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Developing globally-accessible medicines for pandemic preparedness: An analysis of three alternative innovation models

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ABSTRACT

Recent infectious disease crises (e.g. COVID-19, Ebola, mpox) show that the mainstream market-driven innovation model cannot ensure both rapid innovation and equitable global access to vaccines, drugs, and diagnostics critical for pandemic preparedness and response. Alternative models that may better address global access needs exist, but analysis of their merits is limited. We analysed the pharmaceutical innovation 'niche' for pandemic products and 35 alternative initiatives within it, to inductively derive a typology of three archetypal alternative models: The National Biosecurity model is well-established, proliferating since COVID-19, driven and funded primarily by the public sector, and delivering innovation for national needs. The Cosmopolitan Public Private Partnership model combines global access with innovation, but relies on voluntary participation, and must navigate tensions between public and private interests. The Open Science Collaborative Network model accelerates innovation through scientific cooperation and builds global access into early R&D stages, but remains small-scale, nascent, and requires effective coordination. Cosmopolitan and Open Science models offer significant advantages for achieving innovation with global access, but require sustained political, financial and technical support. Alternative innovation models should be institutionalised during inter-pandemic periods, when markets for pandemic products are economically unattractive, and political resistance to systemic change is easier to overcome.

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Pandemic preparedness and response; access to medicines; alternative innovation models; pandemic products; global health equity

Introduction

Development of, and equitable access to health technologies is critical for pandemic preparedness and response (PPR), but the current innovation system is unfit for this purpose. While it has demonstrated the capacity to quickly develop safe and effective technologies, recent infectious disease crises (e.g. COVID-19, mpox, H1N1) suggest that global access to such technologies is likely to be unequal and inequitable (Alonso Ruiz et al., 2024; Sparke & Anguelov, 2012). Of the 13 billion doses of COVID-19 vaccines administered worldwide by the end of 2022, only 2% reached low-income countries (LICs) (Our World in Data, 2023). In 2024, the endemic regions of West and Central Africa experienced mpox outbreaks that the World Health Organization (WHO) characterised with its highest level of alert, a Public Health Emergency of International Concern (PHEIC).

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However, these countries could only access a small proportion of global mpox vaccine supply (by one estimate, only 10% of needed supplies by the end of 2024), while most was allocated for smaller outbreaks in Europe and the United States (Oxfam, 2024; Tovani-Palone et al., 2023). Political leaders have agreed that greater equity in access to health technologies is needed to prevent and contain pandemics, reflected in the WHO Pandemic Agreement adopted at the 78th World Health Assembly in 2025 (WHO, 2025). This decision acknowledged 'the need to address gaps in preventing, preparing for, and responding to health emergencies, including in development and distribution of, and unhindered, timely and equitable access to, medical countermeasures such as vaccines, therapeutics, and diagnostics […] prioritizing the need for equity' (WHO, 2021). However, the path towards this goal remains unclear, sparking substantial disagreement between countries and other stakeholders.

Further empirical evidence and analysis of efforts to make pandemic products more globally accessible are merited to inform ongoing policy debates. Many complex factors shape who benefits from pandemic products, from a country's wealth and industrial capacity to its political relationships, from people's confidence in their health systems to leadership and societal trust (Adhikari et al., 2022; Alonso Ruiz et al., 2024; Arsenault et al., 2023; Sparke & Williams, 2024; Suzuki & Yang, 2022). Scholars also found that ensuring equitable access to medicines requires not only post-product-development interventions, such as price negotiations or pooled procurement, but also looking upstream at potential changes to the underlying innovation model itself (Suleman et al., 2020; Swaminathan et al., 2022; 't Hoen, 2009). Therefore, we focus here on one important determinant of global access: how different approaches to the research & development (R&D) of pandemic products can produce greater or lesser equity in access. We describe the mainstream, profit-driven pharmaceutical innovation model, which restricts access by design, then identify and assess the suitability for global access objectives of three alternative innovation models that have been implemented.

Innovation models for pandemic products

The mainstream pharmaceutical innovation model is market-driven with a profit-maximisation core purpose. This leads to prioritising the most profitable disease targets, meaning that critical but less-lucrative therapeutic areas such as antibiotics or neglected diseases do not attract sufficient scientific effort. In addition, financing R&D relies on intellectual property (IP) or other monopoly rights to set prices as high as societies are willing to bear, restricting access and straining health budgets. Furthermore, fierce competition between R&D firms restricts the open sharing of knowledge that could accelerate scientific progress and reduce wasteful duplication (Swaminathan et al., 2022).

These systemic pathologies are exacerbated by 'the increasing influence of the financial sector' (Busfield, 2020) on the pharmaceutical industry since the 1980s, often referred to as 'financialisation'. Among the myriad implications of financialisation is that maximising shareholder value has eclipsed R&D as a core objective of some large pharmaceutical firms (Busfield, 2020; Fernandez & Klinge, 2020; Tulum & Lazonick, 2019). Research has found that some firms spend more to boost share prices with dividends and share buybacks than on R&D, for example (Lazonick & Tulum, 2023). Firms are also found to prioritise higher market value of intangible assets such as patents, over product development, for instance delaying full development of an Ebola vaccine prior to the 2014 West African Ebola crisis (Herder et al., 2020). Many large firms increasingly outsource R&D rather than investing in-house, acquiring promising technologies through mergers and acquisitions of, or in-licensing from, smaller firms (Busfield, 2020; Pammolli et al., 2020).

Many of these characteristics of the mainstream innovation system also apply to the specific niche for pandemic products (Moon et al., 2025). We adopt the term 'pandemic products' in this article to refer to technologies for outbreaks of infectious disease that may become pandemics, recognising also closely-related terms such as products for emerging infectious disease (EID) (Ndow et al., 2019) or biosecurity (Koblentz, 2010). During epidemics or pandemics, demand

for products spikes as populations and governments scramble to counteract disease threats. Firms that control needed health technologies exert strong market and political power during such crises, and profits can be considerable (Sparke & Williams, 2024). For example, Pfizer's global revenue doubled from $41.6 billion in 2020 to reach an all-time-high of $81.3 billion in 2021 due to the Pfizer/BioNTech Covid-19 vaccine; it leaped again to $100 billion in 2022 on the strength of COVID-19 vaccine and therapeutics sales (Pfizer, 2023). Moderna had never brought a product to market prior to COVID-19, but overnight became one of the world's 20 largest pharmaceutical firms based on its COVID-19 vaccine sales (Dunleavy, 2023). Both companies prioritised sales to high-income countries (HICs); they supplied developing countries and the COVID-19 Vaccines Global Access (COVAX) initiative with major delays and in limited volumes, and despite supply shortages did not transfer technology to other firms to scale up production (Alonso Ruiz et al., 2024; de Bengy Puyvallée & Storeng, 2022; Kavanagh & Singh, 2023). During emergencies, pandemic products fit aptly into the mainstream innovation model, characterised as profit-oriented, highly-priced, with little to no sharing of technology and very restricted global access.

