Public Sector Contribution to Vaccine Research and Development

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ABSTRACT: This paper explores the public sector's often undersold role in vaccine research and development (R&D). Further, it examines the recent shift in vaccine innovation policy caused by the urgency of the COVID-19 pandemic. Due to factors such as lack of repetitive dosage, high levels of at-risk investment, and long, large clinical trials, it is difficult to incentivize the private sector to invest in vaccine R&D. To counter these difficulties, vaccine innovation policy focuses on both push and pull incentives to ensure vaccine R&D is proceeding. Government institutions make large at-risk investments to offset the risk for private sector investment into vaccine R&D. Additionally, the government creates innovation policies that make intellectual property rights (IPR) more favourable for those who invest in vaccine R&D. With the removal of IPR for COVID-19 vaccines, the public sector became more instrumental in incentivizing private sector investment, using techniques such as mass ex-ante government vaccine procurement agreements, public-private partnerships, and increased government investments. With more significant government investments in downstream development and manufacturing activities, there is concern that the basic scientific research required for advances in vaccine technology will diminish. With the COVID-19 pandemic still unfolding, it is difficult to determine whether vaccine innovation policy will remain as it is now. However, even if vaccine innovation policy shifts post-pandemic, the public sector must continue to play an important role in vaccine R&D.

KEYWORDS: innovation policy, COVID-19 vaccines, public sector involvement, vaccine R&D, push incentives

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Introduction

The pharmaceutical industry often touts the idea that COVID-19 vaccines and the unprecedented speed at which they were produced is thanks to capitalism and the private sector.[1] However, though the private sector has played a vital role in COVID-19 vaccine research and development (R&D), research has shown that less than two percent of funding for the COVID-19 vaccine came from the private sector.[2] This paper will argue that the public sector has played an active and integral role in vaccine R&D. Furthermore, in the face of the COVID-19 pandemic, the public sector's involvement has become even more crucial, not only for basic vaccine R&D but also for late-stage research and manufacturing. The essay will examine the notion that patent law, while essential in this context, is insufficient to incentivize the private sector to invest in vaccines. It is instead up to the public sector to incur costs for the public good by providing funding to effectively incentivize the private sector to participate in vaccine R&D. Furthermore, this paper will look at the public sector's role in the creation of COVID-19 vaccines and examine how the public sector has adopted an even more active role in vaccine R&D and downstream vaccine production activities since the onset of the pandemic.

Challenges in Encouraging Vaccine Production

Compared to therapeutics, vaccines are not as profitable, and thus it is hard to convince the private sector to choose to produce vaccines instead of therapeutics.[3] Several prominent issues keep vaccines from being as profitable as their therapeutic counterparts. For one, vaccines are preventative measures which often leads to reluctance among consumers to pay premium prices for them. Additionally, the broader social benefit of herd immunity created by vaccines is not easily harnessed into a profit by the private sector.[4] Vaccines are also long-lasting, making companies miss profits from repetitive dosage.[5] Though vaccines are administered to a more significant number of people than just individuals who suffer from a condition or disease (who would be the consumers of most

therapeutics), the vaccine still does not earn as much profit because of the lower associated price that people are willing to pay for a preventative measure.

Furthermore, there is a lower tolerance for associated side effects, making for longer and more extensive clinical trials that further slow down the already approximately 10-year-long process of developing and manufacturing vaccines.[6] Vaccines represent substantial at-risk investments, as manufacturing facilities must be constructed before vaccine approval, which entails the potential loss of significant funds if the vaccine doesn't receive distribution approval.[7] Patents are available for vaccines and often last the same amount of time as they do for therapeutics. However, as established above, therapeutics make higher profits and have less associated investment risk. Therefore, patents alone are often insufficient to incentivize the private sector to produce vaccines over therapeutics.[8]

Push and Pull Incentives

Considering the challenges of encouraging vaccine production, the public sector must offset these issues with its own incentives to ensure vaccine R&D moves forward, given the grave importance of vaccination for public health. Vaccine innovation policy encompasses two primary approaches: pull incentives, grounded in intellectual property rights (IPR), and push incentives, which rely on upfront government funding to drive innovation.[9] It is important to note that in the case of vaccines, push and pull incentives complement one another, helping incentivize private companies to participate in vaccine development and manufacturing.

