npj Vaccines

https://doi.org/10.1038/s41541-026-01493-x

Article in Press

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Received: 4 February 2026

Accepted: 18 May 2026

Cite this article as: Fleming, D., Smith, E., Ostrowsky, J. *et al.* Trends in funding for coronavirus vaccine research and development: implications for preparedness against future coronavirus threats. *npj Vaccines* (2026). https://doi.org/10.1038/s41541-026-01493-x

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Trends in funding for coronavirus vaccine research and development: implications for preparedness against future coronavirus threats

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Abstract

The COVID-19 pandemic triggered unprecedented investment in coronavirus vaccine R&D, but the long-term trajectory of this funding remains unclear. We mapped coronavirus vaccine grant support from 2020 through 2025, and found an early surge focused on ancestral SARS-CoV-2, a pivot toward broadly protective coronavirus vaccines (BPCV), and then a steep decline in publicly available funding overall, especially in the United States. Reduced sustained investment may weaken future preparedness and response globally to emergent coronavirus threats.

Introduction

When the SARS-CoV-2 (COVID-19) virus emerged in late 2019, there was an unprecedented mobilization of global scientific and financial resources to mitigate the ensuing pandemic.[1] The urgency to develop vaccines against COVID-19 led to a surge of public and private investment, which catalyzed remarkable vaccine innovation and delivery in record time. In the years following that initial response, however, the funding landscape has undergone a dramatic shift. Monitoring grant funding provides a useful indicator of investment in R&D for pandemic preparedness and response. Here, we examine trends in coronavirus vaccine research funding from the start of the COVID-19 pandemic through the end of 2025 and assess implications for sustained coronavirus vaccine research, development, and implementation.

Methods

We analyzed trends in funding for coronavirus vaccine research from 2020-2025 using the Pandemic PACT Research Programme Grant and Evidence Gap Tracker Database,[2] a tool that captures global pandemic prevention and response funding from publicly available sources (i.e. governmental, foundation, and philanthropic grant mechanisms) for multiple infectious diseases, and evaluated funding for broadly protective coronavirus vaccine (BPCV) development as addressed by the strategic goals and milestones of the Coronavirus Vaccines Research and Development (R&D) Roadmap (CVR).[3] The CVR provides a comprehensive research and policy plan for researching, developing, and implementing BPCVs to enhance preparedness for future coronavirus pandemics.[4] The Center for Infectious Disease Research and Policy (CIDRAP) at the University of Minnesota developed the CVR, with input from more than 50 global subject-matter experts and support from the Gates Foundation and the Rockefeller Foundation, and continued support from the Coalition for Epidemic Preparedness Innovations (CEPI).

From the Pandemic PACT database of over 24,000 Coronaviridae-specific research funding grants from January 2020 through December 2025, we used the embedded filter function to extract 1,491 grants categorized as "vaccine research, development, and implementation." We then applied a custom-built Microsoft Excel Visual Basic for Applications (VBA) macro to sort titles and abstracts based on a hierarchy of search terms reflecting likely relevance to BPCV development. In brief, the macro logic applied a triage process, first scanning for "high-confidence" terms that implied the research was geared towards protection against multiple coronaviruses. If no high-confidence terms were present, the macro searched for "medium-confidence" terms. If two or more medium-confidence terms were found, the grant was classified as "high-confidence." In the third step, grants were searched for "low-confidence" terms; these grants were more numerous due to the less restrictive nature of the search terms. If no terms were found for any confidence category, the grant was categorized as having "no relevance" to BPCV research. Each grant was then manually verified for its confidence rating by a CIDRAP researcher. Awards triaged as "high-confidence" were manually verified by reviewing grant titles, followed by abstract screening if titles were non-conclusive. Medium-confidence grants typically required more in-depth analysis of the abstract by CIDRAP researchers to determine relevance to BPCV development, and relevance was determined primarily by title analysis, followed by abstract analysis if the content of the title suggested that the grant might include research on BPCV development. Low-confidence grants represented most coronavirus research funding in the Pandemic PACT database; their lack of alignment with BPCV development was verified by title analysis, and occasionally abstract analysis, if warranted.

CIDRAP researchers then assigned each grant to one of two categories based on the breadth of intended coverage of the target vaccines: **1) BPCV**: The funding was provided explicitly for the design, production, and testing of vaccines that target both existing SARS-CoV-2 strains and variants that have not emerged yet, or multiple coronaviruses; or **2) Non-BPCV**: The funding was directed toward vaccines that target specific, existing SARS-CoV-2 variants (funding for vaccines against other coronaviruses, such as MERS, was classified as BPCV because of its applicability as a proactive tool to mitigate a future pandemic), toward vaccines that target non-human animals, or toward basic science research that wasn't directly aimed at vaccine production. All high-confidence grants and

any low- and medium-confidence grants that were manually identified as relevant by a CIDRAP researcher were categorized in the "BPCV" category; all other grants were categorized as "non-BPCV." For each category, grants were indexed by start year; the total award (in USD) per grant was attributed to that year.

This workflow enabled a tiered and efficient evaluation of thousands of grants, maximizing fidelity while minimizing oversight risk. The result is a curated dataset that reflects both the volume and trajectory of global funding for coronavirus vaccine development.

The Rapid Response Phase: A Pandemic-Driven Funding Boom (2020-2022)

The early response to the COVID-19 pandemic was characterized by urgency. