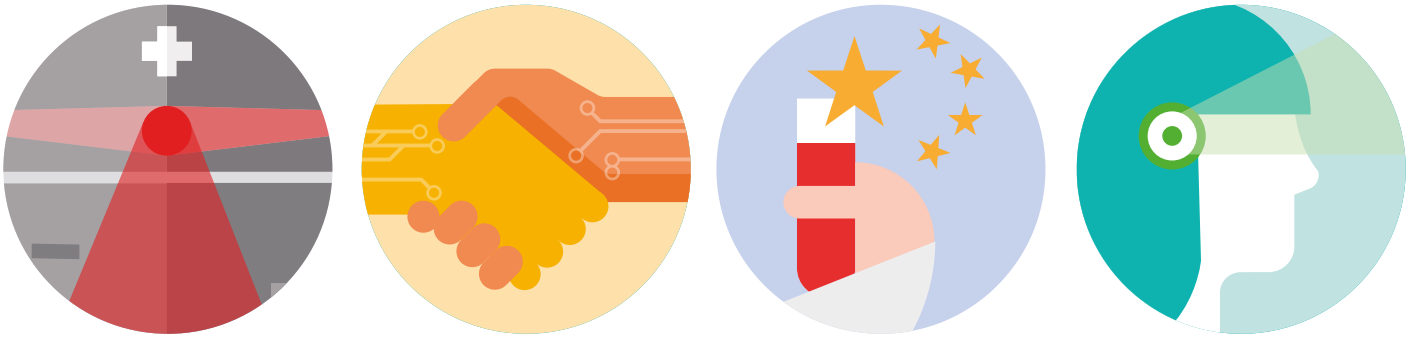


BMJ

Scenario Planning

Future of global research

Foreword

At BMJ, everything we do is focused on achieving our vision of A Healthier World.

The wider environment in which all companies operate is experiencing huge change, due in no small part to rapid and dynamic advances in technology, against a backdrop of political and economic turbulence and evolving societal structures.

To help our thinking about how BMJ can best adapt to this increasingly complex landscape we decided to run the Future of global research project, taking an innovative approach to scenario planning based on Saïd Business School's Oxford Scenarios Programme (OSP).

This initiative has helped us to explore how the global research environment is evolving, and to examine both the critical research trends that will impact on our industry, and the wider global disruptions that are driving so much change.

Our scenarios are not intended to predict the future, which will most likely include elements from each of our stories. Rather we have used scenario planning, and the "inherent human capacity for imagining futures[1]" as an engaging and creative way to challenge our thinking and create preparedness for different future outcomes.

We are excited to introduce our four scenarios. We hope they will provoke conversation across our community, and contribute to creating A Healthier World.

We would like to extend our thanks to the OSP faculty and to our friends at the Royal Society of Chemistry for their support. We are also grateful to the leading external figures and subject experts who have shared their valuable insights with us.

Peter Ashman, Chief Executive

[1]Ramírez and Wilkinson, *Strategic Reframing: The Oxford Scenario Planning Approach*

Introduction

BMJ wanted to understand the changes that are occurring in global research, and the critical disruptions that are driving them.

We used scenario planning as a way of exploring a rapidly changing industry and environment, and gaining additional external perspective in order to challenge conventional thinking.

We conducted interviews with 50 internal and external stakeholders and ran a series of workshops to identify the key themes that may shape our future. The outputs of these interviews and workshops were used as inputs to our four scenarios.

Our scenarios are not an attempt to predict the future, but are rather an engaging way to stretch our thinking and view the landscape in which we operate through a different lens, thus helping us to prepare for different future outcomes.

We are using our scenarios to test our ambition and approach, and to engage with the research community to help shape global research in a way that we all can benefit from in the future.

Read more about the benefits of scenario planning, and see our case study here: **bmj.com/company/scenarioplanning**

Analysing the present: trends and themes

We identified nine key trends and themes that may shape the future of global research. These raised a number of questions about the future:

Wider trends

Technology

Artificial intelligence, machine learning and automation

Technology will continue to have a huge impact on society, but exactly how transformational will it be?
Is what we mean by "artificial intelligence" really machine learning, which is actually quite a low level of AI formed of clever algorithms? Or could the holy grail of a neural network exploring questions for itself and learning from that become a reality? Will human intervention continue to be needed and, if so, in what form?