However, innovation models for pandemic products operate very differently between pandemics. Most of the time, pandemic products attract very little private investment because the timing and magnitude of outbreaks – and therefore, of market demand – is highly uncertain. Some products sit on a shelf unused for many years, losing patent life, waiting for an outbreak to occur. Market risks are one reason governments have played a much more active and substantial role.

For most pharmaceuticals, public investment focuses on the earlier stages of R&D, laying the scientific foundation for later-stage product development by private firms (Sampat & Lichtenberg, 2011). However, for pandemic products public actors engage in both early- and late-stage R&D, and also play an active role in facilitating and de-risking R&D through matchmaking, regulatory support and advance purchase commitments (Elbe et al., 2014; Moon et al., 2022; Sunyoto, 2020). For example, the United States (US) government invested $31.9 billion not only to fund key technologies underlying mRNA COVID-19 vaccines, but also to pay for clinical trials, scale-up production, and de-risk private investments through advance purchase commitments, as well as procurement after regulatory approval (Lalani et al., 2023). A biosecurity framing legitimises the greater role governments often play in the development of pandemic products, compared to other areas (Elbe, 2018; Long, 2021).

In the US, where the pandemic product R&D system is most developed, public actors take an active role in prioritising pathogens for product development, and channelling direct funding for R&D from defence (e.g. Defense Advanced Research Projects Agency (DARPA)), and civilian agencies (e.g. Biomedical Advanced Research and Development Authority (BARDA)). These measures are designed to *push* product development through grants or tax breaks, and *pull* development through prizes, extended market exclusivity, and/or government procurement contracts for stockpiles or use (Matheny et al., 2007). Beyond the US and other HICs, the governments of some low- and middle-income countries (LMICs) including China, Russia, India or Cuba also play a central role in their PPR R&D systems (Sunyoto, 2020).

While public funding and actors play an essential role in R&D for pandemic products, private actors have captured many of the benefits and profit substantially when outbreaks emerge, prompting calls for governments to do more to ensure public access to the benefits of public investments. In response, some notable changes are underway: in May 2025 the WHO Pandemic Agreement was adopted with provisions committing states to develop and implement policies on publicly-funded pandemic-related R&D 'that promote timely and equitable access to such products, especially for developing countries' (Article 9; WHO, 2025). In January 2025, the US National Institutes of Health (NIH) adopted a new policy requiring licensees of government-owned patents to provide and publish plans for patient access to resulting products (NIH, 2025).

Beyond publicly-financed R&D, the COVID-19 pandemic has prompted broader calls for new approaches to R&D for pandemic products to better meet both innovation and access goals

(Torreele et al., 2023a). Literature proposing how to reach this objective is emerging, such as Torreele's (2023b) call for developing regional R&D resilience in LMICs through intensified technology transfer. Others stress strengthening collaboration between public and private actors (Dzau et al., 2022), with international actors such as GAVI, CEPI, and others aligning behind this strategy under 'The 100 Days Mission' (CEPI, n.d.).

This study complements the literature on PPR R&D, including critiques of the existing system and proposals for new approaches, by offering an empirically-based analysis of three alternatives to the mainstream commercial model that have been implemented for pandemic technologies: the National Biosecurity, Cosmopolitan Public-Private Partnership, and Collaborative Network models. The article concludes with an assessment of each innovation model's potential to deliver both innovation and global access to pandemic-related products, and the political opportunities to effect needed systemic change.

Methodology

This article is part of a broader research project that explored paths to equitable pharmaceutical innovation. A description of the project's conceptual framework and methodology has been published elsewhere (Moon et al., 2025); the following section therefore focuses on the methodology for this paper.

For this qualitative study, we conducted a scoping review of the PPR R&D literature (Sunyoto, 2020). In addition, from the project database of ~140 R&D initiatives potentially representing alternative innovation models (Global Health Centre, 2023), we identified 35 organisations active in PPR. We categorised them as either implementers (i.e. who conduct R&D, 19 organisations) or funders/facilitators (i.e. who finance and support R&D, 16 organisations), and gathered data on their characteristics based on publicly available information (Table 1)

Ten organisations from the sample of 35 accepted to be interviewed, including eight implementers and two funders. We gathered primary data through semi-structured interviews with representatives of these organisations from 2021 to 2023, to deepen our understanding of their innovation models. The interviews were transcribed, translated (where necessary), anonymised, and coded using the Dedoose software, to categorise relevant themes. We analysed the initiatives using the broader project's conceptual framework of key elements comprising alternative innovation models (Appendix 1) (Figure 1).

We iteratively and inductively derived the typology of the three alternative innovation models co-existing in the PPR niche. Finally, in November 2023, we organised an online workshop to gather feedback from PPR innovation experts on our emerging findings, and revised our analysis in response. To arrive at our conclusions, we triangulated our findings between the literature, publicly available information on initiatives, interview data, team discussions and the expert workshop.

This study has a number of limitations. First, the 35 organisations were selected from a database focused on alternative innovation models, and therefore they do not include actors we considered to be implementing the mainstream innovation model (e.g. large firms such as Pfizer). Therefore, this overview does not cover the full PPR niche including the mainstream model, but rather focuses on alternative approaches to innovation with the potential to achieve global access goals. Second, only a sub-set of these 35 actors agreed to be interviewed, and resource constraints precluded further data collection. As the primary purpose was to discern inductively different innovation models and how they function, this early-stage research focuses on constructing the object of study. Future research could undertake a comprehensive mapping of R&D activities and organisations in the PPR niche, and/or conduct more in-depth studies of particular organisations, products or policies engaged in alternative innovation models. Finally, this study depicts innovation models for pandemic products at a particularly significant moment in their evolution – the aftermath of the COVID-19 crisis – but the initiatives examined and broader ecosystem continue to evolve, and will be subject to new

Table 1. Overview of sampled organisations active in the PPR niche.

