The background features an abstract graphic of concentric, overlapping arcs in white, cyan, and yellow, creating a sense of depth and movement. The arcs are arranged in a way that suggests a digital or networked environment.

Frontiers:

*Digital  
Phenotypes*

*Health research in the  
digital age*

5-6 November 2015  
London

*'Digital phenotypes'* describes the use of new digital technologies to capture individual data from a range of sources outside of current healthcare settings, including wearables, health apps, mobile devices, social media, online platforms, forums, crowd sourcing, citizen science and mobile tracking surveillance.

The purpose of the 'Digital Phenotypes – Health research in the digital age' Frontiers meeting was to explore how new digital technologies and the digital phenotype data they generate are changing approaches to biomedical research, and to advise what the opportunities are for investment and support in this area. Global experts were invited to share their vision and brainstorm possible suggestions for how funders could catalyse the application of new digital technologies in basic and translational biomedical research.

### Digital phenotypes: definition

With more connected digital devices than people on earth, everyone is leaving behind a continuous digital footprint as part of their everyday life. What people search for, how they engage with social media, and what their mobile devices and wearables are streaming all give away detailed clues as to what they are experiencing, feeling and doing. New technologies and digital platforms therefore make it easy to capture constant streams of up-to-date information on individuals, presenting new tools for research and an untapped source of health-related data.

### Digital phenotypes: opportunities in research

Emerging digital technologies and platforms open up a multitude of opportunities for research. They serve as novel tools and methods for basic research through monitoring, data collection and data classification, as well as for translational research and the development of new therapeutics.

From chronic diseases to infectious diseases, from patient experiences to adverse effects, massive amounts of information about people's interactions in clinical settings are coming through new digital channels, creating new digital phenotypes. Being able to categorise and organise this information in a way that is useful could change the way one tackles global health problems, performs research and practises medicine, as well as the way people manage their own health. For example, basic research designed to monitor and prevent the spread of infections could use data from:

1. social media statuses – relating to the symptoms, onset and duration of illnesses and the impact of health interventions
2. mobile phone tracking – to look at population movement to predict the spread of disease
3. online news and reports – to provide information relating to disease incidence and deaths
4. biosensors – to detect a range of disease markers.



New technologies and digital data collection can lead to improved understanding and give new insights into a number of health issues, some of which are highlighted below.

### Examples of how online activity and new devices can be used to improve understanding of different health issues

- **Lifestyle:** Tracking activity on social media throughout the day can give insights into an individual's lifestyle choices and behaviour, and wearables and mobile phone apps can provide information on physical measures such as step count, calorie intake and use, heart rate, body temperature, sleep patterns and weight.
- **Obesity research:** In relation to lifestyle (as detailed above), patterns from online searches could potentially provide information on body mass index (BMI); data on movement, physical activity levels, weight, glucose levels and calorie use can be drawn from wearables, sensors and mobile phone apps; and correlations have been drawn between what you 'like' on Facebook (food and activities) and how obese you are.
- **Drug safety and adverse drug reactions:** Mining online discussions on blogs, forums and social media can be used to assess patient reactions, as can online search engines.
- **Foodborne illness:** Ten per cent of food reviews posted online relate to incidences of food poisoning, giving information about when and where illnesses occur and their symptoms and duration. This information is commonly used by the US Centers for Disease Control and Prevention to track illnesses.
- **Mental health issues:** Searches of discussions on blogs, forums, social media and apps may indicate how many people are suffering from mental health illnesses. Games and devices can be used therapeutically as well as to collect data.
- **Social factors that influence health:** Mining online statuses, picture uploads and the use of search engines, eg around unemployment, can allow studies of correlations between social factors and health outcomes.

Chunara et al. Assessing the online social environment for surveillance of obesity prevalence. *PLoS One* 2013;8(4). <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0061373> [accessed 12 February 2016].

## Digital phenotypes: opportunities in research

### More, better and different approaches

Digital technologies offer a significant advantage in terms of scale and reach, increasing access to new and diverse populations – including those in rural areas – that can participate and be studied in research (eg those that neither fall into the categories of being 'sick' or 'healthy', such as cancer survivors). New technologies can offer particular advantages in regions with limited public health infrastructure and enable access to global-scale populations, while also mediating much quicker and easier access to people and data than previously possible and at a much lower cost.