Several global and national publicly funded organizations are involved in creating push incentives for vaccine R&D. The US National Institute of Health (NIH) is the most significant international contributor to research and spent $2 billion on vaccine-related R&D in 2018.[10] NIH funding focuses on the initial innovation stage, funding the discovery of basic scientific principles later applied to vaccine creation instead of late-stage financing development.[11] The Global Influenza Surveillance and Response System (GISRS), run by the World Health Organization (WHO), receives approximately $56

million annually from governments to develop vaccines responding to pandemics and the seasonal flu.[12] The Defense Advanced Research Projects Agency (DARPA), administered by the US Department of Defense, also contributed considerable funds to developing RNA-based vaccine technologies in the 2010s.[13] The Canadian government provided funding for the phase 1 clinical trials of the VSV-EBOV Ebola vaccine, taking on this cost to encourage the further development of the vaccine.[14] As an additional incentive, under the Bayh-Dole and Stevenson-Wydler Acts in US legislation, private companies that receive public research funding can patent any resulting invention.[15] This policy demonstrates the complementary nature of intellectual property incentives and public sector funding in US affairs. The previous incentives are all examples of ex-ante government spending, meaning the monetary or patent commitments are made prior to vaccine approval. These are at-risk investments for the public sector, offsetting the risk for the private sector to invest in vaccine R&D. However, unlike the private sector, the government can reap the benefit from the broader social benefit of vaccine production. Therefore, even though public sector investment is at risk, the potential reward comes not just in monetary form but also in improved public health, thus resulting in healthier, more protected citizens in the long term.[16]

Policy Model for Stimulating Vaccine R&D

The Orphan Drug Act (ODA) is a successful policy model for stimulating vaccine development.[17] The ODA was established in 1983 in the US with an aim to provide enough incentive to small and large biotechnology companies alike to create therapeutics and other treatments to prevent and treat rare diseases.[18] Without these incentives, these rare disease treatments and preventatives would remain non-existent as companies would likely not see as much profit due to their implicitly smaller consumer base. The ODA employs push strategies and one pull strategy to lower R&D costs for the private sector. The push strategies included a 50 percent tax credit on clinical trials (cut to 25% in 2017) and a research grant program targeted at the early stages of innovation.[19] The pull strategy is “a guaranteed seven-year market exclusivity.”[20] Orphan drug

designation, achieved when a therapeutic is designed for a disease that affects less than 200 000 people, can also be applied to vaccines.[21] The ODA has had great success in pulling companies into the market of orphan drugs within the USA, with 370 orphan drugs gaining market approval since the establishment of the act.[22] This model could be helpful for application outside of the US context as well as to vaccines without an orphan drug designation, with the goal of offsetting the challenges in incentivizing private vaccine development. The ODA is an example of a policy that effectively incentivized participation in a previously undervalued area of the market and could be used as a model by the public sector to continue improving its incentives for vaccine development.[23]

Shifting Innovation Policy

Innovation policy has shifted because of the COVID-19 pandemic. What would have been an unideal ten years of inventing, producing, and distributing the COVID-19 vaccine during this global crisis prompted the implementation of measures to expedite the approval process. The allocation of additional personnel to assess and authorize COVID-19 vaccines, augmentation of informal deliberations and swift scientific guidance instead of awaiting formal gatherings, and expediting vaccine classification were all considered indispensable actions.[24] IPR for COVID-19 vaccines was also waived during the pandemic in the hopes that this would increase access to vaccines for lower-income countries.[25] The waiving of IPR effectively removed the pull incentive for private companies, so the public sector became even more instrumental in assisting and incentivizing private companies with their vaccine candidates. Finally, there were mass ex-ante government procurement agreements with pharmaceutical companies to secure vaccines for their respective countries, causing a massive spike in demand.[26]

Basic Scientific Research Involved in Vaccine R&D

In addition to the innovation that occurred during the COVID-19 pandemic, it is vital to consider the public sector's involvement in the scientific discoveries that made the quick

production of the COVID-19 vaccine possible. The NIH was and remains a critical player in funding research and working within the pre-COVID innovation system; It funded scientists engaging in basic vaccine research. Barney Graham, a scientist at NIH, used his public funding to create a viral spike protein that would prove to be an essential part of the current vaccines.[27] Another key element of the current vaccine, RNA modification, was developed by Karikó and Weissman at the University of Pennsylvania with project funding from the US National Institute of Allergy and Infectious Diseases (NIAID).[28] Finally, the lipid nanoparticle used in vaccines was developed by Robert Langer (the co-founder of Moderna) and colleagues at the Massachusetts Institute of Technology[29]. RNA modification, lipid nanoparticles, and Graham's viral spike protein are essential building blocks in the most successful COVID-19 vaccines. These examples demonstrate the importance of publicly funded research on the COVID-19 vaccine and show how instrumental the public sector has been in vaccine R&D before and during the COVID-19 pandemic.[30]

Organizations Involved in COVID-19 Vaccine Development

There are several government organizations and public-private partnerships which serve to demonstrate the indispensable role the public sector played in COVID-19 vaccine R&D, downstream research, and manufacturing. Looking into all public sector organizations that participated in the funding of COVID-19 vaccines would be beyond the scope of this paper, so I have chosen a sample of organizations which are some of the most influential and demonstrate that the public sector deserves massive credit for helping to create the COVID-19 vaccine. These examples also highlight the complexities of public-private interactions.

