Open innovation in health

A guide to transforming healthcare through collaboration

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Acknowledgments

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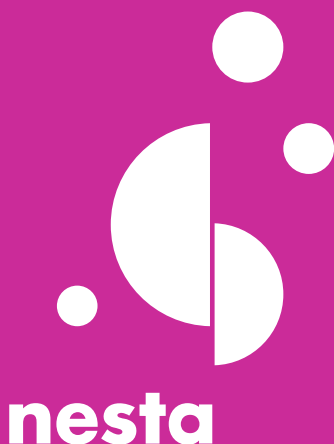
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Executive summary

This guide explores examples of open innovation in the field of health from around the world. It analyses the ways that companies, governments, researchers and citizens are collaborating to improve the innovation process, from the way that problems are identified to how new products and services are created and then adopted by providers of healthcare.

Open innovation is a simple idea: the best ideas and knowledge aren't necessarily found within big companies, top universities or established networks. Methods that tap a wider range of people can generate better ideas, at lower cost. They can also democratise innovation, giving a wider range of people a say in setting priorities.

However, that is easier said than done, and there often needs to be an active process to develop these ideas into a useful form. This is why we think this guide will be useful: it provides many practical examples of organisations that have embraced open innovation methods and highlights the lessons that we think will be useful for other organisations that want to try to improve their innovation processes with open innovation methods.

While this guide is primarily aimed at policy and decision-makers looking for ways to improve health innovation, we think that many of the lessons and principles it contains can also be applied in other sectors.

The guide was developed as part of a collaborative project - São Paulo: Open Innovation in Health - funded by the UK government's Prosperity Fund and the São Paulo State Government. The project was developed in partnership between the governments of the United Kingdom and the State of São Paulo (Brazil), and implemented by Nesta and 100%Open (UK) and Fundação Carlos Alberto Vanzolini and Fundação Instituto de Administração (Brazil).

Over a 12-month period, the partners worked together to design and implement two open innovation pilots in the State of São Paulo. This experience helped to demonstrate how the ideas in this guide can be used to inform a health administration's strategies and practices. Although health systems vary widely across countries, there is much scope for mutual learning about ways to promote and support innovation.

What do we mean by open innovation in health?

In this guide, we use the term 'open innovation' to describe new forms of collaboration between different people and organisations involved in health innovation. In particular, we document new kinds of collaboration between three sets of actors:

• **Public sector** (health service and/or research organisations) and **private sector organisations**.

• **Health service/research organisations** and their **employees** (practitioners and researchers).

• **Health service/research organisations** and the **people they serve** (citizens/patients).

While collaboration in itself is nothing new in health innovation, these initiatives are distinctive in the way that they blur traditional divisions of labour between different actors. They can be seen as an attempt to move towards what we perceive to be more 'porous' health innovation systems - systems where, for example:

• **Evidence and data** are generated openly and collaboratively.

• **Ideas** can come from anywhere, not just health professionals and researchers.

• Innovation is informed by the **needs** of patients and the **knowledge** of practitioners.

• **International collaboration is encouraged** as policymakers realise that health systems around the world can benefit from each other's learning.

It is important to note that open innovation methods can be combined with proprietary approaches to intellectual property (IP). In that sense, they can prove useful for universities and businesses that adopt traditional models of research and development.

The initiatives outlined in this guide tend to be underpinned by one or more of the following three main objectives:

1. **Making health innovation more efficient**. Many open innovation initiatives attempt to make health innovation quicker, cheaper, better directed towards already-identified areas of need, and more widely adopted and diffused.

2. **Informing health innovation with a better understanding of health system and patient/ citizen needs**. Inventors do not always understand the needs of health systems and patients, or may not have access to the information and data required to best meet them. Open innovation initiatives can help overcome these gaps.

3. **Making health innovation more democratic**. Health innovation has traditionally been dominated by professionals, while patients, members of the public or people working in non-health sectors have found it harder to get their ideas into the system. As a result, health innovations may fail to address citizens' priorities. Open innovation can give citizens and patients more opportunities to participate and set the agenda.

These objectives are not mutually exclusive. Some initiatives simultaneously pursue all three. It is nevertheless important to recognise the tensions between them: for example, pursuing more democratic decision-making may result in a more efficient innovation system, but it may involve extra costs in the short term.

Open innovation across the innovation cycle

This guide analyses 18 types of open innovation initiative, illustrated by examples from around the world. It identifies open innovation approaches across the innovation cycle:

Problem identification

The first stage in the innovation process is problem identification: gathering information about experiences and needs, facts about the transmission of diseases and evidence about the efficacy of interventions, both to inform the development of innovations and to help policymakers and funders best target their resources. At this stage, open innovation can mean involving a wider range of actors in collecting and sharing data to more efficiently monitor health issues, for example through data mining and data crowdsourcing. It can also mean giving citizens a role in informing the health innovation agenda, through peer research and participatory priority setting.

Community Health Agent Programme, Brazil

The Brazilian Community Health Agent Programme employs community health agents (CHAs) - established residents of a given neighbourhood, with the ability to build effective relationships with other local residents - to provide insights into the problems experienced by the communities they work in. These insights are used to inform the wider public health activities. In São Paulo, intelligence gathered by CHAs was used to inform health workshops for groups who have been identified as at particular risk.[1] Evidence suggests that the model leads to better access to and satisfaction with services, and it has been associated with substantial improvements in both child and adult health.[2]

Invention

Inventors are often imagined as lonely geniuses working away in a lab. By contrast, open innovation involves bringing a wide variety of actors together to generate new ideas and possibilities. Open innovation at this stage can take the form of collaborating to tackle neglected health issues, for example through **challenge prizes** and **data-sharing initiatives**. It can also mean bringing innovators close to health systems and patient needs, for example through **pre-commercial procurement programmes**, **clinician innovation programmes**, and **ethnographic** and **design approaches**. It can equally mean opening up the invention process to citizens, so that innovation processes better reflect their priorities, using methods such as **co-production** and **co-design**.

The Bright Ideas Fund

The Bright Ideas Fund, launched in 2009 by Guy's and St Thomas' Charity (GSTT), exists to support and invest in the innovative ideas of staff working in Guy's and St Thomas' Hospitals in London.[3] It supports frontline practitioners to take new ideas from concept to the prototyping stage, by providing funding and advice on intellectual property and helping innovators to find commercial backing. A notable example is Desperate Debra, a teaching tool for practising delivery techniques for emergency caesareans, developed in 2011 with support from the fund.[4] Through the scheme, the consultant obstetrician who came up with the idea was able to collaborate with a team including a consultant midwife and a professor of obstetrics working at the hospital. He also received intellectual property and legal advice from a specialist at GSTT. Desperate Debra has been successfully commercialised and is now used as a standard practice training tool.

Adoption and diffusion

Innovation has sometimes been described as invention plus adoption.[5] There is ample evidence that good ideas do not 'sell themselves': the processes by which new ideas are tested, adapted and ultimately adopted are vital. Collaborative approaches to promote successful and timely adoption of new ideas include publicising promising innovations, for example through **online marketplaces** and **diffusion support programmes**.

The NHS Innovation Accelerator

The NHS Innovation Accelerator is a fellowship programme launched by NHS England in 2015. It supports selected participants - a mix of clinicians, SMEs and academics - to scale up their innovations within the NHS in order to improve health outcomes.[6]

Fellows accepted onto the accelerator receive mentoring from health system and innovation experts, and a bursary. In its first 17 months, the accelerator supported 17 fellows to get their interventions taken up in 419 organisations, and to raise over £20 million in funding. One successful innovation accepted in the first year of the NIA was the PneuX Pneumonia Prevention System, a cuffed ventilation tube which aims to prevent ventilator-associated pneumonia (VAP), the most common cause of hospital-acquired mortality in Intensive Care Units in England. Since the joining the NIA, PneuX has had a successful hospital trial, including an economic evaluation which showed a saving of £718 for each patient receiving treatment with the PneuX.[7]

Success factors and challenges for open innovation initiatives

What does all of this mean for decision-makers looking to use some of these ideas in practice? Based on our research and our learning from applying open innovation ideas in São Paulo, this guide identifies some important success factors:

1. **Respond to gaps in the innovation system**. Open innovation initiatives are most effective when they address a clear need or specific barrier to innovation. For example, the Zeroto510 accelerator in Memphis, USA was set up to address regulatory issues, while the NHS Innovation Accelerator aimed to help professionals gain the skills and networks they need to spread their innovations.

2. **Capitalise on existing strengths and resources**. When attempting to set up open innovation initiatives, capitalise on resources which are present. The Open Medicine Project South Africa (TOMPSA) has made use of the wide availability of smartphones to create software innovations that address the needs of frontline health practitioners.

3. **Start small and simple**. While health policymakers are under immense pressure to tackle their most challenging problems first, open innovation is a relatively new set of methods. Many successful initiatives start with low hanging fruit, or with fairly modest ambitions. Succeeding on these projects can help demonstrate impact, and generate support to expand and achieve greater things.

4. **Gain support from health leadership**. Support from leadership is widely cited as a key factor in the success of open innovation initiatives. In certain cases, these figures play the role of 'rogues' within the system who are willing to support and advocate for the initiative from within. In other cases, the involvement of high profile leaders or institutions adds prestige and even creates a brand for the project.

5. **Build strong relationships with health services at different levels**. While these relationships with high level leaders are important, strong relationships with health services at different levels also tend to play an important role in enabling a strong understanding of system needs or timely feedback.

6. **Support teams of innovators**. Having the right core team is indispensable. For example, in the case of fellowships and accelerators, this is a question of finding a group of people with the right skills and experience (for example entrepreneurial experience, or expertise on regulation and IP) who are willing to give of their time to work behind the scenes in order to provide participants with the resources they need. This might involve setting up meetings and opportunities to exchange across different organisations, or providing specific training to fill innovators' skills gaps.

7. **Provide opportunities for interdisciplinary working**. Several programmes provide opportunities for participants to work closely with people from different professional backgrounds, with whom they might not usually have contact. This gives people new perspectives, and also means participants can fill each other's knowledge gaps (for example, clinicians who may lack expertise in IP).

8. **Focus on innovators as well as innovation**. Successful programmes often emphasise their recognition of the importance of choosing the 'right innovators', rather than just the right innovations - for example, innovators committed to public benefit from their innovations rather than simply profit, as well as innovators with the people skills to drive widespread diffusion of their ideas.

The new possibilities offered by these more 'open' forms of innovation also come with new challenges and tensions. These are discussed throughout the report, and range from the complexities of patient- or citizen-generated data to the challenges of opening priority setting up to greater participation while avoiding capture by narrow (but influential) sectional interests. The challenge facing aspiring 'open innovators', we suggest, is not to perfectly resolve these tensions, but to negotiate them.

1. Introduction

This guide explores how innovation in health can become more open and collaborative. It is for policymakers and decision-makers in health systems looking for ways to improve health innovation - for example, to make it cheaper, faster, more democratic and more responsive to real-world needs.

The guide is structured as follows:

- **Section 2: Open innovation in health: an overview** explains what we mean by open innovation in health.

- **Section 3: Open innovation across the innovation cycle** introduces a range of initiatives from around the world that have attempted to open up health innovation to input from a wider range of people and organisations.

- **Section 4: Creating more porous health innovation systems** draws out lessons from these open innovation initiatives, and explores how policymakers and decision-makers can use these lessons to improve health innovation.

Although the examples in this guide are all specific to the health sector, the principles of open innovation we describe, and the lessons that we draw out, can be applied in other sectors as well.

Why we created this guide

This guide was developed as part of a collaborative project - São Paulo: Open Innovation in Health - funded by the UK government's Prosperity Fund and the São Paulo State Government. The project was developed in partnership between the governments of the United Kingdom and the State of São Paulo (Brazil), and implemented by Nesta and 100%Open (UK) and Fundação Carlos Alberto Vanzolini Foundation and Fundação Instituto de Administração (Brazil).

Like many middle-income settings, São Paulo faces a dual challenge - fighting infectious diseases, notably Zika and dengue, while also tackling 'diseases of affluence', like heart disease and diabetes. Addressing these problems requires innovation in a range of areas, from surveillance techniques and diagnostics to service models and behaviour change campaigns. While São Paulo has considerable strengths in terms of innovation, the project partners were interested in the potential benefits that a more collaborative and open approach to innovation processes could bring to health outcomes.

Our project aimed to identify and test methods of open innovation that could help health research institutes in the State of São Paulo accelerate the incorporation of scientific research results into products and services to improve population health. To do so, the project team analysed open innovation initiatives in health systems around the world, and designed and implemented two open innovation pilots.

Working together on this project helped show that although the health systems, contexts and challenges in the UK and São Paulo are distinct, the two countries also display some similar problems and opportunities. We believe that this demonstrates the possibility for considerable mutual learning between practitioners and policymakers in different health systems. While initiatives developed in one context cannot usually be transposed completely unchanged to a new location, there is real potential for adoption and adaptation of these approaches in new places.

2. Open innovation in health: an overview

This chapter starts by providing a brief introduction to the concepts of health innovation and innovation systems. We consider some of the key problems that have been associated with conventional approaches to health innovation. Finally, we give an overview of open innovation approaches and how they may offer solutions to some of these problems.

Health innovation: a brief introduction

Innovations are new ideas that are put into practice, creating value for users or customers. They can be radical, completely changing the way that things are done, or incremental, making small improvements over what has gone before.

Applied to health, innovation has a wide range of meanings. Health innovation includes innovations in healthcare, as well as innovations to prevent illness and promote health and wellbeing. It might take the form of new products, services, processes, organisations or policies. In fact, it often involves several of these simultaneously. Successfully launching a new technological innovation, for example, might require developing complementary technologies, new business models, new processes, new roles for patients and clinicians, or policy changes.

Types of innovation in health

	Examples
Technological and clinical innovations	New therapeutic drugs, diagnostic tests, medical devices, software, surgical techniques
Process and service innovations	New institutions, business models, service models, clinical pathways, roles, education and training
Systems innovations	Policy innovation, systems reform

Adapted from: Hertog et al (2005)[8]

It is important to note that health innovation - like other kinds of innovation - means more than just invention. The innovation process is often understood as a series of stages, starting with identifying a problem that needs solving, and finishing with the spread of a new solution to a wider market.

Identifying, breaking down,
and carrying out research
into different health problems

Problem identification

Developing ideas
for new services
or products, or
new ways of
providing a
service

Invention

The wider uptake
of the idea,
service or product
into use across
the whole
organisation or
many organisations

Diffusion

Adoption

Putting new ideas into practice,
including prototyping, piloting,
testing and evaluating
safety and effectiveness

Health innovation systems and their challenges

For the purposes of this guide, we take the term 'innovation system' to mean everyone who is involved in health innovation in a given place. This could include companies, universities and research institutes, local or national government, NGOs, community groups and individuals. These actors perform a range of functions, from developing policies designed to support innovation, through to knowledge generation, financing, and the application of new technologies and processes.