New digital technologies also enable the capture of significantly more data, with the number of measuring parameters and the variety of data one can collect from an individual and populations increasing. Streaming of digital data from devices and platforms allows data to be collected continuously in real time, providing longitudinal data that can be compared to snapshots that are captured through more traditional means, eg clinical visits. It can be argued that this data is more representative of an individual's health, reducing artificiality in samples while also enabling signals to be detected much earlier, resulting in better-quality healthcare and research. Such large, longitudinal datasets hold huge potential for understanding global health problems, such as obesity, cancer, heart disease, and infection surveillance and interventions.

### The wider community

New technologies also connect and facilitate greater interaction between all stakeholders (citizens, researchers and healthcare professionals). Not only does this increase the number of approaches that can be used in research and the amount of data that can be collected, but it can also encourage greater awareness, learning and management of one's own health, removing the barrier to engagement. In addition to 'data donation', online platforms and digital tools are also enabling citizens to actively contribute to science and research through direct involvement in science classification and project analysis. Due to the sheer number of people that can be involved in projects and the large volume of data that citizens can analyse, citizen science presents a transformative model for the way research is performed, helping to build huge databases and resources that can be used by a variety of different disciplines in research.



In the future, traditional and digital approaches will not be distinct – marking a fundamental departure from the current model of just performing research and capturing data based on what researchers think matters. An integrated approach will allow both passive and active involvement in research, which will not only increase the methods available and parameters measured but also increase the value of current approaches and available data, allowing researchers to build a bigger picture by using multiple sources.

### Digital phenotypes: the challenges

The field of digital phenotypes has emerged in a very short space of time, with an explosion in the availability of new technologies and digital streams. However, with so many players and such a vast and varied landscape, it is hard to know what is appropriate and useful for science and health purposes. For example:

- How are the technologies and data currently being used in research, and are they being used appropriately?
- Are the biomedical questions being asked and the technologies' applications appropriate to improving health?
- Who are the key stakeholders?

In the digital age where new technologies and devices are often seen as 'sexy', their value to and impact on health can be overlooked. At the moment it is commerce that is pushing these new tools and digital streams, rather than the benefits they hold for health and science. The context in which new technologies and digital phenotype data are used and integrated into research is critical, with many arguing that there needs to be a departure from hypothesis-driven research criteria to facilitate new innovation. Following on from this, there is also a lack of consensus around what the impact of digital research should look like; the long-term impact to health should outweigh the short-term success of the technology.

### Explosion of technology and digital data

Many of the available devices and platforms are commercial, and while they have massive public appeal, issues around the accuracy, reliability, sensitivity and validity of these devices and platforms and the data they produce place significant limitations on their use for research. Likewise, research-grade technologies and platforms that are validated, controlled and regulated are of little appeal to the mass market and for population-wide use. Ideally, one requires a device or platform that is appealing to many, provides a robust approach and generates valid, filtered data. As such, a key challenge in this area is the need for the standardisation of technologies and data across academia and industry, alongside the need for rigorous scientific validity-testing models to evaluate the effectiveness of new technologies for science and health. Such models do not exist within industry, and it is unclear whether current academic validation models and standards can be adapted to test new technologies and data in this way. Even if they can, new technologies and devices have such a short shelf life that by the time a technology is validated it can often be out of date, with something new and improved replacing it. Clinically validating new tools and the data produced in a quick and efficient manner, while creating the necessary evidence base for research, is a significant challenge in this field, hindered by the need for future proofing. Moreover, even if a technology is shown to be effective and worthwhile, the added barrier of conservative peer review of new technologies and methods, both for funding research projects and publishing research, is a significant roadblock, especially if there is no clear biological question.