Geopolitical

Globalisation and protectionism / nationalism

What will the dynamic be between globalisation and increasing trends towards protectionism and nationalism? Will one come to dominate? With continued globalisation and investment, could we see innovation and creativity flourish in the East, Latin America and Africa? Could protectionist policies in the West stifle innovation and undermine the global network of scientists and researchers?

Socio-economic

Distrust of experts and personalisation of brand
Post-truth society has led to the distrust of experts amongst the public, voters and patients, and also within disciplines such as science where professionals may not trust long-established processes. Technology allows people with a small voice to be heard - there is a longer tail of democracy. These trends have resulted in phenomena such as the personalisation of brand, the sharing economy, crowdsourcing and the growth of citizen science. How will global research evolve to reflect these trends?

Global research themes

Research types

Translational, serendipitous, data driven and interdisciplinary

With funding levels stable at best, can Western investment in curiosity-driven, serendipitous research be sustained alongside translational, outcomes-focused research? Will randomised clinical trials still be needed as we see a merging of clinical practice and research, where research is conducted using real-time data and automation? Could the increasingly interdisciplinary nature of research help address big global problems such as antimicrobial resistance and mental health?

Research actors

Disruptive and uncertain

How will academic researchers, industry players and other actors adapt to a world of big data, stratified medicine and real-time, speed-driven research? Could economic pressures lead to private industry becoming the dominant player? If so, will the winners be pharma, Big Tech, or even a fusion of the two? As science speeds up there may be challenges in maintaining the researcher pipeline. Who, or what, could step in? Will the public & patients determine the research agenda more directly, or even become researchers of the future?

Funding landscape

Cost of research, collaboration and open science

The increasingly high cost of research is an important factor in determining the nature of future research collaborations. More cross-industry collaboration is being driven by the open science agenda of funders. Will collaborative and open research help address the world's big problems better and cut down on wasteful replication, or will greater involvement from industry evolve the higher social purpose of research into a system commanded by the people with the most money?

Research evaluation

Economic impact and research stories

Funders are driving huge change through the development of economic outcome measures and research stories as a method of evaluation. They are also working with social scientists to develop new ways of measuring what the public value in research, which is sometimes different from molecule-based health and economic benefit. How will this impact the research ecosystem?

Future of research communication

Evolution and authenticity

The many actors in this space require different levels of content to meet their needs. Today's ten and eleven year olds - our research actors of the future - expect instant gratification. What impact will these trends, together with the real-time availability of research data and rapidly advancing technology have on research communication methods? What is the future of peer review, what roles do brand and trust play, and which of the actors in this space will rise to the challenge?

Healthcare

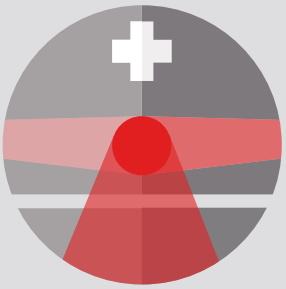
Sustainability, connectedness and privacy

How will humans respond to the changes being asked of us in terms of our relationship with our bodies? Will we feel more empowered about our health as new technologies collect our data, or will ethical and social concerns hinder advances? How will the way in which healthcare is funded impact on clinical research and on the way that we design health economics for new medicines?

Looking to the future: four plausible scenarios

Overview

We have developed four plausible future scenarios to help make sense of the complexity of change in the turbulent, wider world in which we operate. Our scenarios explore how some of our nine trends and themes might play out and interact in different ways. Set in the year 2037, they aim to provide perspective on critical disruptions that will likely impact the future of research. These scenarios are "useful fictions", intended to help create preparedness for different future outcomes and test our ambition and approach.