No.	Organisation	Type	Organisational Form	Country	Focus Area
1	Access to Advanced Health Institute (AAHI)	Implementer	Not-for-profit; PDP	United States of America	16 vaccine adjuvant formulations and 13 active clinical trials for 12 infectious disease and cancer targets
2	Bio-Manguinhos / Fundação Oswaldo Cruz (Fiocruz)	Implementer	National government agency	Brazil	More than 60 products including vaccines, diagnostics and biopharmaceuticals
3	Bavarian Nordic	Implementer	Private company	Denmark	Vaccines for Tick-borne encephalitis, Smallpox, Mpox, Rabies, Cholera, Typhoid fever
4	Nanogen Pharmaceutical Biotechnology	Implementer	National government agency	Viêt Nam	APIs and therapeutic products for various disease areas, including COVID-19
5	International AIDS Vaccine Initiative (IAVI)	Implementer	Not-for-profit; PDP	United States of America	10 vaccines in development for HIV, emerging infectious diseases and TB
6	mRNA Vaccine Technology Transfer Hub, South Africa	Implementer	Not-for-profit; PDP	South Africa	Vaccine development for COVID-19, using mRNA platform technology
7	COVID Moonshot / DNDi	Implementer	Not-for-profit; Academic, PDP	Switzerland	Vaccine development for COVID-19
8	VaxEquity	Implementer	Private company	United Kingdom	Vaccine development for Influenza, COVID-19 using mRNA platform technology
9	Instituto Butantan	Implementer	National government agency	Brazil	Vaccines for multiple diseases, including Influenza, COVID-19
10	The Jenner Institute / University of Oxford	Implementer	Not-for-profit; Academic, PDP	United Kingdom	Vaccines for COVID-19, Malaria
11	Sabin Vaccine Institute	Implementer	Not-for-profit, PDP	United States of America	Vaccine development for Sudan ebolavirus and Marburg virus disease
12	SIGA Technologies, Inc.	Implementer	Private company	United States of America	Vaccines for Smallpox, Mpox, and other orthopoxviruses
13	Texas Children's Hospital Centre for Vaccine Development at Baylor College of Medicine	Implementer	Not-for-profit; Academic, PDP	United States of America / India	Vaccines for COVID-19, neglected diseases
14	Instituto Finlay de Vacunas	Implementer	National government agency	Republic of Cuba	Vaccines for: COVID-19, Meningococcal disease, Leptospirosis, Diphtheria, Tetanus, Typhoid fever
15	SK bioscience	Implementer	Private company	Republic of Korea	Vaccines for: Influenza, Herpes Zoster, Varicella, Typhoid fever, Pneumococcal infections, COVID-19; Multiple vaccines in development
16	Biomedical Advanced Research and Development Authority (BARDA)	Implementer / Facilitator / Funder	National government agency	United States of America	Broad translational science portfolio across multiple disease areas and research centres
17	Spanish National Research Council (CSIC)	Implementer	National government agency	Spain	Broad portfolio across multiple disease areas and research centres
18	Rapidly Emerging Antiviral Drug Development Initiatives AViDD Center (READDI-AC)	Implementer	Not-for-profit; Academic	United States of America	Discovery of broad spectrum antiviral drugs
19	International Vaccine Institute (IVI)	Implementer	Intergovernmental Organisation, PDP	Republic of Korea	Oral Cholera Vaccine 7 vaccines in development for multiple disease areas

(*Continued*)

Table 1. Continued.

No.	Organisation	Type	Organisational Form	Country	Focus Area
20	European Vaccine Initiative (EVI)	Facilitator	Not-for-profit, PDP	Germany	Supports and coordinates vaccine R&D
21	Medicines Patent Pool (MPP)	Facilitator	Intergovernmental Organisation, PDP	Switzerland	Facilitates IP licensing and technology transfer for pharmaceutical products
22	FIND (Foundation for Innovative New Diagnostics)	Facilitator	Not-for-profit, PDP	Global	Diagnostics development across multiple disease areas
23	World Health Organisation (WHO) COVID-19 Technology Access Pool (C-TAP)	Facilitator	Not-for-profit	Global	Facilitates equitable and affordable global access to COVID-19 health products
24	Innovative Health Initiative (IHI)	Facilitator / Funder	Not-for-profit	Belgium	Supports R&D for multiple disease areas
25	ANRS | Maladies Infectieuses Emergentes	Facilitator / Funder	National government agency	France	Supports R&D for multiple infectious disease areas
26	Conscience Network / Structural Genomics Consortium	Facilitator / Funder	Not-for-profit; PDP	Canada	Supports open science drug development projects
27	Bill & Melinda Gates Foundation	Facilitator / Funder	Not-for-profit	Global	Supports R&D across multiple disease areas, with a focus on neglected diseases of poverty
28	Coalition for Epidemic Preparedness Innovations (CEPI)	Facilitator / Funder	Not-for-profit	Global	Supports the development of vaccines for EID outbreaks
29	Pandemic Prevention Platform (P3) / Defense Advanced Research Projects Agency (DARPA)	Facilitator	National government agency	United States of America	Supports the development of products for EIDs
30	European and Developing Countries Clinical Trials Partnership (EDCTP)	Facilitator / Funder	Not-for-profit	Netherlands / South Africa	Supports R&D for multiple neglected and emerging infectious diseases
31	InnoCentive COVID-19 Challenges / Wazouku	Facilitator / Funder	Private company	United Kingdom	Supports open science 'problem solving' innovation for COVID-19 vaccines
32	Open Society Foundations (OSF)	Facilitator / Funder	Not-for-profit	United States of America	Supports innovation and global access efforts for PPR R&D
33	Wellcome Leap R3 program: RNA Readiness & Response	Funder	Not-for-profit	United Kingdom	Supports the development of RNA-based products for PPR
34	Global Health Investment Corporation (GHIC)	Funder	Not-for-profit	United States of America	Supports R&D for multiple disease areas
35	International Centre for Genetic Engineering and Biotechnology (ICGEB)	Facilitator / Funder	Intergovernmental Organisation	Italy / India / South Africa	Promotes research, training, and technology transfer to industry of biotechnologies

shocks. Given the continuing threat of pandemics and the unresolved challenge of equitable access to pandemic products, ongoing research in this area is necessary.

Results: Typology of alternative innovation models

We did not find a simple or single alternative innovation model. Rather, we found that implementers combined a mix of alternative and mainstream elements, and adopted heterogeneous approaches in pursuing their mission. We clustered the sampled implementers (19) across three archetypes that captured the most essential features of each model. We label the mainstream commercial approach Model 1; and the alternatives Model 2. National Biosecurity; Model 3.

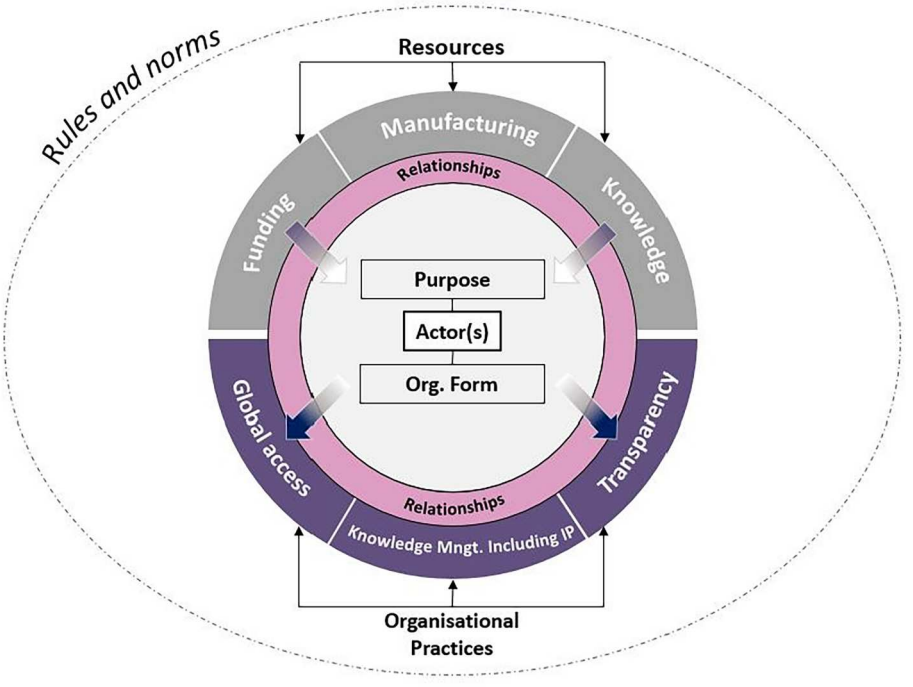

Figure 1. Analytical framework of an innovation model.

