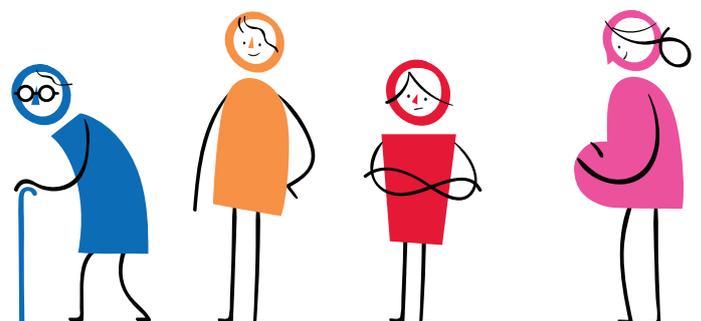
Current and emerging biomedical and digital technologies are creating new opportunities for the prevention, diagnosis, treatment and monitoring of disease on an ever more personalised basis, both within the health system and beyond. As these technologies and their applications advance they are likely to play an integral role in shaping healthcare and the ways in which citizens manage and optimise their health.

PHG Foundation have produced a series of visual summaries highlighting existing and anticipated healthcare utility of a range of cutting edge technologies and biomedical advances. These developments have the potential to improve and expand our abilities to assess, to understand, and to intervene in health and disease processes. Each summary includes an overview of the opportunities and challenges to their routine use for health. The technologies can be broadly categorised according to their overarching applications in health.

### Biomedical 'omics technologies for greater molecular level characterisation of individuals

'Omics technologies enable the comprehensive or global assessment of a set of molecules in a given sample. The field has been driven by technological advances and falling costs for the high-throughput generation of data. Crucially this data is enabling the more detailed characterisation of the molecular make-up of our cells, tissues, and organs – information which is facilitating tremendous opportunities for:

- Identification of new disease biomarkers and development of new therapeutics
- Informing more precise diagnosis
- Greater stratification of populations to better target health interventions

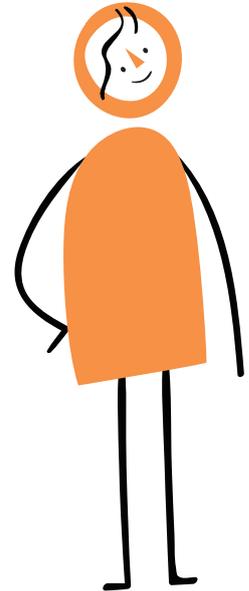


## Emerging technologies

Whilst the application and understanding of genomics in particular has advanced rapidly over the past 20 years, developments have also highlighted the immense complexity of interpreting genomic variation in the context of health and disease.

It is widely recognised that the growing armoury of other 'omics approaches are key to elucidating how the instructions laid down in our genome are expressed within our cells. Specifically, these other 'omics technologies can measure:

- Messenger (m)RNA: 'transcriptomics' to reflect the genes that are being expressed at a given point
- Proteins: 'proteomics' to understand the overall composition, abundance, structure and function of the full set of proteins coded for by our genes
- Metabolites: 'metabolomics' to quantify the products of cellular metabolic processes
- Chemical modifications that attach to DNA to regulate gene expression: 'epigenomics'



Increasingly 'omics technologies are being applied in combination to examine the inter-dependency between the various biological processes (e.g. gene expression and epigenetic regulation), and to understand how our genes interact with environmental factors. An example of the latter is 'nutrigenomics' which attempts to examine the interaction of nutrition and genes using an array of 'omics analytical tools to measure changes occurring *in vivo*.



Another factor bolstering the promise of 'omics is the growing ability to apply these approaches to a broad array of samples types - from collective populations of microorganisms (microbiome analysis) - to individual cells (single cell analysis) - to DNA circulating in blood (liquid biopsy). The analysis of fragments of tumour DNA found circulating in a patient's bloodstream is already being applied in the clinic to inform treatment decisions for some forms of lung cancer.

