OECD publishing

COLLABORATIVE MECHANISMS FOR SUSTAINABLE HEALTH INNOVATION

THE CASE OF VACCINES AND ANTIBIOTICS

OECD SCIENCE, TECHNOLOGY AND INDUSTRY
POLICY PAPERS
March 2023 **No. 145**

OECD
BETTER POLICIES FOR BETTER LIVES

OECD Science, Technology and Industry Policy Papers

This paper was approved and declassified by written procedure by the Committee for Scientific and Technological Policy (CSTP) on 15 March 2022 and prepared for publication by the OECD Secretariat.

Note to Delegations:

This document is also available on O.N.E under the reference code:

DSTI/STP(2021)30/FINAL

Collaborative Mechanisms for Sustainable Health Innovation: The case of vaccines and antibiotics

Hermann Garden

The provision of key health technologies and products such as vaccines and antibiotics is insufficient in purely competitive and volume-based markets, requiring new revenue streams for sustainability. Recent developments in health innovation suggest that innovative collaborative mechanisms can be effective in addressing this issue. In the domains of vaccines and antibiotics, these approaches should incorporate shared research investment, long-term access planning, the provision of manufacturing infrastructure, supply chains, and financial returns. Collaborative approaches such as subscription models could be piloted at the regional level, while other models could be developed to delink innovation, manufacturing, and access from sales volume and revenue. Finally, blended finance instruments from the development field could encourage greater collaboration among established and emerging stakeholders in health innovation. These stakeholders should work together to create, test, access, and implement more collaborative approaches to health innovation to share upfront investments, mitigate risks of failure, and accelerate market access.

Keywords: Health innovation, vaccines, antibiotics, health resilience, collaborative platforms, business models, blended finance, public-private partnerships

Foreword

This document is an output of the OECD Working Party on Bio-, Nano-, and Converging Technology (BNCT), in particular the project on "Collaborative platforms for pandemic preparedness and health resilience". The project forms part of Module 2 "Collaborative technology platforms for sustainable development" (PWB 1.3.2.2.1 2021-2022).

The document builds on results for the following activities conducted by the BNCT:

- An *ad-hoc* study on collaborative platforms for pandemic preparedness and health resilience (Q3 2020).
- A webinar "Collaborative platforms for pandemic preparedness and health resilience: future directions" (14 December 2020).
- An expert consultation "Business Model Innovation for Emerging Technology and Health Resilience" (29 April 2021).
- A multi-stakeholder panel "Innovating global health: collaborative action where markets fail" at the BNCT-CSTP high-level conference "Technology in and for society" (6-7 December 2021) [link to conference recordings].
- A workshop "Policy directions for critical health technology innovation and access" (28-29 September 2022, Seoul, Korea). Participants discussed the appropriate policy and economic ecosystems to realise the full potential of critical health technologies for global health challenges.

The project informs and contributes to other projects and horizontal activities across the OECD:

- The CSTP PWB activity on STI financing for the SDGs: global health and climate transitions [DSTI/STP(2020)19].
- The CSTP cross-cutting project 'Societies in times of crisis and beyond: developing responsive and resilient science and innovation systems' [PWB OR 3.2.1.3.1].
- A cross-Directorate activity "Building the Resilience of Health Systems", which is led by the Directorate for Employment, Labour and Social Affairs (ELS), and supported by Central Priority Funding, Lead Output Area 2.4.1 "Achieving High-performing Health Systems."

The project kindly received voluntary contributions from the government of Korea and the Ipsen Foundation.

Executive summary

The Covid-19 pandemic offers a case of how multi-sector collaboration can accelerate research, development, and regulatory review of health technologies to address health crises and novel societal priorities. However, the pandemic has also revealed significant issues in global access to medicine, and the need for improving the system. It has exposed innovation gaps across all types of pathogens (bacteria, fungi, parasites, and viruses) as a source of epidemic outbreaks, human suffering, and negative economic consequences. The contribution of health technologies to positive long-term socio-technical transitions will require both governments and corporations to build an innovation ecosystem that bridges market and societal needs. Addressing global health priorities such as pandemics, population ageing, equitable access to healthcare, undernutrition, obesity, and mental health will require such an ecosystem.

Investment in innovation in antibiotics and other antimicrobials, pandemic vaccines, and diagnostics, has, regrettably, been historically low. Despite the emergence of several frameworks and public-private partnerships (PPPs) to drive innovation for global health, key elements of an innovation ecosystem and sustainable markets remain absent. At the heart of the issue is what constitutes and sustains a pharmaceutical market across research, innovation, demand, manufacturing and supply, access, cost-effectiveness, and return of investment. When markets and commercial prospects are limited, innovators find it difficult to secure funding, to develop a sustainable pipeline, and to ensure adequate returns.

Policy questions about how to realise sustainable research, product development and equitable access in the pharmaceutical sector grow out of fundamental tensions between open innovation, sharing, ownership and protection. Collaborative business models will be required to organise and facilitate multi-sector engagement, value exchanges, and to realise more open approaches to intellectual property (IP) licensing. From a business model perspective, activities should focus on novel structural funding, stewardship, sustainability, and risk-sharing instruments dedicated to pandemic preparedness and other areas where markets and return of investment are limited.

In the field of health technologies for pandemic preparedness and resilience, the paper identifies key issues that contribute to market failure: limited financial returns, inadequate market infrastructure and lack of coordination, concentrated markets and a small number of innovators and investors committed to R&D for WHO priority health issues. There is need for collective action among governments, non-profit organisations, funders, investors, public research and the pharmaceutical industry.

Key policy messages are:

- **Issues of market failure:** for some health technologies, markets are limited, and innovators find it difficult to secure funding, to develop a sustainable pipeline, and to ensure adequate returns. Insufficient societal prioritisation (societal demand), generally due to opaque benefits of pandemic preparedness, antimicrobial effectiveness, the availability of diagnostic tools, and health resilience, helps contribute to market failure.
- **Policy makers taking a lead:** strengthening investment in science, infectious diseases R&D, and resilient health systems offer significant positive societal externalities. Policy interventions should facilitate the generation of scientific evidence that underpins investment and portfolio discussions

of early-stage R&D. Policy makers have a key role to play in supporting public funding, ownership, and oversight where investment risks for health technology innovation are high and market returns limited.

- **Strengthening responsible innovation:** in order to realise the public benefit objective, responsible innovation principles must protect the interests of all stakeholders involved in the creation, translation and commercialisation of knowledge.
- **Making access a policy priority:** equitable access to health technology is not charity but should be a leading principle of business models for pandemic preparedness and health resilience. Inclusivity in research, knowledge sharing and equitable access to healthcare can only be achieved through a whole-of-society approach that includes policy makers, patients, funders, health care providers, researchers, and industry.
- **Leveraging new business models:** health technologies that are underprovided by purely competitive, volume-based markets require new revenue streams for sustainability. Approaches should include shared research investment, long-term access planning, provisions (pull mechanisms) for manufacturing infrastructure, supply chains and financial returns. Subscription models and other collaborative approaches to delink innovation, manufacturing and access from sales volume and revenue should be tested at regional level for possible future global implementation.
- **Leveraging blended finance:** blended finance could promote broader collaboration across established and new stakeholders in health innovation. In order to strengthen the use of blended finance in areas where traditional, competitive markets do not deliver, actors should: (1) enable more long-term planning, (2) build-in agility to react to short-term developments and stakeholder flexibility, (3) better connect financing of early-stage research with future market needs, (4) develop values and align incentives for all parties involved.
- **Integrate local stakeholders into global innovation networks:** innovators in health technology, especially start-ups and small- and medium-sized enterprises (SMEs), should build regional networks and engage in global partnerships to de-risk operations, address information asymmetry, leverage financial resources and leverage on intangible assets (IP, data, knowledge, and competencies). Involve local stakeholders in collaborative partnerships, including researchers, companies, beneficiaries and receiving communities, to help connecting investment with local markets and healthcare needs.
- **Develop and test novel approaches to health innovation:** emerging health technologies come with a high degree of global interdependence and strategic competition that should be balanced with multilateral cooperation on a regional and global scale. Stakeholders should co-create, test, access and roll-out more collaborative approaches to health innovation in order to share upfront investments, risks of failure, and to speed-up market access. Innovation platforms, such as CARB-X, CEPI, GARDP, and IHI, offer fertile ecosystems to spearhead sustainable and anticipatory solutions for global health.
- **Support communication and information sharing:** encourage interdisciplinary and cross-sector dialogue to share experiences from across technologies and public health needs. Despite the different root causes for market failure, the critical role of novel antibiotics, vaccines and diagnostics in pandemic preparedness and health resilience mandates cross-sector learning.
- **Assess performance of collaboration:** embrace a ‘measuring’ culture along the value chain of health technology innovation and delivery. Monitor and shape the economic and social impact of business models designed to pool together resources across actors. Evaluation standards and indicators on the performance of collaborative action should be practical but also theoretically robust.

Table of contents

Tables

Figures

Boxes

1 Introduction

Biomedical research and pharmaceutical innovation have been key drivers of longevity, health and well-being (Lichtenberg, 2017[1]; OECD, 2018[2]). However, the Covid-19 pandemic has laid bare the fragility of health technology innovation, manufacturing, and supply chains in areas that are critical for patients, public health and well-being. The context suggests that new innovation models will be needed in order to deliver health technologies that are often underprovided by purely competitive, market-based systems: vaccines, antibiotics and other antimicrobials. Governments and innovators are increasingly interested in the manifold forms these solutions can take. Indeed, antibiotics development and stewardship has been a priority at the G20 Health Ministers' Meeting 2021 in Rome, Italy, and at the G7 under both the United Kingdom and Germany presidencies 2021 and 2022.

The pandemic has created a greater awareness of global health needs, gaps, and unequal access to health products and care all over the world. It is crucial that global health stakeholders, including governments, policy makers, funders, researchers, companies, and intergovernmental agencies capitalise on this momentum and realise opportunities of business models that deliver health technologies as common pool resources (Gray et al., 2019[3]; World Health Organization (WHO), 2021[4]). Collaborative platforms, such as CARB-X, CEPI, GARDP and IHI have proven their important function in health innovation and resilience. They drive the development of global goods of science that can be translated into broader and more equitable product access. In this context, the Access to Medicine Index (ATMI)[1] highlights a heightened level of partnerships between pharmaceutical companies to curb Covid-19 (Access to Medicine Foundation, 2022[5]).

However, Covid-19 has also exposed long ignored innovation gaps across all types of pathogens, such as bacteria, fungi, parasites, and viruses as a source of epidemic outbreaks, human suffering, and negative economic consequences. The Covid-19 pandemic has created strong momentum to stimulate R&D infectious diseases monitoring, prevention and therapy. For example, as announced at the second Global COVID-19 Summit 12 May 2022, the United States National Institutes of Health (NIH) has agreed to license 11 health technologies (e.g. the SARS-CoV-2 stabilised spike protein) to the WHO Covid-19 Technology Access Pool (C-TAP).[2] The programme aims to share intellectual property (IP), data and know-how in order to facilitate timely, equitable and affordable access of Covid-19 health technologies.[3]

Covid-19 has triggered debates and actions to respond to the deficiencies in our current model of governance over the development, scale-up, translation, and manufacturing of health technologies. Facing disruption in the supply chain for a range of medicines, countries have discussed the possibility to strengthen manufacturing capacity at a national and regional level. Similarly, the lack of manufacturing on the African continent has been the topic of multiple discussions as its population is dependent on external players, thus last in line. The development of manufacturing infrastructure and supply chains requires horizontal, cross-sectoral approaches. There are various reasons for innovation gaps, supply shortages, and inadequate access in some health technologies. At the heart of the issue is what constitutes a sustainable pharmaceutical market: research, innovation, demand, clinical and cost-effectiveness, manufacturing, access, and return of investment. When markets incomplete and commercial prospects are limited, innovators find it difficult to secure funding, develop a sustainable pipeline, and to ensure financial returns. There is growing multi-stakeholder support to better balance the economic, health and social externalities of novel health technologies (Chen and Toxvaerd, 2014[5]; OECD, 2017[6]; OECD,

2021[7]; Roh and Kim, 2017[8]; UK G7 pandemic preparedness partnership, 2021[9]). However, despite the emergence of multiple frameworks for strengthening societal needs in global innovation ecosystems key elements of how to complement traditional, volume-based and profit-based markets remain absent.

> *"Health system resilience can be defined as the capacity of health actors, institutions, and populations to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and, informed by lessons learned during the crisis, reorganise if conditions require it."* (Kruk et al., 2015[10])

This paper brings together recent developments at national and international level to drive innovation and sustainable market development for technologies that are critical for people, societies and health resilience but where investment risks are high and financial returns limited. Drawing on examples from vaccines and antibiotics the paper outlines challenges for innovation and product delivery where purely competitive markets fail. It discusses how health technologies that are at risk of market failure but that have a critical role in society could be provided as a public good. Collaborative approaches offer opportunities to achieve a more sustainable ecosystem that delivers cost-effective, safe, secure and inclusive health technologies.

2 Where markets fail

Infectious diseases – some with epidemic potential and resistant to available vaccines and antimicrobials – represent a major public health challenge. Collective end-to-end approaches to possible future pandemics and other health crises are needed.

Classification of goods

Inadequate responses to infectious disease outbreaks and public health threats, such as AMR, influenza, Ebola, SARS and Zika, have prompted the WHO and other key stakeholders in global health to discuss new financing mechanisms for the provision of common goods for health (World Health Organization (WHO), 2021[4]). For example, the Global Health 2035 report highlights that "to meet the challenges of the next generation", international collective action must increasingly focus on global functions: "provision of GPGs [global public goods] (especially R&D), management of externalities, and leadership and stewardship" (Jamison et al., 2013[11]).

> *"A public good is a commodity, measure, fact or service: which can be consumed by one person without diminishing the amount available for consumption by another person (non-rivalry); which is available at zero or negligible marginal cost to a large or unlimited number of consumers (non-exclusiveness); which does not bring about disutility to any consumer now or in the future (sustainability)" (Reisen, Soto and Weithöner, 2004[12]).*

Table 1. Classification and examples of goods

		Rivalry: high	Rivalry: low
Excludability	high	Private goods: food, clothing, automobiles, contraceptive pill, antimicrobials, vaccines, diagnostics	Toll goods (club goods): theatres, private clubs, day-care centres
	low	Common pool resources: groundwater, fisheries, forests	Public goods: policy, communicable disease control, immunisation, herd immunity, antimicrobial efficacy

Note: low rivalry means that the use of a product or service by one person has only a minor impact on use by another person; low excludability means that one person is unlikely to be barred from using and accessing a product or service due to the use of others. For example, public goods do not dwindle in supply so that users are not excluded or limit the consumption by others.

Due to their critical function in health resilience and value provided to the global community pandemic vaccines and antimicrobials can be considered a global public good (Moon et al., 2017[13]; Su et al., 2022[14]).

Source: adapted after Moon (2017[13]), Ostrom (2010[15]), Tarrant (2019[16]; Su et al., 2022[14]).

Where markets are imperfect or incomplete, often characterised by a not Pareto efficient allocation of resources[4], multi-sector co-operation and sustainability-driven business model are needed in order to use limited resources efficiently, allow for adequate return of investment, and drive equitable access (Arrow, 1963[17]; Greenwald and Stiglitz, 1986[18]; Mwachofi, Assaf and Al-Assaf, 2011[19]; Lüdeke-Freund and

Dembek, 2017[20]). Market failure in general, and the health sector is no exception, can be associated with imperfect information, a lack of competition, investment risks, limited return of investment and the unique ecosystems of product externalities (broader effects to society other than the manufacturer or the consumer). Positive and negative 'externalities' of health technologies (e.g. greater public benefit than financial profit, better health and well-being, health spending growth, sustainability of public funding) compound to the complexity of markets. Vaccines and novel antibiotics provide useful examples of markets that are not ideal in economic theory and where is opportunity for government and civil society intervention (Barnett et al., 2002[21]).