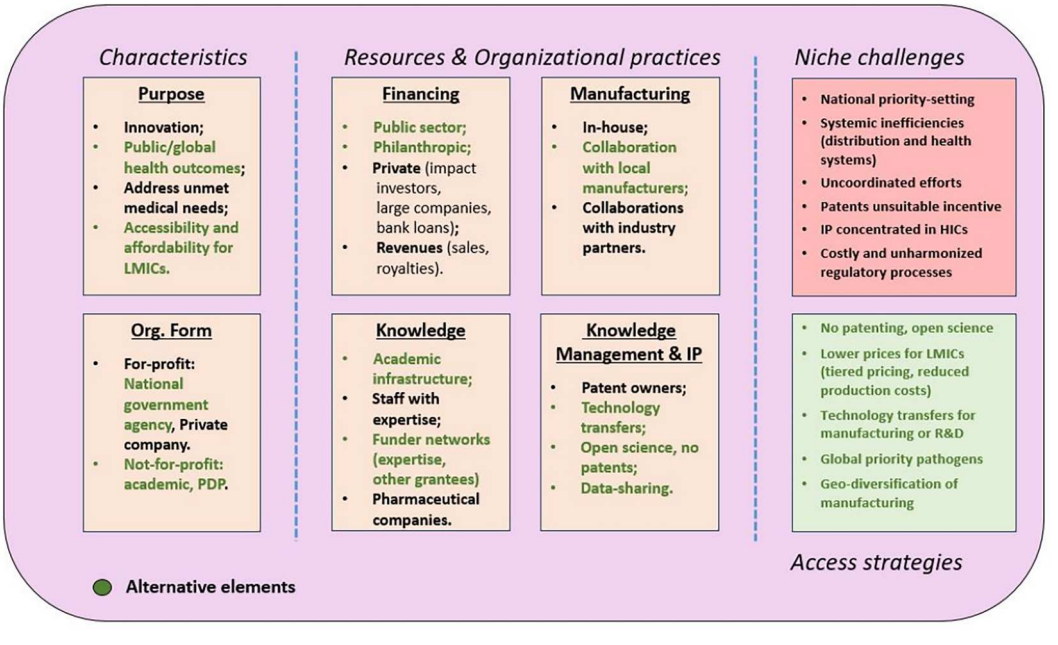

Figure 2. Summary of key differences between the mainstream pharmaceutical innovation system and the PPR R&D niche.

Cosmopolitan Public Private Partnership; and Model 4. Open Science Collaborative Network. We describe each of these in greater detail below following the above-mentioned conceptual framework, and identify how each model mobilises four kinds of essential resources (i.e. financing, knowledge, manufacturing capabilities, and relationships) and the organisational practices they adopt with respect to knowledge management including intellectual property, access, and transparency. This categorisation allowed us to clarify key distinctions between the models and identify their strengths and weaknesses (Figure 2). Actual initiatives may vary from the archetype or exhibit features of more than one, as reflected in Figure 3.

Model 2. National biosecurity model

The National Biosecurity model is currently the predominant approach to PPR R&D in inter-pandemic times – as noted in the introduction, during pandemic emergencies Model 1 is the most commonly found. Model 2 is comprised of the national public-sector driven initiatives that conduct R&D with the primary goal of preparing for health emergencies (Sunyoto, 2020). In contrast to Model 1, the main purpose is public health and/or national security rather than profit. In addition to national government agencies, private companies also participate as implementing actors within this model, characterised by substantial public support and nationally-driven priority setting and access strategies.

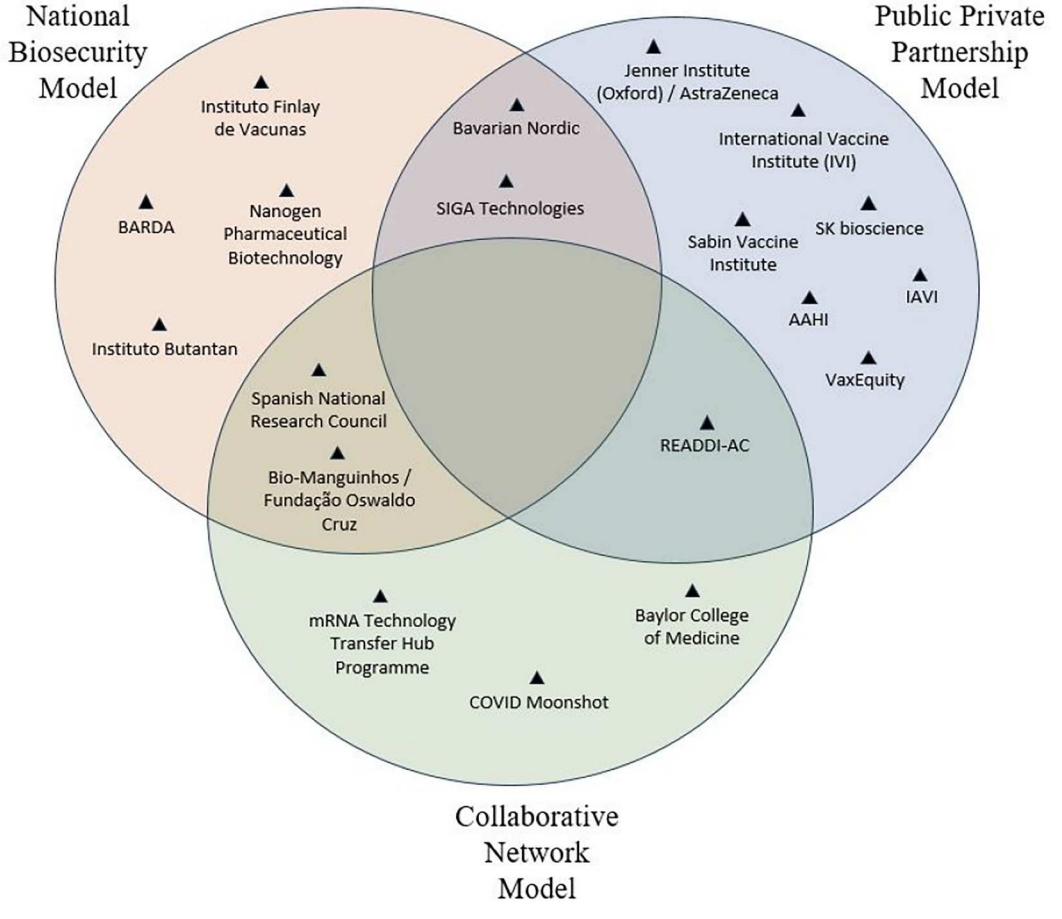

Figure 3. Map of sampled PPR organisations across alternative innovation models.