Example: the health innovation system in the State of São Paulo

Citizens and civil society	Individual citizens and organised groups formed by people with common interests, such as community and patient associations. Examples include Association for Supporting Children with Cancer, Association of Friends of Autism, Brazilian Dyslexia Association.
Implementers	Small and medium-sized enterprises (SMEs), large companies and startups in fields such as medical equipment, pharmaceutical products and services (hospitals, diagnostic, therapeutic, outpatient services). Intermediary agents: insurance companies and the national public health system, called SUS (Unified Health System), which organise and influence the supply and demand for health products and services. Associations of companies, including: the Brazilian Medical Devices Manufacturers Association (ABIMO), Brazilian Association of High Technology Products Industry for Health (ABIMED), Federation of industries of the State of São Paulo (FIESP), Union of the Pharmaceutical Products Industry in the State of São Paulo (SINDUSFARMA).
Institutes of Science and Technology (ICTs)	Universities, hospitals, and scientific and technological institutions, such as University of São Paulo (USP), Clínicas Hospital, and the seven institutes connected to the State Secretariat of Health, among them the Adolfo Lutz Institute.
Funding agents	Federal public funds: Ministry of Health - Research Programme for the Health Unified System (SUS), National Council for Scientific and Technological Development (CNPq), Brazilian Innovation Agency (FINEP), National Development Bank (BNDES). State public funds: São Paulo Research Foundation (FAPESP). Foreign and international organisations: National Institutes of Health (NIH), Pan American Health Organization (PAHO). Venture capital funds, seed money and private equity, and relevant associations such as Brazilian angels association – Associação Anjos de Brasil (angel investors), Brazilian Association of Private Equity and Venture Capital (ABVCAP). Philanthropy, including Brazilian foundations, such as the Tide Setubal Foundation and Maria Cecilia Souto Vidigal Foundation, and international funders, such as Bill & Melinda Gates Foundation.
Connectors	Government Departments: Health; Economic Development, Science, Technology and Innovation. Technology Transfer Offices – NITs (TTOs). State Council of Science, Technology and Innovation in Health. Council of Research Institutions of the State of São Paulo (CONSIP) Rede Inova São Paulo – a network of research institutes' TTOs. Brazilian Alliance of the Innovative Health Care Industry (ABIIS).
Facilitators	Brazilian Association of Technical Standards (ABNT). Accredited calibration and testing laboratories. Professional associations in fields such as neurology, obesity, Alzheimer's, intensive care medicine, surgery, ophthalmology, allergy and immunopathology, anesthesiology, oncology, diabetes, rheumatology and hematology.
Innovation environment	Some technology parks,[9] such as the SUPERA Technology Park in Ribeirão Preto, with a strong healthcare focus. Several technology-based incubators, including the Innovation, Entrepreneurship and Technology Centre (CIETEC), the largest in Brazil, located at USP's campus in São Paulo. Several accelerators and spaces to support entrepreneurship.

Health innovation systems tend to have a number of distinctive features, when compared to the innovation systems of other sectors. First, state health systems represent major - in many cases the major - customers for innovations, but they are also extremely complicated (and often fragmented) customers. Secondly, health innovation systems are unusual in that their major innovation customers - health systems - are distinct from their major innovation 'users' (patients/citizens). Another distinctive structuring dimension of health innovation systems is the special status of biomedical knowledge in contemporary societies - and of the experts who have mastered this knowledge and institutions in which it is enshrined.

Established health innovation systems certainly produce a lot of innovations: in 2013, globally 124,000 patents were filed in the fields of pharmaceuticals and biotechnology alone.[10] Nevertheless, there are some well documented problems with dominant models of innovation in health:

1. **Inefficiency**. Health innovation is often inefficient in several ways. It may be:

   • **Slow**: While the oft-quoted refrain that it takes, on average, 17 years to move from evidence to clinical practice has now been scrutinised and contested,[11] it is widely agreed that the process of research translation is subject to significant time lags.[12]

   • **Expensive**: In many countries, health expenditure is rising faster than economic growth. This is due not only to increasing demand for existing services, but also (in some instances) to the escalating costs of innovation, particularly drug development and clinical trials.[13]

   • **Poorly targeted**: Health innovation does not always address the areas that have been identified as high priority. For example, there is a recognised lack of innovation to tackle so-called neglected tropical diseases.[14] Meanwhile, influential innovation theorist Clayton Christensen argues that too much money is invested in innovating high-end technologies, and not enough on low-cost, 'disruptive' solutions.[15]

   • **Poorly adopted and diffused**: Even when there is good evidence that new practices, technologies or service models are effective, adoption and diffusion across systems can be limited.[16] For example, while practitioners generate a considerable amount of innovation, these rarely spread to other settings.[17] There has also traditionally been little flow of ideas from the Global South to the Global North.[18]

2. **Gaps in understanding of needs**: Those involved in the design of innovations are often several steps removed from the world of healthcare practice. Inventors may not truly understand the needs of clinicians, or may not have access to the information and data required to best meet them. By the same token, even innovations developed by experienced clinicians may suffer from a failure to address key patient needs that are sometimes obscured from a clinical perspective.

3. **Dominated by professionals**, with the assumption that only they have the expertise to innovate and set the agenda.[19] Patients, members of the public or people working in non-health sectors have found it harder to get their ideas into the system. As a result, health innovations may fail to address the priorities of citizens.

The potential of open innovation for health

How might some of these problems be overcome? Some answers can be found in the emerging set of approaches that we group together in this report as forms of **open innovation**.

Open innovation in health, as we define it in this guide, refers to new forms of collaboration between different actors involved in the health innovation process. Notably, it refers to new kinds of collaboration between:

- **Public sector** (health service and/or research organisations) and **private sector** organisations.
- **Health service/research** organisations and their **employees** (practitioners and researchers).
- **Health service/research** organisations and the **patients and citizens** they serve.

Collaboration in health innovation is nothing new. What makes open innovation approaches distinctive is the way in which they blur traditional roles between actors. For example, public health systems have long collaborated with pharmaceutical companies, but traditionally this has involved companies developing profitable products and the state distributing the results for public benefit. Through **product development partnerships** however, pharmaceutical companies come to apply their expertise to neglected (and traditionally unprofitable) health challenges. Meanwhile, through **clinician innovator programmes**, public sector health organisations encourage staff innovation and entrepreneurship. Likewise, **peer-research driven approaches** allow citizens to play the role of researchers rather than passive 'patients' or 'service users'.

These approaches, as we define them, can be understood as driving towards more 'porous' innovation systems. We suggest that porous innovation systems are those where, for example:

- **Evidence and data** are generated openly and collaboratively.
- **Ideas** can come from anywhere, not just health professionals and researchers.
- Innovation is informed by the **needs** of patients and the **knowledge** of practitioners.
- **International collaboration is encouraged** as policymakers realise that health systems around the world can benefit from each other's learning.

Chesbrough's concept of open innovation

Making innovation happen is complex. It requires managing uncertainties and achieving changes that provoke a wide range of reactions from enthusiastic embrace to active resistance. As a result, the field of knowledge called innovation management proposes strategies, models and practices to increase success rates. It is in this context that the concept of open innovation arose in the last couple of decades.

The main promoter of this idea is Professor Henry Chesbrough of University of California, Berkeley. *In Open Innovation: The new imperative for creating and profiting from technology* (2003) he sets out his research on why Xerox failed to capture value from the outstanding results generated by its Palo Alto Research Center (PARC). Chesbrough says that the main reason was that *"Xerox managed PARC through a closed innovation paradigm: The corporation sought to discover new breakthroughs; develop them into products; build products in its factories; and distribute, finance and provide technical assistance to those products – all within the four walls of the company."*

Chesbrough noted that most of PARC's achievements occurred only when researchers left Xerox and started working in small companies or set up their own businesses. As those companies could not afford to carry out all the steps involved in the closed innovation paradigm they had to develop business models which involved collaboration with other companies on the development and commercialisation of their technologies.

Chesbrough described this 'open innovation' approach as *"a new paradigm to understand industrial innovation"*. In an open innovation context, ideas from outside the company and external paths from the company to the market are given the same level of importance as internally generated ideas and traditional paths to bring new products to the market. This term was coined by Chesbrough to describe a process that businesses have embraced for a number of years.

Many businesses have been quick to adopt open innovation practices. Some of the main reasons for this are: (i) developing new complex products requires knowledge diversity, so even the most powerful company will not have all the required skills; (ii) contemporary markets demand new solutions at speed, which large companies' organisational structures are not well adapted to deliver; and (iii) pressure from users to participate in the development of new products. While open innovation has many things to offer firms, it is difficult to get right and there are plenty of examples of companies embracing the wrong open innovation model.

This project takes the position that the concept of open innovation can have a broader scope than the business models of private economic agents. Taking inspiration from Chesbrough's proposal, it proposes the idea of an **open innovation ecosystem**, in which engaged players, intelligent rules and effective articulation of opportunities encourages interactions that also support the public interest - in this case, in the health sector.

Open innovation initiatives can be understood as attempts to tackle one or more of the three kinds of innovation system problems described earlier. One objective is a more efficient use of resources: making health innovation quicker, cheaper, better directed towards already-identified areas of need, and more widely adopted and diffused. A second objective is to inform innovation processes with a better understanding of health system and patient/citizen needs. Going a step further, a final objective is to make health innovation more demand-driven, and in political terms, more democratic.

In the initiatives we cover in this report, those involving collaboration between public and private actors often aim to make health innovation more efficient, while those involving collaboration between state and citizens tend to be associated with the drive for 'democratisation'. However, this is not always the case. Some state-citizen partnerships, for example data crowdsourcing initiatives, are directed more towards efficiency, rather than allowing citizens to influence the innovation agenda.

These different objectives are not mutually exclusive. For example, initiatives that make use of collaboration in order to inform the innovation process with a better understanding of needs can help these needs to be met less wastefully, and thus can also be regarded as improving efficiency. Likewise, initiatives directed towards a democratisation of innovation may lead to greater efficiency, if this democratisation allows for a better understanding of needs and targeting of resources.

However, there can also be tensions between these objectives. For example, a patient organisation struggling to inform the innovation agenda might be seen as bringing to light the 'real needs' of patients, but it might also be perceived as advocating for the interests of its members against those of the larger population. To ignore such tensions, and to treat initiatives driving towards the democratisation of innovation as simply rational exercises in identifying 'real needs', would be to obscure their essentially political character.

The sometimes contrasting, sometimes overlapping objectives of open innovation initiatives explored in this report are set out in the diagram below.
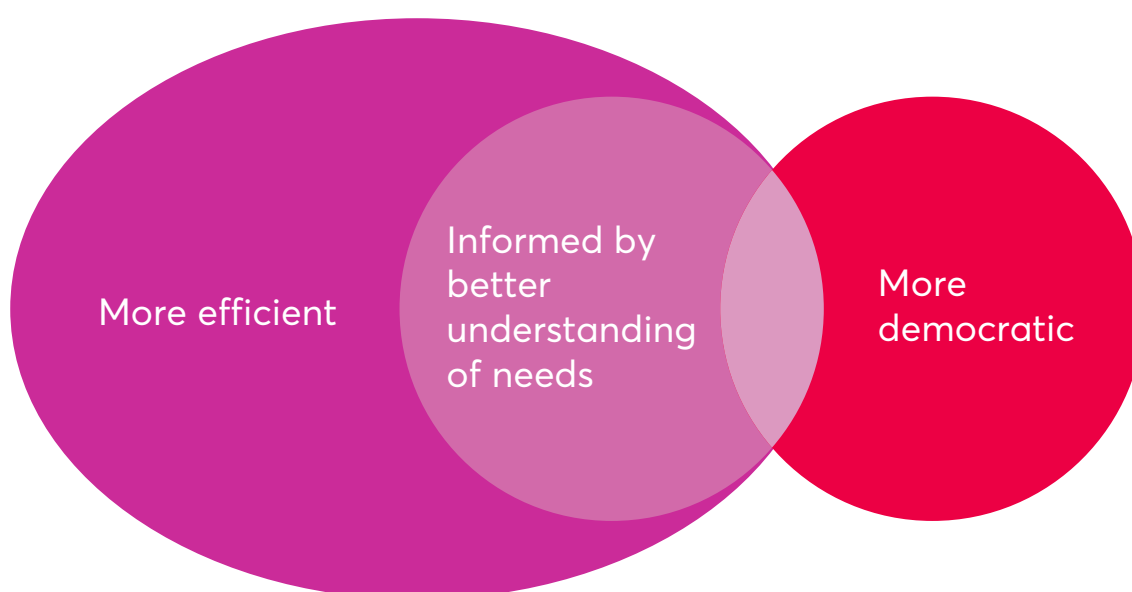
Patients, citizens: a note on terminology

Many open innovation approaches in health involve people who use health services or the wider public who benefit indirectly from them. This is often referred to as 'patient involvement'. However, some people challenge this terminology, as they argue that 'patients' are seen as passive 'receivers' of healthcare. Meanwhile, the term 'citizens' suggests a more active role, and one which proceeds from the rights of citizenship. We recognise that these different terms reflect different ideas about the ideal role of lay people within the health system. In this report we generally use the term 'citizen', in acknowledgement of the active role that people can play in health innovation. However, in some instances we use 'patient' instead, as (arguably) a more appropriate way of highlighting the experience and expertise of an individual with a particular condition.

Open innovation approaches can be applied **right across the innovation cycle**, with different specific objectives at each stage. For example:

- At the stage of **problem identification**, open innovation can mean involving a wider range of actors in collecting and sharing data to more efficiently monitor health issues, for example through data mining and data crowdsourcing. It can also mean citizens playing a greater role in informing the health innovation agenda, for example through **peer research** or **participatory priority setting**.

- At the stage of **invention**, it can mean collaborating to tackle neglected health issues more efficiently by incentivising involvement or lowering costs, for example through **challenge prizes** or **data-sharing initiatives**. It can also mean collaborating to inform invention with a better understanding of health system and patient needs, for example through **pre-commercial procurement programmes**, **clinician innovation programmes**, or **ethnographic** and **design approaches**. It can equally mean opening up the invention process to the participation of patients/citizens so that the development of innovations is more informed by their priorities, for example through **co-production** or **co-design initiatives**.

- At the stage of **adoption and diffusion**, it can mean bringing key stakeholders together to publicise promising innovations and to help get them more widely into frontline use, for example through **online marketplaces** or **diffusion support programmes**. This can facilitate so-called 'reverse innovation', as the potential of innovations from low- and middle-income countries gets more widely appreciated.

3. Open innovation and the innovation cycle

This section explores 18 types of initiatives from around the world, that in different ways represent a more collaborative, 'open' approach to innovation in health. They are grouped by stages of the innovation cycle: problem identification, invention, and adoption and diffusion.

As will become apparent from the examples, open innovation for health as we define it can encompass a diverse set of initiatives. They include structured programmes (like accelerators and fellowships), online platforms (like online communities and marketplaces) and approaches/methodologies (like real time monitoring). Some are led by organisations in the health sector, others by civil society or companies.

However, broadly speaking, all can be categorised in terms of one of three types of partnership: public sector-private sector, organisation-employee, and organisation-citizen. They can also all be understood as driven by one or more of the objectives set out in Section 2: increasing efficiency, informing innovation with a better understanding of health system or patient/citizen needs, and democratising innovation. The table below sets out the 18 initiatives in terms of their stage, partnership type, and primary objective(s), based on our analysis of interview data and desk research findings.

Stage	Types of initiative	Type of partnership	Key objective(s)		
			Increasing efficiency	Improved understanding of patient/ system needs	More democratic
Problem identification	Real-time monitoring	Public-private	●		
	Crowdsourcing data	Organisation-citizen	●		
	Peer research	Organisation-citizen	●	●	●
	Online communities	Organisation-citizen	●	●	●
	Participatory priority setting	Organisation-citizen	●	●	●
Invention	Challenge prizes and platforms	Public-private	●		
	Product Development Partnerships	Public-private	●		
	Data sharing initiatives	Public-private	●		
	Accelerators	Public-private	●	●	
	Fellowships	Public-private	●	●	
	Ethnographic and design approaches	Organisation-citizen	●	●	
	Pre-commercial procurement programmes	Public-private	●	●	
	Clinician innovation programmes	Organisation-employee		●	●
	Co-design and co-production initiatives	Organisation-citizen		●	●
Adoption and diffusion	Online marketplaces and communities	Public-private	●		
	Diffusion support programmes	Public-private	●		
	Scouting	Organisation-employee	●		
	Improvement collaboratives	Organisation-employee	●		

a. Problem identification

Successful innovations provide solutions to tangible problems and real needs. Identifying problems, gathering insights on needs and deciding on priorities are therefore important first steps in the innovation process.

Much health data is gathered through epidemiological studies or clinical practice. This leads to two significant problems:

- **Limits in research capacity and high costs of collecting data**: Data can only be collected as far, and as fast, as there are skilled researchers available to collect it. This can cause delays that might undermine effective responses, for example in an epidemic or humanitarian crisis.