Scenario A | Techtopia

Machines have taken over many roles previously performed by humans, and the unemployed masses receive a universal basic income. Research is funded by private industry, in particular by big technology corporations, and is predominantly undertaken by computers. Robots perform surgery and take images, and machines interpret the results.

Scenario B | Sustainable Health: 2037

Nations have come together to manage a programme of "softer globalisation" to help society adapt to technological advances and secure future economic sustainability. Transformational technology facilitates research collaboration to solve some of the world's biggest health problems. Research is conducted by large, interdisciplinary teams that are assisted by powerful machine learning.

Scenario C | Post-West Power Shift

Austerity and protectionism in the West mean that nations are focused on issues of national security and economic health, and research is suffering from reduced capacity and output. Sustained economic growth in the Global South has led to the dominance of many Asian, African and South American countries led by China, the new powerhouse in research and education.

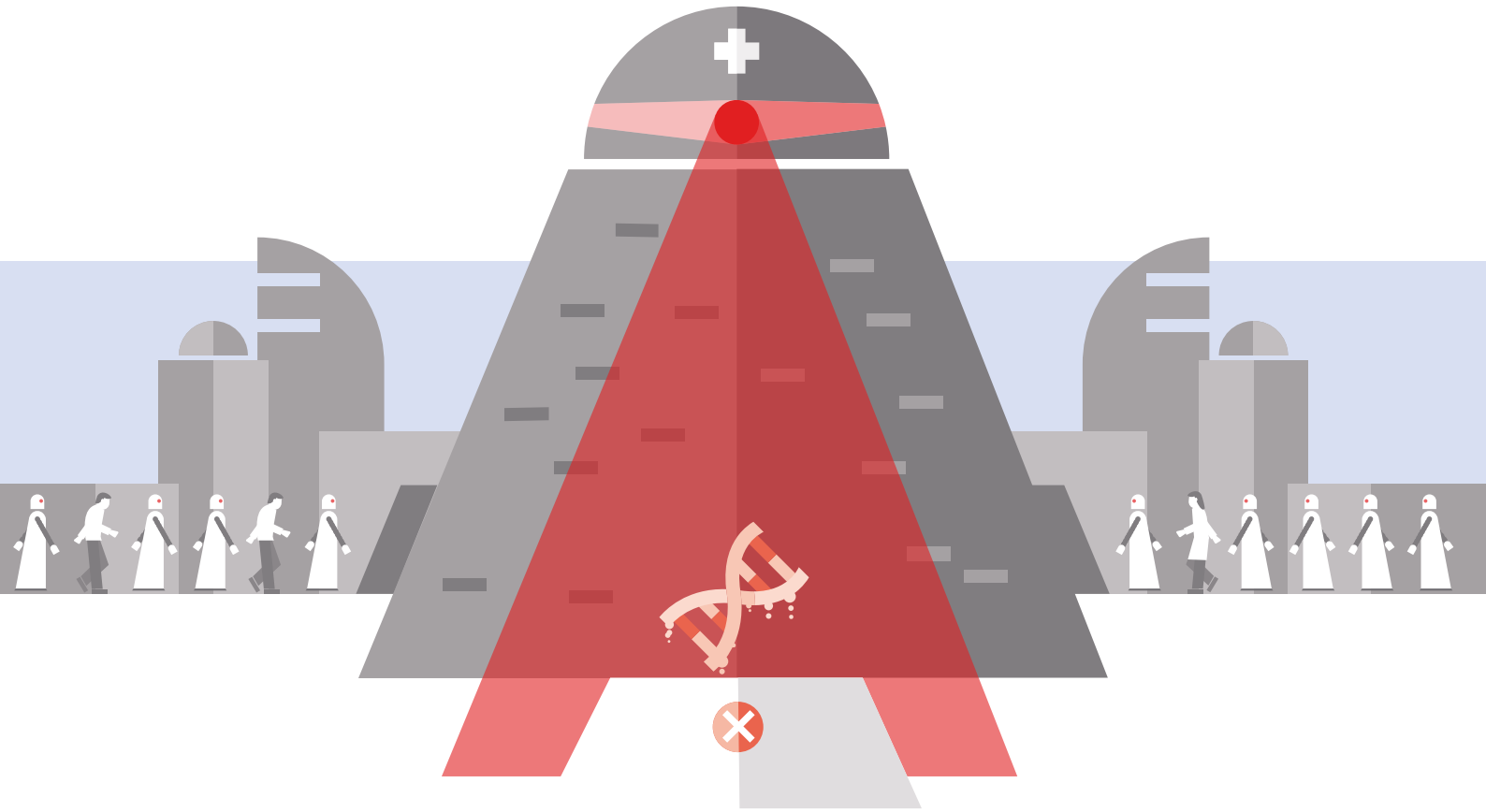
Scenario D | Neighbourhood Science

Individuals and communities are empowered by their ability to connect to others with similar interests. They use high connectivity to fund specific, localised research on the issues that matter to them, with a focus on wellbeing and quality of life. Research is as likely to be conducted by citizen scientists and patients as by trained investigators.

Scenario **A**

Techtopia

The world is technologically advanced, with fewer people in employment as machines and technology have taken over many roles that were previously carried out by humans. There are a few key private technology corporations dominating all elements of medical research, owning most of the data and choosing where to invest. There is a smaller, private ecosphere driven by philanthropic entrepreneurs who are paying for research to be undertaken in neglected areas. All medicine is personalised and mapped against the genetic predisposition of individuals. Disease interception and genetic modification is the norm.



This is a world shaped by transformational technology, and the private technology corporations who control it. Many jobs are now performed by artificial intelligence and robots. Empathy and imagination are highly valued employee attributes, and those who work for the private corporations are rewarded well. The unemployed masses receive a universal basic income.

Research is entirely funded by private individuals or corporations as public taxation revenues are depleted. Corporations require economic returns: intellectual property from which they develop new products and services, or data that they can use to drive more research.