Model 2 appears to be proliferating in the wake of COVID-19, with a growing number of national and regional public actors created and/or involved in PPR. Many governments have invested in their PPR R&D systems in response to COVID-19, including in Indonesia (BRIN, 2021) and Brazil (Lima & Gadelha, 2021). New biosecurity institutions have also been created, for instance the European Union's Health Emergency Preparedness and Response Authority (HERA) in 2021, and in 2022 Japan's Strategic Center of Biomedical Advanced Vaccine Research and Development for Preparedness and Response (SCARDA) and the African Pharmaceutical Technology Foundation established by the African Development Bank.

Figure 4 delineates the main characteristics of the National Biosecurity model for PPR R&D. Organisations adopting this model rely on core public financing, but also tap into philanthropic and/or private investment, and revenues from sales. Benefitting from sustained government funding, national government agencies are well-established, and have the ability to expand their portfolio and build manufacturing and commercial infrastructures. However, the funding of LMIC-based public agencies is relatively small compared to HICs. The US national biosecurity system developed over 50 products successfully prior to COVID-19 (Sunyoto, 2020). Nevertheless, there are downsides to the public funding model, such as the divergent priority-setting agendas pursued by different public funders, both at the national and international level:

> The biggest challenge I think, for these types of situations, is trying to get these types of [public sector] players to align behind the strategy. (Implementer)

If public actors were to collaborate and develop a common global strategy, one implementer adds that 'in a perfect world' they would pursue a financing model 'where it is multiple governments that fund [a project] for global application'.

Organisations adopting the National Biosecurity model primarily use knowledge created through the internal public/academic structure in which they participate, and they might develop in-house manufacturing infrastructure or outsource manufacturing. Since COVID-19, many

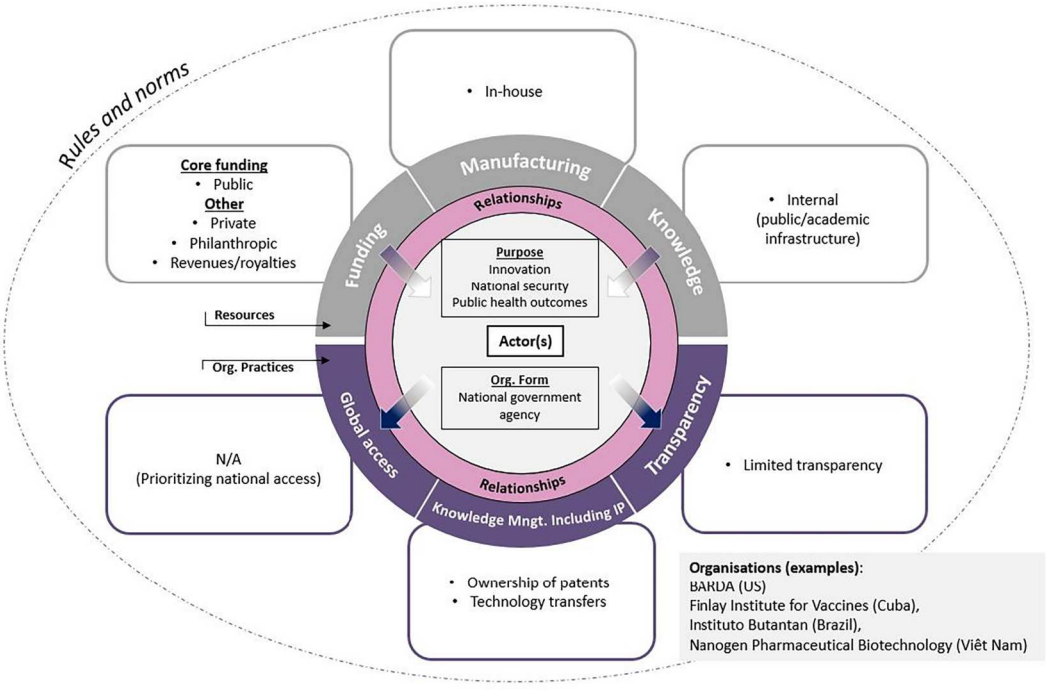

Figure 4. Alternative innovation model 2: national biosecurity.

initiatives sought to expand LMIC capacities to manufacture pandemic-related products after export bans in producing states cut off supply during the pandemic. LMIC-based implementers (including Finlay, Fiocruz, Butantan, Nanogen), in particular, must balance affordability and sustainability in their innovation models since they usually do not supply to high-income markets.

Although they might transfer technology, these organisations usually hold patents to attract more investment, or as part of a national strategy to meet supply needs during outbreaks. One organisation holds patents to conform to global norms:

> I'm giving you this example to explain that even though IP is something that we respect and with which we work, we don't like it. That is to say, we would like to be without it, to be open, to be able to share completely. (Implementer)

Governed by national security interests, National Biosecurity organisations are unlikely to be transparent about costs and agreements, with some variations: for instance, CSIS and Bio-Manguinhos / Fundação Oswaldo Cruz (Fiocruz) host open science initiatives as one approach within their broad scope of R&D activities.

Finally, these organisations are likely to prioritise national over global access needs. Adopted in both HICs and LMICs, this model frames PPR R&D as a national biosecurity strategy to protect the wellbeing of citizens. A clear example of this model is BARDA, known to leverage substantial public resources for the development and stockpiling of pandemic-related products, focusing heavily on prioritising US national security.

Model 3. Cosmopolitan public-private partnership model

The Cosmopolitan Public-Private Partnership (CPPP) model refers to initiatives in which public and/or philanthropic funding is provided to not-for-profit actors (e.g. public, academic, philanthropic) and for-profit companies working together with the aim of enhancing global access to their products. The organisations adopting this model weave in a multi-purpose mission of innovation and global accessibility of pandemic-related products:

> The primary goal or mission is saving as many lives as possible as quickly as possible. And one of the ways of doing that is through innovation [...] that's serving the needs of people in Low – and Middle-Income Countries. (Funder)

> Earning is not our goal. Our idea is to have the financial resources necessary to maintain a quality standard that allows us to continue to produce, continue to innovate, and continue these commercial agreements. (Implementer)

This innovation model is represented by a range of actors working in product development partnership (PDP) structures, whose characteristics are illustrated in Figure 5. It is relatively recent, embodied in initiatives such as CEPI, or several of the initiatives that emerged in response to COVID-19. For example, the Oxford-AstraZeneca vaccine partnership was supported by public and philanthropic funding with the explicit intent to make the vaccine affordable and accessible, and to supply COVAX; it delivered over 2 billion doses globally by 2022, second only to Pfizer, but in contrast supplied primarily LMICs (Alonso Ruiz et al., 2024)