It is understood that some public goods, such as herd immunity and antimicrobial efficacy, depend on health technologies which are mostly provided by companies as market-based products (i.e. private goods, see Table 1). Thus, they come with a degree of rivalry and excludability due to investment needs, potential overuse, manufacturing constraints and price. Their unique product characteristics make it costly (but not impossible) to not exclude potential beneficiaries from obtaining benefits from their use. Also, due to their collective nature, societies may take their benefits for granted, not fully appreciating the extent of public health impact (Gaudin et al., 2019[22]). In this context Moran (2019[23]) and Tarrant et al. (2019[16]) use the example of antibiotic efficacy to illustrate how a collective resource can be exhausted due to over-use of antibiotics across human and animal healthcare and agriculture. However, often the development and sustainable supply of novel antibiotics cannot be matched by an adequate return of investment – leading to market failure (Mannix, 2020[24]; Outterson et al., 2021[25]; World Health Organization (WHO), 2021[4]). Innovation, supply and management of health technologies to address infectious diseases often requires collective financing across public and private sectors because companies cannot charge a market price that generates adequate profit to sustain business and supply. Therefore, policy makers, funders, investors, companies and payers should include aspects of common property and resilience alongside product innovation and access.

Vaccines

Vaccine innovation and supply in particular is characterised by risks, in part because of complex manufacturing and supply security issues, a limited market size, the need for affordable pricing and demand patterns that often do not reflect the public benefit of vaccines. This situation does not favour investment in vaccine innovation, regulatory approval and manufacturing – especially not at affordable prices in LMICs that are challenged by fragmented infrastructure and healthcare systems. The licensing and implementation of a new vaccine into routine immunisation and outbreak response requires data-intensive quality, safety and efficacy information, reliable forecasting, stable supply chains at scale, appropriate and quality controlled storage facilities and vaccination infrastructure (Plotkin et al., 2017[26]). Also, regulatory, legislative and political issues affect procurement and access to quality, affordable vaccines (World Health Organization (WHO), 2020[27]). Stable and well-functioning regulatory systems (WHO maturity level 3 or above) with transparent, streamlined and predictable processes are critical to close the gap between the time a new vaccine becomes available in industrialised countries and its supply in developing countries (Makenga et al., 2019[28]). However, a distinction should be made between vaccine markets for infectious diseases and for cancer, allergy and autoimmune diseases in term of risk profiles (combining research and development timelines and transition rates) and productivity gaps (Pronker et al., 2013[29]).

Following the concept of immunisation as a global public good (Su et al., 2022[14]), investment decisions for vaccine innovation and manufacturing include economic, medical, epidemiological, ethical and political aspects. Large social externalities, such as herd immunity, health system robustness and ethical considerations add to the complexities of vaccine markets (Bärnighausen et al., 2014[30]; Fahlquist, 2018[31]; Luyten and Beutels, 2017[32]). For example, public health and economic benefits from immunisation programmes can be greater than the sum of the direct health benefits of a vaccinated person

but individuals do not often consider the positive impact that their vaccination decisions may confer on a larger community (Chen and Toxvaerd, 2014[5]; Bärnighausen et al., 2014[30]).

As noted by Dr Jayasree K. Iyer, CEO, Access to Medicine Foundation, at the OECD webinar Collaborative platforms for pandemic preparedness and health resilience (2020), vaccine manufacturing remains concentrated, and few companies are involved in the vaccine space despite strong and increasing global demand. According to the WHO (2020[27]) four large manufacturers (GSK, Pfizer, Merck, and Sanofi) provide 90% of global vaccine value, and five produce 60% of global volume (Serum Institute of India (SII), GSK, Sanofi, BBIL and Haffkine). Also, manufacturer diversity (number of suppliers per vaccine product) has a significant impact on supply security and access: one third (19 out of 56) of the vaccine products used globally are manufactured by fewer than three companies. For example, supply security issues are of highest concern for meningitis (MenA), human papillomavirus vaccines (HPV), and pneumococcal conjugate vaccines (PCV) with only two or less prequalified suppliers. The WHO (2020[27]) reports that fifty-six countries (42% of 132) indicated vaccine supply shortages or stock outs in 2019. On the contrary, competition between manufacturers and low prices for some traditional vaccines has forced companies to leave the market (World Health Organization (WHO), 2019[33]). For example, the median price per dose for the Bacillus Calmette–Guérin (BCG) tuberculosis vaccine self-procured by purchases in high-income countries is USD 1.00, for the bivalent oral polio vaccine (bOPV) USD 1.01, for the measles vaccine USD 3.09 and for the diphtheria and tetanus vaccine (DT) USD 0.81 (World Health Organization (WHO), 2020[27]).

The global market value for vaccines has been estimated at USD 33 billion in 2019 (for comparison, this is 2% of the global pharmaceutical market) (World Health Organization (WHO), 2020[27]). Significant public and charitable funding, successful partnerships between a broad range of public and private stakeholders, robust R&D pipelines and emerging immunisation technologies, such as virus-like particles and nanoparticle subunit vaccines, nucleic acid technologies and rational vaccine design, are a key driver for innovation and market growth (Brisse et al., 2020[34]; Cross et al., 2021[35]; Pagliusi, Che and Dong, 2019[36]). Fortune Business Insights (Fortune Business Insights, 2022[37]) projects a further increase of the global vaccine market to USD 125.49 billion in 2028. Notably, mid-size manufacturers in Asia are already following the positive trend through an expansion of their portfolios (World Health Organization (WHO), 2020[27]). However, in order to further strengthen vaccine innovation and to enable large-scale immunization efforts some issues need to be addressed, for example: inadequate funding for clinical research in academia, risks for upscaling and manufacturing yet unlicensed vaccine candidates, long time between first regulatory approval and global deployment and challenges in the public-private collaboration (Greene et al., 2021[38]; Janse et al., 2021[39]).

Antibiotics

Antimicrobial resistance (AMR), and antibacterial drug-resistance in particular, represents a leading threat to public health in countries around the world (Centers for Disease Control, 2019[40]; European Commission (EC), 2017[41]; EU/ OECD, 2019[42]; Ryu, 2017[43]). Each year, over 2.8 million antibiotic-resistant infections occur in the US alone, leading to more than 35 000 deaths (Centers for Disease Control, 2019[40]). A study by Cassini et al. (2019[44]) showed that the number of disability-adjusted life-years (DALYs) due to infections with antibiotic-resistant bacteria in the EU to be similar to the combined burden of influenza, tuberculosis and HIV (170 DALYs and 183 DALYs per 100 000 population, respectively). A recent study by Murray et al. (2022[45]) estimates that the health impact of bacterial AMR is at least as large as other major infectious diseases such as HIV and malaria.

Despite the value of antibiotics to society, the number of truly novel FDA-approved antimicrobial drugs (i.e. molecules with novel mechanisms of action or other distinguishing characteristics) has decreased over time and their commercialisation delayed (Boluarte and Schulze, 2022[46]; Butler et al., 2022[47]; Miethke

et al., 2021[48]). Interviews with policy makers and other experts in AMR performed by Årdal et al. (2021[49]) revealed that 12 of 13 countries face shortages of existing antibiotics, 8 of 13 indicated that inadequate supply of specific antibiotics resulted in greater use of broad-spectrum antibiotics, thereby potentially increasing AMR. According to Boluarte and Schulze (2022[46]) 84% of the revenues generated from a new antibiotic come from the US – most novel antibiotics are not even provided by markets outside the US (Kallberg et al., 2018[50]). This innovation gap is mirrored by companies leaving the business: from 2017 to 2021 six companies have discontinued the development of antimicrobials or declared bankruptcy; 2 others announced massive layoffs (Boluarte and Schulze, 2022[46]; Boucher et al., 2020[51]).

Why do antibiotics markets fail? One reason is an unsustainable innovation ecosystem where investors and companies see limited prospects for financial returns in a relatively small antibiotics market of USD 38.3 billion (total global market 2018) (Frank et al., 2021[52]). For example, the annual US market for antibiotics has been USD 20 million to USD 100 million, which is well below the required revenues of USD 300 million in order to cover investments for, e.g. R&D, licensing, post-approval studies, manufacturing (Access to Medicine Foundation, 2021[53]; Boluarte and Schulze, 2022[46]; Clancy and Hong Nguyen, 2019[54]).

Some of the challenges to antibiotics innovation, manufacturing and supply are unique, such as antibiotics stewardship, short treatment courses, relatively low prices and, arguably, an under appreciation of personal and societal value. Other issues (e.g. high investment costs, development failure rates) are shared with R&D in chronic diseases (Boluarte and Schulze, 2022[46]): it can take up to 15 years and over USD 1 billion to develop and deliver a new antibiotic. Hence, companies are facing significant funding gaps and business risks at two stages along the trajectory of health innovation: first, when transitioning a potential future antibiotic from Phase 1 to Phase 3 ('R&D Valley of Death'), and, second, when introducing an approved drug into markets ('Commercial Valley of Death') (Access to Medicine Foundation, 2021[53]). Paradoxically, antibiotic rational use and stewardship are directly connected to inadequate innovation pipelines, inadequate private sector engagement and a lack of "preparedness" for future developments in AMR (UK G7 pandemic preparedness partnership, 2021[9]).

The pandemic has been a driver for the formation of new and novel forms of collaboration between 'unusual' partners and disciplines who have not been working together before (Liu et al., 2020[55]; Maher and Van Noorden, 2021[56]). Despite the unfavourable market conditions some SMEs and pharmaceutical companies remain committed to antimicrobial R&D – often as part of collaborative partnerships. Small- and medium-sized enterprises (SMEs) have an important role in antimicrobial innovation and between 200 and 300 small companies worldwide now conduct the vast majority of research work on novel antibiotics. There is broad agreement that without new, more collaborative antibiotic development and business models, the majority of promising molecules, data, and IP in the pharmaceutical pipeline will not be commercially viable. A key challenge to SMEs is the difficulty in "valuing intangible assets" (OECD, 2019[57]). In this context The Combating Antibiotic Resistant Bacteria Biopharmaceutical Accelerator (CARB-X), the Coalition for Epidemic Preparedness Innovations (CEPI), Global Antibiotic Research and Development Partnership (GARDP) and Gavi, the Vaccine Alliance, have been playing a leading role to better integrate start-ups and SMEs into multi-stakeholder platforms for global health challenges.

These examples demonstrate shared challenges and some notable common ground with regard to the need for a greater diversity of stakeholders engaged in infectious diseases prevention, monitoring and therapy. The cases also show unique features in relation to technology readiness and health system uptake of diagnostic tools for infectious diseases. For example, an inadequate evidence base of the clinical use of diagnostics (clinical trial data, validation and cost-effectiveness assessments), limited laboratory infrastructure, a lack of a single diagnostic platform and standards and insufficient policy alignment between countries and regions remains a weak link in antimicrobial stewardship (O'Neill, 2015[58]). Access to affordable diagnostic and monitoring devices is an important challenge for populations, especially the ones in low- and middle-income countries (LMICs). According to WHO only 1% of primary care clinics in LMICs have basic diagnostic capacity, while 18 of the 20 conditions responsible for the most years of life

lost in those countries required a laboratory diagnostic assessment. As health infrastructure for diagnostics is limited in LMICs, this prevents companies for reaching and expanding their diagnostic products in new markets, reaching economies of scale. Similar to the factors discussed as drivers for market failure in vaccines and novel antibiotics, O'Neill (2015[58]) identified weak financial returns and a mismatch between the individual, commercial and social value of diagnostics as reasons for slow innovation and use of new diagnostics. However, tensions between R&D incentives, market protection and an increase of revenues have to be considered for the development of policy instrument mixes (Coburn et al., 2021[59]).

3 Collaborative action

The looming health crisis of AMR and the Covid-19 pandemic have further strengthened the commitment by public funders, philanthropy and industry to further strengthen collaborative research, innovation and manufacturing for novel antibiotics (Frank et al., 2021[52]; Gotham et al., 2021[60]; Pelfrene, Botgros and Cavaleri, 2021[61]; Rodríguez-Baño et al., 2021[62]). For example, the case of Aspen Pharmacare, arguably Africa's first Covid-19 vaccine plant, has shown that initiatives led by individual stakeholders focused on selected disease areas and technologies are neither effective nor sustainable. The company (Aspen SA Operations) signed a licensing agreement with Johnson & Johnson (J&J) to use Covid-19 vaccine drug substance (supplied by J&J), in order to bottle and sell Aspen-branded Covid-19 vaccines to public sector markets in Africa.[5] However, the lack of orders and significant maintenance costs of the sterile manufacturing facilities could force the company to return to the production of other pharmaceuticals (Barnes, 2022[63]; Cocks, 2022[64]).

New governance arrangements, financing approaches and business models can help reduce the world's vulnerability to future pandemics and drive innovation where markets fail. For example, the G20 High Level Independent Panel on Financing the Global Commons (IPPPR, 2021[65]) suggests to implement a Global Health Threats Fund in order to support "research and breakthrough innovations that can achieve transformational change in efforts to prevent and contain future pandemics, complementing existing R&D funding mechanisms like CEPI." In this vein, the One Health framework, discussed at the G20 Health Ministers' Meeting 6-7 September 2021 in Rome, Italy, has become a guiding principle for multisector responses to pressing global issues at the intersections of people, animals, plants and the environment.[6] Health ministers pledged to strengthen collaborative efforts on health security, strengthening vaccine confidence and fighting AMR.

A report by the OECD (2020[66]) encourages cross-sectoral learning and investment for global public goods, such as biodiversity, climate stability, and health security. Multi-lateral initiatives that drive co-creation, policy experimentation and the implementation of better governance structures will be important to manage public goods, strengthen pandemic preparedness and enable fair and equitable access to vaccines (OECD, 2020[66]; OECD, 2021[67]). Recently, and particularly within the last five years, Mission-oriented innovation policies (MOIPs) have attracted a great deal of attention. MOIPs are defined by OECD as a co-ordinated package of policy and regulatory measures tailored specifically to mobilise science, technology and innovation in order to address well-defined objectives related to a societal challenge, in a defined timeframe. These measures possibly span different stages of the innovation cycle from research to demonstration and market deployment, mix supply-push and demand-pull instruments and cut across various policy fields, sectors and disciplines (Larrue, 2021[68]). Concretely, a mission-oriented policy is a 'proactive platform for collective actions' articulating, for each selected challenge, a collectively developed agenda, a dedicated structure of governance to take and monitor the effects of common or mutually consistent decisions and, finally, a tailor-made and integrated policy mix (OECD, 2023[69]).

An increasing number of countries have turned to these policy approaches, often through different pilots and experiments, in particular to tackle global warming and global health issues. For example, in Germany, the High Tech Strategy 2025 has set Combating cancer has one of its 12 national missions in order to 'prevent as many new cases of cancer as possible and enable cancer patients to lead a better life'. At the EU Level, the Mission on Cancer – one of the five the Horizon Europe missions – aims at "improving the

lives of more than 3 million people by 2030 through prevention, cure and for those affected by cancer including their families, to live longer and better". In the United-States, the Cancer Moonshot, launched in 2016, is starting in 2022 its second phase with the objective of reducing the cancer death rate by half within 25 years and improve the lives of people with cancer and cancer survivors.