Research is conducted in cloud labs and is mainly an automated process using predictive and big data technologies. Where data doesn't provide an immediate answer, computers generate new hypotheses and interrogate vast databases. Human researchers and engineers correct data and software errors. They also judge the morality of research programmes.

Networks of researchers have shrunk as concerns about IP and industrial spying reduce sharing and collaboration. Researchers are more insular, pursuing "moonshot" type research for corporations. Down-to-earth and curiosity-led research is neglected, unless it yields financial returns. Philanthropic entrepreneurs fund research into problems affecting poorer populations based on their personal hopes for change.

The rise of developmental and evolutionary robotics has rid the need for entire medical disciplines. Robots perform surgery and take images, and machines interpret the results. The skill in these disciplines is now in programming, engineering, and keeping machines and software healthy.

All humans have their DNA mapped and analysed to predict disease and reduce risk. Technology alters gene expression and "designer" babies are commonplace. Wearable and implanted data chips are the norm and individuals - particularly those who cannot afford personalised medicine - are constantly monitored, providing data of great value to technology companies.

Medical advances keep people well for longer. Life expectancy continues to rise, while the global population is shrinking. Machines have replaced human carers. Patients are triaged in the cloud when data flags up worrying trends. Medical facilities are small and are owned and run by the technology corporations, directly assisting their research programmes. Virtual reality is replacing many real social interactions, and loneliness no longer exists as a health problem.

Insights from leading figures

"At the moment ... an awful lot of time is spent [working on] alliances and programmes, and doing all that scholarly research work that needs to be done to set up research trials. A lot of that is going to be swept away and much of the research can and will be automated and done in real time ... This is a very different way of conducting research than conventional research. It will be data driven and the people who can master the technocratic arrangement of both the technology and the commercial underpinnings of that will win... Many people conducting research in a conventional way will look like dinosaurs."

"In 20 years we will all have extremely capable, remarkably autonomous freeform digital assistants. There will be a lot of shake up in roles done by people. A lot of what's happening now in AI, is taking things that were previously the purview of human intellectual capability and turning that into things that will be done by machines, in other words important thinking jobs."