The flexibility of philanthropic funding is particularly desirable for CPPP organisations:

> Those [public] grants and financial resources only cover the research costs, but they don't cover how much we need to pay all the quality assurance people, they don't cover all the regulatory activities, and they don't cover the program management teams. (…) That's where philanthropic funds come into play because those are flexible. (Implementer)

Nevertheless, philanthropic funding remains limited – to embark on an end-to-end project, interviewees argued that the global health community must coordinate and contribute much more financially:

> The global health community wants to be able to generate global goods like this. Someone has to put their hand in their pocket at a level that they don't do right now. (Implementer)

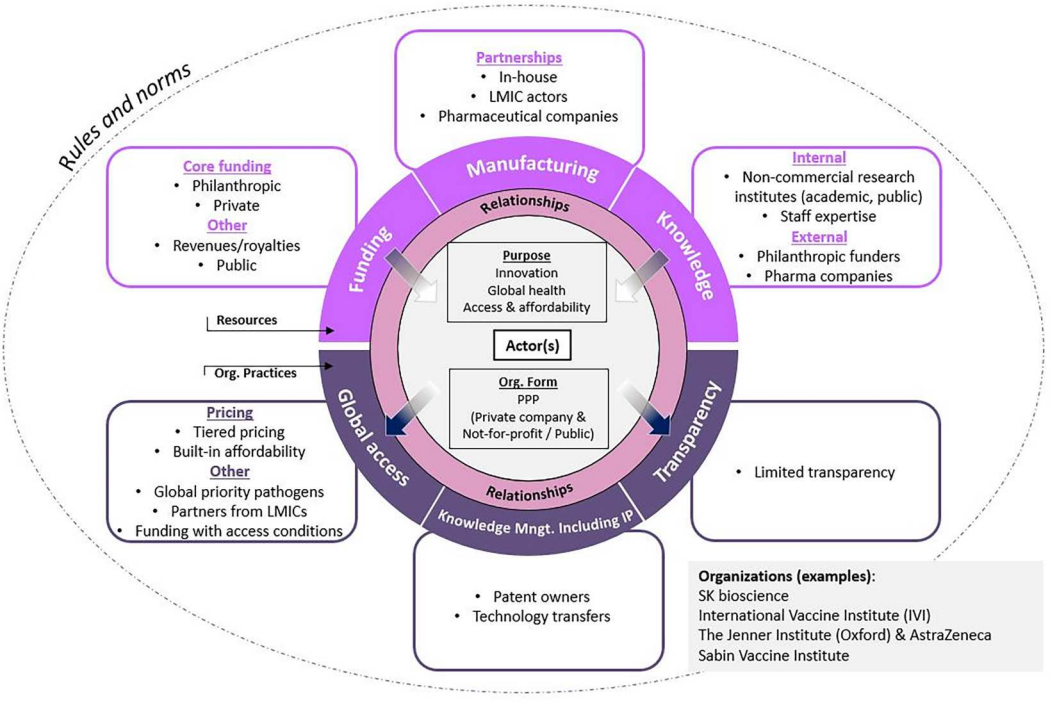

Figure 5. Alternative innovation model 3: cosmopolitan public-private partnership (CPPP).

Some CPPP organisations underscored the important role philanthropic funders played in providing expertise. One interviewed grantee mentioned the changing role of philanthropies, who increasingly provide access to experts in areas such as scientific innovation, or regulatory processes. Plugging grantees into a global network where partners can interact and collaborate towards common goals ('matchmaking'), is seen as essential.

> Anytime we're investing in a new company, we say: 'Hey, we want to invest in you, and we want you to work on [Therapeutic_Area]. Not only are we going to advise you on that, but we're going to connect you with all these partners that we have.' […] 'Once we decide to partner with you, you become part of the network. And there's a lot of synergies from all of you working together.' (Funder)

In exchange for philanthropic support, for-profit organisations might agree to certain conditions to enhance global access to the final products. Before, these conditionalities focused primarily on pricing and supply commitments, but recently, funders have included some technology transfer provisions for LMICs. For one interviewed funder, typical access terms include securing a 'specific number of doses, or specific output, or specific production facilities that are dedicated to meeting that need for the countries who wouldn't otherwise have access'. An interviewed funder described how they reserve manufacturing capacity from their grantees, in an effort to mitigate the challenges faced during the COVID-19 pandemic to secure manufacturing capacity to supply LMICs. Another strategy for affordability is adopting a tiered pricing model, wherein LMICs are supplied at lower prices than HICs. A CPPP private company claims this is a typical requirement from their philanthropic funders, but they are also looking to develop mechanisms to commercialise in HICs at higher prices, to remain sustainable and support their ability to supply in LMICs.

Nonetheless, there are challenges to enhancing global access through access conditions, as witnessed during the COVID-19 pandemic, when patents were already in place, and

philanthropic funders found it difficult to convince pharmaceutical companies to pursue an access strategy:

> We keep coming in once [IP] is already set in place, and then we just keep trying to push and control towards making sure that those technologies really get applied toward global health applications. […] But part of the question is, how do we get ahead of that, and actually help to create platforms, where everybody coming to the table already understands that whatever is created, will come with very, very strong, equitable access, not just provisions. (Funder)

They argued that when large pharmaceutical companies from HICs control the relevant IP, they will likely make only small concessions towards access, if any. Arguably, stronger access conditions implemented during the early stages of platform technology development are needed to mitigate the risks of reduced access for LMICs in the event of an outbreak, when prices soar and product developers are usually less interested in pursuing access:

> Maybe part of what we want to do is create some platforms that have the access provisions baked in from the start, but maybe that's a 20-year play. If we would have started this 20 years ago, where would we be now? We'd be in a really different place. […] Do we want to keep doing that for another 20 years and always be behind the curve? Or do we want to start something now that 20 years from now is going to look brilliant?' (Funder)

Finally, this model also employs elements found in the mainstream commercial model (Model 1), such as patent ownership and low transparency over costs and agreements.

Model 4. Open science collaborative network model

Finally, the Open Science Collaborative Network model refers to not-for-profit, often academic-led initiatives that conduct early-stage R&D with an open science approach, often without seeking patents, in order to build global access into potential new products further downstream. It recently emerged in the niche, gaining traction in the midst of an inequitable, slow response to COVID-19. Its defining characteristics are illustrated in Figure 6.