As shown by Covid-19 vaccines, a plethora of scientific and structural capacities and capabilities, such as frameworks for emergency use, clinical trials, monitoring/pharmacovigilance, and legal and regulatory capacity, need to be implemented globally in order to enable rapid risk-benefit assessments and to ensure the necessary measures for deployment (e.g. liability and indemnification, immunisation frameworks). Hence, ideally – authorised vaccines for any pathogen with epidemic or pandemic potential should be available as part of a robust preparedness framework. In practical terms, however, this is not the case because of a lack of commercial market for epidemic vaccines (which has been the rationale for establishing CEPI), inadequate data in achieving necessary documentation for regulatory authorisation prior to an outbreak, and unpredictability of outbreaks of new and unknown pathogens.

A study conducted by the OECD in 2020 shows alignment across stakeholders[7] in global health on how policy could help increase the responsiveness, efficacy and capacity of the innovation ecosystem in order to respond to health crises:

- Explore novel structural funding, sustainable business models and risk-sharing instruments dedicated to pandemic preparedness and other areas where markets and return of investment are limited.
- Support collaborative platforms and other agile forms of public-private partnerships across established, new and 'unusual' stakeholders (e.g. philanthropy, local research and health care providers).
- Support scientific task forces with regular rotation to provide policy makers access to key experts on an ad-hoc basis.
- Foster discussion across the Sustainable Development Goals (SDGs): what can be learned from SDGs in terms of strengthening health resilience?
- Increase the transparency of *ad-hoc* funding opportunities and allocation.
- Further strengthen regulatory alignment and review the effectiveness of the International Health Regulations (IHR) (Fifty-eighth World Health Assembly, 2005[70]) as an overarching framework that defines countries' rights and obligations in handling public health events and emergencies that have the potential to cross borders.

Collaborative platforms

As a response to pressing global health challenges, such as AMR, epidemic outbreaks, tropical infectious disease, malnutrition and dementia, diverse collaborative platforms across countries and sectors have emerged for the development of new health technologies and processes (Jarrett, Yang and Pagliusi, 2020[71]; Munro, 2020[72]; Schwartz and Yen, 2017[73]). Acknowledging the close links between human health, agriculture, animal health and the environment, the collaborative One Health approach offers viable options to drive collaborations across diverse communities to further strengthen health resilience. For example, the European One Health Action Plan against AMR[8] and the call "A roadmap towards the creation of the European partnership on One Health antimicrobial resistance (OH AMR)"[9] aim to bring together funders, policy makers, relevant agencies and authorities and the research community in order to strengthen coordination and collaboration among different fields of research and innovation with relevance to AMR.

Collaborative platforms for health innovation can be described as multi-sector arrangements around shared goals, resources and values for research, product development and delivery (Garden, Hawkins

and Winickoff, 2021[74]; Gawer, 2014[75]). Viewed together, collaborative platforms demonstrate a trend towards finding the right kind of mix of public and private elements. Indeed, building and sustaining value – scientific, economic, and social – in the context of global health is a defining challenge across actors.

Other key objectives of collaborative platforms consist of efforts to sustain both internal and external legitimacy; pursue both flexibility – to adapt members' contributions and composition to the evolving nature of the target challenges – but also stability, to enable the establishment of trust and shared routines; ensure intent and consensus over goals, but also diversity of ideas and approaches to promote innovation; guarantee both the autonomy of independent partners but also accountability towards shared goals and performance metrics (Provan and Kenis, 2007[76]; Saz-Carranza and Ospina, 2011[77]).

The pandemic offers a case of how multi-sector collaboration can accelerate research, development and regulatory review of health technologies to address global health crises and novel societal priorities. It has been a period of innovation and partnership, with the pharmaceutical industry showing just how quickly it can move to address a healthcare crisis. Enhanced resources and benefit sharing, and a commitment to consensus-oriented decision making across policy makers, industry, funders, non-governmental and philanthropic organisations can deliver innovative health technologies that must cope with fragmented demands, investment risks and significant externalities. However, there are policy issues not only in implementing more sustainable and integrated business models for health technology innovation but also in strengthening long-term, cross-sector partnerships. In this vein, Yu (2016[78]) suggest a more nuanced framework that takes into the account the expertise of collaborative partners and the nature of the pharmaceutical industry: integrated drug discovery and development platforms offer a collaborative approach to manage significant upfront investments, risks of drug development failure and to speed-up market access. Yu (2016[78]) describes the integrated drug discovery model as an approach where "the respective expertise of academia and industry are brought together to take promising discoveries through to proof of concept as a way to de-risk the drug discovery and development process."

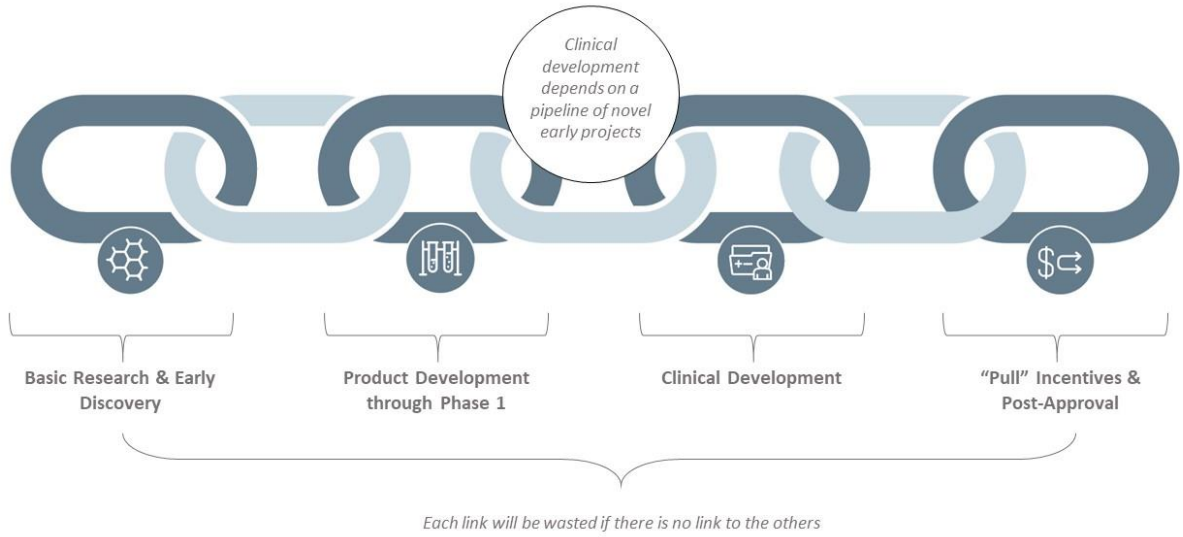
A role model for cross-sectorial open innovation in areas of market failures is the Innovative Health Initiative (IHI, formerly the Innovative Medicine Initiative (IMI)). Representing the world's biggest public-private partnership (PPP) in life sciences with a budget of EUR 5.3 billion from 2008-2020, IHI offers a unique framework to spark tight collaboration between key players and stakeholders involved in health research, including universities, research centres, the pharmaceutical and other industries, small and SMEs, patient organisations and medicine regulators. IHI is jointly funded by the European Union and the European pharmaceutical industry. IHI has invested more than EUR 1 billion of its budget in 14 innovative projects tackling AMR. Researchers are pursuing a holistic approach that includes collaboration across the health, food and environmental sectors and tackles prevention of infections, hygiene, stewardship measures, as well as a sound push and pull incentives ecosystem. A cornerstone of the successful partnership is the commitment of dedicated resources, scientists and expertise to the projects by the private partners.[10]

Several new molecular entities coming out of these projects have entered clinical stages. A dedicated clinical network today connects over 1 000 hospitals and labs in more than 30 European countries. This interdisciplinary IHI project (COMBACTE-NET and related projects)[11] is working on 11 clinical trials with six antibacterial molecules, while advancing epidemiological capacity. Another IHI project showcasing the value of leveraging public and private R&D efforts is the development of an Ebola vaccine.[12] With a market authorisation by the European Commission, a WHO prequalification and an expert-backed recommendation, the IHI co-funded Ebola vaccine is close to widespread uptake to prevent future outbreaks (Ishola et al., 2021[79]). Both the large clinical trial infrastructure developed under COMBACT-NET and the Janssen Pharmaceuticals Ebola vaccine have had major impacts on our collective ability to cope with the Covid-19 pandemic in Europe and beyond.

Interdisciplinary and multi-sector collaboration can provide the necessary means to better understand complex diseases and to innovate in established – often resource intensive and lengthy – processes for the delivery of novel medicines and diagnostics (Johnston, Goldsmith and Finegood, 2020[80]; Yu,

2016[78]). The close connections between key stakeholders and functions along the trajectory of antimicrobials research, development and delivery are shown in Figure 1. The Combating Antibiotic Resistant Bacteria Biopharmaceutical Accelerator (CARB-X), the Coalition for Epidemic Preparedness Innovations (CEPI) and Gavi, the Vaccine Alliance, have been playing a leading role to deliver multi-stakeholder impact for global challenges. The pandemic has been a driver for the formation of new and novel forms of collaboration between 'unusual' partners and disciplines who have not been working together before (Liu et al., 2020[55]; Maher and Van Noorden, 2021[56]). The positive trend in collaboration and data sharing has been confirmed by a recent study conducted among 3 436 researchers: over a third of the respondents expect collaboration to increase due to the pandemic (Hahnel et al., 2020[81]).

Figure 1. Essential links along antimicrobial innovation chain



Source: CARB-X, 2021, courtesy

Openness and information sharing are important factors for the efficiency of research and use of limited resources. Glasziou and Chalmers (2016[82]) estimate that 85% of health research is wasted because of inadequate practices for information sharing, research design and the mobilisation of existing knowledge. In order to realise the public benefit objective, responsible innovation principles must protect the interests of all stakeholders involved in the publication, translation and commercialisation of knowledge (Yu, 2016[83]; Yu, 2021[84]). In the context of AMR and to further support the sharing of research data, Kim et al. (2020[85]) suggest to analyse the incentives and possible mechanisms for a better integration of all stakeholders in the field.

However, Provan and Kenis (2007[76]), followed by other scholars in the field (Berthod et al., 2016[86]; Saz-Carranza and Ospina, 2011[77]), highlighted tensions within collaborative partnerships for being at the same time open, inclusive, efficient in terms of decision-making, and meeting partner expectations. The concept of open innovation (Chesbrough, 2017[87]; Gassmann and Enkel, 2004[88]; OECD, 2015[89]) offers an example of how priorities of knowledge sharing (critical for the creation of value), and ownership (vital for value appropriation) can generate tensions between stakeholders (Foege et al., 2019[90]). From the perspective of The Research Investment for Global Health Technology Fund (The RIGHT Fund),[13] Korea, collaboration can only be sustained if each partner benefits in a measurable way from the partnership. Broadly taken, public research institutions profit from resources and infrastructure, industry partners often require business opportunities and other competitive advantages as an incentive to join

alliances (Hampl, 2019[92]; Kivleniece et al., 2017[93]). At the interfaces between the Korean Ministry of Health and Welfare (MOHW), life science companies, and the Bill & Melinda Gates Foundation, the not-for-profit status of the RIGHT Fund helps managing competing interests and goals across collaborative partners.

Today, many platforms need to be self-sustaining, which means having a viable model for funding and access. Collaborative platforms that aim to drive innovation in common pool resources are often pursuing both economic and social returns according to commercial and welfare logics. Therefore, they need to develop apt performance metrics and clear heuristics of goal-setting and prioritisation. This point is particularly salient to inform organisational adaption to challenges that have a fluid, rapidly evolving nature and to performance evaluation that encompasses both short-term outputs and long-term outcomes and impact (Angeli, Raab and Oerlemans, 2020[93]).

Table 2. Comparing the scope of antimicrobial innovation platforms

	AMR Accelerator	CARB-X	REPAIR Impact Fund
Platform type	non-profit partnership	non-profit partnership	independent foundation with corporate interests
Funding type	non-profit, non-dilutive	non-profit, non-dilutive	for-profit, dilutive
Product types	therapeutics, prevention	therapeutics, prevention, diagnostics	therapeutics, prevention
TRL	3-6	3-6	3-5
Royalty on IPR?	yes	no	no
Patent/ inventions	2	47	NA

AMR Accelerator: IMI Antimicrobial Resistance (AMR) Accelerator
CARB-X: Combating Antibiotic-Resistant Bacteria Biopharmaceutical Accelerator (CARB-X)
REPAIR: Replenishing and Enabling the Pipeline for Anti-Infective Resistance (REPAIR) Impact Fund
IMI: Innovative Medicines Initiative (IMI)
Non-dilutive funding: funding that does not require the innovator/ grant recipient to cede ownership or control.
Dilutive funding (equity financing): funding that requires the innovator/ grant recipient to cede full ownership and control.
TRL: technology readiness level (TRL)
Source: https://amr-accelerator.eu; https://carb-x.org; https://www.repair-impact-fund.com

Finally, because collaborative platforms are often emerging, bottom-up, collaborative arrangements arising in specific settings for a specific challenge, their suitability and success might be inextricably linked to contextual factors and to the nature of the challenge being addressed. These models are deeply situated in a highly context-specific understanding of value, technology and socio-technical solutions to health challenges which might undermine the extent to which they can be generalised to other contexts. While it is broadly understood that collaborative platforms leverage cross-sector and transdisciplinary innovation for global health, only limited evidence is available about the business models and governance approaches that support their inclusiveness, performance and long-term sustainability (Garden, Hawkins and Winickoff, 2021[74]; Kreiling, Robinson and Winickoff, 2020[94]). How such experiences may be translated in best practices is therefore an important point for further investigation and discussion.

New business models

Collaborative efforts to develop more inclusive business models in global health derive from the conclusion that a new innovation ecosystem is needed for entrepreneurs who wish to run an economically sustainable business and who are sensitive to the social, ethical and environmental impact of their activities. There is a growing recognition that health innovation solely driven by competitive markets can have negative consequences on society and may not deliver where economic benefits are at risk, hard to measure and

potentially peripheral to an innovator's mission (Årdal et al., 2020[95]; North, 2020[96]; OECD, 2018[2]; OECD, 2018[97]).

A business model is an elusive concept that may be described as how an organisation (a firm or other type of organisation) creates, delivers and captures value (economic, social or other forms of value) in relationship with a network of exchange partners (Massa and Tucci, 2014[98]; Massa, Tucci and Afuah, 2017[99]). Business model innovation tends to refer to the design of novel business models for newly formed organisations or to the reconfiguration of existing business models. Often, sustainable business models describe a purpose, such as creating value for partners, promoting open access, development of technology and delivery of products, services, and standards for society. They depend on a kind of "social contract" and shared resources that entails mutual responsibilities across governments, policy makers, research institutions, companies, funders and civil society organisations (OECD, 2017[100]; Pedersen et al., 2020[101]). Amidst these diverse sources of value that must be built, trust and trustworthiness are key to establish consensus on both the expected outcomes and the mode of governance. However, organisations from different societal sectors often operate according to different institutional logics (e.g. for-profit vs welfare-enhancing) and prioritise different goals (Angeli, Raab and Oerlemans, 2020[93]). Also, Årdal et al. (2020[95]) have shown that countries were uncertain which business models and incentives may be appropriate for their country. The authors noted a need for policy guidance on how to implement multinational pull and push mechanisms into country settings without disrupting national processes for health technology assessment, medicine pricing and reimbursement.