In spite of the explosion of data available, another significant problem in this area is access to and sharing of data, which is still very much an existing problem for health data captured in current healthcare settings (never mind digital phenotype data), with privacy and security issues at the centre of the debate. A considerable amount of online information is publically available; however, this presents a number of ethical issues (see later) as well as challenges for data integration, the latter due to inconsistencies and heterogeneity in the data and the presence of walled gardens around different data sources. Some technology companies do make digital data available for research; however, this is often restricted and released in a highly processed form rather than as raw data, which undoubtedly places

limitations on how it can be used. There are also many digital systems that can't yet be accessed, for example Snapchat and Tinder, where issues around interpreting and mining both text and image-based signals present added challenges. Even when researchers gain appropriate access to data, there are subsequent challenges regarding the sharing of data between members of the public and researchers, within the academic research community itself, and between academia and industry – all of which are considered haphazard and inconsistent by most.

Assuming researchers gain access to data and have identified an appropriate use, one of the most pressing challenges is making sense of the huge volume of noisy, heterogeneous data. There is no consistent model for the algorithms and methods that should be used in order to harness and make sense of such data in a harmonised way. Appropriate mining of the data and filtering out the false positives presents a significant challenge: set the threshold of an algorithm too high and vital signs can be missed, but set it too low and every change in the data can cause an alert. Even when suitable thresholds are used, the very nature of large pools of digital health data makes it hard to decipher individual-level responses, rendering their use more appropriate for population-level studies. To overcome this statisticians, mathematicians, computer scientists and modellers are needed to integrate the data and get something meaningful from it; however, this can be extremely time-consuming, which is often not taken into consideration in research projects and their funding. There is also a lack of incentives and rewards for such 'core scientists', who crucially enhance projects via technology development or data management. This can result in their roles being undervalued and inadequately supported. Moreover, in a world where successful research outputs are still primarily based on publications, the development of robust and useful datasets along with technology development is overlooked. Rethinking recognition of non-conventional research outputs is crucial to enabling digital technologies and the data they generate to be used in research in a meaningful way.

### **Industry and academia have different drivers**

One of the main challenges in this area for academia is a lack of world-leading expertise (eg coders, modellers and designers, who aren't incentivised to choose research over the fast pace of industry) to use the technologies and data appropriately for science and health purposes. Likewise, the necessary expertise in basic and translational biomedical research and medicine is somewhat missing in the technology sector, preventing new technologies from offering their maximum benefit to health. The use of new digital technologies in research therefore cannot move forwards in the isolated environment of academia or industry; it will require a partnership between these different sectors in order to be successful. Aside from the fact that the two sectors approach the space with varying motivations (industry's push for profits and academia's desire for publications), any partnership will have to overcome the fact that the sectors work in fundamentally different ways, on different timescales and according to different standards. The journey from discovery science in academia to technology transfer and finally to a commercial market can take many years, during which the technology landscape can completely shift, potentially rendering any developments null and void. Moreover, given that industry is driven by profits, there are limited investment opportunities for developing interesting technologies that may be highly beneficial for health and science but which have no commercial application, or to pursue technologies that fail at the first hurdle, which are frequently abandoned and yet could have a great health impact.

In spite of the different motivations and pressures, the commercial sector is showing a genuine interest in the health space; however, those involved often fail to realise the true impact that new technologies could have for health and science, and even when they are aware, there is uncertainty as to how best to engage. Guidance is needed to facilitate such engagement, which will need to take into careful consideration the community, given that public participation is essential to the sharing of digital phenotypes; the public can often be deterred if they think a company is gaining financially from them.



## The ethical issues

The ethical implications of using new technologies and digital phenotype data in research are wide-ranging and complex. Making progress in a previously unexplored area means that traditional ethical frameworks are unlikely to be fit for purpose.

Fundamental to any ethics discussion must be the issue of consent. How does one achieve this? In what context is it necessary? Are the public fully informed of the ethical issues? Users often do not realise the implications of open-source data platforms like Twitter or tracking apps on mobile phones and how the information gathered through them could be used. As such this raises significant ethical concerns about whether someone should expect to have that information, which can be deeply personal, used as part of a research study or given to a technology company if they make it available online, and whether researchers should actually ask for consent to use this publicly shared data. If consent is given from users, there is the added challenge of validating that consent and ensuring participants understand what they are taking part in. Of course one would presume that digital health studies would seek digital consent, but how can one be certain that, from a legal standpoint, people are who they say they are and, from a healthcare standpoint, that they have the disease and symptoms they say they have?