"AI technologies will be game-changing for the analysis and publishing of research - taking large datasets and creating learning and patterns of behaviour. It will be common within 10 years to be able to check up for things that are likely to happen in the future rather than check up on things that have happened."

Weak signal: Genetic re-engineering

CRISPR/Cas9 is a gene-editing technique that can target and modify DNA with groundbreaking accuracy. It is possible to snip out a section of DNA sequence from a gene and put a different one in very quickly and accurately. There is an international moratorium on all therapies for making heritable changes in human genes until they are proved safe and effective, however, in February 2016 UK's independent fertility regulator gave a research team permission to use CRISPR to explore the mechanisms of miscarriage with human embryos.

Weak signal: Wearable technologies are on the rise

Manufacturers are looking at ways of assisting patients with particular medical needs through wearable technologies. For example, Novartis and Google teamed up to investigate the possibility of building a smart contact lens that can measure glucose levels of diabetes patients through their tears.

Scenario B

Sustainable Health: 2037

In this world governments are focused on collaborative efforts to solve some of the world's biggest problems. They are entrusted to manage a programme of "softer globalisation" to provide society with the opportunity to adapt to technological advances and secure future economic sustainability. Governments have worked together to introduce regulated data collection about individuals, ensuring it is used transparently and ethically. High levels of international, industry and cross-industry collaboration are encouraged through government incentives.

By 2025 migrating populations have significantly increased owing to conflict and the expected large-scale impact of climate change. Together with global population ageing, this has exerted unprecedented pressure on public services. Civil society is also threatened by the large-scale replacement of professional workers by machines. Nations are coming together to address these big, global issues.

An international treaty enshrining the right to work is signed in 2027. A combination of regulation and taxation have encouraged a diverse and highly collaborative research ecosystem including technology corporations, academic research institutions, patient groups, venture philanthropists, charities, smaller biotech companies and crowd-funded labs. National governments sign up to a joint research framework prioritising areas that will make the biggest difference to global population health such as infections, dementia, and chronic disease prevention. Curiosity-driven research is also common, particularly in Africa where innovative local and international start-ups are attracted to the relatively low research costs.

In 2037 an open science culture prevails in which international, cross-industry and interdisciplinary collaborations are the norm, and research data and software are freely available. Researchers progress their careers by producing high quality data sets in areas prioritised by governments, which are assessed in accordance with international outcome measures. Most researchers combine scientific qualifications with advanced engineering, programming or policy and communications expertise. A large proportion are employed by international health agencies.

Global surveillance and laboratory systems continually monitor data to detect outbreaks, analyse epidemiological trends and predict the spread of diseases. Patients donate their live data via implanted sensors to the International Health Service, which is managed using proven and trusted technology pioneered at England's Digital National Health Service. Research institutions pay to access this data on behalf of researchers transparently and ethically.

Machine learning allows computers to analyse and interpret huge datasets in real time, rapidly reaching influencers of the world's most costly diseases. Dementia incidence, for example is plummeting. DNA analysis to inform clinical management and research is possible at the point of care. Behaviour change tools using virtual, augmented and mixed reality technology are rapidly making lifestyles healthier, even in remote regions.

However, the replacement of human-to-human interaction by pervasive technology is exacerbating mental health problems associated with social isolation and loneliness. Ever increasing life expectancy raises a new ethical question: at what point do longer lifespans yield diminishing returns for society?

Insights from leading figures

"I think the key driver is to improve value for money because by working with others you can pool resources and address big problems that a single organization could not address in the same way. There's maybe a trend for research to get bigger, there are bigger problems that need to be looked at from different angles."

"Inter-industry collaboration stops the replication of data over and over in other companies also working in that space..."

"I could see the open data agenda is moving forward and expanding, and more things will be made publicly available at an earlier stage with the potential to have more discussions earlier on. ... Consortia could get larger. Technology and machines get more and more expensive so they need to be shared between more researchers. So there'll be more sharing of data and equipment".

"In order to have any traction on research outcomes, you need to run those sorts of trials across borders, because that is the only way you get sufficient numbers of people who are phenotypically similar to be able to do that sort of research. So you've not only got the supply side becoming international, but the demand side of the people who use it, is also international".