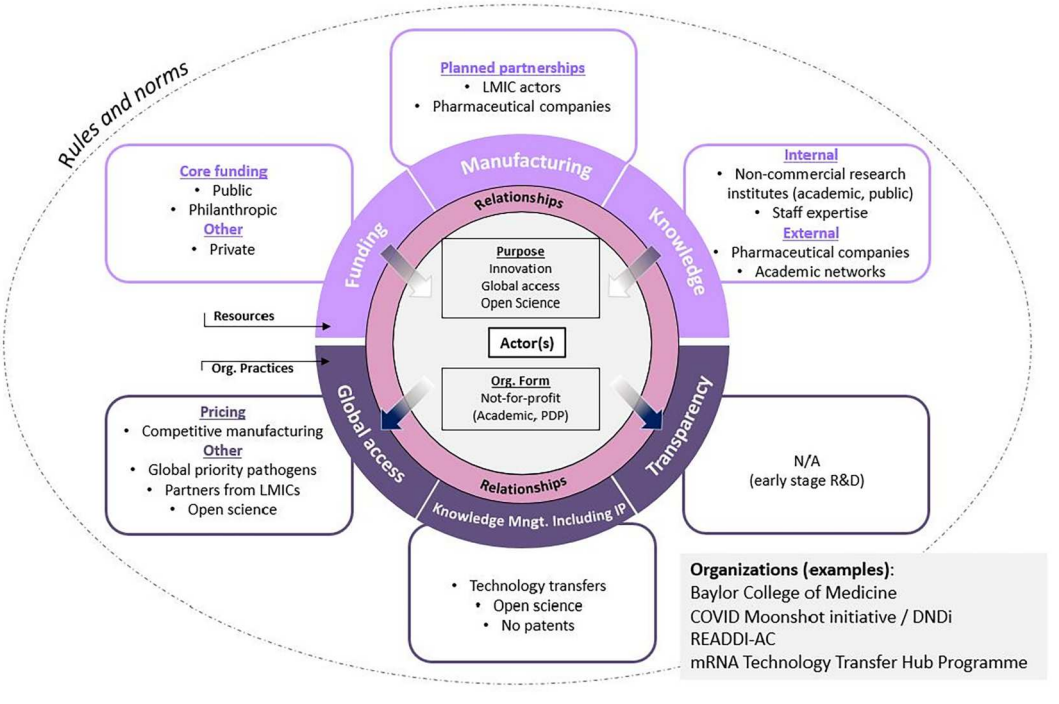

Figure 6. Alternative innovation model 4: open science collaborative network.

Initiatives adopting this model assume adaptable and dynamic organisational forms. For example, to avoid the 'rigidity' often encountered in academic institutions, one academic implementer operates as a PDP to facilitate R&D processes:

> We actually created ourselves embedded in this academic system, but operating as a biotechnology company with quality assurance units, with quality control, with document control, with a quality system, which you could claim that normally academic institutions are a little bit less amenable. (Implementer)

Their core resources come from public and philanthropic actors, similar to the other models. However, many of these organisations were created or accelerated thanks to the sudden availability of funds during the COVID-19 pandemic, in line with the cycle of panic followed by neglect that characterises global pandemic responses.

> There was a lot of money released and everyone needed to find something. It was an emergency. But pre-COVID-19, there's no funding for it. I mean, you just try and try and try. Not interested. (Implementer)

In this model, internal knowledge is generated by non-commercial research actors (e.g. academic, public research institutes), and external knowledge from participation in open science consortia. Most importantly, initiatives share new knowledge and data within collaborative networks, or more broadly by putting information into the public domain to further scientific progress: a core feature of the model. In theory, access is facilitated in this way by not patenting the technology, and allowing others to continue researching and/or manufacturing the product without IP barriers. The model is designed to expand supply, increase competition between producers, and lower prices during outbreaks when demand spikes.

> What we are developing is not pure openness, in the sense that we permit regulatory exclusivity and protection of patient privacy. But the quid pro quo for that protection is your agreement not to patent what we do together. You can't restrict other people from looking at your data and using it in novel ways. In some ways, we're trying to mitigate the cost of the IP system. Because our goal is to make this as accessible as we can, and try to promote competition. (Implementer)

While some of these implementers consider the possibility of filing for patents in the future, others reject patents as a feature of their innovation model:

> What we don't want are patents that prevent others from working on the drugs we are supporting. Given this, patents are totally out. […] Regulatory data exclusivity is fine, because one can keep this market advantage while sharing all data and materials, allowing others to replicate and build upon it. What we don't want is data that cannot be shared. (Implementer)

Without patents, implementers claim it is easier to transfer technology to industry partners in multiple LMICs, in the process enhancing global access to essential pandemic related products. For instance, the Baylor College of Medicine transferred technology for its COVID-19 vaccine Corbevax to Biological E, an India-based company that conducted the clinical trials, registration, production, and distribution in India, with over 100 million doses administered. For some implementers, it is important to collaborate with a 'different type of private' company from LMICs:

> We are really interested in that, those who need to do this are those who are really left behind […] And not only by adopting the scale out, or receiving of technologies that come from multinationals, but the fact that they need to adopt the concept of developing their own indigenous products. (Implementer)

However, these organisations still face a number of other challenges, such as difficulties navigating regulatory pathways in the absence of an established industry partner. One academic implementer reported facing prejudice from regulators who believe that academic dossiers are less advanced than those from experienced multinational companies. Other interviewees confirm that large companies are expected to take promising science from universities and public actors, and bring it through registration and commercialisation, a role

reinforced through the high costs incurred for an authorisation request, that only established actors can afford:

> We know what the route is, and we have to try to fill all the boxes. […] There are 25 boxes that need to be filled with different things, some of which are things like who's going to pay the $3 million to the FDA to submit a regulatory filing, whose name to put on the documents […]. (Implementer)

Discussion

This study identified three alternative innovation models for PPR that differ from the mainstream model, and described how they function and perform with respect to enhancing global access. Below we assess their relative merits and consider how they interact within the broader ecosystem.

Strengths and weaknesses of the three alternative innovation models

The National Biosecurity (Model 2), which remains the most dominant, benefits from a relatively secure financing structure primarily sourced from public institutions. It allows for long-term planning and ensures that national governments can prioritise pandemic threats that align with their domestic security concerns. Notably, this model has been adopted not only by high-income industrialised countries, but also LMICs with pharmaceutical capacity (e.g. Brazil, China, Cuba, India, Russia). Countries that can build such capacities can benefit considerably in future emergencies, but many LMICs will not have the financial, scientific, or industrial means to build fully self-sufficient systems, placing this model's national focus at odds with global needs. Historically, governments that have developed vaccines or therapeutics for epidemic and pandemic threats have either stockpiled them for domestic use, or exercised significant control over their distribution, often at the expense of equitable global access (Elbe, 2018). The COVID-19 pandemic exemplified this trend, as countries with domestic R&D and production capacity secured access to vaccines, while those without faced delays and supply constraints. Given the security implications of biopharmaceutical sovereignty, many governments are doubling down on this model post-COVID-19, further reinforcing nationalistic tendencies in pandemic R&D governance.