A key question for policy makers and other stakeholders in pandemic preparedness and health resilience is how to design business models that enable sustainable collaborative action where markets are incomplete and fail. Downstream of the innovation trajectory limited commercial prospects and fragmented markets can affect product launch and patient access across industrialised and low- and high-income countries (Outterson et al., 2021[25]; Schneider, Harrison and McClellan, 2020[102]; WHO, 2016[103]). As an example, of the 15 FDA-approved antibiotics in the past decade, 7 are sponsored by companies that have passed through bankruptcy or have market capitalisations that are a fraction of the R&D funds invested to bring the antibiotic to market (Kim et al., 2020[85]). It is therefore important to advance our current knowledge on how innovative business models could bridge research, economic and societal priorities whilst remaining time-efficient, result-oriented and financially sustainable (Williams, 2020[104]).

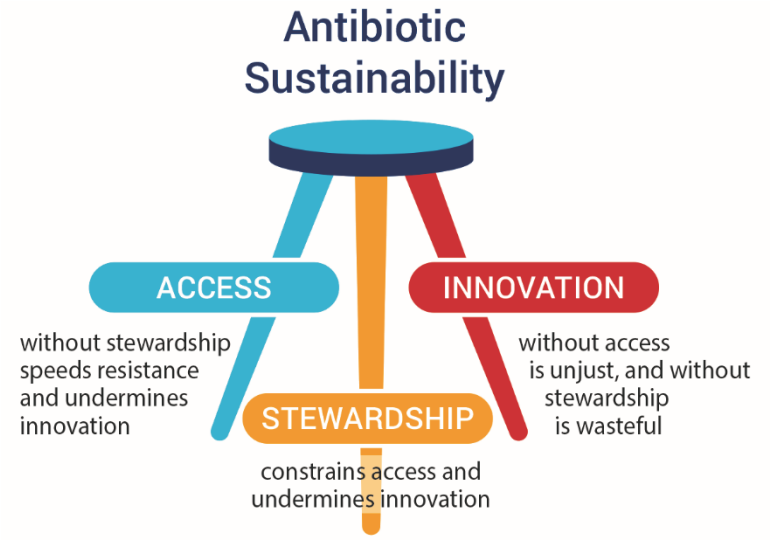
A shift in perspective from business models as instruments of sheer value creation to business models as devices that facilitate stakeholder relationships and corresponding value exchanges has been proposed by Freudenreich et al. (2020[105]). (Angeli and Jaiswal, 2016[106]; Yunus, Moingeon and Lehmann-Ortega, 2010[107]; Yu, 2020[108]). Extensions of this framework are proposed by an increasing number of authors; however, the approach of 'valuing value', also in non-financial terms, remains a fundamental challenge for those actors experimenting with social, sustainability-oriented or hybrid collaborative platforms and organisations (Oskam, Bossink and de Man, 2020[109]). Hence, long-term transformational change will require government policy and corporate changes aimed at building an innovation ecosystem that bridges market and societal needs presented by health priorities, such as pandemics, population ageing, inequity, undernutrition, obesity and environmental threats.

Technologies aimed at solving systemic global health challenges are not disconnected from the socio-cultural local environments.[14] The norms and values of the receiving markets and communities will ultimately shape technology uptake, hence social impact and return on investment. From a business model perspective this has significant consequences for innovators and collaborative platforms. There is a need for broad stakeholder engagement, including representation of beneficiaries and local, receiving communities. This could reduce barriers to uptake that derive from information asymmetry and increase value generation in its broader sense. More flexible, context-specific platform designs with an international scope and locally-focused networks would help to address regulatory, cultural, infrastructure, supply chain and sustainability barriers. Actors in health technology innovation should join forces to realise a paradigm-shift of how to define and realise business models that operate at the margins of commercial viability and

enable long-term social commitment over short-term financial returns. For example, CARB-X is not just about funding innovation – the platform also supports novel approaches to stewardship and access (see Figure 2):

- Innovation delivers new solutions to address the global threat of drug-resistance.
- Access supports patient care and helps control the spread of drug-resistant bacteria.
- Stewardship reduces product misuse and overuse and promotes responsible use.

Figure 2. Action to address antibiotic resistance



Source: Hoffman and Outterson (2015[110])

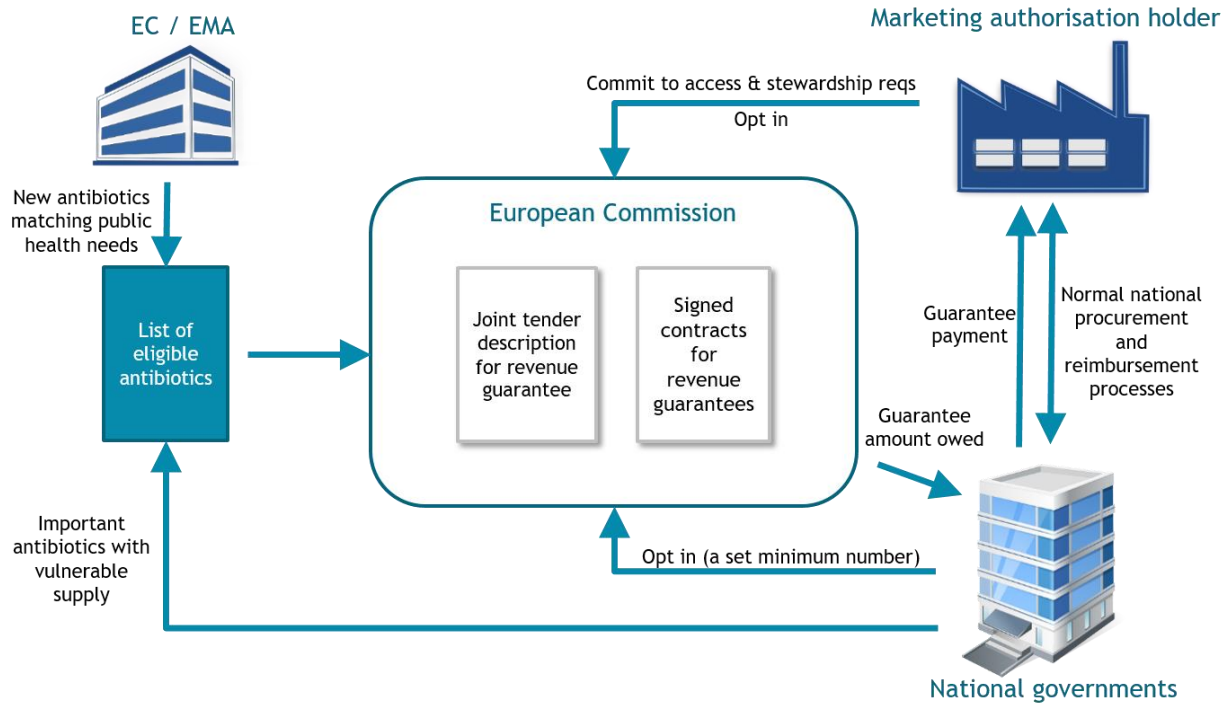
More collaborative business models have been described across a variety of industries and are conceptualised to include in the profit equation not only financial returns but also welfare-enhancing outcomes (Angeli and Jaiswal, 2016[106]; Towse et al., 2017[111]). Examples are:

- The Economy for the Common Good (ECG) model: brought forth by the European Economic and Social Committee (EESC)[15] suggests a more inclusive approach to Corporate Social Responsibility (CSR, "the responsibility of enterprises for their impacts on society") in order to realise a European Ethical Market (European Commission, 2011[113]). The framework positions companies as a driver of delivering shared value and preventing and mitigating possible adverse outcomes.
- The Human-Centred Business Model (HCBM): the HCBM has been developed by World Bank's Global Forum on Law, Justice and Development[1617] and the OECD Development Centre.[18] It offers a new approach that brings together diverse stakeholders – academia, private sector and professional associations, civil society, and international organisations – to develop a business ecosystem where corporate strategies, public policies and regulations incentivise companies to pursue sustainable development (Lessidrenska and Boyer, 2020[113]). The HCBM project seeks to develop an innovative – human-centred – business model based on a common, holistic and integrated set of economic, social, environmental and ethical rights-based principles.[19] It is structured around six pillars: (1) guiding principles, (2) the legal framework, and corporate governance solutions, (3) financial mechanisms, (4) fiscal policy, (5) procurement policies and (6) stakeholders relationship techniques.[20]
- Healthy Vaccines Market Framework (HVMF): the Healthy Vaccines Market Framework (HVMF), developed by Rodes Sanches et al. (2021[114]) aims to promote and encourage strategic and

collaborative dialogue across the global market by expanding upon the breadth and depth of existing frameworks. Its goal is to advance the understanding of the downstream impact caused by individual market-shaping activities and how these activities work together to strengthen or degrade the health of vaccine markets over time to address public health needs through sustainable innovation and equitable access. The HVMF identifies four key characteristics of healthy vaccines markets: (i) balanced supply and demand; (ii) affordability and return on investment (ROI); (iii) product innovation and quality; and (iv) sustainable buyer and supplier risk.

- Diagnostic Market Stimulus pots (DMS): Diagnostic Market Stimulus pots (DMS) are based on the Gavi model to purchase large quantities of vaccines (O'Neill, 2015[58]). DMS would offer money to be allocated by a global payer and paid out to incentivise the development and purchase of diagnostics technology to help tackle the problem of drug resistance. Companies would sign up to a DMS and sell their products under certain conditions, such as at affordable prices. Every time a product would be sold, a payment would be made from the pot. Different from the Gavi model, the DMS tops up a payment per product sold without an agreed minimum volume of sales or overall payment.
- Subscription model: pull incentives such as subscription style business models offer long-term solution to innovation and access where markets fail. In the context of antimicrobial resistance (AMR), subscription models aim to reward manufacturers for the development and supply of novel (Barlow et al., 2022[115]; Outterson and Rex, 2020[116]) antibiotics based on the estimated value to patients and society, not the volume of drugs sold. Some countries, such as the United Kingdom and Sweden, have initiated pilot studies where healthcare providers and manufacturers agree on an upfront payment (a fixed lump-sum) to support product development and to offer annual fees (guaranteed annual revenue) to ensure supply 'delinked' of the volume (Cookson, 2022[117]; Gotham et al., 2021[60]; Plackett, 2020[118]). The European Union Joint Action on Antimicrobial Resistance and Healthcare-Associated Infections (HCAIs) (EU-JAMRAI) has suggested a multinational revenue guarantee to secure guaranteed profits for antibiotics manufacturers and a reliable supply for healthcare providers (see Figure 3).

Figure 3. EU-JAMRAI proposal for a multinational pull incentive



Note: EU-JAMRAI is the European Union Joint Action on Antimicrobial Resistance (AMR) and Healthcare- Associated Infections (HCAIs).
Source: (Årdal et al., 2020[95])

Some argue that the aim and context of a business area should inform the choice and implementation of the collaborative model (Fredriksson et al., 2017[119]). However, identifying a common ground between stakeholders typically takes time and effort (Rocchi et al., 2021[120]). In order to realise the full potential of sustainable business models, Lüdeke-Freund and Dembek (2017[20]) note the importance of establishing and maintaining links and communication across academia, industry and government. Recent studies are therefore dedicated to identifying sustainable business model 'patterns', i.e. proven and practically applied approaches, as well as tools for their development (Breuer et al., 2018[121]; Lüdeke-Freund et al., 2018[122]).

Intellectual property considerations

In times of crisis and to strengthen the resilience of health systems for future shocks, it is critical to encourage both innovation and equitable access to safe and efficacious health technologies worldwide. In order to create and capture value, companies increasingly depend on complementary inputs (information, services, goods) made by loosely connected, oftentimes new and yet independent actors. Governance choices surrounding value creation include (i) who has decision rights over assets, intellectual property (IP) and data; (ii) who has access to these assets; and (iii) who can derive revenues from their commercialisation.

Traditional, pipeline-based innovation approaches draw value from unique data, intellectual property (IP), consumer reach and volume/revenue-based markets. However, these types of assets are increasingly challenged by recent socio-technical and digital transitions and new actors that catalyse the formation of more collaborative business models (OECD, 2020[123]; OECD, 2021[124]; Wells et al., 2020[125]). For example, platform-enabled ecosystems and open science partnerships that, rather than principally relying on IP and single source funding models, offer a fertile ground to co-create where markets fail (Gisby and Micca, 2022[126]; Gold and Edwards, 2022[127]).

It has been widely accepted that intellectual property rights (IPR) of different kinds have an important role to innovators to reveal to investors the quality of the portfolio, its technological capabilities and potential future profitability (Dai and Watal, 2021[128]; OECD, 2015[129]; Sachs, 2020[130]). Like shared investment, collaborative platforms and novel IP arrangements form part of new business models to address market failure (Gold and Edwards, 2022[127]). It is understood that more shared IP systems help balancing competing interests for health technology innovation, access and economic growth (Krikorian and Torreele, 2021[131]; Swaminathan et al., 2022[132]). While IP has been demonstrated to promote innovation (OECD, 2010[133]), it has been discussed by some that IP and a lack of transparency in terms of licensing can impede information and knowledge sharing and access to affordable medicines (Bubela, FitzGerald and Gold, 2012[134]; Feldman et al., 2021[135]; Gurry, 2020[136]). The need for an efficient and transparent marketplace for the exchange of IP rights has been discussed for years, however, there does not appear to be any mechanism for monitoring, let alone pointing out and publicising, or enforcing deviations from the supposed norms embodied in organisational policies.

IP access and sharing arrangements ranging from patent pools, patent pledges to good licensing practices offer a potential complementary mechanism to increasing access to new technologies, especially in developing countries (Cervantes, Copeland and Žarnic, 2018[137]; Mrad, 2017[138]). Shifts in collaborative approaches, a strengthening of open science and the digitisation of R&D may offer alternative ways to lower the costs of innovation, to recoup investments and to ensure equitable access. Three recent examples should illustrate how IP can be managed collaboratively in order to fight Covid-19 and prepare for future crises:

- The Medicines Patent Pool (MPP)[21] signed a licence agreement with Merck Sharp & Dohme (MSD) for molnupiravir, an investigational oral Covid-19 antiviral medicine (Willyard, 2021[140]). WHO-Unitaid commented on the agreement as "…a positive step towards creating broader access to the treatment as quickly as possible by allowing generic licensees from around the world to prepare supplies and create more affordable versions of the medicine, pending WHO recommendations and other regulatory authorisations."[22] The MPP is an implementation partner of the Covid-19 Technology Access Pool (C-TAP) that provides a platform for developers of Covid-19 therapeutics, diagnostics, vaccines and other health products to voluntarily share their intellectual property, knowledge and data with multiple quality-assured manufacturers.
- In order to boost manufacturing and equitable access to Covid-19 vaccines in developing countries, the World Trade Organization (WTO) has reached an agreement to temporarily waive IPRs for Covid-19 vaccines in eligible member countries (WTO, 2022[140]). The agreement will be active for five years, aiming to provide equitable access to Covid-19 vaccines. Under certain conditions countries will be allowed to waive IPRs on Covid-19 vaccines without the permission of the patent owner – offering an adequate remuneration that considers the humanitarian crisis and ensures vaccine affordability. Developing countries that have Covid-19 vaccine manufacturing capacity are encouraged to supply its domestic market and "may allow any proportion of the products manufactured under the authorization in accordance with this Decision to be exported to [other] eligible Members, including through international or regional joint initiatives that aim to ensure the equitable access of eligible Members to the COVID-19 vaccine covered by the authorization." Notably, the decision includes Covid-19 vaccine ingredients and processes necessary for the manufacture of the vaccine, however, it doesn't provide provisions for the transfer of technology that is critical for the vaccine manufacturing. A possible extension of patent waivers to Covid-19 diagnostics and therapeutics will be discussed during the fall meeting of the TRIPS Council.
- Gilead Sciences put in place programmes for the voluntary licensing of remdesivir, an antiviral drug initially developed for hepatitis and Ebola that has been approved by the United States Food and Drug Administration (FDA) for the treatment of Covid-19 in adults and paediatric patients. The company reportedly has put in place joint procurement and licensing agreements with LMICs and generic manufacturers in order to support equitable access.