- **Health professionals usually decide priorities for research and innovation**: Health researchers and practitioners may have quite different views from patients on what is important to research and on priorities for innovation. One example could be differing priorities around outcomes from surgery. Clinicians might be interested in measuring success of, say, a knee operation in terms of increased mobility, but patients may be more concerned about managing pain. Patients/citizens may also perceive the value of 'social' interventions more clearly than professionals, whose training has frequently relied on strongly biomedical conception of health.

This section explores initiatives that attempt to open up the problem identification process in two senses:

- Generating health intelligence in more open ways, which aim to bypass capacity and access limitations, for example through **real-time monitoring** and **crowdsourcing data**.

- Involving a wider range of people in setting priorities for research and innovation, through **peer research**, **online patient feedback systems and communities**, and participatory priority setting.

More open ways of generating health intelligence

Real-time monitoring

Real-time monitoring uses data generated by members of the public for 'real-world' purposes rather than as survey respondents - including data generated passively. Most frequently this has taken the form of initiatives monitoring **internet activity** to map and predict disease outbreaks, starting with Google Flu Trends in 2008.[20] This emerging field, which seeks to complement existing disease surveillance methods, is highly contested, with concerns ranging from accuracy to coverage. Yet a number of approaches are starting to show promising results.

HealthMap is a platform that uses online sources to monitor the outbreak of diseases. Developed by a team of researchers at Boston's Children's Hospital in 2006, the website and app bring together data from online news aggregators and social media platforms to produce real-time intelligence on the current global state of infectious diseases. A notable early example of the use of HealthMap was in tracking cholera in Haiti after the 2010 earthquake. The real-time nature of the platform represented a significant advance in intelligence, as subsequent analysis confirmed significant correlation between the picture provided by HealthMap and the picture provided by official data from health agencies - the difference being that official case data was typically not available until two weeks after the first outbreak.[21]
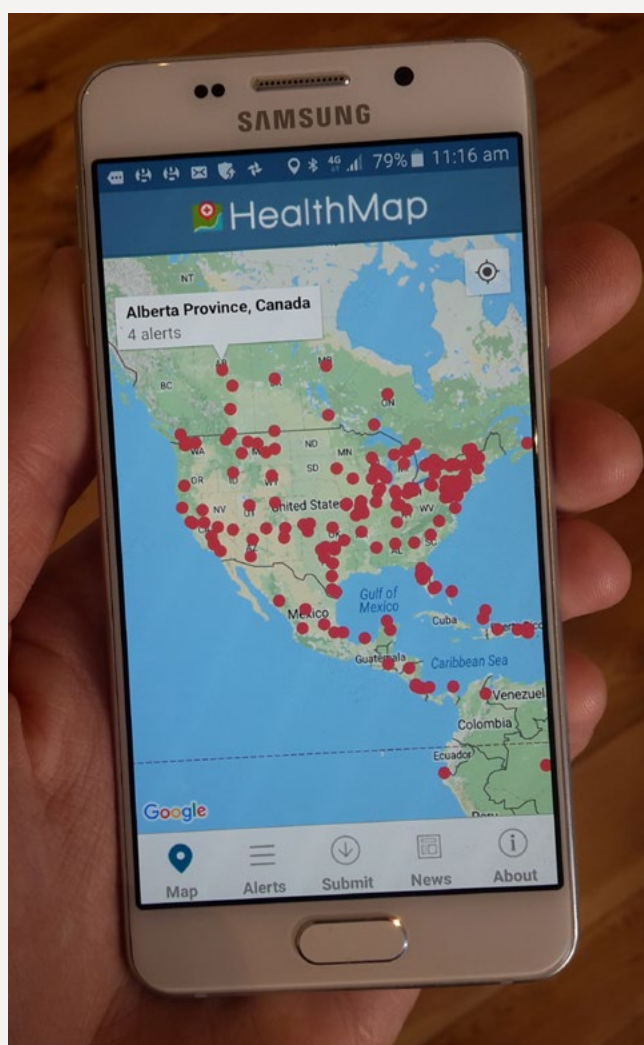
The HealthMap mobile phone app.

Another increasingly popular form of real-time monitoring makes use of **mobile phones** and the data they passively generate. Globally, over 4.7 billion people had a mobile phone subscription by the end of 2015.[22] Location data generated by people carrying mobile phones – network data, GPS data or Bluetooth and WiFi beacon data - can be a useful resource for health planning. At its simplest, this involves matching up data on people's movements with other data sets, such as air pollution maps or records of disease transmission.

For example, one study involving researchers from Princeton and the Harvard Chan School of Public Health tracked the movements of 15 million mobile phone users in Kenya.[23] By comparing this mobile-phone data with a detailed dataset on rubella, the researchers were able to establish a correlation between patterns of movement and rubella incidence, demonstrating that mobile phone movement can be a predictor of the spread of infectious disease.

Crowdsourcing data

While some forms of real-time monitoring rely on passively generated data, others require a more active contribution from individuals, who are sometimes cast here in the more active terms of 'citizen scientists'. These can be characterised as **crowdsourcing data** initiatives.

One form that these initiatives take are online microsurveys - monitoring a particular issue through regular, short surveys, usually through mobile phones or online.

De Grote GriepMeting (the Big Flu Survey) is a system for the real-time monitoring of incidence of influenza-like illness (ILI) in the Dutch and Belgian population. It relies on anonymous volunteers to respond to weekly internet surveys on their symptoms. The system was first launched in the winter 2003-2004 season, and attracted over 13,000 participants in the first year. Because data is obtained directly from the population, the system allows for faster monitoring than traditional methods which rely on data collection by primary care doctors. The system has subsequently been introduced in seven other countries across Europe, enabling direct cross-country comparison, as well as in other parts of the world, including Australia, the USA, Mexico and Brazil.[24]

Data can also be crowdsourced through **mobile apps**, which people can download to track and manage their own health issues. Meanwhile, researchers are increasingly using smartphones, which are packed with a number of sensors, to collect data. A key feature of the most successful apps is an attractive 'offer' to the patient, which incentivises its use - for example, the opportunity to better track your own condition. (The same principle of an attractive 'offer' drives the success of non-mobile internet platforms too, see discussion of PatientsLikeMe below.)

One of the most successful studies so far is the mPower study by the Parkinson's Disease Foundation, where researchers developed an app which both collected survey data and used mobile phone sensors to record movement. The attraction of the app for users is the ability to track and get more information about symptoms. The app allowed researchers to carry out a number of diagnostic tests remotely, including activities which test memory and balance.[25] By using the app, the researchers succeeded in enrolling three times more participants than the previous largest Parkinson's study.[26]

The potential of 'citizen science' to drive innovation by cheaply generating large, rich datasets whilst simultaneously benefiting patients day-to-day, has been widely advocated.[27] However, these new forms of data collection are also associated with new challenges. Questions have often been raised about the validity of patient-generated health data, and in particular around its representativeness, given the tendency of participants in citizen science to have high socioeconomic status and be highly educated.[28] Addressing this challenge is crucial for advancing the project of citizen science, and needs to be understood as a 'social' challenge, related to the way in which an initiative interacts with and involves people, as well as a technological one.

Involving a wider range of people in setting priorities for research and innovation

Peer research-driven approaches to problem identification

A range of approaches use peer research methods in an attempt to involve 'communities' themselves in the process of problem identification.

Community organising is a well established model of popular political action in the USA, and has more recently spread to other parts of the world. The model involves residents or alliances of civil society institutions in a given area coming together to take action on issues that impact their members, such as housing, low pay, and increasingly, health. The starting point is typically a 'listening campaign' - a series of conversations to identify recurrent problems and priorities, which are not always visible to decision-makers. While community organising is best known as a form of political action, it can also be a method of identifying problems and priorities for innovation.

A well documented example is the Healthy Neighbourhoods Project, launched in Contra Costa County in San Francisco in 1994. It is notable for the unusual degree of control which was handed over to participants to define problems. Although the County Public Health Department received funding for tobacco control, years of well intentioned intervention had failed to inspire enthusiastic local participation. They therefore took the unprecedented step of using resources instead to employ six trained resident community organisers to carry out listening campaigns with residents. These identified distinctly different health priorities: substance abuse and gang crime. As a result, the County recruited 120 community health advocates, who drove a series of successful campaigns. Their work led to the installation of speed-bumps, removal of a tobacco billboard, successful advocacy for an evening bus service, increased police patrolling and improved street lighting, funding for youth sports programmes, computer classes and job training.[29]

A more recent model is **community-led commissioning**, In this model, peer research is carried out to inform commissioning decisions, rather than to inform demands (as in the more conflictual model of community organising).

An example is Connected Care, developed by the UK mental health and substance abuse-focused social enterprise Turning Point. Connected Care works by recruiting and training local residents to become Community Researchers. Community Researchers often have first-hand experience with, or particular need for health and care services. Crucially, they must have the ability to make contact with individuals from marginalised or hard-to-reach groups, for example those with mental health issues or drug and alcohol problems. The researchers carry out a Community Audit, which involves speaking with 10-15 per cent of local residents to identify unmet needs and gaps in provision. After analysis, the findings of the Community Audit are reported to local health and care commissioners who use them to understand needs and shape changes in provision. Connected Care has now been implemented in 20 localities in England.[30]

Arguably, the model that attempts to incorporate peer research most fundamentally into the process of problem identification for health is **Community Health Workers (CHWs)**. The CHW model, popularised by the 1978 Declaration of Alma-Ata,[31] involves recruiting local people, usually with only basic training, to perform a range of health services for other members of their 'community' (i.e. people who live in the same area). The CHW model has attracted interest as a form of service delivery, and CHW programmes have been associated with impressive improvements in population health (highly regarded examples include CHW programmes in countries such as Nepal, Bangladesh and Brazil).[32] However, the model also represents a way of incorporating peer-led problem identification into the health system - particularly when CHWs are sustainably funded and work closely with other health system actors.

CASE STUDY

Community Health Agent Programme, Brazil

The Brazilian Community Health Agent Programme (O Programa dos Agentes Comunitários de Saúde) forms part of the Brazilian Family Health Strategy (FHS), a national primary healthcare strategy which has led to substantial improvements in population health.

The FHS model involves interdisciplinary healthcare teams including a doctor, a nurse, a nurse assistant and four to six community health agents (CHAs). CHAs are full-time paid employees. Usually they have had no previous health training, and are only required to have completed secondary education.[33] The crucial recruitment criterion is being an established resident of a given neighbourhood, with the ability to communicate well with local residents. CHAs are assigned approximately 150 households, each of which they must visit at least once a month. During these visits, the CHAs carry out a range of tasks, such as helping with prescriptions or making appointments. They also gather data, and identify health issues and risk factors affecting members of the household.

Credit: Prefeitura de Olinda (Olinda City Government) https://www.flickr.com/photos/prefeituradeolinda/4029522762/in/photostream/ **License:** 2.0 Generic (CC BY 2.0)

Community health agents in Olinda, northeastern Brazil.

CHAs liaise closely with the clinicians on their team and feedback their findings at regular meetings, providing a strong insight into the problems experienced by the community. These insights are used to inform the wider public health activities of the Family Health Teams. For example, Family Health Teams operating in the São Paulo periphery have used intelligence gathered by CHAs to inform workshops on different health topics, targeted at particular groups who have been identified as at particular risk.[34]

Evaluations of the FHS model have shown that it not only leads to greater satisfaction among users than traditional health centres, but also leads to better health outcomes For example, it has led to large reductions in infant mortality. In adults, benefits have included reduced mortality from cardiovascular diseases.[35] There is also evidence that FHS has improved detection of cases of neglected tropical diseases.[36] The model has been used only to inform local service provision, however it has the potential to feed into wider-scale research and innovation.

Online patient feedback systems and patient communities

Like peer research-driven approaches, online patient communities and patient feedback systems aim to generate insights that might be missed by traditional methods of problem identification. These platforms particularly lend themselves to a focus on patients' experience of health services.

Patient Opinion, launched as a non-profit social enterprise in 2005, is a website where UK patients can anonymously report their experiences of health and social care services, in the form of online 'micro-conversations' about particular hospitals or services. Because the feedback is public and collected in real time, it has the potential to drive service change more urgently than data collected via traditional means, such as the NHS patient satisfaction survey. Health service commissioners are also able to subscribe to the platform, allowing them to identify particular areas of concern for both patients and providers. By 2015, the platform was being used at some level by over 90 per cent of NHS trusts in England and all health boards in Scotland. Over 120,000 stories had been posted, and over 80 per cent of stories were regularly receiving responses.[37]

Another interesting model is the **online patient community**. As their name implies, these aim to capitalise not only on the accessibility and anonymity of internet platforms, but the sense of 'community' they can create.

PatientsLikeMe, founded in 2004 in Cambridge, Massachusetts, is a for-profit site which allows patients to freely share stories and data with each other around health conditions they share. Data is then sold to researchers and companies for research purposes. As well as partnering with research and industry, the site also partners with patient organisations to create online communities around particular conditions. While in one sense PatientsLikeMe is a means of crowdsourcing real-world data, like the initiatives set out in the previous section, it also offers distinctive insights about patient experiences. For example, when patients discuss issues such as problems in setting treatment goals or getting enough time with their doctor, this generates qualitative data which can be coded and analysed to better understand factors in patient empowerment.[38]

Participatory priority setting

Another set of approaches focus on enabling wider participation in the priority setting process. In doing so they bring the political dimension of problem identification to the fore.

One form this has taken is **health councils** - bodies that provide an opportunity for citizens to participate in health system decisions.

The Conselhos de Saúde (health councils) system in Brazil was codified in the same 1988 'Citizens' Constitution' that established the Brazilian Public Health System (SUS). The conselhos exist at municipal, state and national level. They are composed of users of Brazil's unified health system (SUS; 50 per cent) who are representatives of civil society groups (for example churches, LGBT groups, disabled groups, unions, ethnic associations, neighbourhood associations), health managers (25 per cent) and health workers (25 per cent). Meetings for municipal-level councils (Conselhos Locais de saude, CLs) are usually monthly, and provide the opportunity to raise local health issues and scrutinise health spending. Health councils are also responsible for approving annual plans and health budgets; without approval, the municipality does not receive funding from the Health Ministry.[39]

Studies of different CLs have produced contrasting verdicts on their success in enabling wider participation in priority setting. Some have been successful in presenting innovative proposals, incorporating citizens who are usually marginalised, and promoting the redistribution of resources to deprived areas.[40] Other CLs have been less effective, experiencing difficulty in achieving autonomy from powerful political interests, with citizens scrutinising plans but lacking opportunities to substantially inform them.[41] Under what conditions are CLs able to function more successfully?

An insightful set of responses to this question has been suggested by a comparative study of the CLs of six different sub-municipalities in the deprived periphery of São Paulo. The systematic comparison of these CLs, cross referred with data on the redistribution of healthcare services across São Paulo between 2000 and 2008, reveals important differences between CLs in areas with a history of social mobilisation and those in areas without one. In areas with a greater history of mobilisation, CLs were characterised by a higher participation of less-educated, non-white and female citizens. Discussions featured more

confrontation and conflict, but had more success in monitoring services and offering innovative proposals. CLs in areas with a stronger background of mobilisation also displayed more connections with political actors, and a greater capacity to raise funds, which may partly explain the apparently greater redistribution of health resources towards these sub-municipalities between 2000 and 2008. The study highlights the positive relationship between mobilisation and participation and suggests that health councils will be most effective when they combine participation with mobilisation.[42]

A municipal-level health council meeting in Goiânia, Central-West Brazil.

More recently participatory priority setting has also taken the form of **online platforms**, often crowdsourcing research priorities, for example using a survey to ask people with a given condition what issues they care about, and using this to create a set of unmet needs. Examples of this include the James Lind Alliance's **dementia priority setting exercise**.[43]

While there are many priority setting exercises similar to this, it has been pointed out that the link between what patients say they want and what happens to the research agenda as a result is not always clear. In the Netherlands, researchers developed the 'Dialogue Model' to involve patients in setting research agendas for a number of conditions and then followed up with research funders and policymakers to track the outcomes.[44] Their main finding was that, while in some rare cases research funders have funded priorities identified by patients, in the majority of cases these priorities are not picked up. Here, as with other models of participatory priority setting, a challenge remains in finding ways for patients to overcome their traditional subordinate relationship with clinicians and researchers.