The CPPP (Model 3) explicitly integrates a global access mandate, with initiatives such as CEPI structuring agreements for equitable access. These initiatives leverage public and philanthropic funds to incentivise the private sector to accept access provisions, such as tiered pricing, licensing agreements, and technology transfer. However, a major limitation is the reliance on the voluntary willingness of private firms to engage in such partnerships, and the perennial tension firms face between commercial incentives to maximise shareholder value and enhance global access. During the COVID-19 response, despite COVAX's ambitions, most large pharmaceutical firms prioritised profitable bilateral deals with wealthier nations over global supply (de Bengy Puyvallée & Storeng, 2022). If private companies receive sufficient national public financing without access conditions, they have little incentive to accept philanthropic funding with global access provisions attached (e.g. from CEPI or BMGF). The voluntary nature of this model and the challenge of aligning public and private interests makes it less reliable for PPR.

Finally, the Open Science Collaborative Network (Model 4) offers a fundamentally different approach, based on collective scientific knowledge generation through open sharing of data and other forms of knowledge. In working without patents and planning for technology transfer from the early stages of R&D, this model holds promise for disrupting traditional pharmaceutical monopolies, as demonstrated by the Baylor COVID-19 Corbevax vaccine, for which technology was transferred for further development and production by companies in India and Indonesia (Mahoney et al., 2023). However, this alternative innovation model is relatively new, and relies on a network of capable actors committed to global access to bring a potential technology beyond early R&D stages. With the exception of Baylor, initiatives adopting this model are relatively small-

scale and early-stage. Fragmented funding, lack of regulatory and commercialisation infrastructure, and vulnerability to knowledge appropriation by commercial actors (e.g. firms patenting follow-on innovations) pose significant risks. The limited scale of such initiatives also raises concerns about their capacity to compete with well-financed, profit-driven counterparts in the long-term. Overall, this model is promising and offers important advantages, but will require sustained resources, political and technical support, and strong coordination of the network – and to demonstrate it can deliver.

Implications for the politics of PPR innovation

Having analysed three alternative innovation models separately, we now consider how they may interact and co-exist with the mainstream commercial model whose weaknesses they were developed to address. As noted in the Introduction, the economic interests of large firms pendulum-swings between emergencies, when markets are lucrative and pricing power is strong, to inter-pandemic times when business interest evaporates. The actors developing candidate products in inter-pandemic times are largely academic institutions, public labs and small and medium enterprises (SMEs) financed primarily with public funds. Prior to COVID-19, total R&D investment in EID was estimated at less than $1 billion ($886 million) in 2018 (Chapman et al., 2020), compared to an estimated $240 billion/year in total global biomedical research spending (Røttingen et al., 2013). Public funding accounted for an estimated 70-80% of EID R&D since 2014 (Chapman et al., 2022). In other words, unless there's a pandemic, the market isn't worth the attention of the biggest players.

This characteristic of pandemic product R&D has important political implications. During pandemic emergencies, few actors can act as effective counterweights to large pharmaceutical firms and their home states acting in concert (Sparke & Williams, 2024). However, the political balance sheet looks quite different in inter-pandemic times. SMEs reliant on public or philanthropic funding are likely to be more willing to accept global access conditions. For instance, Novavax, an SME with limited experience bringing products to market, received $399 million from CEPI to pay for development and production of its COVID-19 vaccine and accepted strong access conditions in exchange (Martin, 2022). It is during inter-pandemic times that access-oriented alternative innovation models can be expanded and institutionalised, as long as there are funders willing to invest and/or political actors willing to amend the rules. This is one reason why efforts such as the Pandemic Agreement or policy changes such as those at US NIH, mentioned earlier, are both politically feasible and meaningful. Further such actions should be considered in other countries and at regional levels to support the flourishing of alternative innovation models for pandemic products.

Conclusion

The catastrophic threat of potential pandemics requires finding ways to develop safe, effective technologies to counteract them quickly, and ensuring that such technologies are globally accessible. Evidence suggests that it is eminently feasible to develop health technologies rapidly outside the mainstream commercial R&D model. However, there are diverse approaches within the niche. Each of the three alternative innovation models operating simultaneously in the niche, offers advantages over the mainstream commercial model, but has its own strengths and weaknesses in jointly delivering innovation and access.

In response to the COVID-19 pandemic, more governments across all income levels appear to be adopting the National Biosecurity model. However, while this model may enhance national health security and seems more politically and therefore financially sustainable than the others, it does not systematically aim for global access. Some countries may fare better in future pandemics, but a system dominated by the National Biosecurity model is likely to replicate the highly unequal and inequitable outcomes of the COVID-19 vaccine crisis. International rules, such as those negotiated

in the WHO Pandemic Agreement adopted in 2025, and other cross-border arrangements will be needed to structure cooperation between nationally-oriented R&D actors, if more equitable access to pandemic products is to be realised.

The CPPP and Open Science Collaborative Network models offer important advantages over the National Biosecurity model for achieving global access, but both are relatively less developed, smaller, and face challenges competing with the National Biosecurity model. They will require sustained political and technical support, financial investment and a critical mass of actors committed to achieving innovation and access, if these models are to deliver.

Finally, the three models co-exist in an ecosystem in which they can compete, and/or collaborate with each other and with the mainstream commercial model. Collaboration is the far more logical modus operandi for PPR, for which speed and equitable access are paramount, and resources scarce. Collaboration can be structured in different ways: for example, actors can agree to tie access conditions to publicly-funded research in the National Biosecurity model; or, actors can share knowledge more openly and transfer technology more reliably (in all 3 models). Realising innovation and access to pandemic products requires a vision for the future evolution of the niche that ensures the three models do not undermine, but rather complement each other to deliver outcomes that better serve the global public interest. Finally, as with most pandemic policies, it is far better and politically easier to institutionalise alternative innovation models before the next emergency. Systemic changes should be made today to better protect everyone in the next pandemic.

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Data availability statement

Where consent was obtained, the interview data that supports the findings of this study are available on an open data repository.

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Appendices

Appendix 1. Thematic Framework devised and employed for qualitative coding of interviews.

Level 1 Codes	Level 2 Codes	Level 3 Codes
Actors	Facilitators	
	Financing organisations	
	Governing organisations	
	Implementing organisations	
	Regulators	
Resources	Financing	Private
		Philanthropic
		Public
		Revenues
		Other
	Knowledge, data, information	
	Manufacturing capacity	
	Relationships	
Organisational Practices	Mission and values	
	Manufacturing practices	
	Intellectual Property (IP) and knowledge management	
	Operational goals	
	Pricing policies	
	Priority-setting	
	Funding strategy (for funders)	
	Roles of organisations	Implementer
		Facilitator
		Funder
		Governing
Rules and Norms	Legal standards and formal rules	
Niche-Level Information	N-Resources	N-Financing
		N-Knowledge, data, information
		N-Manufacturing
		N-Relationships
	N-Rules and norms	N-Social expectations
		N-Formal rules
		N-Informal rules
	N-Actors	N-Implementers
		N-Facilitators
		N-Financing
		N-Governing
		N-Regulators