CEPI offers another example of an innovation platform that is wholly committed to equitable access to the vaccines it funds. All funding agreements include equitable access provisions. Therefore, in line with the Covid-19 Technology Access Pool (C-TAP) proposals, CEPI funding agreements require awardees to publicly disclose clinical trial data, disseminate project results such as assays and correlates of protection and publish research under open access license terms.

CEPI does not seek to own the IP developed from partnerships; the platform doesn't require IP to be licensed to the Medicines Patent Pool (MPP). Instead CEPI requires awardees to manage their IP in such a way that equitable access can be realised through the Covid-19 Vaccines Global Access Facility (COVAX),[23] one of three pillars of the Access to Covid-19 Tools (ACT) Accelerator.[24] At an OECD webinar in December 2020, Richard Wilder, General Counsel and Head of Business Development (CEPI), noted that this should be the most effective way of delivering accessible vaccines as quickly as possible without stifling innovation or delaying the urgent vaccine development process. Moreover, to continue developing Covid-19 vaccines at speed, CEPI's approach is to collaborate with awardees in the selection of the additional manufacturers ("trusted partners"). To enable sufficient manufacturing capacity and equitable access, CEPI requires that awardees agree to the transfer of technology to trusted partners, and the establishment of manufacturing capacity in two or more jurisdictions.

The RIGHT Fund requires awardees and project participants to sign and adhere to global access agreements. In terms of IP and licensing approaches, guiding principles of The RIGHT Fund global access policy are:[25]

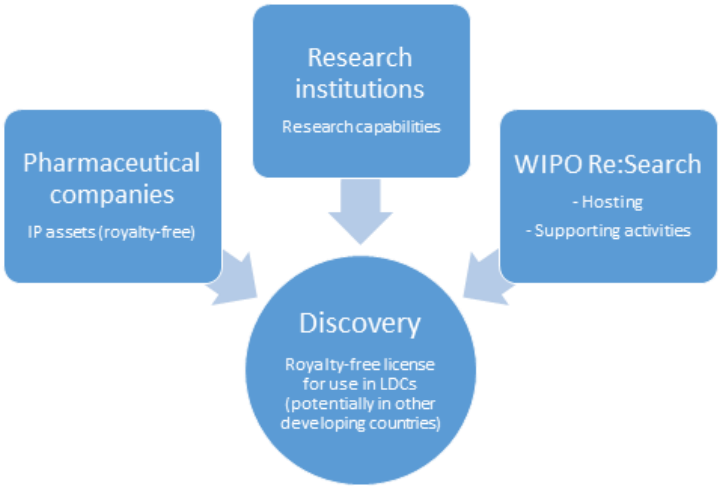
- All information and knowledge gained from grants, projects or other investments funded by the RIGHT Fund (collectively "Projects") should be promptly and broadly disseminated.
- Products, data and other innovations resulting from Projects should be made available and accessible in terms of price, quantity, quality and timeframe so as to benefit beneficiaries.
- Awardees and Project participants may apply for and maintain IP rights to developments of Projects. The RIGHT Fund shall not take ownership of IP rights to funded developments provided that the RIGHT Fund will be entitled to royalty-free, irrevocable and worldwide licenses to access and use IP rights to funded developments.
- Product access policy: when awardees and Project participants are successfully granted a patent deriving from Projects, awardees and Project participants will grant royalty-free, irrevocable and worldwide licenses to users operating for the benefit of the public market in least developed countries (LDCs).

More upstream of the innovation trajectory, the Joint European Disruptive Initiative (JEDI) Billion Molecules against Covid-19 GrandChallenge, follows a different strategy.[26] JEDI is an independent, non-profit common-good initiative for disruptive innovation to bring Europe in a leadership position in breakthrough technologies. It is launching Technology GrandChallenges to push the frontiers of science & technology, and to invent the Next Big Thing. It aims to provide Europeans and democracies with the means of technological and scientific power, for prosperity and societal resilience. JEDI Billion Molecules against Covid-19 Grand Challenge partners are convinced that both competition and collaboration stimulate collective intelligence.

WIPO Re:Search offers yet another approach to advance early-stage research in health technologies through cross-sector intellectual property sharing (see Figure 4).[27] It is composed of 158 members operating in 46 countries on 6 continents. To date, WIPO Re:Search has fostered over 160 R&D collaboration activities, of which more than 50 are currently active and 8 are advancing through key milestones on the product development pathway. The public-private partnership brings together leading pharmaceutical companies and research institutions for catalysing collaborative innovation in neglected tropical diseases, tuberculosis and malaria, and to drive progress toward the Sustainable Development Goals (SDGs) (Manner, Graef and Dent, 2019[141]). Pharmaceutical companies who participate in the partnership make their intellectual property available to researchers everywhere via royalty-free licenses.

Products resulting from licenses through WIPO Re:Search are licensed on a royalty-free basis for use and sale in least developed countries. The partnership includes provisions for favouring developing countries' access to resulting technologies.

Figure 4. WIPO Re:Search fosters discovery



Source: WIPO, courtesy

Blended finance

Collaboration, shared finance and IPR arrangements lie at the heart of business models that enable the provision of common pool resources. To achieve long-term and meaningful change, stakeholders need to take action in terms of long-term funding and valuation collectively. In general, companies and other private investors do not and cannot finance the development and supply of a public good or pool resource if others can free-ride and if the market doesn't provide adequate returns. In these cases, so-called "blended finance" offers mechanisms to de-risk innovation and to engage the private sector at scale.

The OECD (2021[142]) defines blended finance as "the strategic use of development finance for the mobilisation of additional finance towards sustainable development in developing countries." In general, blended finance concerns the use of public financial resources to attract various private resources (e.g. worldwide invested assets of banks, pension funds, insurers, foundations and endowments and multinational corporations) for specific aims. Though blended finance has been on the rise in its use to close the investment gap in SDGs with aggregated financing reaching USD 140 billion in 2018 (OECD, 2019[143]), the majority of finance is related to the diffusion and implementation of existing technologies and related infrastructure (e.g., clean energy, agriculture) rather than innovation.

Adapting these modes of blended finance from the development finance community (OECD, 2018[144]), funders are exploring ways to shift from a public funding model for R&D and innovation towards more of a financing model. The international community has sought to bring together and pool funding from multilateral institutions and development banks as well as philanthropies such as the Bill & Melinda Gates Foundation or the Wellcome Trust (Stiglitz, 2006[145]). The Covid-19 pandemic, has accelerated the search for new, blended financial instruments to increase funding for global public goods.

Blended finance has often been seen from the perspective of Official Development Assistance (ODA) which takes aim at challenges experienced in developing countries. However, many areas or activities of STI, including health technology need to be developed in and for developed countries, albeit with

deployment globally. In this context, blended finance has a great potential to help overcome the traditional barriers to funding innovation in early stages and support survival through the so-called "Valley of Death" (Ellwood, Williams and Egan, 2022[146]; USAID, 2021[147]).

Blended finance can take various forms, especially through the integration of different financial instruments ranging from grant, debt and equity to guarantees. Each instrument has distinctive features in terms of where the capital source comes from, how the return to investment is to be realised, and how to mitigate risk. Kwon and Barry (2022[148]) cluster financial instruments into four groups. The first cluster comprises grants and technical assistance, which both tend to stem from general public funding and capacities. The second cluster includes outcome funding, impact bonds and impact-linked finance, which stand out from the rest in that they connect impact with financial rewards. The third cluster consists of the various debt and equity instruments, like market-rate, concessional or subordinated debt. The fourth cluster comprises first-loss instruments and guarantees.

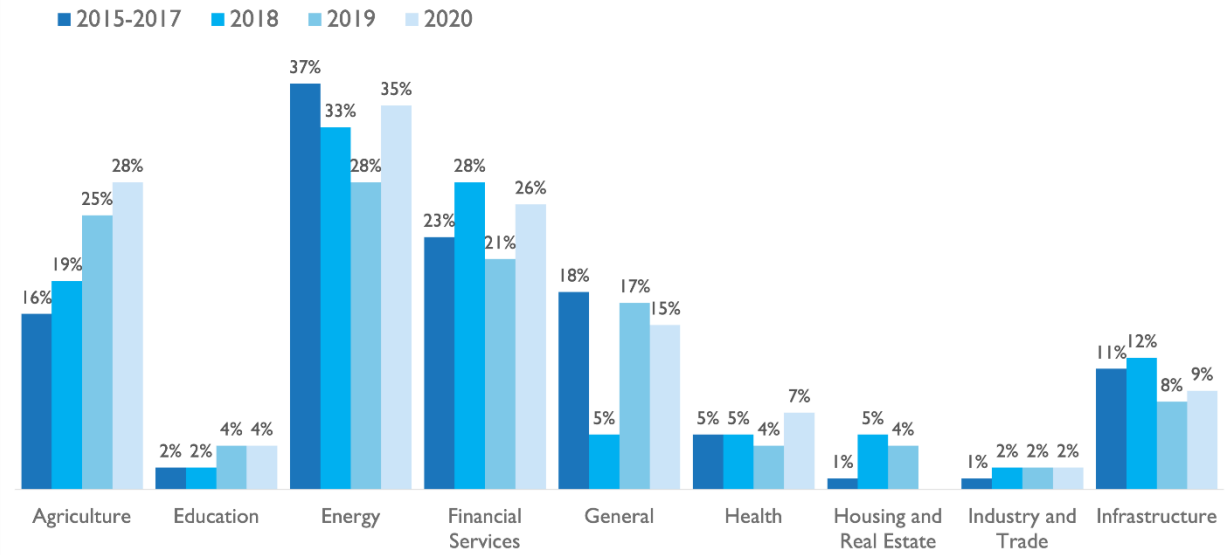
The importance of incentives in blended finance cannot be overstated given that blended finance by definition means channelling additional financing sources, particularly private ones, which are not otherwise interested in STI investment. However, there could be a number of disincentives and barriers to the expansion and further use of blended finance, for example:

- Lack of common purpose: it can be hard to unite different groups around a common goal. Different parties have different incentives/barriers to participation; even the private sector is quite heterogeneous.
- Lack of awareness and capacity within governments: shifting from grant/philanthropic mindset to that of an investor requires training within these institutions; over time, successful case studies can have a positive demonstration effect.
- Underlying market failures: blended finance can act as a bridge but will not be a sustainable solution unless there are visible policy changes or market shifts to support future commercial markets.
- Risk of crowding out: the private sector may have concerns about government participation in blended finance as a replacement for policy action; governments worry about displacing commercial investments.

STI projects for global health tend to invest relatively more on the early phase of the innovation cycle, in contrast to climate transition investment which focuses more on large scale demonstration. The financing gap in the area of global health typically occurs at the late stage of clinical trials when it is necessary to confirm safety and effectiveness of new health technologies. On the contrary, financing challenges in climate transition tend to rest in early phases of innovation when new technologies need to compete with prices of already established solutions.

The current use of blended finance for health-related innovation priorities is low compared to energy, agriculture and infrastructure (see Figure 5). In practice, large pharmaceutical companies and research institutions have a more significant role in global health, while SMEs actively engage in STI projects for climate transition. To strengthen the use of blended finance in the health sector, key actors, including the pharmaceutical industry, should discuss opportunities and challenges.

Figure 5. Health sector less targeted by blended finance



Note: Proportion of closed transactions by sector.
Source: Convergence (2021[149]).

At a round table discussion at the US Development Finance Corporation (DFC), stakeholders suggested potential steps to further support blended finance for global health:[28]

- Recognise that blended finance is not a magic bullet, so be realistic and align expectations among stakeholders regarding investment returns, impact on health outcomes, upfront costs and other aspects of blended finance deals.
- Focus on simplicity as much as possible.
- Foster more communication and collaboration between USAID and the new DFC.
- Build USAID staff capacity and understanding of principles and best practices, including disseminating lessons from the agency's roadmap on blended finance for global health.
- Build partner government capacity to oversee and monitor private sector involvement.
- Build relationships and trust by creating a "community of interest" for stakeholders, taking advantage of the U.S. role as a trusted partner in many countries to serve in the role of convener.

An example for catalytic funding within blended finance instruments is the Infectious Diseases Finance Facility (IDFF) by EIB. This facility supports projects which have passed the pre-clinical stage and for which clinical validation is needed for further development. Blending loan and equity in the facility could outperform loans alone in terms of allowing more risk-associated investment and provide advantages over simple grant support, especially in terms of allowing recovery of invested funds and ensuring more targeted support for high-priority R&D.

Another example, discussed at the OECD CSTP-Wellcome Trust-University of Oxford-Norway Research Council Workshop on "Blended Finance: New approaches for Financing STI for achieving the Sustainable Development Goals" (2020) is the InnovFin Infectious Diseases by EIB which funds innovative players active in developing vaccines, drugs, medical and diagnostic devices and research infrastructure for combatting infectious diseases. Financing targets projects that have completed the pre-clinical stage and for which clinical validation is needed for further development. It is offering a range of tailored products which provide financing in support of research and innovation by small, medium-sized and large companies and the promoters of research infrastructure. Instruments being used by the IDFF range from standard

debt instruments (e.g. senior, subordinated and mezzanine operations) to risk-sharing instruments (e.g. equity-type operations) (OECD, 2020[150]).

In addition to a catalytic fund which could provide a layer of risk mitigation lowering the amount of additional investment, more advanced and sophisticated risk mechanisms such as guarantees or first loss provisions would be of value for health technology. The Global Health Investment Fund (GHIF), see Box 1, could be a useful example how guarantees play an important role to construct blended financing for health technology. The objective of the fund is to provide capital to late stage projects to support final clinical trials and early stage commercialisation. The fund is supported by a partial guarantee enabling managers to target transactions with lower risk adjusted internal rate of return than would traditionally be possible in a private equity fund.

Box 1. Global Health Investment Fund

The fund is a USD 108 million investment fund. It was sponsored by the Bill and Melinda Gates Foundation, and the structure of the fund included participation from the governments of Canada and Sweden through their Development Finance funds and several industrial partners who are essential for developing, commercialising and delivering products.

The fund is supported by a partial guarantee from the Gates foundation. The guarantee takes a first loss position in case of impairments. Even with a 20% impairment, investors are fully paid, while in the case of 100% impairment, an additional guarantee by the foundation kicks in and ensures a 60% repayment of the original investment to the investors.

Source: (OECD, 2020[151])

The history of large-scale push funding leading to late-stage failures in drug development demonstrates how push funding alone may not result in successful innovation. Combining push funding with demand-pull measures, such as AMC (advanced market commitment, see Box 2), can be a potential solution with a view to make blended finance more feasible and more attractive. The way Advanced Market Commitment (AMC) works is that governments assess their needs and place advance commitments to purchase an innovative health technology project. In theory, this makes private investment more feasible.

Box 2. Advanced Market Commitment

An advance market commitment (AMC), also known as an advance purchase commitment, is a binding contract that provides a guaranteed market for a product. AMCs are most likely to be funded by governments or philanthropic organisations. An AMC may be negotiated prior to a product's regulatory approval or following it if focused on reserving or expanding supply for a purchaser. AMCs can improve the availability and access to health technologies for those on whose behalf they are awarded.

Source: (OECD, 2020[151])

While the long and risky innovation pathway in health technology poses challenges for adopting blended finance, it could also provide an opportunity for fomenting creative blended finance arrangements. Since the pharmaceutical industry is highly R&D intensive, private funding for innovation from industry can take a lead in further developing the blended finance framework.