In contrast to institutions or platforms established or funded by health service or research organisations, **patient organisations** represent a civil society-led mechanism for patients to participate in priority setting. These groups take a variety of forms, from large charities serving people who suffer from common conditions such as diabetes and heart disease, to smaller charities serving patients with rarer conditions, such as amyotrophic lateral sclerosis

(ALS). Smaller organisations sometimes form umbrella groups, including international alliances to pool resources and increase their impact. While these groups play an important role in helping to establish online communities on sites such as PatientsLikeMe (as well as others such as HealthUnlocked), they have sometimes also set up their own platforms to provide opportunities for their members to inform their lobbying efforts and research commissioning.

One example of this is the British Heart Foundation's **'Heart Voices'** platform, where patients with heart disease can sign up to be involved in attending discussion groups, completing surveys, or joining steering groups to inform policy statements or influence research funding decisions.[45] Another example is the **AKU society**, a UK-based group with sister organisations around the world, which serves people with Alkaptonuria, a rare genetic disorder. The society has successfully raised EU funding for a trial of a potential treatment, and has also managed to obtain funding for a centre of excellence to advance research in the UK.[46]

While participatory priority seeks to redress the traditional power imbalance between health professional and citizen, it can also be seen to unleash another challenge: the domination of powerful civic interest groups, or the 'usual suspects'. These might include groups able to wield disproportionate influence thanks to socio-economic status and education, for example a middle-class dominated patient organisation. They might also, if more unusually, include groups representing the 'organised poor', for example in the São Paulo periphery, where health councils in sub-municipalities with strong histories of social mobilisation were found to be less politically and civically plural, contributing to a tendency to reproducing the positions of existing social health movements.[47]

The challenge of interest group domination creates real tensions for participatory priority setting initiatives, which, as with any democratic institution can only be negotiated rather than completely 'designed away'. However, vigorous interest group participation does not necessarily threaten the democratisation of priority setting. In the case of the health councils in the São Paulo periphery, those in sub-municipalities with stronger histories of social mobilisation for health were characterised by greater proportions of female, non-white and less-educated participants - and, apparently, greater success in achieving a fairer distribution of health resources.

b. Invention

Invention is not a one-off 'eureka' moment, but an iterative process of development and testing. It is the part of the innovation cycle which has traditionally received the most attention[48] and, it has been argued, the most investment.[49] Despite this, a number of persistent barriers have been observed at the invention stage of the health innovation process. These barriers include:

- **Market failure**. Accessing funding is widespread challenge for innovators, and not distinctive to the world of health innovation. However, health innovation is characterised by a distinctive market failure in the case of health issues particularly facing low- and middle-income countries - it is difficult to incentivise innovation to tackle health issues for which solutions are less obviously lucrative.

- **Barriers to entrepreneurship**. Would-be entrepreneurs often lack financial and informational resources to take their ideas beyond the first stage.

- **Lack of understanding of health system and patient needs**. Those involved in the design of innovations are often several steps removed from the world of healthcare practice. Inventors may not truly understand the needs of health systems, or may not have access to the information and data required to best meet them. By the same token, even innovations developed by experienced clinicians may suffer from a failure to address key patient needs that are sometimes obscured from a clinical perspective.

- **Cultural and structural barriers to the involvement of health professionals in innovation**. Health practitioners, with their wealth of frontline experience, are often prevented from contributing to the invention process by time pressures or lack of organisational support.

- **Patients and citizens relegated to a passive role**. Patients and citizens typically lack opportunities to participate in invention, and usually play a passive role in keeping with traditional conceptions of the clinician-patient relationship. This results in a failure to draw on their insights and ideas, and to take into account their priorities.

To address these barriers, a variety of collaborative or 'open' methods of invention have emerged. These include attempts to:

- Overcome market failure by sharing and lowering the costs of research and development, for example through **challenge prizes**, **product development partnerships** and **data sharing initiatives**.

- Support entrepreneurship through **accelerators** and **fellowships**.

- Inform the invention process with a better understanding of health system and patient need, for example through **ethnographic and design approaches** and **procurement programmes**.

- Supporting healthcare professionals to innovate, for example through **clinician innovation programmes**.

- Open up the invention process to greater participation from citizens and patients, for example through **co-design** and **co-production** initiatives.

Overcoming market failure

In recent years a wide range of collaborative models have emerged that seek to overcome market failure, especially - but not exclusively - in innovating to tackle health challenges facing low- and middle-income countries. While addressing all these is beyond the scope of this report, here we consider a few interesting models.

Challenge prizes and platforms

Challenge prizes were popular in the 18th century but fell out of favour as technological innovation became concentrated in universities and corporate laboratories. In recent years prizes have enjoyed a return to prominence, not least in the field of health.[50] They provide a direct financial incentive for innovators to work on challenges which are particularly affected by market failure. These include health challenges particularly affecting poorer countries, such as neglected tropical diseases - but are not limited to them. For instance, investing to develop better diagnostics for bacterial infections could reduce the inappropriate use of antibiotics, but holds little short-term economic incentive either for the health systems that rely on cheap antibiotics or the pharmaceutical companies that sell them.

Challenge prizes in their 'pure' form award prizes to the best 'solution', rather than fund development costs. Because of this, they have been described as a 'pull' incentive. However, many challenge prizes actually take a more hybrid form. The USAID Grand Challenge Prizes, for example, fund development costs for several shortlisted submissions. Like other forms of crowdsourcing, challenge prizes have the potential to make the invention process more cost-effective and opening it up to a wider range of actors and thus a wider pool of ideas.[51] They also provide an incentive for different organisations in the innovation system, including from different sectors, to collaborate.

In 2014, Ebola broke out in west Africa, eventually killing over 11,000 people. In the midst of the outbreak, USAID launched the Fighting Ebola Grand Challenge to support the rapid development of a number of cost-effective solutions to apply to the current and future outbreaks. One of the winning submissions, out of 15,000 suggestions, was a protective suit for health workers.[52]

A Liberian nurse puts on protective clothing before entering an Ebola ward.

The new suit features a number of improvements on existing models, notably better ventilation, meaning that health workers can work for much longer in hot conditions. It is also much easier to put on and take off, reducing opportunities for error. Alongside crowdsourcing a number of ideas, the prize enabled collaborations between universities and industry, for example between Du Pont and John Hopkins University for the production of the protective suit.[53]

In addition to challenge prizes, several **challenge platforms** have also emerged. These are online hubs where 'solution seekers' can post different challenges, to reach a large online community of 'solvers'. A well-known example is **Innocentive**, a Massachusetts-based company, that posts challenges on behalf of a range of 'seeker' organisations, in return for a commission. Seeker organisations have included corporations as well as philanthropic foundations such as the Rockefeller Foundation and the Humanitarian Innovation Fund. These challenges are opened to Innocentive's community of over 375,000 'problem solvers', who can join for free.

Product Development Partnerships

Product Development Partnerships (PDPs), which have come to prominence in the last 15 years, have frequently been used as a way to bring forward innovation to tackle neglected diseases. They vary in format, but usually consist of collaborations between public or philanthropic funders, industry (notably pharmaceutical companies) and academia, with resources and risks being shared. PDPs may take the form of a non-profit, virtual or semi-virtual R&D organisation. Like private pharmaceutical companies, PDPs usually employ a 'portfolio approach', pursuing numerous innovations simultaneously in order to spread risks.[54]

Although intellectual property (IP) practices vary in different PDPs, an agreement is typically reached which provides for a substantial return on the company's investment, in return for a commitment to distribute the product at a price affordable in low income countries. In this way PDPs aim to incentivise private sector contribution to drug development while also tapping into academic expertise, while still ensuring that resulting innovation is affordable.[55]

A well-known example is the Medicines for Malaria Venture (MMV), launched in 1999 in Geneva with funding from the Rockefeller Foundation, Gates Foundation, and three European governments. It focuses on developing and delivering high quality and affordable antimalarial medicines. Since launching, it has developed six new antimalarials, which have enabled over 500 million courses of treatment.[56] Coartem® Dispersible, for example, is a pediatric malaria treatment developed by MMV in collaboration with the pharmaceutical company Novartis. The IP belongs to Novartis, in return for a commitment to distribute the product in countries where malaria is endemic, including making it available at-cost to the public sector in these countries. Failure to do so gives MMV the right to manufacture and sell the treatment in those countries. The product has been placed on the WHO essential medicines list and been approved by numerous national regulatory agencies; by 2010, 35 million treatments had been supplied.[57]

Data sharing initiatives

Another set of initiatives seeks to reduce the costs of innovation through data sharing. In some cases these can be understood as a kind of PDP.

Tres Cantos Open Labs Foundation (TCOLF), a charity launched in 2010 and largely funded by GlaxoSmithKline, supports researchers to work alongside GSK researchers on developing cures for neglected tropical diseases, providing open access to key GSK data sets. Since it was established, the Open Lab has supported 42 projects, involving 37 different organisations in 14 countries.[58]

A step further than this kind of 'open data access' is 'open source research.' The Open Source Malaria project, set up in 2011 by researchers at the University of Sydney using the GSK Tres Cantos Antimalarial data set (TCAMS). The project allowed researchers around the world to collaborate virtually on activities ranging from designing and synthesising new generations of antimalarial compounds to interpreting results, inspired by the model of open source software development. Critically, a condition for participating was to agree not to individually seek patents to protect contributions. The project has attracted a wide range of contributions and published its first paper in 2016.[59]
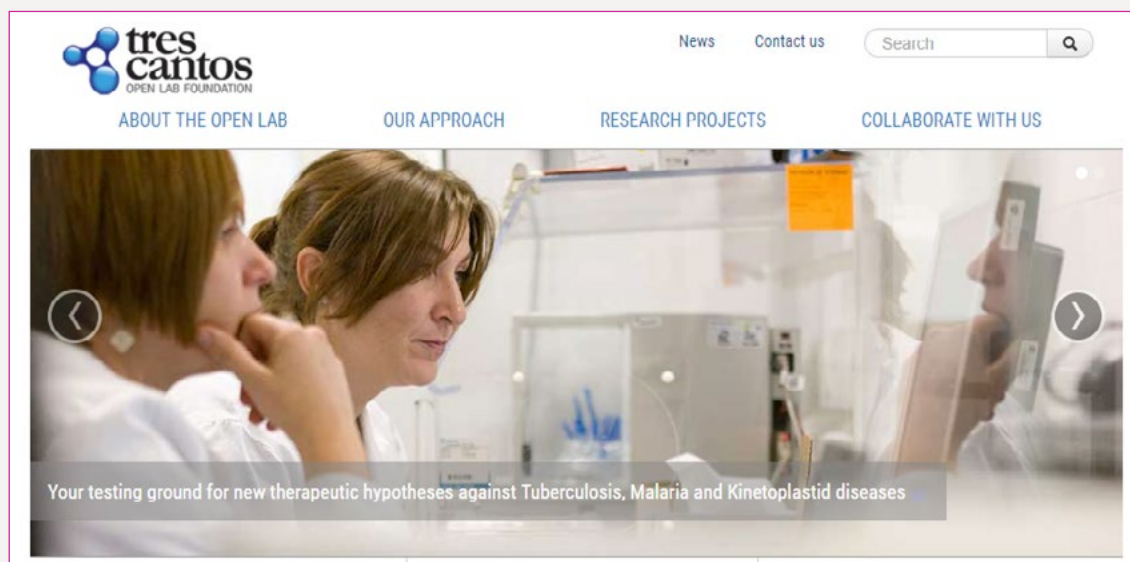

The Tres Cantos Open Lab Foundation.

Supporting entrepreneurship

Accelerators

Health-focused startup accelerators are an increasingly popular model for stimulating invention. Accelerators provide direct support, both financial and informational, to innovators and entrepreneurs. They promote collaboration in a number of ways: they usually recruit teams, rather than individual entrepreneurs, and participants are recruited in cohorts, which provides an opportunity for teams to learn through peer support. Crucially, many programmes also have strong industry links and provide opportunities for entrepreneurs to better understand the needs of purchasers and find potential markets for their products.

Zeroto510 is an accelerator programme focused on medical devices, run under the umbrella of public-private partnership Memphis Bioworks.[60] By providing access to seed funding, experienced mentors and design and manufacturing resources, the programme aims to overcome the regulatory and financial barriers often faced by clinicians and engineers in entering the medical device market. Since launching five years ago, the programme has supported the creation of 20 new companies and facilitated $9.2 million in investments.[61]
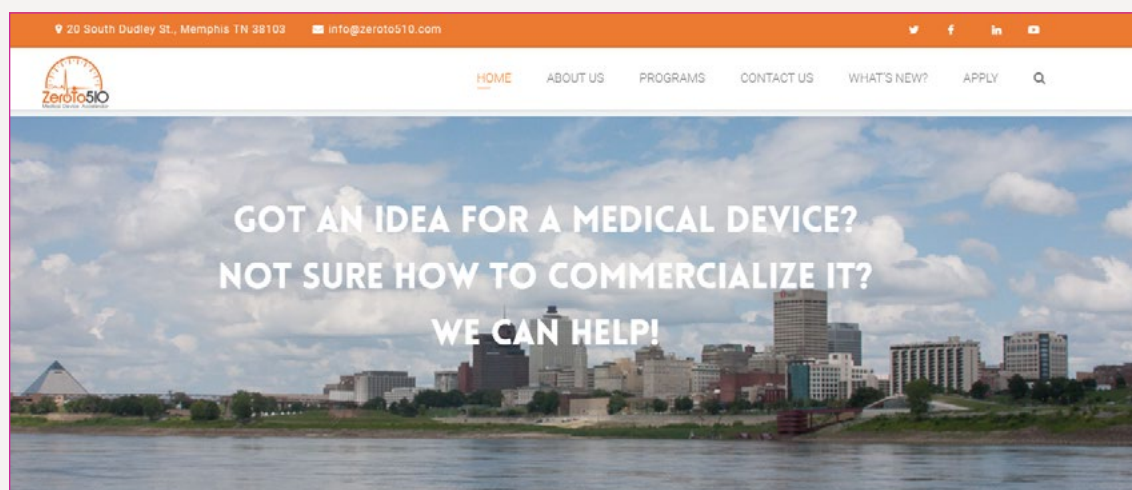
ZeroTo510 - an accelerator in Memphis, USA.

A notable example from the 2015 cohort is GlucosAlarm, a glucose sensor designed to measure sugar levels of diabetic patients, developed by a team of Mexican entrepreneurs.[62] It has gained attention for its potential to facilitate self-monitoring.

Fellowships

Health innovation fellowships, like accelerators, provide a combination of standardised and individual support to innovators to stimulate invention. Key differences are that innovators usually participate in fellowships as individuals rather than in teams, they usually receive a bursary rather than seed funding, and the programmes are usually less intensive, running for up to a year. The extended length of fellowships allows for a more in-depth process of problem identification, and provides fellows greater opportunities to engage in frontline settings and better understand clinical needs.

Another collaborative aspect of fellowships is that they are often interdisciplinary, bringing engineers or people with coding skills into a hospital setting to work on issues they wouldn't usually be exposed to.

CASE STUDY

School of International Biodesign, India

"We try to expose them to all the paradoxes of India, the smaller cities, the townships, the mega-cities – the Boston in India, the Malawi in India, the Nigeria in India. This is the time when they fall in love with problems. We don't like people falling in love with solutions – because then they are wedded to the solution no matter how useless it is. It is falling in love with the problem that will drive the development of an innovative solution".[63]

Dr Prashant Jha, Fellowship Director, School of International Biodesign

The School of International Biodesign (SIB), based in New Delhi, aims to cultivate a new generation of medical technology innovators in India. Funded by the Indian Ministry of Science and Technology, the School is run as a collaboration between Hiroshima University, Indian Institute of Technology (IIT) Delhi, the All India Institute of Medical Sciences (AIIMS) and Queensland University of Technology.