Weak signal: International initiatives

The UN's 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development came into force in January 2016. The new Goals are unique in that they call for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection.

Weak signal: Legislation for quotas of human workers?

A recent study by the International Bar Association claimed robotics could force governments to legislate for quotas of human workers. The UN has recently opened a new centre in the Netherlands to monitor artificial intelligence and predict possible threats, including the risk of mass unemployment.

Scenario C

Post-West
Power Shift

Economic headwinds have led Western governments to refocus research funding, while increasingly populist policies are curtailing international movement and collaboration. Meanwhile, sustained economic growth in the Global South is causing a geographic shift in the international research landscape. This scenario explores a world where the West has lost its dominance and China leads the way in healthcare research.

Harder economic times and populism in the West have curtailed international movement, and political agendas now focus narrowly on issues of national security and economic health.

In the West, contraction of higher education institutes and "brain drain" have reduced overall research capacity and output. Nations aim to fund "less, more useful" research, with a focus on demonstrating short term, tangible economic impact or benefit. Curiosity-driven research is scarce. Lower impact or negative research may be hidden if it is detrimental to impact assessment and funding allocation.

Researchers are employed by public research and healthcare facilities. Public payers focus on fast, low-cost, "real world" research on costs and benefits of healthcare interventions. Niche areas of biotech which boost industry, to which academic research has increasingly close ties, still attract national funding. Incremental advances in the UK in areas such as genetic and regenerative medicine reflect the high market value of the associated IP.

Sustained economic growth has led to the dominance of many Asian, African and South American countries, led by China which is the new global research and education powerhouse. These "emerged countries" attract the best researchers, particularly in fields with long term research objectives, which are off the agenda in many Western countries, and in traditional holistic care which is widely practised alongside Western medicine. Many experienced researchers have returned from the West to their countries of origin, using their international connections to poach the best researchers. International collaboration has, however, declined, the global open science movement has stalled and advances in precision medicine have slowed without the availability of large international data sets.

Only selected research is shared internationally. Research misinformation may be fed to competitor nations in high value fields and some cash-strapped domestic research may also be untrustworthy.

Nationally-open, local language repositories and platforms for research and data prevail. China has led the way with mega-systems that allow researchers to complete most tasks at the touch of a button. Integrated, AI-powered research impact metrics assess the national economic, social, and scientific impact of all datasets, research papers, software, materials and other research outputs in real time.

Insights from leading figures

"There will be a shift to the East in 10-20 years. The Western privileged position at the top of the pile of innovators will be challenged by a fast-moving, ambitious Eastern tiger... ".

"We used to think of these places [India, China, Africa] as recipients of funding, but actually they are the new intellectual engines".

"...[Europe] don't want to lose access to the UK as much as we don't want to lost access to them. I don't know if an arrangement can be struck, rather like Norway or Switzerland, to continue – it's the participation, not the money that's important."

Weak signal: Rise of populism

The Munich Security Report 2017 states:

"Liberal democracies have proven to be vulnerable to disinformation campaigns in post-truth international politics. Citizens of democracies believe less and less that their systems are able to deliver positive outcomes for them and increasingly favor national solutions and closed borders over globalism and openness. The willingness and ability of Western democracies to shape international affairs and to defend the rules-based liberal order are declining. The United States might move from being a provider of public goods and international security to pursuing a more unilateralist, maybe even nationalistic foreign policy...Populist parties are now part of the government in about a dozen Western democracies...there is also a backlash against so-called "globalism" ... We may, then, be on the brink of a post-Western age"

Weak signal: Growth in research output and quality in Asia

The Nature Index 2016 Rising Stars supplement shows that Chinese institutions are leading the world in rapidly increasing high quality research outputs. 40 of the top 100 highest performers across the globe are from China, with 24 of those showing growth above 50% since 2012.