### Biomedical technologies for more personalised therapeutic interventions

The knowledge derived from 'omics based analysis is informing advances in regenerative medicine for the repair, replacement or restoration of function to damaged or diseased human cells or tissues. Although predominantly at the pre-clinical research or clinical-trial phase, remarkable progress in this field is facilitating individually tailored therapies for patients - whether through use of their own cells, or by direct targeting of their genetic variation.

This vast field includes cell-based therapies which make use of stem cells, including those derived from the patient, which can be differentiated into other specialised cell types. Stem cell therapy can be combined with advanced genome editing techniques, to directly manipulate genetic code with the objective of correcting the genetic aberration underlying a disease. Cellular systems can also be re-engineered using synthetic biology approaches - the most promising application of which is the reengineering of cancer patient's immune cells to allow them to detect and destroy cancer cells that may otherwise subvert the immune system.

### Digital and/or data driven technologies for more personalised disease and health monitoring or for therapeutic interventions

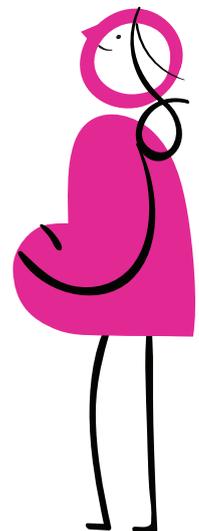
Digital technologies, in many cases originally developed for use in other sectors, are becoming pervasive in healthcare.

Mobile technologies are creating opportunities to obtain more regular health-related information on individuals (e.g. heart-rate, or movement activity) and to deliver care remotely (e.g. through telemedicine consultations or smartphone health apps).

Virtual reality technologies, originally developed within the gaming industry as headsets that display computer rendered simulations, are being considered for healthcare applications to treat mental illnesses.

Medical imaging data is providing the digital foundations for the use of 3D printing in healthcare to create bespoke patient customised personalised implants and anatomical structures for surgical planning.

The miniaturisation and portability of data-driven and digital-health devices is delivering further opportunities to monitor the health of individuals remotely and more frequently. These include implantable biosensors to provide real-time measurements of biomarkers within our bodies, and portable bioassays for the near-person and point of care diagnosis or monitoring of disease. The capabilities of these devices are likely to expand as bioengineering approaches such as nanomedicine and microfluidics that operate on very small scale (nanometres and millimetres respectively) evolve sufficiently to underpin new or enhanced biosensing applications.



## Enabling informatics technologies for harnessing health data

Advances in information technologies are integral to the developments in data-driven medicine. The increase in the ability to generate data has far outstripped our capacity to manage, store, and analyse this data in order to maximise its value. The 'internet of medical things' (IOMT) is one approach to addressing the massive challenge of integrating different datasets generated across a range of disparate medical devices through the use of sensors, cloud computing and cloud storage.

Artificial intelligence, including machine learning approaches are viewed as one of the most transformative technologies for healthcare owing to the capabilities to derive insight from very large and complex datasets in ways not previously possible.

Beyond overcoming the technical obstacles for collating and analysing data, blockchain - a radical approach for the sharing of data - is heralded for its potential to offer more secure, safeguarded and trusted data management solutions.

### The shape of things to come?

The continuing development of technologies such as those described here (as well as others) are expected to have a major role in shaping trends for health management.

- Increasing portability and ubiquity of digital and data-driven sensing devices may result in a growth in the number of health technologies that interact directly with citizens outside of a health setting or that are available via providers outside organised health systems
- Greater molecular characterisation of individuals combined with targeted cellular therapies may enable earlier and/or more precise disease diagnosis to be closely followed by potentially curative tailored treatments
- The unprecedented volumes of health-related data now being assessed through advanced analytical approaches such as AI may reveal disease risk before symptoms manifest, and may better inform the management of long term disease to prevent complications
- Mobile and internet-enabled or connected devices may empower citizens to take greater control over their own health

**These are just some possibilities, which may or may not arise, but overall it is clear that in combination these technologies are facilitating the most detailed and holistic view of health that has yet been possible.**

#myhealthyfuture



CAMBRIDGE UNIVERSITY  
Health Partners

phgfoundation  
making science work for health