Tied to consent is the issue of data ownership; data arises from individuals who use, in general, commercial technology. From this, one could argue that the data is owned either by the user or the technology developer. Determining where data ownership lies will be critical for determining with whom responsibility and safeguarding duties lie. Depending on the technology and digital phenotype data used, this may differ across different studies, and so a robust yet agile ethical framework is needed to answer these complex questions and permit the safe and meaningful use of digital technologies in research.

## Citizen engagement

Digital phenotypes are created through the community engaging with new technologies and digital platforms and 'donating' their data. However, there is very little understanding of how citizens engage with technologies and what is useful to them, which significantly hinders uptake and use. There is also a potential risk that the end users of any new technology will tend towards the computer-literate, the younger generation, the wealthy and the 'worried well'. Thus, there is a risk that certain parts of society could be excluded from 'population'-wide studies that rely on new technologies, with such studies not truly being representative and consequently yielding wrong assumptions about health and disease. Even when there is engagement it will often be accompanied by 'user fatigue', and maintaining sustained, long-term compliance and use of new technologies and platforms will be a huge barrier to creating new research models and the development of accurate and reliable longitudinal datasets. To facilitate sustained engagement from the community, consideration must be given to what the return on and subsequent value of engagement is to the public, which will indeed differ across different regions and cultures.

## Overcoming the challenges

There is a real opportunity for global organisations to accelerate and galvanise the use of new digital technologies and digital phenotype data in research. Developing and sharing models for best practice, convening world-leading experts from different disciplines and sectors, and providing large-scale investment are all necessary to promote a closer path between science, technology and innovation. To do this appropriately, the following areas should be considered.

### Understand the landscape

There is currently no roadmap for the appropriate use of new digital health technologies and the opportunities they present for biomedical research, and while this presents obvious challenges, it also creates the opportunity for funders to lead the way and begin to map out the field. Mapping out what technologies and data are available, how these new tools can be used for research and the impact they can have needs to be completed before such tools can be used appropriately. This should not be limited to looking at their impact on scientific research, but





should also build a picture of the ethics, policy, legal and regulatory landscape. Such information could be used to create a registry or database, which would need to be updated with input from all communities. As such, this roadmap would have to include the different stakeholders involved and identify what is required from and for whom, for which a neutral mediator will be critical to engage all of these communities. Cultural contexts and varied needs in different geographical locations should also be considered, to identify how technology could make a difference to science and health globally. Digital health shared-thinking meetings that convene different sectors to share technologies, developments and projects could go a long way to facilitate this, help map out the field and speed the pace of innovation, and could also provide a forum for new collaborations to be established.

#### **Set the standards**

Given the explosion of technologies and digital phenotype data available, there is an urgent need for the development of robust principles and best practice guidelines for technologies, platforms and the usage of data. These should be based around a clearing house of standards rather than a single one, with multi-sector input to help bridge the gap between industry and academia and to help identify what is robust and ethically sound. Only when there are guiding principles can one begin to devise sophisticated methods for evaluating and validating technologies and data to determine what is effective and meaningful for biomedical research. To facilitate this, there needs to be greater funding for such evaluation and validation studies, which needs to be agile, accepting of when technology might fail and data may not be meaningful. The more that teams can move towards focusing on doing a lot of experimentation, failing, adapting and learning the better. The funding environment also needs to be more accommodating of this model of supporting innovation.

There is a need for infrastructure to facilitate the sharing of technologies and data within a trusted research environment. Best practice guidelines and standards should be developed; trusted relationships between academia and industry should be established; and more importantly, incentives for sharing resources should be sought – incentivising the public

to share their data with researchers as well as the creation of an environment that promotes sharing within academia and between academia and the technology industry. Incentivisation will best be achieved through transparency – by showcasing the benefits of sharing and what good this can achieve for global health and by clearly articulating what technologies and data were used, who they belonged to and how they were used. Large-scale revolutionary projects require international collaboration and the free flow of data and resources between research teams (the work of CERN is a good example of this). This open environment does not yet exist within the field of health research, but could be catalysed if funders were to require that all research outputs, including data, technologies and methods, be made open source. Centralised models should be explored to identify what would best achieve this open environment – for example, for digital phenotype data would a data repository model or federated data analysis be more appropriate? Of course, the creation of new privacy and security models will be fundamental to this, for which one could harness the new technologies themselves – eg codes for apps and photo uploads.

#### **Bridge the gap between academia and industry**

Currently, there is a clear gap between academic research and technology-sector expertise, and a need for a trusted third party to bridge this gap, nurture the people in this space and help form trusted partnerships. Guidance is required to assist engagement between the technology industries, the health sector and science in a meaningful way. Such guidance should identify how multi-sector partnerships may work and what the opportunities for collaboration could be. Sharing models of best practice – demonstrating partnerships between the technology industry and academia that have worked well – could be used to help achieve this, clearly explaining what is needed for success and how common challenges around issues such as intellectual property can be overcome.

True acceleration in this area will only be achieved through the development of formal pathways to collaboration, where partnerships are established at the early stages of projects. Substantial investment will be essential in order to attract and incentivise industry engagement and the right expertise. Matched funding with other organisations in the technology sector could be explored to help foster greater engagement, as could venture-capital-type investment for long-term strategic support given the highly competitive nature of the commercial world. In all cases, it is vital that industry engagement involves small and medium-sized enterprises (SMEs) that demonstrate agility as well as larger technology companies with broader expertise.

Industry is driven by innovation, and thus another part of this complicated puzzle is the ability to provide flexible funding for it. There is a need for better mechanisms to support novel ideas and the development of ambitious new technologies that may not yet have been conceived. Whether such mechanisms exist as small pots of 'seed funding' issued in a quick and agile manner or as larger pools of funding for blue-sky thinking, action is needed to enable better support for innovators, targeted at the next generation. Such funding should not be limited to academia but also be provided to the technology sector, to allow the sector to pursue a technology or data platform for health and science purposes where the commercial application may be uncertain. Funding mechanisms also need to be more mindful of the length of time it can take to get such partnerships off the ground and establish contracts of mutual benefit between academia and industry; greater flexibility needs to be built into grants to allow time for relationships to establish.

### **Address the skills gap**

Leadership and training, especially for the next generation, will also be critical to help address the gap in expertise between industry and academia. A cohort of researchers who have the skills and capabilities to use new technologies and digital phenotype data effectively in research is needed. Optimal future leaders would have knowledge of biomedical research and health problems as well as of product design, user experience and coding, creating a cohort of 'hybrid' researchers. The career structures of these future leaders would look different to usual academic pathways, and any new schemes need to be mindful of the skills, training and incentives required to facilitate this.

Cross-discipline and cross-sector training and mentorship will be critical for developing such skills, in which industry training modules – design, development and coding – will be key. Incorporating such modules into doctoral training programmes could be an effective model for influencing the next generation of researchers, as could the development of 'digital fellowships' with formal mentoring from both a senior researcher and a senior expert from the relevant industry sector. All current fellowship models rely on mentoring from the academic sector; however, if there is not sufficient expertise in academia, then other models need to be made available to support effective training and development. Alternatively, a model of 'exchange fellowships' may be more appropriate, allowing industry experts and academics to train in the opposite sectors, understand their needs and develop creative ideas in context. Support for such transition should be offered equally to technology-industry experts as well as to academics. Central to any training or exchange scheme will be the resources and incentives used to support them. Put frankly, to attract world-leading modellers, coders, and software and technology developers from industry into science and research, competitive salaries and packages must be provided.

Addressing the skills gap cannot be limited to developing new expertise and skills for 'digital researchers'; it should also take into consideration the need for greater support for core scientists with critical skills and expertise already in academia but for whom there is an absence of career structure, eg statisticians, data managers and technologists. Moreover, there is the need to consider cross-discipline training and support for discipline hopping within normal academic realms, eg a statistician becoming embedded in an epidemiology department or a behavioural scientist being embedded in an engineering department. Much greater flexibility and dynamism is needed to allow bright young people to get the necessary exposure and training to pursue great ideas.