In fact, the Anti-Microbial Resistance (AMR) action fund is a unique example where industry itself takes a lead. The AMR Action Fund has been organised by its partners to address a critical market failure in bringing AMR assets to beneficiaries and has a core mission to invest in the clinical development of novel antibiotics to bridge them up to commercialization. Industry furnishes 80% of the fund, while philanthropic institutions and development banks make up the rest. The fund assumes 5 years with capital deployment and a subsequent period of 5-7 years with additional investments as an "engaged owner". Exits are expected after some 15 years. It has a strong fund-raising traction with more than 20 pharmaceutical companies expected to contribute USD 1 billion with additional investments (OECD, 2020[150]).

It can be concluded that blended finance might help response to the need for broader collaboration across established and new stakeholders in health innovation. In order to strengthen the use of blended finance in areas where competitive markets do not deliver, actors should:

- enable more long-term planning
- build-in agility to react to short-term developments and stakeholder flexibility
- better connect financing of early-stage research with future market needs
- develop value and align incentives for all parties involved

Measuring performance and impact

Collaborative approaches are becoming increasingly salient to address global health challenges (Dentoni, Bitzer and Schouten, 2018[151]; Raab, 2022[152]), but also to the development and deployment of health technologies. The use of limited resources in global health has to be based on good business model performance. The development of methods and tools to assess the performance of collaborative platforms and business models is still a nascent research field (Rauter et al., 2019[154]). Policy makers can support the development and collection of methodological approaches to facilitate the assessment of the performance and cost-effectiveness of mostly publicly funded global health interventions (Gaudin et al., 2019[155]).

Measuring performance should start with identifying and classifying the various business models. Nuzzo et al. (2019[156]) have identified performance ratings and peer competition as important components of resilient health systems. Angeli and Jaiswal (2016[106]) suggest eight strategies as courses of action, activities and deliberate organisational choices that underpin the success of business models: co-creation of patient needs, community engagement, continuous involvement of customers, medical technology innovation, focus on human resources for health, strategic partnerships, economies of scale and cross-subsidisation.

Assessing the performance of collaborative action for health innovation requires a deeper analysis of product availability, supply, access and affordability. Developing useful assessment tools will depend on understanding the status quo in this field, the availability of data and methods to measure and manage the value created (and destroyed) for various stakeholders and the impact on the societal level. For example, approaches to technology assessment offer investors and innovators the means to better evaluate the economic performance, social impacts and environmental effects of products and business operations.

The OECD (2015[157]) proposes social impact measurement to be an ongoing process of dialogue among the different stakeholders involved in the measuring process and interested in its results. Social impact assessment aims to assess the social change, value and impact produced by the activities or operations of any for-profit or non-profit organisation. Because the change might be positive or negative with possible unintended consequences the need for measuring social and environmental impact is especially important for companies contributing to public health and sustainable development (Hehenberger and Buckland, 2021[158]; Krlev and Angeli, 2022[159]; Marsh et al., 2016[160]). Krlev and Angeli (2022[159]) suggest a systematic, six steps social impact assessment strategy:

1. Accounting for complexity and clarifying the goal of the measurement.
2. Defining scope and measures.
3. Choosing the appropriate measurement design.
4. Compose instruments to generate different types of data.
5. Refining measures through differentiation of the individual components.
6. Pre-testing and executing the study.

Driven by the need to measure and demonstrate the economic, social and environmental sustainability of business models, approaches to social impact measurement are rapidly evolving (Angeli, Jaiswal and Shrivastava, 2022[161]; Krlev and Angeli, 2022[159]). Policy makers, public funders, philanthropists and innovators can support the development of ecosystems for multi-stakeholder experimentation to structure and implement a measuring culture into health technology innovation where markets fail.

4 Conclusions

Policies that support the sustainable supply, accessibility and affordability of health technology are a key pillar of multisectoral action for creating a dynamic innovation ecosystem across priorities of good health, well-being and economic growth. However, there is a growing recognition that health innovation solely driven by competitive markets can have negative consequences on society and may not deliver where economic benefits are at risk, hard to measure and potentially peripheral to an innovator's mission.

Collaborative approaches to address market failure and to build more sustainable innovation ecosystems can be spurred and coordinated by governmental action. Companies are critical actors to lead the development, translation and supply of health technologies 'in and with society'. However, as different stakeholders come together from different sectors, their ways of working, objectives and culture, which reflect their different societal mandate and ownership structure, are bound to create internal tension within the partnership and to require careful negotiation. Where tensions between long-term public health priorities and short-term financial goals, and between social and market outcomes need to be navigated, collective goal setting, transparency and flexible financing and evaluation practices are needed.

Novel, blended finance mechanisms can attract and better integrate private resources, to de-risk innovation and to enable access where markets fail. In order to help to develop larger blended finance transactions for health innovation, funders should deploy catalytic finance to develop a more dynamic investment ecosystem in the sector and ultimately incentivise private investment in health innovation. At the same time, governments should help support the sustainability of ecosystems by utilising pull mechanisms of innovation.

In order to deliver novel, more integrated business models for health technology innovation, delivery and access, there is a need to better understand how the 'value' of novel medicines, vaccines and diagnostics is perceived and measured across all stakeholders. Actors should join forces to realise a paradigm-shift of how to define and realise business models that operate at the margins of commercial viability and enable long-term social commitment over short-term financial returns. More research and interdisciplinary, multi-stakeholder collaboration is necessary to analyse how the new business models that are being tested at national level can be scaled-up across countries and health technologies.

References

Access to Medicine Foundation (2022), *2022 Ranking: Company report cards & comparison*, https://accesstomedicinefoundation.org/sectors-and-research/index-ranking#index--methodology (accessed on 20 February 2023). [5]

Access to Medicine Foundation (2021), *Biotechs are saving the world from superbugs.*, http://www.amrbenchmark.org (accessed on 23 May 2022). [54]

Aimo Kannt, T. (2016), "Managing risks in drug discovery: reproducibility of published findings", *Naunyn-Schmiedeberg's Arch Pharmacol*, Vol. 389, pp. 353-360, https://doi.org/DOI 10.1007/s00210-016-1216-8. [166]

Angeli, F. (2014), "With the help of a foreign ally: biopharmaceutical innovation in India after TRIPS", *Health Policy and Planning*, Vol. 29/3, pp. 280-291, https://doi.org/10.1093/heapol/czt015. [164]

Angeli, F. and A. Jaiswal (2016), "Business Model Innovation for Inclusive Health Care Delivery at the Bottom of the Pyramid", *Organization & Environment*, Vol. 29/4, pp. 486-507, https://doi.org/10.1177/1086026616647174. [107]

Angeli, F., A. Jaiswal and S. Shrivastava (2022), "Integrating poverty alleviation and environmental protection efforts: A socio-ecological perspective on menstrual health management", *Social Science & Medicine*, Vol. 314, p. 115427, https://doi.org/10.1016/j.socscimed.2022.115427. [161]

Angeli, F., J. Raab and L. Oerlemans (2020), "Adaptive Responses to Performance Gaps in Project Networks", Emerald Publishing Limited, https://doi.org/10.1108/s0733-558x20200000067013. [94]

Årdal, C. et al. (2020), "Antibiotic development — economic, regulatory and societal challenges", *Nature Reviews Microbiology*, Vol. 18/5, pp. 267-274, https://doi.org/10.1038/s41579-019-0293-3. [96]

Årdal, C., Y. Lacotte and S. Edwards (2021), "National Facilitators and Barriers to the Implementation of Incentives for Antibiotic Access and Innovation Marie-Cécile Ploy 2 and on behalf of the European Union Joint Action on Antimicrobial Resistance and Healthcare-Associated Infections (EU-JAMRAI) †", https://doi.org/10.3390/antibiotics10060749. [50]

Arrow, K. (1963), "Uncertainty and the welfare economics of medical care", *The American Economic Review* 5. [18]

Barlow, E. et al. (2022), "Optimal subscription models to pay for antibiotics", *Social Science and Medicine*, Vol. 298, https://doi.org/10.1016/J.SOCSCIMED.2022.114818. [116]

Barnes, O. (2022), "African leaders urge global vaccine body to buy locally made Covid jabs", *Financial Times*. [64]

Barnett, A. et al. (2002), *Research for poverty reduction: DFID research policy paper*, DFID, UK, http://www.dfid.gov.uk/ (accessed on 25 August 2021). [22]

Bärnighausen, T. et al. (2014), "Valuing vaccination", *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 111/34, pp. 12313-12319, https://doi.org/10.1073/PNAS.1400475111. [31]

Berthod, O. et al. (2016), "From High-Reliability Organizations to High-Reliability Networks: The Dynamics of Network Governance in the Face of Emergency", *Journal of Public Administration Research and Theory*, Vol. 27/2, p. muw050, https://doi.org/10.1093/jopart/muw050. [87]

Boluarte, T. and U. Schulze (2022), *The Case for a Subscription Model to Tackle Antimicrobial Resistance Another Pandemic on the Horizon*. [47]

Boucher, H. et al. (2020), "Antibiotic Development Incentives That Reflect Societal Value of Antibiotics", *Clinical Infectious Diseases*, Vol. 72/9, pp. e420-e421, https://doi.org/10.1093/cid/ciaa092. [52]

Breuer, H. et al. (2018), "Sustainability-oriented business model development: Principles, criteria and tools", *International Journal of Entrepreneurial Venturing*, Vol. 10/2, pp. 256-286, https://doi.org/10.1504/IJEV.2018.092715. [122]

Brisse, M. et al. (2020), "Emerging Concepts and Technologies in Vaccine Development", *Frontiers in Immunology*, Vol. 11, https://doi.org/10.3389/fimmu.2020.583077. [35]

Bubela, T., G. FitzGerald and E. Gold (2012), "Recalibrating Intellectual Property Rights to Enhance Translational Research Collaborations", *Science Translational Medicine*, Vol. 4/122, https://doi.org/10.1126/SCITRANSLMED.3003490. [135]

Butler, M. et al. (2022), "Analysis of the Clinical Pipeline of Treatments for Drug-Resistant Bacterial Infections: Despite Progress, More Action Is Needed", *Antimicrobial Agents and Chemotherapy*, Vol. 66/3, https://doi.org/10.1128/AAC.01991-21/SUPPL_FILE/AAC.01991-21-S0001.PDF. [48]

Cassini, A. et al. (2019), "Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis", *The Lancet Infectious Diseases*, Vol. 19, pp. 56-66, https://doi.org/10.1016/S1473-3099(18)30605-4. [45]

Centers for Disease Control, U. (2019), *Antibiotic Resistance Threats in the United States, 2019*, CDC, https://doi.org/10.15620/cdc:82532. [41]

Cervantes, M., H. Copeland and Ž. Žarnic (2018), *Accelerating the development and diffusion of low-emissions innovations*, OECD, https://www.oecd.org/sd-roundtable/papersandpublications/Accelerating%20the%20development%20and%20diffusion%20of%20low-emissions%20innovations.pdf (accessed on 27 May 2021). [138]

Chen, F. and F. Toxvaerd (2014), "The economics of vaccination", *Journal of Theoretical Biology*, Vol. 363, pp. 105-117, https://doi.org/10.1016/J.JTBI.2014.08.003. [6]

Chesbrough, H. (2017), "The Future of Open Innovation", *Research-Technology Management*, Vol. 60/1, pp. 35-38, https://doi.org/10.1080/08956308.2017.1255054. [88]

Clancy, C. and M. Hong Nguyen (2019), "Estimating the size of the U.S. Market for new antibiotics with activity against carbapenem-resistant Enterobacteriaceae", *Antimicrobial Agents and Chemotherapy*, Vol. 63/12, https://doi.org/10.1128/AAC.01733-19/FORMAT/EPUB. [55]

Coburn, J. et al. (2021), "Appraising research policy instrument mixes: a multicriteria mapping study in six European countries of diagnostic innovation to manage antimicrobial resistance", *Research Policy*, Vol. 50/4, p. 104140, https://doi.org/10.1016/j.respol.2020.104140. [60]

Cocks, T. (2022), "South Africa's Aspen COVID-19 vaccine plant risks closure after no orders, executive says", *Reuters*, https://www.reuters.com/business/healthcare-pharmaceuticals/safricas-aspen-covid-19-vaccine-plant-risks-closure-after-no-orders-executive-2022-05-01/ (accessed on 20 May 2022). [65]

Convergence (2021), *The State of Blended Finance 2021*, Convergence. [150]

Cookson, C. (2022), "UK launches world-first 'subscription' model for antibiotic supply", *Financial Times*. [118]

Cross, S. et al. (2021), "Who funded the research behind the Oxford–AstraZeneca COVID-19 vaccine?", *BMJ Global Health*, Vol. 6/12, p. e007321, https://doi.org/10.1136/bmjgh-2021-007321. [36]

Dai, R. and J. Watal (2021), "Product patents and access to innovative medicines", *Social Science and Medicine*, Vol. 291, https://doi.org/10.1016/J.SOCSCIMED.2021.114479. [129]

Dentoni, D., V. Bitzer and G. Schouten (2018), "Harnessing Wicked Problems in Multi-stakeholder Partnerships", *Journal of Business Ethics*, Vol. 150/2, pp. 333-356, https://doi.org/10.1007/s10551-018-3858-6. [152]

Development Finance Institutions (DFIs) (2017), *DFI Working Group on Blended Concessional Finance for Private Sector Projects*. [165]

Ellwood, P., C. Williams and J. Egan (2022), "Crossing the valley of death: Five underlying innovation processes", *Technovation*, Vol. 109, p. 102162, https://doi.org/10.1016/J.TECHNOVATION.2020.102162. [147]

EU/ OECD (2019), *Antimicrobial Resistance Tackling the Burden in the European Union Briefing note for EU/EEA countries Contents*, EU/ OECD, https://www.oecd.org/health/health-systems/AMR-Tackling-the-Burden-in-the-EU-OECD-ECDC-Briefing-Note-2019.pdf (accessed on 12 October 2021). [43]

European Commission (2011), *EU strategy 2011-14 for Corporate Social Responsibility*, EC, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0681:FIN:EN:PDF (accessed on 21 September 2021). [113]

European Commission (EC) (2017), *A European One Health Action Plan against Antimicrobial Resistance (AMR)*, European Commission (EC) , Brussels, http://www.who.int/entity/drugresistance/documents/surveillancereport/en/index.html (accessed on 30 September 2021). [42]

European Economic and Social Committee (2023), *European Economic and Social Committee*, https://www.eesc.europa.eu/en (accessed on 22 February 2023). [169]

Fahlquist, J. (2018), "Vaccine hesitancy and trust. Ethical aspects of risk communication", [32]

Scandinavian Journal of Public Health, Vol. 46, https://doi.org/10.1177/1403494817727162 (accessed on 22 May 2022).