The global top 10 of most improved institutions is occupied by academic heavyweights such as the Chinese Academy of Sciences (first). Nine Chinese institutions in total occupy the top 10 positions, including Peking University (second), Nanjing University (third) and the University of Science and Technology of China (fourth). South Korea's new Institute for Basic Science (11th) increased its contribution to high-quality journals by more than 4,000% in four years. The King Abdullah University of Science and Technology (KAUST) is placed 19th. Nanyang Technological University, Singapore, takes the final place in the top 20.

Scenario **D**

Neighbourhood Science

In 2037 social media has empowered the individual. People are able to join both physical and virtual communities, large and small, to resolve societal and health related problems. They are highly connected to others with similar interests, and use crowdsourcing to fund specific, localised research with a focus on wellbeing and quality of life for themselves and their communities.

In the wealthier world connected and empowered communities are taking matters into their own hands. Educated since primary school about the importance of "healthy information diets" and environmental health, they have rejected a system that allows big corporations to freely manipulate their data for clicks, and for economic concerns to dominate the research agenda.

The voice of the people drives the setting of scientific priorities. Interest has shifted from finding cures for diseases historically prioritised by industry, towards research that can improve quality of life. There is increasing investment in research at the boundaries of health and social care, such as behavioural and environmental sciences, and enabling those suffering with debilitating conditions to live with a sense of belonging and of being a valued part of community and civic life.

Expiring patents, reverse engineering of drugs and reduced support from public agencies have reduced Big Pharma's influence. Smaller biotech and pharmaceutical start-ups and venture philanthropists invest in investigator-driven studies, often with long research cycles. Universities partner with them and also with the crowd-funded labs that have evolved into well-funded entities.

Clinical research is a niche interest, given that the big chronic diseases have declined in most developed countries. Highly innovative and technology-driven studies solve circumscribed problems, benefiting relatively few people and driven by self-defined interests of patient and community networks, small charities, and start-ups. Funds come from small investors, public appeals based on emotional human interest stories and - when a study has longer term profit potential - from the biotech companies, venture philanthropists and university start-ups.

Population-based research focuses on social and 'framily' wellbeing and sustainable lifestyles. Data come mostly from 'real-world' sources, in particular from social networks and community apps that share personal stories and health information. Funding for such studies comes from crowdsourcing, selling patient data to trusted entities, and from food and fitness companies. This research is as likely to be done by citizen scientists and patients as by trained investigators. Use of primary care services has fallen dramatically, with informed patients receiving support from their communities in settings closer to home.

In less developed countries research is still driven by the need to survive in the face of poverty, instability, and climate change although international research communities get crowd-sourced funds and investment from venture philanthropists to evaluate and implement immunisation and other large scale disease prevention programmes. Engineers use their local and technology know-how to develop innovative health diagnosis and improvement tools, receiving crowd-sourced and charitable funds to implement wider-scale adoption of their products.

Insights from leading figures

"...the rise of the voice of the people in setting scientific priority ... we may find that people are less interested in a cure for X and are more interested in things that are more nebulous ... not clinical in the way that we define it".

"The mistrust of experts may change very much the way in which we think about research and research prioritisation. There are some folks down in Hackney ... using second-hand equipment from UCL and they get their reagents from proper universities, and they are either jobbing scientists or they were jobbing scientists, or they're people who do other jobs that have a science background, and they are doing real experiments, and they are uploading their research".

Weak signal: Public engagement in science

A key recommendation of the EU's Directorate-General for Research and Innovation is to mobilise and involve citizens:

"... the future EU R&I programme should aim to become the biggest co-created and co-creation programme in the world. The EU R&I programme should provide incentives for stakeholders and end-users to participate more widely in its multi-annual programming, for example through identifying, debating and possibly even deciding which EU-level missions to choose...This could give rise to new types of partnerships... where "people" are working together with the public and private sector".

Weak signal: Crowdsourced health studies

The King's Fund states that social media is already supporting new online communities of patient groups, and the impact of on health and social care can be expected to grow, particularly with increased transparency about services and outcomes. Furthermore, the data-driven social network, Patients Like Me, has conducted the largest number of crowdsourced health studies so far, and has over a million users with rare diseases.

Further reading

Scenario planning resources

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