In the course of studies at Stanford University, Dr Jha, one of the founders of the programme, was impressed by the substantial opportunities for exchange and collaboration across disciplinary and institutional barriers - in contrast to most Indian universities, where medicine and engineering faculties tended to be parallel worlds. The idea for SIB was born out of the desire to encourage this interdisciplinary and collaborative spirit among young Indian innovators.

Credit: Courtesy of Prashant Jha.

SIB participants during the 'discovery' phase.

From 2008 to 2014, the SIB was run in collaboration with Stanford University as the Stanford-India Biodesign programme. Participants of the fellowship would spend six months at Stanford working on need identification and concept development before returning to India for the remaining 18 months to repeat this process in their home setting. Development would be carried out at AIIMS, with the Biomedical Engineering department at IIT Delhi providing engineering support. An impressive pipeline of innovations emerged out of this first iteration of the programme.

As more Indian students graduated from the SIB and enjoyed success in getting innovations onto the market, organisers realised that there was now a sufficient mass of people, with a sufficient body of knowledge and experience, to transition to a slightly different kind of programme, based on more two-way exchange between partners. In 2014, SIB was revamped as a more international programme, and renamed the School of International

Biodesign. In its new form, the fellowship is open not only to Indian applicants but also students from partner universities in Australia and Japan. Fellows, who are a mix of recent medical, engineering, business and design graduates, and professionals with a few years' experience under their belt, receive a stipend and travel costs for the 12 months of the fellowship.

While in the original incarnation of the programme, the initial learning process was somewhat 'off context' in terms of addressing Indian needs, in its current form participants spend ten months out of the first year in India. The first stage for participants is the **'discovery'** phase, during which students find real-world problems to engage with - in Dr Jha's words, something that strikes them as *"unacceptable and not OK"*. Fellows spend time in clinics and a range of frontline settings, and also visit patients in their homes. In describing the programme, Dr Jha emphasises the importance of this process, by which fellows become "married to a problem" they truly care about solving. Although participants apply to the programme as individuals, they are matched together into interdisciplinary and international teams, to maximise the possibilities for creative collaboration. Dr Jha likens himself to a 'marriage arranger' in this process of creating - hopefully - perfect matches.

The second stage is the **'define'** phase, some of which takes place at partner universities in Australia and Japan. At this stage, a problem is chosen, and teams drill down into a problem to define the particular issue they will work on, bearing in mind the skillsets of each team and the tools available to them.

Next, at the **'design'** phase, teams work with users to come up with a whole range of possible products. These are then assessed in terms of acceptability and affordability, to determine which might be worthy of further development.

The final **'deploy'** stage takes place once participants have graduated from the programme, and involves the refining of prototypes, seeking regulatory approval and filing for IP protection. SIB is less focused on providing support at this stage than at previous stages; although the programme organisers are able to open doors in terms of access to funding, they play the role of enablers rather than incubators or accelerators.

One of the many successful innovations that has emerged from the SIB programme is HiCARE LIMO, designed for caregivers working with patients who have suffered traumatic injuries but have not yet been able to receive definitive care. It is a cardboard splint that allows the temporary immobilisation and protection of injured limbs. The technology was licensed by HLL Lifecare Ltd, an Indian healthcare products manufacturing company, and has been used to treat nearly 30,000 patients in over 16 states in India.[64]

Credit: Courtesy of Prashant Jha.

SIB participants during the 'discovery' phase.

Informing the invention process with a better understanding of health system and patient needs

Ethnographic and design approaches

A direct, collaborative method for informing invention with a better understanding of needs is the use of ethnographic or 'design' methods - i.e. starting with a period of in-depth, ideally 'participant', observation. Ethnographic methods are not new as a means of problem identification, and have been widely used in applied qualitative research on health since the 19th century. What is rather novel is the more direct integration of these methods into the invention process.

The **Mayo Clinic Centre for Innovation** (CFI) is well-known for its integration of ethnographic-style design methods in the process of developing innovations for use in the non-profit, Minnesota based Mayo Clinic health system. A good example is the role of ethnographic methods in the development of the Asthma Connected Care app to support asthma management among students.[65] The app was initially developed following consultations with the Mayo Clinic's asthma caregivers, which identified the need to keep teenage patients - especially those with chronic asthma, who routinely deviated from their healthcare regimen - connected to providers.[66]

The first version of the app worked well with the majority of student users with whom it was piloted, but failed to improve asthma management for the remaining minority of cases. Close observation by designers was able to offer an explanation for this which went beyond simply blaming patients for failure to 'comply': the two groups had distinctly different psychological outlooks towards their condition. While the larger group tended to 'accept' their condition, the smaller group felt more 'at war' with it. These insights led the application to be redesigned, with information presented in different ways that were more acceptable for the smaller group.[67]

The final version of the app was found to improve the students' sense of connection to their site of care. It was also found to improve their medication adherence, which itself provided reassurance and thus improved satisfaction for practitioners and parents. Finally, the app was found to provide a much richer and a more timely dialogue with practitioners than the standard face-to-face appointment.[68]

Pre-commercial procurement programmes

Pre-commercial procurement involves the procurement of research and development of new and innovative products and services which are not yet ready for market. It is mainly used by public sector bodies as a way to stimulate technological innovation.[69] Pre-commercial procurement programmes in health are characterised by close collaboration between innovators and health services or commissioners, in an attempt to develop products which respond closely to identified health service needs.

The **Small Business Research Initiative for Healthcare** (SBRI Healthcare) is an NHS England initiative that funds collaborative technology development. It aims to bring products into the marketplace which respond to established health needs. As national programme director Karen Livingstone puts it *"it is so much better if we can start with a rich understanding of NHS needs, with industry and health services working together to co-produce a solution that fixes a problem…essentially SBRI gives intelligence and knowledge to suppliers, about what the NHS really needs."*[70]

The programme starts with a thorough process of problem identification. Starting with high level priorities set by NHS England, the national SBRI Healthcare team consults with various stakeholders in the healthcare system to understand their needs. The team then comes up with a specific challenge based on this, which is put out to competition to SMEs and early-stage businesses, initially to test the feasibility of their ideas. If this is successfully demonstrated, companies may receive a second phase of funding for product development and prototyping. Although the public sector has the right to license the subsequent technology, intellectual property (IP) is retained by the company.[71]

SBRI Healthcare has supported over 100 companies and given contracts for the development of over 30 new products.[72] Parkinson's Tracker is an example of a promising innovation supported by the scheme. Using a smartphone app and a web portal, it helps patients with Parkinson's disease manage their medications. Developed in close collaboration with a range of patient groups, academic and clinical partners, health modelling has suggested that it could save the NHS of over £20 million per annum.[73]

Supporting practitioners to innovate

Practitioner innovation programmes

Health practitioners' experience and understanding of unmet needs is a frequent source of good ideas for innovations. However, lack of time, lack of entrepreneurial know-how and a culture in which practitioners tend to be thought of as passive implementers of best practice rather knowledge creators, mean that these ideas frequently fail to get beyond the idea stage. Practitioner innovation programmes enable frontline workers to develop ideas into new solutions, bringing their untapped insight to bear on the invention process.

Cleveland Clinic Innovations (CCI), launched in 2000, is the in-house innovation centre for the Cleveland Clinic, a large non-profit health system based in Cleveland, USA, with additional locations across the United States, the Middle East and Europe. It scans for and supports the commercialisation of innovations from a wide range of sources, but has a particular commitment to supporting innovations developed by its own employees. Unlike in many US health systems, doctors are salaried rather than paid per operation, which affords time in their schedules for research or innovation.[74] Appropriate compensation for staff-inventors is a crucial part of the model, and they receive a large percentage of the proceeds from any licensing agreement or spin-off company (staff generally wish to continue with their clinical practice, rather than becoming full-time entrepreneurs). If a technology is deemed to merit a new venture, an independent team of investment and operational professionals will facilitate spin-off company formation, fundraising and governance. CCI has generated over 40 active spin-offs,[75] and enabled a return of over $80 million to staff innovators.[76] Innovation is also reflected in human resources and promotion policies.

A smaller-scale example is the **Bright Ideas Fund**, launched in 2009 by Guy's and St Thomas' Charity (GSTT).[77] It supports practitioners to take new ideas from concept to the prototyping stage, by providing funding and advice on intellectual property and helping innovators to find commercial backing. Staff are invited to submit ideas responding to particular areas of need. A notable example is Desperate Debra, a manikin developed in 2011 with support from the fund.[78] Desperate Debra is a teaching tool for practising delivery techniques for emergency caesareans, which affect around 20,000 births per year in the UK. The idea for this innovation came from a consultant obstetrician. Through the scheme, he was able to collaborate with a multi-professional team including a consultant midwife and a professor of obstetrics working at the hospital, and he received intellectual property and legal advice from a specialist at GSTT. Desperate Debra has been successfully commercialised and is now used as standard practice in the Royal College of Obstetricians and Gynaecologists Operative Birth Simulation Training Course (ROBuST).

Credit: Courtesy of Graham Tydeman.

Desperate Debra being used in a training session.

The Rigid Wheelchair developed at Hospital das Clínicas, São Paulo.

Another interesting example of a successful practitioner-driven innovation is the **Rigid Wheelchair**, developed within the Institute of Physical Medicine and Rehabilitation at the Hospital das Clínicas in São Paulo. Due to strict spending limits, the hospital was unable to purchase an imported wheelchair that it needed for one of its patients. Instead of purchasing something that didn't quite meet the needs of the patient, staff worked with a local company to design one. The wheelchair they designed is lighter, cheaper and more durable than commercial alternatives and the company that built it is now planning to market it to other hospitals across Brazil.[79] The hospital is now planning to build a team and a process to manage innovation, to support and incentivise new methods and new ways of working that come from hospital employees.[80]

Other initiatives provide an opportunity for practitioners to participate in the invention process without necessarily taking on a lead 'inventor' role - which may sometimes be a more realistic approach to increasing clinician participation. Participatory design methods have been fruitful in this regard, for example in the South Africa-based **Open Medicine Project**.

CASE STUDY

The Open Medicine Project, South Africa

The Open Medicine Project South Africa (TOMPSA) is a participatory method applied within a primary health care setting. TOMPSA is a collaboration of healthcare workers, researchers, mobile technology designers and developers, who are tackling health system problems, especially in the developing world, by creating smartphone applications. Launched in South Africa in 2012, it capitalises on both the insights healthcare professionals have into health system challenges, and the relatively high availability of smartphones in many low- and middle-income settings. While TOMPSA was launched as a non-profit, it has since created a for-profit spin out, EM Guidance, as a means of ensuring sustainability.[81]

The idea for TOMPSA came out of the experiences of its South African co-founders Dr Mohammed Dalwai and Dr Yaseen Khan, while working in various challenging frontline settings. Dr Dalwai's experience of an avoidable patient death, caused by incorrect triage, highlighted the need for systems to make easier the work of overstretched and under-

resourced frontline health practitioners. Dr Khan noted that implementing necessary changes entirely from within the relatively bureaucratic South African health system was difficult; an external structure was needed to generate and introduce innovations.

A key part of TOMPSA's model is drawing on the insights of primary health workers through participatory design sessions, alongside technology designers, and with academic input, to map out information needs. The input of frontline health practitioners helps to militate against what Dalwai identifies as *"a perverse incentive among many software companies to make the product as complicated as possible"*.[82] Avoiding this tendency, TOMPSA has been able to produce simple, practical tools which have a wide appeal for practitioners working in challenging settings. Since launching, the project has produced mobile applications covering HIV, tuberculosis, emergency and primary healthcare. They have been used by more than 300,000 health practitioners in over 198 countries around the world.[83]

Credit: Courtesy of Mohammed Dalwai.

A TOMPSA co-design session.

A good example of TOMPSA's work is the PHC Clinical Guide App, launched in 2015. Access to safe and effective medicines in South Africa has been improved through the production since 1996 of peer-reviewed Standard Treatment Guidelines (STGs)and Essential Medicine Lists (EMLs). However, the fact that the lists are produced every three years means that they can quickly become outdated, with healthcare workers often lacking access to the latest versions.[84] The PHC Clinical Guide app, addressing a need identified in co-design workshops with frontline health practitioners, makes the STGs/EMLs accessible through a free mobile app, which is immediately updated with new information and medicines ratified by the review process. The app is already being used by around 10,000 clinicians,[85] and has been downloaded in 56 countries besides South Africa.

Opening up the invention process to greater participation from patients and citizens

Co-design and co-production initiatives

While health practitioners are one source of (often) untapped insight, an even more neglected source of ideas are patients themselves. A range of participatory approaches have emerged which attempt in different ways to incorporate patients and citizens into the invention process. Many of these approaches place emphasis on making these initiatives a partnership of equals, where patients and citizens play a more leading and less tokenistic role. These approaches have been used in both primary and secondary health care settings.

The Lambeth Collaborative, established in 2010, brings together healthcare practitioners, carers, patients and third sector organisations in the London Borough of Lambeth, with the aim of improving the outcomes of people living with long-term mental illness. The collaborative holds meetings twice per month, where participants work together to develop ideas that could improve service delivery. Co-design workshops, incorporating prototyping, user journey mapping and analysis of narrative-based research, are at the core of the Collaborative's work.[86] The aim is to draw more systematically on the perspectives and understanding of service providers and users than has traditionally been the case in commissioning practices.

A significant development arising from the Collaborative's work has been the creation of the Living Well Network (LWN) as the new 'front door' to the adult mental health support system, introduced in 2013. The LWN is a hub bringing together staff from primary mental health care, triage from secondary care, voluntary and community organisations and peer support interns with lived experience of mental health problems. Individuals do not need to be referred by a doctor to access the LWN, but can self-refer, or be referred by a friend or other agency.[87]

The Lambeth Collaborative brings together healthcare practitioners, patients and third sector organisations to improve the outcomes of people living with long-term mental illness.

Once an individual accesses the LWN, they may receive support from someone at the hub, be referred to a community group or activity, or may receive psychological treatment. This 'front door' enables people to access support much earlier than if they had to wait for referral by a doctor, reducing later crises and pressure on secondary care. Since its launch in 2013, there have been over 1,200 introductions to the LWN, which has led to a significant reduction in referrals to secondary care.

c. Adoption and diffusion

Investment in new technologies has not usually matched investment in initiatives to promote their take up and spread. This is now widely recognised as a problem, leading to an 'innovation pile-up'.[88] Meanwhile, there is an increasing realisation that traditional assumptions about how to drive the adoption and spread of health innovations - what the WHO has described as a *"combination of publications, training and policy"*[89] **- are misplaced. In response, some collaborative approaches to overcome the challenges of adoption and diffusion have emerged.**

Adoption and diffusion - a note on definitions

Adoption and diffusion are closely associated terms, although under certain definitions they refer to distinct processes. In several NHS England policy documents, for example, adoption is defined as *"putting [a] new idea, product or service into practice, including prototyping, piloting, testing and evaluating its safety and effectiveness"*. Diffusion, meanwhile, is defined as *"the systematic uptake of the idea, service or product into widespread use across the whole service"*.[90]

While definitions like these attempt to neatly separate adoption and diffusion, they are frequently written about as two sides of the same coin: adoption can often be understood as the individual institution's experience of, or role within, the broader process of diffusion of an innovation. Below, we discuss the challenges of adopting and diffusing innovations together, while acknowledging there are distinct challenges associated with the two processes.

A substantial literature exists identifying the different **barriers** to the adoption and diffusion of innovation. Some significant barriers include:

- **Regulation and health technology assessment**. Regulatory barriers vary considerably by country but often include a lack of clarity of regulatory pathways and around what evidence is required for new innovations. Alongside this, in low-income countries, the rigorous standards imposed by international organisations can mean that new technologies are subjected to lengthy and expensive licensing processes, which increases the cost that local manufacturers have to invest in addition to production costs, ultimately making devices too expensive for local markets.

- **Difficulties for innovators in finding buyers, and buyers in finding innovations**. In the language of micro-economic theory, these difficulties are called 'search frictions', a particular kind of market failure.[91] Search frictions can particularly impact the adoption and spread of innovations developed by SMEs, as opposed to established companies which tend to have more contacts within health systems.

- **Internal health system barriers**. Another significant set of barriers to the adoption and diffusion of innovations can be characterised as structural and cultural barriers and barriers which are internal to health systems:

  - **Budget-related risk aversion**. Budgetary pressures mean that the long-term benefits of innovation can be subordinated to short-term budgetary concerns. There is also a lack of investment in research, which means that the evidence that budget holders require to demonstrate that an innovation will deliver value for money is often missing.

  - **Financial disincentives**. Organisations that rely on central reimbursement may find that they stand to lose out from innovative commissioning - a new technology may cut in half the number of operations necessary for a particular condition, and in doing so cut in half a particular income stream.

  - **Institutional conservatism**. A common theme identified by organisations operating in very different parts of the world was skepticism among established clinicians in regard to the potential of certain kinds of innovation, for example digital technologies, or technologies placing more control in the hands of patients. A related barrier involves a skepticism among those involved in health in high-income countries in the value of innovations that come from low- and middle-income countries.[92]

This section explores some of the open or collaborative models that have arisen to address these challenges. These include attempts to:

- Overcome barriers to discovery of innovations and buyers through **online marketplaces and platforms** and **innovator support programmes**.

- Overcome internal health system challenges: reduce risk aversion within health services in regard to innovation adoption, and increase health system capacity for adoption and spread of innovations through **innovation scouting programmes and improvement collaboratives**.

It should be noted that this is not an exhaustive account of collaborative models to overcome barriers to adoption and diffusion. Notably, a number of collaborative initiatives have emerged to address issues related to financial risk in the adoption of innovation, for example risk sharing initiatives at the regulatory stage or Social Impact Bonds at the point of commissioning. However, an adequate treatment of these emerging forms of collaboration is beyond the scope of this report.

Overcoming barriers to discovery of innovations and buyers

Online marketplaces and communities

It is often difficult for health buyers to discover innovations. Marketplaces and online communities help innovators to reach health system buyers (or in some cases patients) and provide buyers with a convenient space to discover and compare potentially useful innovations. They take a range of different forms, from marketplaces aimed at clinicians and health system decision makers, to sharing platforms with a more peer-to-peer orientation.

One example is Maternova, a global online marketplace which tracks and sells innovative ideas and technologies for maternal health. Founded as a for-profit social enterprise in 2009 by an American development professional with a background in maternal health, Maternova is a platform that helps inventors get their inventions into the field, while helping health workers and health-system decision makers to keep up-to-date with new technologies and conveniently buy them together in customizable 'bundles'.[93] The company received seed funding through Investors' Circle, an Impact Investing Network.[94]

Maternova started out as an Innovation Index, tracking innovative, affordable maternal technologies. The site attracted thousands of visitors from around the world. Increasingly, the team received queries from health workers who did not know where to buy the technologies listed on the Innovation index. At the same time, the team was contacted by innovators and small businesses who needed a way of getting their technologies to potential buyers.[95]

The team realised that there was a gap in the field of maternal health for an innovation marketplace. The marketplace that they established now sells to a number of large customers, including the United Nations, and Ministries of Health and private hospitals in over 40 countries. A successful example of diffusion via Maternova comes in the work of the US non-profit Midwives for Haiti, which provides an 'obstetric pak' as a graduation gift to all the nurses it trains.[96]

While online marketplaces aim to help practitioners adopt innovations, some online communities are focused on directly accessing patients and their non-professional caregivers.

Patient Innovation was launched in Portugal in 2014, initially as part of an academic research project examining user innovation. It is a global, open-source platform which focuses on sharing innovations that patients and carers themselves have developed.[97]

People using the site can upload innovations in different categories corresponding to the condition or symptom they address. Innovations range from products available for purchase, such as clothing adapted for people who struggle with fine motor skills, to simple pain management techniques. All posts are screened by a medical team to ensure that the innovations are safe. Over 500 solutions have so far been collected from over 30 countries. To help improve access of patients to these solutions, the site has signed agreements with over 20 patient organisations in over eight countries.[98]

An example of an innovation which has spread thanks to the platform is Robohand, a low-cost 3D printed prosthetic hand, first developed as a collaboration between a South African and an American special effects artist who had developed a 3D printed prop hand. Robohand was shared on Patient Innovation, and has now been accessed by patients in Portugal with similar needs,[99] as well as inspiring the creation of e-NABLE, a large network of volunteers developing prosthetic hands.[100]

Patient Innovation - a platform which helps spread knowledge about new health innovations.

Diffusion support programmes

While online marketplaces and platforms can help innovators and customers to find each other, they are a relatively passive approach and not necessarily sufficient to achieve a broad diffusion of innovation. A survey of practitioners in six countries by the Global Diffusion of Healthcare (GDHI) working group found that only 8 per cent of respondents got ideas to improve their practice from innovation hubs and databases (the most common sources of ideas were patients and professional colleagues).[101]

To address this challenge, the last few years have seen national and international programmes emerge to more actively support innovators in making contact with buyers. Some of these resemble the accelerators and fellowships discussed in the invention chapter, with a combination of individual and cohort support, and networking - the key difference being that the emphasis is on support for adoption and diffusion rather than **invention**. Others can be characterised as more 'active' curator organisations, which offer innovators support and make targeted efforts to drive diffusion, in addition to compiling and spreading information.

CASE STUDY
The NHS Innovation Accelerator

The **NHS Innovation Accelerator** is a fellowship programme launched by NHS England in 2015. It supports selected participants - a mix of clinicians, SMEs and academics - to scale up their innovations within the NHS in order to improve health outcomes.[102]

The accelerator was launched in part to support delivery of the *NHS Five Year Forward View*, a high level strategy for reform to meet major health system challenges. A central part of this strategy is focused on creating the culture and conditions for a more rapid take-up and spread of innovation. It was identified that driving this would require some examples of success, and better knowledge of what does and doesn't work in driving adoption and diffusion. The NIA has been designed to respond to these needs.

Although there is a rigorous selection process to insure that chosen innovations are high quality, the programme does not proceed by mandating the adoption of these innovations within the NHS or a particular part of it. Rather, it aims to build the capacity of good innovators (or inventors) to help them become good 'diffusers'. As the programme director highlights *"we don't just focus on picking good innovations, but also great people who will drive them"*.[103] A key selection criterion is being *"driven by right reasons - scaling up innovation to improve health outcomes, rather than just for commercial gain"*.[104] An important requirement is the ability to devote two days per week to the programme.

While in the first year of the programme an open call was made to innovators working in any health field, in its most recent iteration, desk-based research and surveys with health innovation stakeholders (including Academic Health Science Networks (AHSNs), NHS vanguard sites, and clinical mentors) were carried out to identify areas of particular need. In 2016 the categories under which innovators could apply were prevention, early intervention, and long-term condition management.

Fellows accepted onto the accelerator are partnered with one or more AHSNs and receive mentoring from health system and innovation experts, and a bursary (provided by AHSNs). Within the first month, fellows have to pitch innovations and scaling strategies to an audience of people working within and alongside the NHS system. They have the opportunity to identify areas in which they would benefit from more help, for example health economics or understanding commissioning. They also have the chance to attend 'speed dating'-style sessions with groups of commissioners, patient groups, primary and secondary care providers, where fellows can get honest feedback about their innovations and plans. Fellows meet with the NIA team hosted at UCLPartners at least every six weeks on a 1:1 basis or with their cohort at quarterly events.

Credit: Courtesy of Amanda Begley.

The PneuX tube system, designed to prevent ventilator-associated pneumonia.

In its first 17 months, the accelerator supported 17 fellows to get their interventions taken up in 419 organisations, and to raise over £20 million in funding. One successful innovation accepted in the first year of the NIA was the PneuX Pneumonia Prevention System, a cuffed ventilation tube which aims to prevent ventilator-associated pneumonia (VAP), the most common cause of hospital-acquired mortality in Intensive Care Units in England. Since joining the NIA, PneuX has had a successful hospital trial, including an economic evaluation which showed a saving of £718 for each patient receiving treatment with the PneuX.[105]

Another variety of diffusion support fellowships, usually with a self-proclaimed 'market innovation' orientation, emphasises supporting innovators to scale-up by expanding as providers, thereby bypassing the need to get their innovations adopted by existing (public sector) providers.

An example is Innovations in Healthcare (formerly the International Partnership for Innovative Healthcare Delivery, or IPIHD) a non-profit organisation hosted by Duke University and founded in 2011 by Duke Medicine, McKinsey & Company, and the World Economic Forum.The organisation, along with its sister organisation, the USAID funded Social Entrepreneurship Accelerator at Duke (SEAD), a three-year accelerator programme, works by selecting entrepreneurs with promising healthcare innovations. It then builds up their capacity by connecting them with the opportunities, information, and contacts they need to scale up their work. The programme is international and particularly focused on health challenges in low- and middle-income countries.[106]

Examples of the types of organisations Innovations in Healthcare and SEAD have supported include Jacaranda Health, a non-profit network of affordable, high quality maternity hospitals in Kenya aimed at low-income families. Through Innovations in Healthcare, Jacaranda Health gained access to investment of $150,000 to expand operations.[107]

Overcoming internal health-system barriers to adoption and diffusion

While diffusion support initiatives aim to drive adoption and diffusion by building the capacity of inventors to reach customers, it has been argued that even the most proactive initiatives of this type will not lead to a more systematic adoption and diffusion of innovation within health systems, as they do not address the internal barriers discussed above.[108] Here we consider three interesting groups of models and initiatives which have emerged to tackle these alternative barriers: hospital innovation centres, health system innovation scouting and improvement collaboratives.

Health system innovation scouting

If adopting innovations is to become commonplace rather than associated with particular initiatives, health systems' internal capacity to find and implement useful innovations needs to be improved.[109] The initiatives we group together here as forms of innovation scouting do this in various ways. Some take the form of in-house hospital innovation centres, while others are specific scouting initiatives developed through local academic-health system partnerships.

Hospital innovation centres have become a popular feature for health systems across the USA, particularly since the passage of the 2010 Affordable Care Act, and increasingly in other parts of the world. Innovation centres often also have an 'invention' function, serving as a space for the development of new ideas and practices, as they frequently emphasise it in their external communications. However, by integrating a process of scanning and scouting for existing innovations into the process of designing innovative responses to particular health challenges, they can also be effective as a means for stimulating the adoption of innovations.

CASE STUDY

Mayo Clinic Centre for Innovation

"Our goal always is to look elsewhere and see what others have done, rather than say that everything has to be an entirely new solution. Otherwise you waste a lot of time, when good solutions already exist."[110]

Dr Douglas Wood, Medical Director, Mayo Centre for Innovation

Mayo Clinic Centre for Innovation (CFI) well known for its integration of ethnographic style design methods in the process of developing innovations for use in the non-profit, Minnesota-based Mayo Clinic health system (see the **Invention** section). However, another responsibility that the CFI holds is scanning for existing innovations, to avoid a constant 'reinvention of the wheel' when responding to problems which have already been addressed in various ways elsewhere.

In 2010, the CFI launched a new project to improve primary healthcare. Known as the Community Health Transformation project, it did not begin with a sharply defined problem. Rather, two CFI service designers, with architectural and industrial design backgrounds respectively, started by spending a year carrying out ethnographic research with patients and staff in a rural clinic within the Mayo system. This research produced two key findings: first, that the care team was not working well, and second, that many of the issues patients were experiencing were not 'pure' health issues, but rather issues that required social services.

The CFI has developed a package of initiatives to respond to these issues. While some were designed, others were identified during a process of scanning for existing innovations.

Credit: Courtesy of Douglas Wood.

A Wellness Navigator at the Kasson clinic in Minnesota.

One innovation identified during the scanning process was the **Health Leads** model. First developed in Boston, Health Leads is a non-profit organisation that allows healthcare professionals to 'prescribe' resources like food and heat, by recruiting and training university students as volunteer social assistants who 'fill' the prescription by helping patients to access various available statutory and non-statutory services. The model, which capitalises on the large number of driven and public-spirited students in a university town such as Boston, has had considerable success, and since its 1996 launch has spread to New York, Baltimore and the Bay Area.

The CHT team saw the applicability of this model in rural Minnesota, and worked with the Kasson Clinic to implement **Wellness Navigators**, an adapted version of Health Leads. Initially, Wellness Navigators were student volunteers from the University of Minnesota, as a three-month pilot. However, at the end of the pilot the doctors and nurses who had been working in teams with Wellness Navigators were keen for their work to continue. Rural Minnesota lacking the supply of student volunteers available in university-heavy Boston, the CFI working with Mayo found a way to create the Wellness Navigator as a paid role within the team, which employs local people. The Wellness Navigator role has since been scaled across the entire Mayo health system, and has even attracted interest from some clinicians working in secondary and tertiary care who can see the value of the model. The CFI thus played an important role in identifying and supporting the adoption of a useful innovation, but also in adapting it to make it work in its new context.[111]

In the UK, regional partnerships have established smaller scale initiatives which seek to build similar capacities. For example, Academic Health Science Networks (AHSNs) have been established in 15 regions across England. They connect NHS and academic organisations, local authorities, the third sector and industry at a regional level, and are specifically tasked with supporting the adoption and diffusion of innovation within the NHS.[112] While many of their initiatives have been associated with search frictions faced by innovators (see the NHS Innovation Accelerator discussed above), they have also increasingly engaged in programmes to build the internal adaptive capacity of different units of local health systems.

The Intrapreneur Programme, run by Imperial College Health Partners, a London-based AHSN, is a ten-week programme that works with multidisciplinary teams of frontline staff and executives from different health organisations in North West London. The programme involves workshops with executives to identify a specific innovation challenge, support for the 'owner' of a problem to explore it in more detail, and then a 'learning and doing' journey with challenge teams. The emphasis is placed on building capacity to scout for existing solutions, and adapting them, rather than creating new ones.[113] A team from the Royal Brompton & Harefield NHS Foundation Trust, for example, has used the programme as a means of improving the lung transplant assessments are carried out for high-risk patients. Following the programme, teams have managed to reduce transplant assessment test waiting times, potentially saving two bed days.[114]

Improvement Collaboratives

Healthcare Improvement Collaboratives are a more established collaborative method to promote diffusion of health innovations. They have been used most widely in the USA and other high-income countries, but are also being employed in low and middle-income contexts. While the scouting initiatives discussed above aim to help a specific health organisation adopt and adapt innovations, collaboratives focus on the spread of innovations between organisations. They have been described as *"temporary learning organisations"*[115] that *"bring together groups of practitioners from different healthcare organisations to work in a structured way to improve one aspect of the quality of their service."*

Improvement Collaboratives usually involve a number of teams, made up of professionals from a number of disciplines, and are focused on improving services in a particular area. Participants have the opportunity to attend several group workshops given by experts, which focus on innovations and models that have worked in other locations. Participants then plan, implement and evaluate numerous small service changes. In subsequent workshops and meetings, participants report back on their progress and exchange experiences. They continue to receive support from collaborative organisers and to share ideas with each other between meetings.[116]

The Institute of Healthcare Improvement (IHI), a non-profit based in Cambridge, Massachusetts, is well known for using different kinds of collaboratives to support the diffusion of health innovations. It has developed a widely referred to 'Framework for Spread.' Famous examples of its application have been the IHI's work with the Veterans Health Administration, which used it to help drive significant improvements in patient waiting times in the 2000s,[117] and the 100,000 Lives campaign, which, it is claimed, prevented over 120,000 deaths in 18 months, through the implementation of changes in six areas across several major American health systems.[118]

The collaborative method is increasingly being employed in middle- and low-income countries.[119] A notable example was a collaborative which ran in South Africa between 2006 and 2009, supported by IHI, which focused on improving the national Preventing Mother to Child HIV Transmission (PMTCT) programme. The problem the collaborative aimed to tackle was unexpectedly high transmission rates, despite the availability of the necessary drugs.[120]

The collaborative focused on the Eastern sub-district within the Cape Metro, which had the highest mother-to-child HIV transmission rate in the district. It consisted of two phases: a prototype phase lasting 21 months, and a spread phase lasting 18 months. Every six months, representatives from the participating clinical sites met at workshops on quality improvement methods, which they applied at their home sites in between the sessions, with mentoring from project staff. Successful changes developed in the prototyping phase were put together into a 'Change Package.' These included: a more thorough early antenatal booking procedure; physically accompanying pregnant women to the ARV clinic; and a 'Mother2Mothers' programme providing education and psychological support. These solutions were spread to other participating clinics through the workshops, as well as through monthly meetings.

Significant improvements were recorded both in processes and outcomes: the proportion of eligible HIV positive women receiving the necessary treatment increased to over 80 per cent and the HIV positive rate for exposed infants declined significantly, from 7.6 per cent to 5 per cent.

d. Cross-cycle initiatives

In order to highlight how collaboration has been used to address distinct challenges across the innovation cycle, we have chosen in this section to organise initiatives separately by stage. Frequently, circumstances dictate that an initiative focuses on 'opening up' one phase of the cycle, while other phases are carried out in a more traditional manner. For example, 'open' processes of invention may be preceded by traditional forms of problem identification and followed by traditional forms of adoption and diffusion. This is not necessarily a bad thing - it may be appropriate, for example in the case of a well established problem where there has been plenty of investigation - but where solutions are still needed.

However, there are some initiatives which might be described as 'multi-stage', integrating two or more phases of the innovation cycle, so that, for example, 'open' forms of invention can themselves be informed by 'open' forms of problem-identification. People Powered Results, a programme led by Nesta in the UK, offers an interesting example.

CASE STUDY

People Powered Results (PPR), England

"We have broken down barriers. You can have good ideas, but if you have a cross-team you can cut through the red tape and do the things you've always wanted to."[121]

General Practitioner, Stockport

People Powered Results (PPR) started from the observation that innovation projects in the NHS frequently 'cut up' the innovation cycle, tackling one phase of a problem and then handing it over to another organisation to handle the next stage. Quite often, the understanding of unmet needs that originally underpinned the innovation gets lost in the process. The PPR model was designed to respond to this problem, by promoting 'ownership' of a problem by the people closest to the action throughout the innovation cycle. It has been applied in several regions in England to various types of care, from unplanned admissions for frail elderly patients to a range of specialities within elective care.

PPR was co-designed by Nesta's Health Lab and the Rapid Results Institute, a US non-profit. The model works by empowering frontline staff to test out different approaches and work across professional boundaries within a defined period. In contrast to the conventional 'commissioning' role played by leaders in the health system, leaders are encouraged to engage in 'permissioning', by conveying to workers that relevant standard operating procedures are set aside for the duration of the assignment, and making sure that team members are freed up to give priority to it. Frontline staff are given permission to try new ways of working – for example different working hours, team composition, patient pathways, configuration of IT systems and collaboration with the voluntary sector. This enables a detailed re-configuration of services based on frontline insight.[122]

Each PPR 'cycle' involves a partnership between a particular regional health system and the PPR facilitating team, which provides a combination of facilitation and coaching support to create or reinforce the conditions needed for effective innovation and change. A cycle usually involves three phases: **Design phase**, **100 Day Journey**, and the **Sustainability and Dissemination phase**.

The two-month **design** phase is focused on problem identification and consensus building. The PPR team works with health system leadership (both local and national) to design a challenge which is posed to the frontline. Although the challenge is defined by leadership, the specific goal to be achieved is set by a cross-sector frontline team which is specially formed to respond to the challenge, and thus has to reflect their motivations and needs. For example, the Cardiology and Respiratory team within the Stockport health system was challenged to *"improve patient experience for people with multiple long-term health conditions, and better manage demand in elective care, through: transforming outpatient appointments, rethinking referrals models and/or exploring the potential of shared decision-making."*

Following the design and preparation work with the local leadership teams, the frontline teams convene at a two-day **launch event** to explore and define the ideas they want to prototype, and set their own 'stretch goals' to keep them focused during their 100-day journey. The team is encouraged to make the specific goals 'unreasonable but realistic'.

Credit: Courtesy of Dan Farag.

Frontline practitioners get creative at a PPR design session.

For example, during the two-day launch event with the Stockport Cardiology team, four different ideas were developed: triage of existing referrals and the development of a new referrals process, co-located community-based 'breathe clinic', enhanced condition management discussions and a patient self-management plan.

The **100 Day Journey** involves a process of on-the-fly 'invention', through frontline experimentation and learning, which also tackles internal barriers to the adoption of innovations. Teams are always multi-professional, bringing together frontline practitioners from hospitals, primary care, the voluntary sector, and if appropriate private providers such as care homes. Weekly team meetings facilitate collaborative working, focus on a joint goal, and the capability to carry out rapid cycle testing. A mid-point review reinforces permissioning, consensus on the challenge and goal, and the removal of system barriers.

During the final **Sustainability and Diffusion** phase, meetings are held with frontline teams and system leaders, to consolidate and distil learning, and explore sustaining and scaling the innovations that have emerged. Notably, at a public 'Sustainability' event, the results of the 100 Day Journey are celebrated, and system leadership makes a public commitment to supporting the continuation of the innovations that have emerged – which may involve the decommissioning of existing services. Decisions are also made as to how this environment can be fostered over time with less direct facilitation from the PPR team. This may include further rounds of rapid results initiatives, or training of PPR coaches from within the system.

The PPR model has successfully been applied with health systems in several regions of England. A good example is the project carried out with Mid Essex Clinical Commissioning Group (CCG).[123] The starting problem was the need to improve care for the frail population, for whom rates of unplanned admissions to hospital were extremely high. This problem was presented to frontline teams, who worked over a two-day launch event to define a new model for person-centred care planning. During the 100 Day Journey, three teams were formed to test different elements of the new model simultaneously.

A notable innovation that emerged from this process was the Information About Me (IAM) form, specially designed to enable frail patients to express priorities and shape their care. The IAM form has allowed far better coordination between the different professionals and agencies working with a given frail individual. However, a key finding was that specific interventions were 'only the tip of the iceberg'; the real power of the model lay in the relationships it built between different professionals and organisations who previously rarely communicated.

The pilot achieved a 10-12 per cent reduction in unplanned hospital admissions (on a pre/post evaluation basis) for a patient cohort of 7,000, tracked over an 18-month period. It also accelerated the pace of integration across the health economy, and was attributed by local leaders to the CCG moving from a 'financially distressed' health economy to the region's best financially performing. As the sustainability manager for Mid Essex CCG put it:

"When you go out and meet with professionals, you get a feeling that there's an awful lot more energy in the system, people are working together. The relationships have been developed, there are now direct telephone conversations rather than referrals going off and having to wait several weeks to get a conversation going. That's a huge benefit."

4. Opening up health innovation: Putting lessons into practice

In this section, we draw together insights from our research on what it takes to create successful open innovation initiatives, and provide some guidance for public sector decision makers interested in applying open innovation approaches in health systems. We use the example of São Paulo to show how stakeholders there identified opportunities for open innovation within their specific health system, and designed and implemented initiatives that fitted this context.

Setting up an open innovation initiative

Open innovation initiatives will always need to respond to their context, so there can be no 'single recipe' for success. Instead, we offer a simple four-step process to help decision-makers think through appropriate strategies for their own health innovation systems and contexts. Each step involves considering a number of questions. These are set out below, and in the form of a planning sheet in the annex.

1. Identifying problems and scanning

a. **Identify needs**. What problem or unmet need should the initiative address?

b. **What type of problem is this?** Is it a combination of several problems?

c. **Evaluate current efforts/processes**. How well does the health innovation system currently work to solve this problem? What initiatives are currently in place to address it (if anything)? What is not working? Has anything been tried in the past? Why did it work/not work?

d. **Assets**. What assets are available locally, that an open innovation initiative might usefully draw on?

e. **Learning from other open innovation initiatives**. What types of initiatives have been tried elsewhere to tackle this problem?

2. Defining an approach

    f.   **Objectives**. With all this in mind, what will be the objectives of the initiative?

    g.   **Methods**. What model(s) of open innovation initiative will be used?

3. Working out the details

    h.   **Partners**. Who will the key partners be?

    i.   **Roles**. What contribution will each partner make? Who will the lead partner be?

    j.   **Incentives**. How will each partner be motivated to participate? Why will it be in their interest? How will they benefit from being involved?

    k.   **Resources**. Where will funding come from? And how will it be leveraged?

    l.   **Team**. Who will form the core team to deliver the initiative and coordinate the partners?

    m. **High profile support/endorsement**. Which influential figures or organisations could support the initiative? Whose support would be really valuable?

    n.   **Outputs**. What tangible things will the initiative deliver? For example, how many people will be involved, ideas supported, policies produced, etc?

    o.   **Measuring outcomes and impact**. What change is expected as a result of the initiative? How will outcomes be measured? What metrics could be used? How would failure be managed?

4. Reflection

    p.   **Assessment**. How feasible is the planned open innovation initiative? Why is this a strong model? How could its value be communicated?

    q.   **Challenges**. What challenges - technical, legal, institutional, cultural - might arise when putting this plan into practice? How could they be overcome?

Finding open innovation initiatives to address specific problems

	1. What problem are you trying to solve?	2. What types of initiative could address this problem?	3. Examples
Problem identification	Monitoring of problems is too slow or expensive, or geographically uneven	Real-time monitoring	Healthmap
		Crowdsourcing data	De Grote GriepMeting
	Current processes fail to capture issues important to patients and citizens	Peer research	Community Health Agents
		Online feedback systems/ communities	Patient Opinion
		Participatory priority setting	Conselhos de Saúde
Invention	Market failure blocks development of responses to key health problems	Challenge prizes and platforms	Fighting Ebola Grand Challenge
		Product Development Partnerships	Medicines for Malaria Venture
		Data sharing initiatives	Tres Cantos Open Lab
	Entrepreneurs lack financial and informational resources to take their ideas beyond the first stage	Accelerators	Zeroto510
		Fellowships	School of International Biodesign
	Innovations on the market do not address real system and patient needs	Ethnographic and design approaches	Mayo CFI
		Pre-commercial procurement programmes	SBRI Healthcare
	The ideas and insights of practitioners are untapped	Clinician innovation programmes	Bright Ideas Fund
		Co-design and co-production initiatives	The Lambeth Collaborative
Adoption and diffusion	Innovators cannot access buyers	Online marketplaces and communities	Maternova, Patient Innovation
		Diffusion support programmes	NHS Innovation Accelerator
	Health systems are not effective in adopting and spreading innovations	Scouting	The Intrapreneur Programme
		Improvement Collaboratives	IHI initiatives

Applying open innovation thinking in the State of São Paulo

Identifying needs and opportunities

Public health in Brazil has improved considerably since since the Unified Health System (Sistemo Unico de Saude, or SUS) was established in 1988. Nevertheless, the country continues to face serious health challenges.[124] For example, although there have been significant decreases in mortality from some infectious diseases, others have remained stable (chagas, tuberculosis) or have increased (HIV/AIDS, dengue).[125] At the same time, reflecting economic, social and demographic transitions in Brazilian society, mortality from noncommunicable diseases has grown. These are now estimated to account for 74 per cent of total deaths, a level approaching that of high-income countries. This is associated with rising demand for longer-term care, and rising costs, partly due to greater need for expensive new technologies. Finally, death from violent injuries remain comparatively high.[126]

The State of São Paulo is historically a centre of health innovation in Brazil. Among its assets are the state Health Secretariat's network of seven highly regarded health research institutes.[127] However, while biomedical and epidemiological research is a strength in Brazil, relatively little of this research generates international patents or is translated into interventions such as new medicines, vaccines, and diagnostic kits.[128]

In 2011, the State Health Secretariat,[129] through the Coordination of Science, Technology and Strategic Health Supplies (CCTIES), sought the cooperation of Fundação Instituto de Administração (FIA) to establish a set of Technology Transfer Offices (Núcleo de Inovação Tecnológica, or NITs) to support the commercialisation of the work of researchers based in each of the research institutes. However, despite considerable advances, the

Pitch session to conclude the Technology Acceleration Programme at Instituto Adolfo Lutz.

NITs found it difficult to overcome long standing barriers - both legal and cultural - to the closer collaboration between public and private sectors which would enable a wider translation of research strengths into practical innovations.

Therefore, in 2015, in another partnership with FIA, the Health Secretariat decided to continue to support promotion of innovation in the research institutes, with a stronger focus on cooperation with other relevant actors in São Paulo and Brazil. In this context, in 2016 the Health Secretariat accepted the invitation of the São Paulo State Government and UK Embassy to carry out the Open Innovation in Health project.

The São Paulo: Open Innovation in Health project aimed to address the 'triple burden' of health problems set out above, and to create more practical value from the work of the health research institutes. In line with previous experiments in more open approaches to innovation in various public services in the state, it was felt that involving a wider range of actors in health innovation, and developing fruitful partnerships between them, would be necessary to adequately respond to the complex health challenges of the state and the country more widely. The underlying objective of the project was therefore to improve the capacity of the state's health system to collaborate both 'inside-out' and 'outside-in'.

Defining an open innovation approach to fit the São Paulo context

Supported by the Prosperity Fund (administered by the British Embassy in Brazil) and the São Paulo State Government, the São Paulo: Open Innovation in Health project was delivered as a partnership between the Government of the State of São Paulo (Secretariats of Health and Government) and implementing agents Nesta and 100%Open in the UK, and Fundação Carlos Alberto Vanzolini (FCAV) and Fundação Instituto de Administração (FIA) in Brazil.

A preliminary stage focused on identifying a suitable partner institute for a set of pilots. In 2012 the Health Secretariat (in partnership with FIA) conducted a cycle of visits to the seven

health research institutes involving a survey of all active or recent research projects in the institutes and their respective maturity level regarding innovation.

Instituto Adolfo Lutz (IAL), a leading centre for public health research, emerged from this process as a partner with particular potential. A later survey at IAL succeeded in identifying 98 innovation opportunities, in a wide variety of areas, including new drugs, new diagnostics, software and biotechnology. In addition, there were several other factors which made IAL a viable partner for a set of pilots to explore open innovation, including the presence of a Technological Transfer Office (NIT) capable of supporting project actions within the institution and a strong alignment and commitment of the leadership with the promotion of innovation.

The next stage of the project involved a set of workshops and discussions to determine the form a set of open innovation pilots could take. The workshops brought together a diverse range of actors of the health ecosystem in São Paulo, including research institutes, hospitals, equipment manufacturers and pharmaceutical industry, patient organisations and government. Participants were invited to identify significant unmet health needs in Brazil, and to collaboratively sketch out open innovation initiatives to tackle them, drawing inspiration from examples presented from around the world. The workshops succeeded in highlighting the potential of new forms of collaboration, and generated considerable enthusiasm for putting some of the ideas that emerged into practice.

Following these workshops, partners decided to run two pilots, based on these open innovation methods. The pilots largely focused on the invention and adoption stages of the innovation cycle:

• An accelerator programme that would support selected researchers at IAL to explore a range of business models and eventually commercialise their innovations. This programme was chosen because Instituto Adolfo Lutz researchers had a number of promising ideas with innovation potential, but lacked skills to develop business models and form partnerships.

- A second pilot in the form of a challenge issued to external companies and researchers to develop a new tuberculosis (TB) diagnostic suitable to Brazilian needs, in collaboration with Instituto Adolfo Lutz. The challenge was an attempt to bring new ideas and technologies into IAL in a different way than had been tried before. IAL had experience working with businesses, but this usually involves a business approaching IAL to collaborate on a specific project. IAL had never issued an open call before and wanted to experiment.

The experience of these two pilots is set out in more detail below.

Pilot 1: Tech Push - Technology Acceleration Programme

The technology acceleration programme was designed to enable research groups to work in a more open manner and to promote partnerships and interactions to speed up the development of health innovations into useful products and services. The pilot was designed to test the usefulness of a support programme that could be scaled up to other research groups at Instituto Adolfo Lutz and to other research institutes in the State of São Paulo.