Feldman, R. et al. (2021), "Negative innovation: when patents are bad for patients", *Nature Biotechnology 2021 39:8*, Vol. 39/8, pp. 914-916, https://doi.org/10.1038/s41587-021-00999-0. [136]

Fifty-eighth World Health Assembly, W. (2005), *Revision of the International Health Regulations*, Fifty-eighth World Health Assembly, https://www.who.int/csr/ihr/WHA58-en.pdf (accessed on 23 August 2021). [71]

Foege, J. et al. (2019), "Reconceptualizing the paradox of openness: How solvers navigate sharing-protecting tensions in crowdsourcing", *Research Policy*, Vol. 48/6, pp. 1323-1339, https://doi.org/10.1016/J.RESPOL.2019.01.013. [91]

Fortune Business Insights (2022), *Vaccine Markets*, Fortune Business Insights, https://www.fortunebusinessinsights.com/industry-reports/vaccines-market-101769 (accessed on 22 May 2022). [38]

Frank, G. et al. (2021), *Antimicrobial Resistance Benchmark 2021*, Access to Medicine Foundation , Amsterdam, http://www.amrbenchmark.org (accessed on 21 September 2021). [53]

Fredriksson, J. et al. (2017), *Business model framework applications in health care: A systematic review*, SAGE Publications Ltd, https://doi.org/10.1177/0951484817726918. [120]

Freudenreich, B., F. Lüdeke-Freund and S. Schaltegger (2020), "A Stakeholder Theory Perspective on Business Models: Value Creation for Sustainability", *Journal of Business Ethics*, Vol. 166/1, pp. 3-18, https://doi.org/10.1007/s10551-019-04112-z. [106]

Garden, H., N. Hawkins and D. Winickoff (2021), *Building and sustaining collaborative platforms in genomics and biobanks for health innovation*, OECD, Paris, https://doi.org/10.1787/11d960b7-en (accessed on 6 April 2021). [75]

Gassmann, O. and E. Enkel (2004), *Towards a Theory of Open Innovation: Three Core Process Archetypes*, https://www.alexandria.unisg.ch/274/. [89]

Gaudin, S. et al. (2019), "Common Goods for Health : Economic Rationale and Tools for Prioritization", *Health Systems & Reform*, https://doi.org/10.1080/23288604.2019.1656028. [155]

Gaudin, S. et al. (2019), "Health Systems & Reform Common Goods for Health: Economic Rationale and Tools for Prioritization", https://doi.org/10.1080/23288604.2019.1656028. [23]

Gawer, A. (2014), "Bridging differing perspectives on technological platforms: Toward an integrative framework", *Research Policy*, Vol. 43/7, pp. 1239-1249, https://doi.org/10.1016/j.respol.2014.03.006. [76]

Gisby, S. and P. Micca (2022), *New business models in health care: building platform-enabled ecosystems*, Deloitte. [127]

Glasziou, P. and I. Chalmers (2016), "Is 85% of health research really "wasted"?", *BMJ Opinion*, https://blogs.bmj.com/bmj/2016/01/14/paul-glasziou-and-iain-chalmers-is-85-of-health-research-really-wasted/ (accessed on 31 August 2021). [83]

Gold, E. and A. Edwards (2022), "Overcoming Market Failures in Pandemic Drug Discovery Through Open Science: A Canadian Solution", *Frontiers in Drug Discovery*, Vol. 2, [128]

https://doi.org/10.3389/fddsv.2022.898654.

Gotham, D. et al. (2021), "Reimbursement models to tackle market failures for antimicrobials: Approaches taken in France, Germany, Sweden, the United Kingdom, and the United States", *Health Policy*, Vol. 125/3, pp. 296-306, https://doi.org/10.1016/J.HEALTHPOL.2020.11.015. [61]

Gray, I. et al. (2019), *Business models for innovators working in crisis response and resilience building*, Disasters and Emergencies Preparedness Programme (DEPP) Innovation Labs. [3]

Greene, K. et al. (2021), *Building Public-Private Partnerships to Support Efficient and Equitable COVID-19 Vaccine Distribution, Access, and Uptake*, Duke. [39]

Greenwald, B. and J. Stiglitz (1986), "Externalities in Economies with Imperfect Information and Incomplete Markets", *The Quarterly Journal of Economics*, Vol. 101/2, p. 229, https://doi.org/10.2307/1891114. [19]

Gurry, F. (2020), "Intellectual property, innovation, access and COVID-19", *WIPO Magazine*, https://www.wipo.int/wipo_magazine/en/2020/02/article_0002.html (accessed on 19 October 2020). [137]

Hahnel, M. et al. (2020), *The State of Open Data 2020*, Digital Science, https://doi.org/10.6084/M9.FIGSHARE.13227875.V2. [82]

Hampl, N. (2019), "Drivers of and barriers to partner switch in interfirm alliances: a conceptual model", *Journal of Business Economics 2019 90:4*, Vol. 90/4, pp. 563-589, https://doi.org/10.1007/S11573-019-00965-Y. [92]

Hehenberger, L. and L. Buckland (2021), "Measuring Social Impact Can Help Foster a Stronger European Social Economy", *Stanford Social Innovation Review*, https://ssir.org/articles/entry/measuring_social_impact_can_help_foster_a_stronger_european_social_economy (accessed on 9 November 2021). [158]

Hoffman, S. and K. Outterson (2015), "What Will it Take to Address the Global Threat of Antibiotic Resistance?:", *http://dx.doi.org/10.1111/jlme.12267*, Vol. 43/S3, pp. 6-11, https://doi.org/10.1111/JLME.12267. [111]

IPPPR (2021), *A Global Deal for Our Pandemic Age*, http://www.pandemic-financing.org (accessed on 28 September 2021). [66]

Ishola, D. et al. (2021), "Safety and long-term immunogenicity of the two-dose heterologous Ad26.ZEBOV and MVA-BN-Filo Ebola vaccine regimen in adults in Sierra Leone: a combined open-label, non-randomised stage 1, and a randomised, double-blind, controlled stage 2 trial", *The Lancet Infectious Diseases*, https://doi.org/10.1016/S1473-3099(21)00125-0. [80]

Jamison, D. et al. (2013), "Global health 2035: a world converging within a generation", *The Lancet*, Vol. 382, pp. 1898-1955, https://doi.org/10.1016/S0140-6736(13)62105-4. [12]

Janse, M. et al. (2021), "Barriers Influencing Vaccine Development Timelines, Identification, Causal Analysis, and Prioritization of Key Barriers by KOLs in General and Covid-19 Vaccine R&D", *Frontiers in Public Health*, Vol. 9, https://doi.org/10.3389/fpubh.2021.612541. [40]

Jarrett, S., L. Yang and S. Pagliusi (2020), "Roadmap for strengthening the vaccine supply chain in emerging countries: Manufacturers' perspectives", *Vaccine: X*, Vol. 5, https://doi.org/10.1016/j.jvacx.2020.100068. [72]

Johnston, L., L. Goldsmith and D. Finegood (2020), "Developing co-funded multi-sectoral partnerships for chronic disease prevention: A qualitative inquiry into federal governmental public health staff experience", *Health Research Policy and Systems*, Vol. 18/1, p. 92, https://doi.org/10.1186/s12961-020-00609-6. [81]

Jonathan T. Vu, B. (2020), "Financing Vaccines for Global Health Security", *NBER*. [163]

Kallberg, C. et al. (2018), "Introduction and geographic availability of new antibiotics approved between 1999 and 2014", *PLOS ONE*, Vol. 13/10, p. e0205166, https://doi.org/10.1371/JOURNAL.PONE.0205166. [51]

Kim, W. et al. (2020), "Improving data sharing to increase the efficiency of antibiotic R&D", *Nature Reviews Drug Discovery 2021 20:1*, Vol. 20/1, pp. 1-2, https://doi.org/10.1038/d41573-020-00185-y. [86]

Kivleniece, I. et al. (2017), "Public-private collaboration: A review and avenues for further research", in Mesquita, L., R. Ragozzino and J. Reuer (eds.), *Collaborative Strategy: Critical Issues for Alliances and Networks*, Edward Elgar Publishing Ltd., https://doi.org/10.4337/9781783479580.00039. [93]

Kreiling, L., D. Robinson and D. Winickoff (2020), "Collaborative platforms for innovation in advanced materials"*, OECD Science, Technology and Industry Policy Papers, No. 95*, OECD, Paris, https://doi.org/10.1787/bb5225f1-en (accessed on 6 April 2021). [95]

Krikorian, G. and E. Torreele (2021), "We Cannot Win the Access to Medicines Struggle Using the Same Thinking That Causes the Chronic Access Crisis", *Health and Human Rights*, Vol. 23/1, p. 119, http:///pmc/articles/PMC8233016/ (accessed on 30 May 2022). [132]

Krlev, G. and F. Angeli (2022), "Social Impact Evaluation: Moving from Method to Realist Strategy", in Angeli, F., J. Raab and A. Metz (eds.), *Organizing for Sustainable Development*, Oxon: Routledge. [159]

Kruk, M. et al. (2015), "What is a resilient health system? Lessons from Ebola", *The Lancet*, Vol. 385/9980, pp. 1910-1912, https://doi.org/10.1016/S0140-6736(15)60755-3. [11]

Kwon, T. et al. (2022), *Blended Finance: When to use which approach Decision-making tool and framework*. [149]

Larrue, P. (2021), *The design and implementation of mission-oriented innovation policies: A new systemic policy approach to address societal challenges*, OECD. [69]

Lessidrenska, T. and D. Boyer (2020), "Human-Centered Business Model - Social and Environmental Principles", https://globalforumljd.com/new/sites/default/files/documents/communitiesOfPractice/HCBM_Social%20and%20Environmental%20principles%20-%20Paper%20April-28-2020_0.pdf (accessed on 9 July 2021). [114]

Lichtenberg, F. (2017), "The impact of biomedical innovation on longevity and health", *Nordic Journal of Health Economics*, Vol. 5/1. [1]

Liu, M. et al. (2020), "Can pandemics transform scientific novelty? Evidence from COVID-19", https://arxiv.org/abs/2009.12500v2 (accessed on 12 July 2021). [56]

Lüdeke-Freund, F. et al. (2018), "The sustainable business model pattern taxonomy—45 patterns [123]

to support sustainability-oriented business model innovation", *Sustainable Production and Consumption*, Vol. 15, pp. 145-162, https://doi.org/10.1016/j.spc.2018.06.004.

Lüdeke-Freund, F. and K. Dembek (2017), "Sustainable business model research and practice: Emerging field or passing fancy?", *Journal of Cleaner Production*, Vol. 168, pp. 1668-1678, https://doi.org/10.1016/j.jclepro.2017.08.093. [21]

Luyten, J. and P. Beutels (2017), "The Social Value Of Vaccination Programs: Beyond Cost-Effectiveness", *https://doi.org/10.1377/hlthaff.2015.1088*, Vol. 35/2, pp. 212-218, https://doi.org/10.1377/HLTHAFF.2015.1088. [33]

Maher, B. and R. Van Noorden (2021), "How the COVID pandemic is changing global science collaborations", *Nature*, Vol. 594/7863, pp. 316-319, https://doi.org/10.1038/D41586-021-01570-2. [57]

Makenga, G. et al. (2019), "Vaccine production in Africa: A feasible business model for capacity building and sustainable new vaccine introduction", *Frontiers in Public Health*, Vol. 7/MAR, p. 56, https://doi.org/10.3389/FPUBH.2019.00056/BIBTEX. [29]

Manner, C., K. Graef and J. Dent (2019), "WIPO Re:Search: Catalyzing Public-Private Partnerships to Accelerate Tropical Disease Drug Discovery and Development", *Tropical Medicine and Infectious Disease*, Vol. 4/1, https://doi.org/10.3390/tropicalmed4010053. [142]

Mannix, L. (2020), "Coronavirus: Vaccine development is a case of 'market failure'. Here's why", *The Sydney Morning Herald*, https://www.smh.com.au/national/vaccine-development-is-a-case-of-market-failure-here-s-why-20200413-p54jez.html (accessed on 3 October 2021). [25]

Marsh, K. et al. (2016), "Expanding Health Technology Assessments to Include Effects on the Environment", *Value in Health*, Vol. 19/2, pp. 249-254, https://doi.org/10.1016/J.JVAL.2015.11.008. [160]

Massa, L. and C. Tucci (2014), "Business Model Innovation", in Dodgson, M., D. Gann and N. Phillips (eds.), *The Oxford Handbook of Innovation Management*, Oxford University Press, https://doi.org/10.1093/oxfordhb/9780199694945.013.002. [99]

Massa, L., C. Tucci and A. Afuah (2017), *A critical assessment of business model research*, Routledge, https://doi.org/10.5465/annals.2014.0072. [100]

Miethke, M. et al. (2021), "Towards the sustainable discovery and development of new antibiotics", *Nature Reviews Chemistry 2021*, pp. 1-24, https://doi.org/10.1038/s41570-021-00313-1. [49]

Moon, S. et al. (2017), "Global public goods for health: weaknesses and opportunities in the global health system", *Health Economics, Policy and Law*, Vol. 12, pp. 195-205, https://doi.org/10.1017/S1744133116000451. [14]

Moran, D. (2019), "A framework for improved one health governance and policy making for antimicrobial use", *BMJ Global Health*, Vol. 4/5, p. e001807, https://doi.org/10.1136/BMJGH-2019-001807. [24]

Mrad, F. (2017), "The effects of intellectual property rights protection in the technology transfer context on economic growth: the case of developing countries", *Journal of Innovation Economics & Management*, Vol. 2/23. [139]

Munro, E. (2020), *Strengthening Prevention with Better Anticipation: COVID-19 and Beyond*, [73]

http://www.gcsp.ch (accessed on 28 January 2021).

Murray, C. et al. (2022), "Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis", *The Lancet*, Vol. 399/10325, pp. 629-655, https://doi.org/10.1016/S0140-6736(21)02724-0. [46]

Mwachofi, A., *. Assaf and F. Al-Assaf (2011), "Health Care Market Deviations from the Ideal Market", Vol. 11/3, pp. 328-337. [20]

North, J. (2020), *Challenges to Tackling Antimicrobial Resistance*, Cambridge University Press, https://doi.org/10.1017/9781108864121. [97]

Nuzzo, J. et al. (2019), "What makes health systems resilient against infectious disease outbreaks and natural hazards? Results from a scoping review", *BMC Public Health 2019 19:1*, Vol. 19/1, pp. 1-9, https://doi.org/10.1186/S12889-019-7707-Z. [156]

O'Neill, J. (2015), *Rapid Diagnostics: stopping unnecessary use of antibiotics*, Wellcome Trust, http://amr-review.org/sites/default/files/Paper-Rapid-Diagnostics-Stopping-Unnecessary-Prescription-Low-Res.pdf (accessed on 30 May 2022). [59]

OECD (2023), *Mission-oriented innovation policies for net-zero, in STI Outlook 2023, Chapter 5*, OECD. [70]

OECD (2021), *Health at a Glance 2021*, OECD. [8]

OECD (2021), *Knowledge co-creation in the 21 st century-An international experience-based policy report*, https://doi.org/10.1787/f6d42aa5-en (accessed on 9 July 2021). [68]

OECD (2021), *OECD Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity*, OECD Publishing, Paris, https://doi.org/10.1787/75f79015-en. [125]

OECD (2021), *The OECD DAC Blended Finance Guidance*. [143]

OECD (2020), *Blended Finance: New Approaches for Financing Science, Technology and Innovation for Achieving the Sustainable Development Goals – Final Report from the Workshop*. [151]

OECD (2020), *Development Co-operation Report 2020: Learning from Crises, Building Resilience*, OECD Publishing, Paris, https://dx.doi.org/10.1787/f6d42aa5-en. [67]

OECD (2020), *Digital Transformation in the Age of COVID-19: Building Resilience and Bridging Divides, Digital Economy Outlook 2020 Supplement*, OECD, Paris, http://www.oecd.org/digital/digital-economy-outlook-covid.pdf (accessed on 27 June 2022). [124]

OECD (2019), *Blended Finance Funds and Facilities: 2018 Survey Results*, OECD Publishing, Paris, https://doi.org/10.1787/806991a2-en. [144]

OECD (2019), *Financing SMEs and Entrepreneurs 2019: An OECD Scoreboard*, OECD Publishing, Paris, https://doi.org/10.1787/fin_sme_ent-2019-en. [58]