Operation Warp Speed

In May 2020, the US government announced Operation Warp Speed, a federal program for vaccine, therapeutic, and diagnostics development, directing approximately $15 billion to the fight against COVID-19.[31] Most of this funding was led by the Biomedical

Advanced Research and Development Authority (BARDA), with 77% of its budget allocated to vaccine development and administration.[32] During the COVID-19 pandemic, BARDA, which was previously a small agency, took on a more prominent and active role in R&D and manufacturing than the NIH.[33] In addition, BARDA differs from the NIH as it mainly focuses on downstream activities such as manufacturing, late-stage clinical trials, and scaling up production, demonstrating how innovation policy has shifted in the face of COVID-19.[34] Through Operation Warp Speed, six corporations' vaccine candidates were funded at-risk b: Moderna, Pfizer/BioNTech, AstraZeneca, J&J/Janssen, Novavax and Sanofi/GSK.[35]

Pfizer, Moderna and the Public Sector

The public sector's involvement with Pfizer and Moderna has been somewhat contentious. Pfizer claims to have had no funding from the public sector for its vaccine; however, the company fails to mention that its partner, BioNTech, has received significant funding from the German government.[36] On the other hand, Moderna has received nearly $6 billion in funding from the NIH and collaborated extensively with NIH scientists in the development of its vaccines, so much so that the NIH now co-owns the Moderna vaccine patent.[37] However, this public-private relationship has not been smooth – the NIH is currently embroiled in a patent battle with Moderna as they failed to include government-funded scientists on a patent request. Moderna has paid the NIH $400 million in compensation, but the patent dispute has not yet been resolved, and the NIH is considering taking formal legal action.[38] Both cases highlight how the public sector's mass amount of funding contributed to vaccines has been undervalued and underrecognized by the private sector.

Coalition for Epidemic Preparedness Innovations

The Coalition for Epidemic Preparedness Innovations (CEPI) also plays a small but essential role in the innovation incentive mechanism. CEPI is a public-private partnership created in 2017 after the Ebola outbreak to develop vaccines for emerging infectious diseases.[39] The organization receives funding from various sources,

including the private sector, philanthropies, and government agencies from 30 countries.[40] CEPI has committed almost $1.2 billion to multiple vaccine candidates and aims to create a diversified COVID-19 vaccine portfolio.[41] CEPI and WHO are co-leading COVID-19 Vaccines Global Access (COVAX), an initiative vital in acquiring COVID-19 vaccines with advanced purchase commitments to distribute to lower-income countries.[42] Importantly, CEPI also plays a coordinating role "including 'matchmaking' to find competent global producers for different types of vaccines currently in development, eyeing the need for global scale up."[43] Facilitating collaboration amongst global private actors also acts as a push mechanism for innovation.[44] Therefore, as a public-private partnership, CEPI plays a vital role in the COVID-19 innovation system, and the public sector deserves at least partial credit for its assistance in this global effort.

Conclusion

As government recognition of the continuing COVID-19 pandemic loses traction, government funding for vaccine procurement is diminishing, and the future of further COVID-19 vaccine R&D is worrisome.[45] Advanced purchase agreements for COVID-19 vaccines have played a vital role in ensuring a guarantee for manufacturers. Without such an assured market, manufacturers might reduce or cease production, resulting in a worldwide shortage of vaccines.[46] Without public sector investment, vaccine manufacturing incentives greatly diminish, especially with the waiving of IPR for COVID-19 vaccines, emphasizing once again how important the public sector is in creating COVID-19 vaccine R&D and manufacturing incentives.

As demonstrated above, innovation policy has shifted in the face of COVID-19. More than ever, public funding is targeted at downstream research and manufacturing activities, which was very effective during the pandemic. Still, it's important to note that without the fundamental scientific research contributions of Karikó, Weissman, Graham, and Langer, the speed of COVID-19 vaccine innovation would not have been possible. Therefore, if innovation

policy remains as it is right now, it would be necessary not to let essential research funding fall by the wayside. The success of government vaccine pre-purchasing agreements globally during the pandemic also indicates that this may be a method in the future for incentivizing quality innovation.[47] Nevertheless, it is essential to note that this shift in innovation policy happened in a crisis where urgency was of the utmost importance. An emergency can inspire some individuals to act more selflessly to control the situation and earn accolades for their selfless behaviour.[48] Therefore, with the COVID-19 pandemic still unfolding, it is unknown whether this shifted innovation policy can and will last or whether it was just another crisis response.

Pre-COVID, the public sector played an important role in promoting vaccine innovation and production despite the many factors that make the vaccine industry less profitable than the therapeutics industry. During the COVID-19 pandemic, the public sector's already important role expanded, where urgency was paramount and the public sector incentives needed to offset the waiver of COVID-19 vaccine IPR. Therefore, during the pandemic, the public sector had to play an even more active role in vaccine R&D and downstream research and manufacturing to manage the global crisis. It is yet to be seen whether the public sector will remain in this more active role post-pandemic or whether innovation policy will return to pre-pandemic. With an increasing global understanding of emerging infectious diseases, the importance of vaccines has become apparent. Thus, the public sector must continue to play its role in incentivizing vaccine innovation and production for the sake of global public health.

Notes

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