At the beginning of the process, the Innovation Technology Centre of Instituto Adolfo Lutz identified 12 technologies that seemed to have potential to be developed into innovative products and services. From these, six groups of researchers were eventually selected to join the acceleration programme. The technologies ranged from a new HTLV diagnostic to an educational card game to help students understand the microbiology behind infectious diseases.

The acceleration programme ran over ten weeks and involved a series of workshops, individual mentoring sessions, meetings with external partners and a pitching session. The content covered in these sessions included theory on innovation, commercialisation and diffusion of innovation, practical advice on marketing and finding potential partners, and advice on identifying opportunities and threats. These activities were designed to help the researchers create and refine commercialisation plans and identify alternative business models as well as potential partners, users and customers.

While in the initial pilot of the accelerator was characterised by the opportunity to engage with potential private sector partners, partners recognised that engaging with patients/citizens, patient organisations, hospitals and other stakeholders might also be valuable (depending on the nature of the innovation). These opportunities will be incorporated into future phases of the accelerator.

Pilot 2: Market Pull - Challenge Call

While the acceleration programme represented a 'technology-push' model - trying new approaches to get IAL's research out into the market - partners in São Paulo were also keen to experiment with new ways of getting ideas into the health system. For this, a 'challenge' model was proposed, with the goal of engaging individual stakeholders or groups of stakeholders to provide a solution to a specific health problem. Partners carried out multiple interactions with people and groups to identify the unmet need that would be the focus of the challenge. As a result of these, they decided to focus the pilot challenge on unmet needs in the control of tuberculosis in Brazil.

In 2015, about 4 per cent of new tuberculosis cases and 21 per cent of previously treated cases globally were of a type multiresistant to the antimicrobial used. Brazil ranks 20th among the 30 countries with high tuberculosis incidence and 19th in the list of 30 countries with a high incidence of tuberculosis associated with HIV.[130] For these reasons, tuberculosis has been one of the diseases defined as priorities by the National Ministry of Health since 2003, with an annual average of 71,000 new cases and 4,500 deaths reported in Brazil between 2006 and 2015. Meanwhile, the State of São Paulo diagnoses the

largest absolute number of tuberculosis cases in Brazil - nearly 17,000 new cases were reported in 2016. In 2015, 138,600 molecular rapid tests for the diagnosis of tuberculosis and 231,500 bacilloscopies were carried out in the State of São Paulo.

The new global TB strategy approved by the World Health Assembly in 2014 set targets for eliminating the disease by the year 2035. To meet these goals, it is important that patients suspected of tuberculosis receive a rapid and accurate diagnosis so that resistant cases are identified and an adequate antimicrobial programme is used in the treatment, improving the patient's healing conditions and avoiding the increase of resistance of the mycobacteria that causes the disease.

Instituto Adolfo Lutz has already sequenced the DNA of tuberculosis-causing mycobacteria from Brazilian patients and identified the mutations that confer this resistance to antimicrobial drugs. Brazil also monitors non-tuberculous mycobacteria that cause lung diseases and are a major concern in tropical countries.

A particular problem that partners identified was that molecular tests for rapid diagnosis of tuberculosis were developed in other countries, where the characteristics and distribution of disease and cases of resistance are different from those in Brazil.

The challenge call was based on the premise that Brazil would benefit from a rapid molecular diagnostic test capable of identifying, in a

Exploring open innovation methods at a workshop in São Paulo.

single step, whether a sample contained non-tuberculous mycobacteria or mycobacterium tuberculosis, and if TB was identified, to be able to show whether it was resistant to the two medicines most commonly used to treat the disease. The test would therefore be optimised for Brazil's specific needs. Furthermore, partners specified that the test should be manufactured - or at least, the final phases of assembly should take place - in Brazil. This was seen as necessary to avoid delays in accessing the tests.

The challenge was launched at public events in São Paulo and London, to promote the participation of startups, established companies, consortia and other institutes interested in establishing a partnership with IAL to solve the problem. Like the accelerator, the challenge aims to promote greater 'porosity' in health innovation in Brazil by opening opportunities for ideas and knowledge coming from outside state research institutes. The challenge has been disseminated in a number of countries and to institutions that promote and sponsor health in the world. Notably, the open innovation pilot for project has held talks with UK stakeholders to promote partnerships with UK companies and researchers.

It was decided to provide a three-month window for application, from the day of the challenge call publication at Instituto Adolfo Lutz. At the time of writing, the challenge call was still open. Partners anticipated that the next step would be for a technical committee to evaluate the proposals and take forward the selected ones for negotiation of possible partnerships with the State of São Paulo through Instituto Adolfo Lutz.

Key success factors and learning points

Early results suggest that the pilots have already had success in encouraging more open innovation practices. By February 2017, the accelerator programme had resulted in five expressions of interest from external partners in collaborating with IAL, for example to licence the technologies participating in the accelerator. The State Government has indicated commitment to continuing the accelerator: the programme will have an annual edition in the next years and should involve more research institutes.

Meanwhile, the work that went into preparing the challenge call has laid groundwork for similar initiatives to take place in future. Project

Pitch session to conclude the Technology Acceleration Programme at Instituto Adolfo Lutz.

partners in São Paulo worked closely with the State Attorney's office to define the challenge call in a way that was consistent with federal and state legislation. Having done this (and shown that legal frameworks need not form a barrier), partners anticipate that open calls for partners will be easier to set up in future. From this perspective, the Open Innovation in Health project took place at an opportune moment. In 2016, the previous Federal Innovation Law (2004) was updated. Before this, the governance of technology and innovation partnerships between public and private sector organisations had a diffuse legal basis, with different regulations and norms at federal and state level. The 2016 update of the Federal Law introduced a series of new possibilities for interaction between industry and academia for the promotion of innovation. A working group was created in the state of São Paulo, to analyse and propose possible adaptations of the state's legislation to the new legal framework. In parallel, the São Paulo: Open Innovation in Health project was carried out, seeking to follow the path allowed by the new legal framework for the implementation of innovation projects involving the participation of private actors.

This new legal framework allows agreements to be made with startups and spin-offs created from technology developed by the research institute, helping to overcome a key barrier that prevented effective collaboration with entrepreneurs in the past. For example, the State Government earlier ran a pitching competition for startups, Pitch Gov, which resulted in some agreements with startups to co-develop solutions (for example by giving access to data or locations to test new innovations). However, finding a way to deal with the financial aspects of these agreements presented challenges from a legal standpoint. Before the Open Innovation in Health project, technology transfer and the interaction of the research institutes with industry were hindered by the lack of legal definitions and guidance regarding innovation.

A few valuable lessons can be drawn from the Open Innovation in Health project experience so far:

- **The importance of visible, committed leadership**: Strong support from leaders in the State Government's Health Secretariat (particularly CCTIS and Instituto Adolfo Lutz) were fundamental in the execution of the project, and helped break down existing institutional and cultural barriers. The support given by the leaders gave the project strength and prestige, and empowered the participants in their search for results. In communicating the project to partners, institutional support (e.g. formal invitations to meetings signed by IAL's director), helped overcome initial doubts and scepticism in several cases. Another important factor was the institutionalisation of the project by means of a resolution signed by the State Governor, and the establishment of a Strategic Committee comprising key stakeholders.

- **Promoting ownership of the open innovation agenda within Instituto Adolfo Lutz**. At the beginning of the project, a workshop was held for all area directors at Adolfo Lutz Institute in order to disseminate the concepts of innovation and open innovation and, therefore, to support the work and dedication of the researchers in the acceleration programme as well as all NIT initiatives In this direction.

- **Tackling regulatory and legal issues head on**: In Brazil there are several (real and perceived) regulatory and legal barriers to open innovation. While the law allows collaboration between research institutes and companies, cultural attitudes (for example, a suspicion of business motives among public sector employees) often gets in the way of technology transfer. Partners studied several legal models during the pilot project for cases of interaction between institutes and companies. Interaction with the state Attorney General's office from the project's inception and the involvement of the Secretariats of Health and Government enabled the multidisciplinary team to overcome previous interpretations of the legal framework that placed more limits on collaboration.

Success factors for open innovation initiatives

This section has offered a framework which decision-makers might use in planning an open innovation initiative for health, and has described the São Paulo: Open Innovation in Health project as an example. Finally, here we draw together some key success factors that emerged from our research, which aspiring open innovators would do well to keep in mind:

1. **Respond to gaps in the innovation system**. Initiatives are most effective when they address clear gaps or barriers to innovation. For example, the Zeroto510 accelerator was set up to address regulatory issues, while the NHS Innovation Accelerator was set up to help professionals gain the skills and networks they need to spread their innovations.

2. **Capitalise on existing strengths and resources**. When attempting to set up open innovation initiatives, capitalise on resources which are present. Zeroto510 took advantage of Memphis' status as an established hub of medical device activity, while TOMPSA makes use of the wide availability of smartphones to rapidly create innovations that address real world needs.

3. **Start small and simple**. While health policymakers are under immense pressure to tackle their most challenging problems first, open innovation is a relatively new set of methods. Many successful initiatives start with low hanging fruit, or with fairly modest ambitions. Succeeding on these projects can help demonstrate impact, which is important for gaining the support to expand operations and achieve greater things.

4. **Gain support from health leadership**. Support from leadership is widely cited as a key factor in the success of open innovation initiatives. In certain cases, these figures play the role of 'rogues' within the system who are willing to support and advocate for the initiative from within. In other cases, the involvement of high profile leaders or institutions adds prestige – as in the São Paulo: Open Innovation in Health project.

5. **Build strong relationships with health services at different levels**. While these relationships with high level leaders are important, strong relationships with health services at different levels also tend to play an important role in enabling a good understanding of system needs or providing timely feedback as in, for example, the People Powered Results programme.

6. **Support teams of innovators**. Having the right core team is indispensable. In the case of fellowships and accelerators, this is a question of finding a group of people with the right skills and experience (for example entrepreneurial experience, or expertise on regulation and IP) who are willing to give of their time in order to provide participants with the resources they need. Finding people who are willing to work behind the scenes to make connections, without themselves playing the role of star innovator, is equally important.

7. **Provide opportunities for close interdisciplinary working**. Several programmes provide opportunities for participants to work closely with people from different professional backgrounds, with whom they might not usually have contact. This gives people new perspectives, and also means participants can fill each other's knowledge gaps (for example, clinicians who may lack expertise in IP).

8. **Focus on innovators as well as innovation**. Successful programmes often emphasise their recognition of the importance of choosing the right innovators, rather than just innovations - individuals who will be able to drive adoption and diffusion, and are motivated by more than profit. Our research also suggested that collaborative initiatives with health professionals are most successful when they are properly rewarded for their work, and allowed to keep a good share of the intellectual property.

Annex 1: Open innovation in health initiative planning sheet

Capture your initial thoughts about creating an Open Innovation initiative. Discuss key design decisions and test out thinking with a group of wider stakeholders.

What is the name or working title of your OI Initiative?

First steps

Identify needs
What problem or unmet need do you wish to address?

What 'type' of problem is this?
See column 1 in the table on page 57. Which statement best captures your problem?

Evaluate current efforts/processes
What is currently in place to address this problem (if anything?) What is not working?

Studying other OI initiatives
See column 3 in the table on page 57. Which initiatives have addressed this problem? What can you learn?

Assets
What assets are available locally that you might usefully draw on?

Defining your approach

Objectives
With all this in mind, what will be the objectives of your initiatives?

Working out the details

Partners
Who will the key partners be?

Incentives
How will each partner be motivated to participate?

Team
Who will your core team be to deliver the initiative and coordinate the partners?

Outputs
What will the outputs be?

Methods
What model(s) will you borrow from? (See columns 2 and 3 on page 57 for ideas).

Roles
What contribution will each partner make? Who will be the lead partner?

Resources
Where will your funding come from? And how will it be leveraged?

High profile support/endorsement
Which influential figures or organisations could you get to support the initiative?

Measuring impact
How will you measure and show impact? How would you manage failure?

Reflection

Assessment
How feasible is your OI initiative? Why is this a strong model? And how do you communicate its value?

Challenges
What challenges do you foresee when putting this plan into practice and how might you overcome them?

Annex 2: Project partners

The State of São Paulo Government

Secretariat of Government: Sub-secretariat of Partnerships and Innovation – Innovation Unit

Civil House of the State of São Paulo: Support Unit for Advisory on International Affairs

Secretariat for Economic Development, Science, Technology and Innovation: Sub-Secretariat of Science, Technology and Innovation

State Secretariat of Health: Coordination of Science, Technology and Innovation in Health – CCTIS; Adolfo Lutz Institute – IAL

State Attorney General Office: General Sub-Attorney of General Consultancy

Steering Committee of the Project

Secretariat of Government – Sub-Secretariat of Partnerships and Innovation – Innovation Unit: Sergio Pinto Bolliger and Roberto Meizi Agune

Civil House – Support Unit for Advisory on International Affairs: Danielle Scarpassa do Prado

State Secretariat of Health – CCTIS: Sérgio Swain Müller and Sueli Gonsalez Saes

State Secretariat of Health – IAL: Helio Hehl Caiaffa Filho

Secretariat for Economic Development, Science, Technology and Innovation – Sub-Secretariat of Science, Technology and Innovation: Fernando Martins Rocha and Yolanda Silvestre

State Attorney General's Office – General Sub-Attorney of General Consultancy: Fábio Augusto Daher Montes

FCAV/FIA: Guilherme Ary Plonski

British Consulate in São Paulo: Esther Rosalen

Government Of The United Kingdom

UK Foreign & Commonwealth Office; British Embassy in Brasília; British Consulate in São Paulo

Project delivery teams

Secretariat of Government – Sub-Secretariat of Partnerships and Innovation – Innovation Unit: Roberto Meizi Agune, Alcione de Godoy, Christine Parmezani Munhoz and Sergio Pinto Bolliger

State Secretariat of Health – CCTIS: Sérgio Swain Müller and Sueli Gonsalez Saes

State Secretariat of Health – IAL: Helio Hehl Caiaffa Filho, Denise Hage Russo, Paula Helena Ortiz Lima

Carlos Alberto Vanzolini Foundation – FCAV: Guilherme Ary Plonski, Guiomar Bueno de Moraes Milan and Luis Marcio Barbosa

Institute of Administration Foundation – FIA: Guilherme Ary Plonski, Arnaldo da Silva Junior, Cely Ades and Claudia Pavani

Nesta: Madeleine Gabriel, Isaac Stanley and Tom Saunders

100%Open: David Simoes-Brown, Murray Sim and Yanitsa Vladimirova

Annex 3: Interviewees

Amanda Begley, Director of Innovation and Implementation, UCL Partners.

Allan Daisley, President, Zero to 510.

Natalia Mantilla Beniers, Associate Professor, Universidad Nacional Autónoma de México.

Prashant Jha, Fellowship Director, School of International Biodesign, AIIMS and IIT Delhi.

André Luiz dos Santos, Resident Doctor, Hospital da Irmandade da Santa Casa de Misericórdia, São Paulo.

Graham Tydeman, Consultant Obstetrician, NHS Fife.

Karen Livingstone. SBRI Healthcare Lead Director, EAHSN.

Douglas Wood, Medical Director, Center for Innovation at Mayo Clinic.

Thomas Sudow, Director of Business Development (former), Cleveland Clinic Innovations.

Mohammed Dalwai, Director, The Open Medicine Project.

Vera Schatten P. Coelho, Senior Researcher, Brazilian Center for Analysis and Planning (CEBRAP).

Dan Farag, Head of Rapid Innovation, Health Lab, Nesta.

Roundtable participants

Matthew Harris, Clinical Senior Lecturer in Public Health Medicine, IGHI (Imperial).

Sarah Bowker, Implementation Lead, Healthy London Partnership (NHS England).

Jemma Gilbert, Head of Prevention, Healthy London Partnership (NHS England).

Don Redding, Director of Policy, National Voices.

Endnotes

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