OECD (2018), *Making Blended Finance Work for the Sustainable Development Goals*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264288768-en. [145]

OECD (2018), *Pharmaceutical Innovation and Access to Medicines*, OECD Health Policy Studies, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264307391-en. [2]

OECD (2018), *Stemming the Superbug Tide: Just A Few Dollars More*, OECD Health Policy Studies, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264307599-en. [98]

OECD (2017), *Business Models for Sustainable Research Data Repositories*, OECD, Paris. [101]

OECD (2017), *New Health Technologies: Managing Access, Value and Sustainability*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264266438-en. [7]

OECD (2015), *Enquiries into Intellectual Property's Economic Impact*, OECD, Paris. [130]

OECD (2015), "Open innovation", in *OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society*, OECD, https://doi.org/10.1787/888933274055. [90]

OECD (2015), *Policy Brief on Social Impact Measurement for Social Enterprises - Policies for Social Entrepreneurship*, OECD, EC. [157]

OECD (2010), *The OECD Innovation Strategy: Getting a Head Start on Tomorrow*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264083479-en. [134]

Oskam, I., B. Bossink and A. de Man (2020), "Valuing Value in Innovation Ecosystems: How Cross-Sector Actors Overcome Tensions in Collaborative Sustainable Business Model Development", *Business & Society*, p. 000765032090714, https://doi.org/10.1177/0007650320907145. [110]

Ostrom, E. (2010), "Beyond Markets and States: Polycentric Governance of Complex Economic Systems", *The American Economic Review*, Vol. 100/3, pp. 641-672, https://www.jstor.org/stable/27871226 (accessed on 23 February 2022). [16]

Outterson, K. et al. (2021), "Patient Access in 14 High-Income Countries to New Antibacterials Approved by the US Food and Drug Administration, European Medicines Agency, Japanese Pharmaceuticals and Medical Devices Agency, or Health Canada, 2010–2020", *Clinical Infectious Diseases*, https://doi.org/10.1093/CID/CIAB612. [26]

Outterson, K. and J. Rex (2020), "Evaluating for-profit public benefit corporations as an additional structure for antibiotic development and commercialization", *Translational Research*, Vol. 220, pp. 182-190, https://doi.org/10.1016/J.TRSL.2020.02.006. [117]

Pagliusi, S., Y. Che and S. Dong (2019), "The art of partnerships for vaccines", *Vaccine*, Vol. 37/40, p. 5909, https://doi.org/10.1016/J.VACCINE.2019.07.088. [37]

Pedersen, E. et al. (2020), "Toward Collaborative Cross-Sector Business Models for Sustainability", *Business & Society*, p. 000765032095902, https://doi.org/10.1177/0007650320959027. [102]

Pelfrene, E., R. Botgros and M. Cavaleri (2021), "Antimicrobial multidrug resistance in the era of COVID-19: a forgotten plight?", *Antimicrobial Resistance & Infection Control 2021 10:1*, Vol. 10/1, pp. 1-6, https://doi.org/10.1186/S13756-021-00893-Z. [62]

Plackett, B. (2020), "Why big pharma has abandoned antibiotics", *Nature*, Vol. 586/7830, pp. S50-S52, https://doi.org/10.1038/D41586-020-02884-3. [119]

Plotkin, S. et al. (2017), "The complexity and cost of vaccine manufacturing – An overview", *Vaccine*, Vol. 35/33, pp. 4064-4071, https://doi.org/10.1016/J.VACCINE.2017.06.003. [27]

Pronker, E. et al. (2013), "Risk in Vaccine Research and Development Quantified", *PLOS ONE*, [30

Vol. 8/3, p. e57755, https://doi.org/10.1371/JOURNAL.PONE.0057755.]

Provan, K. and P. Kenis (2007), "Modes of Network Governance: Structure, Management, and Effectiveness", *Journal of Public Administration Research and Theory*, Vol. 18/2, pp. 229-252, https://doi.org/10.1093/jopart/mum015. [77]

Raab, J. (2022), "Organisational networks for sustainable development", in Angeli, F., A. Metz and J. Raab (eds.), *Organising for sustainable development: addressing the grand challenges*, Taylor and Francis Group. [153]

Rauter, R. et al. (2019), "Assessing the Impact of Sustainable Business Models: Challenges, Key Issues and Future Research Opportunities", Palgrave Macmillan, Cham, https://doi.org/10.1007/978-3-319-97385-2_14. [154]

Reisen, H., M. Soto and T. Weithöner (2004), *Financing global and regional public goods through ODA: analysis and evidence from the OECD Creditor Reporting System*, OECD, Paris, https://www.oecd.org/development/pgd/24482500.pdf (accessed on 17 May 2021). [13]

Rocchi, S. et al. (2021), "Value co-creation through multi-stakeholder collaborations for health in fragile settings: the case of the high-risk pregnancy referral tool", in Angeli, F., J. Raab and A. Metz (eds.), *Organizing for Sustainable Development: Addressing the Grand Challenges*, Abingdon, Oxon, UK: Routledge, Taylor & Francis Group. [121]

Rodes Sanchez M. et al. (2021), *Working Towards a Sustainable, Healthy Market for Vaccines: a Comprehensive Framework to Support Policy Dialogue and Decision-Making*, Office of Health Economics (OHE) , London, https://www.ohe.org/publications/working-towards-sustainable-healthy-market-vaccines-comprehensive-framework-support# (accessed on 24 May 2022). [115]

Rodríguez-Baño, J. et al. (2021), "Key considerations on the potential impacts of the COVID-19 pandemic on antimicrobial resistance research and surveillance", *Transactions of The Royal Society of Tropical Medicine and Hygiene*, Vol. 0, pp. 1-8, https://doi.org/10.1093/TRSTMH/TRAB048. [63]

Roh, C. and S. Kim (2017), "Medical innovation and social externality", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 3/1, pp. 1-8, https://doi.org/10.1186/S40852-017-0056-1/METRICS. [9]

Ryu, S. (2017), "The new Korean action plan for containment of antimicrobial resistance", *Journal of Global Antimicrobial Resistance*, Vol. 8, pp. 70-73, https://doi.org/10.1016/J.JGAR.2016.10.013. [44]

Sachs, R. (2020), "Drug Innovation: When Patents Work (and When They Don't) Reexamining Patent Protection", *Milken Institute Review*. [131]

Samans, R. and E. Solheim (2015), *Blended Finance Vol. 1: A Primer for Development Finance and Philanthropic Funders An overview of the strategic use of development finance and philanthropic funds to mobilize private capital for development*, WEF, OECD. [162]

Saz-Carranza, A. and S. Ospina (2011), "The Behavioral Dimension of Governing Interorganizational Goal-Directed Networks--Managing the Unity-Diversity Tension", *Journal of Public Administration Research and Theory*, Vol. 21/2, pp. 327-365, https://doi.org/10.1093/jopart/muq050. [78]

Schneider, M., N. Harrison and M. McClellan (2020), *Recommended Post-Market Incentive* [103]

Strategies to Support the Development of Innovative Antibiotics, Duke-Margolis Center for Health Policy, https://healthpolicy.duke.edu/sites/default/files/2020-09/Recommendations%20Report%20Sept%202020.pdf (accessed on 30 September 2021).

Schwartz, J. and M. Yen (2017), *Toward a collaborative model of pandemic preparedness and response: Taiwan's changing approach to pandemics*, Elsevier Ltd, https://doi.org/10.1016/j.jmii.2016.08.010. [74]

Stiglitz, J. (2006), "Global public goods and global finance: Does global governance ensure that the global public interest is served?", in *Advancing Public Goods*, Edward Elgar Publishing Ltd., https://doi.org/10.4337/9781847201843.00016. [146]

Su, Y. et al. (2022), "Common Demand vs. Limited Supply—How to Serve the Global Fight against COVID-19 through Proper Supply of COVID-19 Vaccines", *International Journal of Environmental Research and Public Health 2022, Vol. 19, Page 1339*, Vol. 19/3, p. 1339, https://doi.org/10.3390/IJERPH19031339. [15]

Swaminathan, S. et al. (2022), "Reboot biomedical R&D in the global public interest", *Nature 2022 602:7896*, Vol. 602/7896, pp. 207-210, https://doi.org/10.1038/d41586-022-00324-y. [133]

Tarrant, C. et al. (2019), "Optimizing antibiotic prescribing: collective approaches to managing a common-pool resource", *Clinical Microbiology and Infection*, Vol. 25/11, pp. 1356-1363, https://doi.org/10.1016/J.CMI.2019.03.008. [17]

The RIGHT Fund (2020), *Global Access Policy*, https://rightfund.org/en/access-policy/ (accessed on 21 February 2023). [167]

Towse, A. et al. (2017), "Time for a change in how new antibiotics are reimbursed: Development of an insurance framework for funding new antibiotics based on a policy of risk mitigation", *Health Policy*, Vol. 121/10, pp. 1025-1030, https://doi.org/10.1016/J.HEALTHPOL.2017.07.011. [112]

UK G7 pandemic preparedness partnership (2021), *100 Days Mission to Respond to Future Pandemic Threats*. [10]

USAID (2021), *Innovator and Investor Support Opportunities From CII's Investing for Impact Series Unleashing Private Capital for Global Health Innovation*, http://www.usaid.gov/cii (accessed on 11 November 2022). [148]

Wells, P. et al. (2020), "A socio-technical transitions perspective for assessing future sustainability following the COVID-19 pandemic", *https://doi.org/10.1080/15487733.2020.1763002*, Vol. 16/1, pp. 29-36, https://doi.org/10.1080/15487733.2020.1763002. [126]

WHO (2016), *Ensuring innovation in diagnostics for bacterial infection*, World Health Organization (WHO), https://www.ncbi.nlm.nih.gov/books/NBK447319/pdf/Bookshelf_NBK447319.pdf (accessed on 30 September 2021). [104]

Williams, O. (2020), "COVID-19 and Private Health: Market and Governance Failure", *Development*, Vol. 63/2, pp. 181-190, https://doi.org/10.1057/S41301-020-00273-X. [105]

Willyard, C. (2021), "How antiviral pill molnupiravir shot ahead in the COVID drug hunt", *Nature*, https://doi.org/10.1038/d41586-021-02783-1. [140]

World Health Organization (WHO) (2021), *Financing common goods for health*, WHO, Geneva. [4]

World Health Organization (WHO) (2020), *Global Vaccine Market Report*, [28

https://cdn.who.int/media/docs/default-source/immunization/mi4a/2020_global-vaccine-market-report.pdf?sfvrsn=48a58ada_1&download=true (accessed on 22 May 2022).]

World Health Organization (WHO) (2019), *Global Vaccine Market Report*, WHO, Geneva, http://who.int/immunization/MI4A (accessed on 21 May 2022). [34]

WTO, M. (2022), *Ministerial Decision on the TRIPS Agreement (WT/MIN(22)/30)*, World Trade Organization, Geneva, https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/WT/MIN22/30.pdf&Open=True (accessed on 27 June 2022). [141]

Yu, H. (2021), "Responsible use of negative research outcomes—accelerating the discovery and development of new antibiotics", *The Journal of Antibiotics 2021 74:9*, Vol. 74/9, pp. 543-546, https://doi.org/10.1038/s41429-021-00439-w. [85]

Yu, H. (2020), "Leveraging Research Failures to Accelerate Drug Discovery and Development", *Therapeutic Innovation and Regulatory Science*, Vol. 54/4, pp. 788-792, https://doi.org/10.1007/s43441-019-00005-5. [109]

Yu, H. (2016), *Bridging the translational gap: Collaborative drug development and dispelling the stigma of commercialization*, Elsevier Ltd, https://doi.org/10.1016/j.drudis.2015.10.013. [79]

Yu, H. (2016), "Redefining responsible research and innovation for the advancement of biobanking and biomedical research", *Journal of Law and the Biosciences*, Vol. 3/3, pp. 611-635, https://doi.org/10.1093/jlb/lsw047. [84]

Yunus, M., B. Moingeon and L. Lehmann-Ortega (2010), "Building social business models: Lessons from the grameen experience", *Long Range Planning*, Vol. 43/2-3, pp. 308-325, https://doi.org/10.1016/j.lrp.2009.12.005. [108]

Endnotes

[1] For more information on the Access to Medicine Foundation: https://accesstomedicinefoundation.org/access-to-medicine-index.

[2] For more information on the WHO Covid-19 Technology Access Pool (C-TAP): https://www.techtransfer.nih.gov/policy/ctap.

[3] See also: https://www.who.int/initiatives/covid-19-technology-access-pool.

[4] "Pareto efficiency, also referred to as allocative efficiency, occurs when resources are so allocated that it is not possible to make anyone better off without making someone else worse off."

[5] For more information on the Aspen-branded Covid-19 vaccine Aspenovax: https://www.aspenpharma.com/2022/03/08/aspen-concludes-agreement-to-manufacture-and-make-available-an-aspen-branded-covid-19-vaccine-aspenovax-throughout-africa/.

[6] For more information on the G20: https://www.g20.org/.

[7] GISAID is a Global Data Science Initiative.

[8] For more information on the European One Health Action Plan against AMR: https://ec.europa.eu/health/antimicrobial-resistance/eu-action-on-antimicrobial-resistance_en.

[9] For more information on "A roadmap towards the creation of the European partnership on One Health antimicrobial resistance (OH AMR)": https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-hlth-2021-disease-04-05.

[10] For more information on the Innovative Health Initiative (IHI): https://www.imi.europa.eu/.

[11] For more information on the COMBACTE projects: https://www.combacte.com/.

[12] For more information on the IHI co-funded Ebola vaccine: https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6246.

[13] For more information on The Research Investment for Global Health Technology Fund (The RIGHT Fund): https://rightfund.org/en/overview/introduction/.

[14] Stated by Dr Federica Angeli (Professor, Chair in Management, Director of Research, The York Management School, University of York, York, UK) during the OECD Expert Consultation on business model innovation.

[15] For more information on the European Economic and Social Committee (EESC): https://www.eesc.europa.eu/en.

[16] For more information on the Human-Centred Business Model (HCBM): https://www.worldbank.org/en/events/2019/02/21/human-centered-business-model.

[17] See also: https://globalforumljd.com/.

[18] See also: https://www.oecd.org/dev/.

[19] See also: https://oecd-development-matters.org/2019/10/21/the-human-centred-business-model-an-innovative-ecosystem-for-sustainable-development/#_ftn2.

[20] See also: http://www.hcbecosystem.info/wp-content/uploads/2020/07/HCBM-Project-Brief-October-2019.pdf.

[21] The Medicines Patent Pool (MPP) is a United Nations-backed public health organisation working to increase access to, and facilitate the development of, life-saving medicines for low- and middle-income countries. https://medicinespatentpool.org/.

[22] For more information on the WTO agreement to temporarily waive IPRs for Covid-19 vaccines: https://www.who.int/news/item/27-10-2021-who-unitaid-statement-on-the-mpp-licensing-agreement-for-molnupiravir.

[23] For more information on COVAX: https://www.who.int/initiatives/act-accelerator/covax.

[24] For more information on the Access to Covid-19 Tools (ACT) Accelerator: https://www.who.int/initiatives/act-accelerator.

[25] For more information on The RIGHT Fund's global access policy: https://rightfund.org/en/access-policy/.

[26] For more information on the Joint European Disruptive Initiative (JEDI) Billion Molecules against Covid-19 GrandChallenge: https://www.jedi.foundation/billion-molecules.

[27] For more information on the WIPO Re:Search project: https://www.wipo.int/research/en/.

[28] See https://www.kff.org/global-health-policy/issue-brief/blended-finance-for-global-health-summary-of-a-policy-roundtable/.