### **Bringing the community with us**

The use of new technologies and digital phenotype data in research requires community engagement, and so it is absolutely critical that the public are put at the centre of any approach to make use of the technology. There is a need for a coordinator and trusted mediator to help explain the impact and benefit that new technologies and digital research could have for the wider public, and to be clear how exactly the data would be used and for what purpose. This is especially important where there is industry involvement, as this can often deter wary participants. Digital platforms could go a long way to help break down these silos, bring people together and forge online communities and ‘engaged cohorts’.

There needs to be a better understanding of the user interface and experience of technology in order to understand what drives the public to engage with technology and what they expect from it. The commercial world continuously requests feedback and listens to what users want from technology, so it understands the end user much better than the academic world; academia needs to learn from this to make health technologies more user-friendly and appropriate. The use of such feedback, often termed ‘co-design’, and an ongoing dialogue between researchers and citizens are therefore vital, and should be embedded in projects from the beginning. International contacts should also be utilised to gain a better understanding of different needs in different cultural contexts and regions. Designers, social and behavioural scientists, and technology developers are therefore important components of any multidisciplinary research team in this area, with support needed for collaborations between the natural and social sciences as well as with the technology sector.

### **An agile ethics framework**

Fundamentally, the ethics framework remains unclear for digital research. There is a need to think more innovatively and develop an agile approach towards ethics, assessing the risks and benefits based on evidence. Different models could be tested with citizens to see what might work best, eg different models of consent; however, what is actually needed is for ethics to be ingrained in research projects from the outset. Bioethicists cannot address the issues in this area on their own; they need to be embedded in

projects from the start as a genuine component of a multidisciplinary team, to identify what would be the most appropriate course in each case and ensure that small changes to scientific design can be made quickly and efficiently without endangering entire projects. This agile approach to ethics should also attempt to move the field towards a mindset in which ethical issues are every team member’s responsibility, by providing field-wide ethics training. Such training should be considered as part of the broader work around addressing the skills gap and training future leaders with the skills necessary to use new digital technologies effectively in research.

### **Fix the funding**

The technology and methods used in digital research are so dramatically different to traditional methods that the discovery process can only happen if the research team is truly multidisciplinary – both in terms of its structure and in the way it works and thinks. It is essential that digital research teams bring together modellers, coders and mathematicians with computer scientists, engineers, technologists, designers, developers, clinicians, basic researchers, social scientists and ethicists to facilitate the most appropriate and meaningful use of new digital technologies and digital phenotype data in research. The funding environment needs to support closer collaboration between disciplines to create a sustainable future for advances that use new digital technologies for science and health. Of course, appropriate review methods and committees for assessing such multidisciplinary proposals will be critical in this process, with there being a need for more diverse representation on committees and as well as a need for those with genuine experience and expertise in this area.

Appropriate assessment of proposals of course also raises the need for better measures of success and research impact. There needs to be a shift towards outcomes-based research to ensure appropriate credit, rewards and recognition are given to a wider range of research outputs, eg new technologies, software, methods or datasets. In many cases such outputs can be more valuable to the wider research community; however, what appropriate credit and rewards look like will need great consideration, especially for the industry experts involved. In those cases where publications do remain the predominant output there is an urgent need for better tracking and rewarding of the different stakeholder contributions to ensure that core scientists and industry experts are properly valued and acknowledged. In spite of the significance

of these issues, they are not unique to the use of digital phenotypes in research; they very much pervade all of modern science and research and so any action in this area will need to be driven by a consortium of funders and research councils.

## **Build the 'physical' environment**

Long-term funding models of investment that provide a pipeline from discovery science to translation through to commercialisation would help catalyse advances in this area. Investing in physical environments and the creation of national centres for excellence or developing the infrastructure to build a network of 'digital hubs' could go a long way towards achieving this.

The centre model is a mechanism often suggested to support multidisciplinary teams, where basic science researchers, technology transfer experts, coders, mathematicians, engineers, software developers and product designers, as well as social scientists and ethical experts, would all be housed under one roof. If this model were pursued, close proximity with industry and clinicians would be necessary to ensure a continuous pipeline from discovery science through to translation and commercialisation. However, it must be acknowledged that housing different disciplines under one roof will only lead to effective collaboration if people are brought together around a common goal or health problem, eg using new technologies to address a chronic or infectious disease. An effective way to test this model for digital research could be to provide fixed-term funding for 'pop-up' centres based on a specific health problem, with sustained investment being provided only if the pop-up achieves a specific health goal.

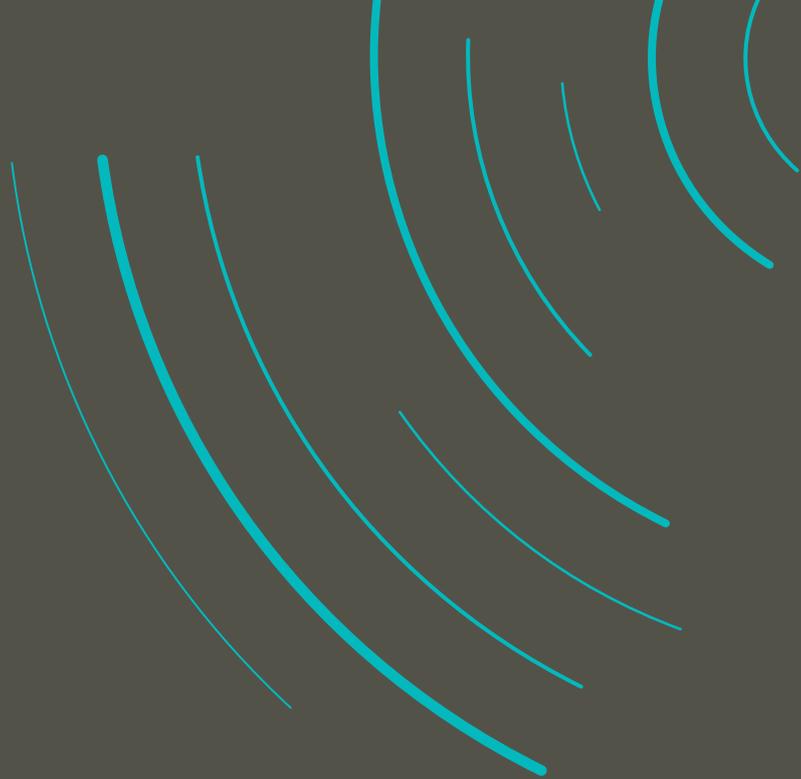
However, given the global nature of health issues and the opportunities that digital technologies present for research and health in different geographical regions, the most sensible approach might instead be the creation of a global network of 'digital hubs'. As an alternative to housing all the necessary expertise under one roof, better infrastructure and stronger links could instead be provided between existing centres that specialise in different areas, alongside building sister links with places like Harvard University and the Massachusetts Institute of Technology (MIT) – eg developers, modellers and coders in Silicon Valley could be linked with epidemiologists and clinicians in a poor resource setting. Global collaboration will be the key to success, and only global organisations with experience of working across sectors and disciplines in different nations will be well-placed to mediate this.

## **Conclusion**

New digital technologies allow health problems to be addressed in new and different ways. To maximise the impact that new technologies can have on research there needs to be a closer path between the funding of science, technology and innovation. There is a need for much more agile funding, with greater support for innovation and collaboration, to support new ideas and technology development, as well as a need for more diverse research teams that involve different sectors and disciplines. Training the next generation of leaders will be fundamental to creating an agile environment, as will ethics and policy to engage the relevant communities from the outset and build trust. A combined approach is necessary to achieve maximum impact, and infrastructure for global collaboration is a must to maximise expertise and the impact that technology can have on health around the world. The effective use of new technologies and digital phenotype data in research entirely rests on a global combined approach, and as such this area needs to be driven forward through a neutral and trusted broker who can bring together the different communities, identify the needs, nurture partnerships and build capacity. It is only through this global combined approach that it will be possible to create an environment where the use of new digital technologies in research will add value to people's lives and improve health outcomes.







## **Wellcome Trust**

The Wellcome Trust is a global charitable foundation dedicated to improving health. We provide more than £700 million a year to support bright minds in science, the humanities and the social sciences, as well as education, public engagement and the application of research to medicine.

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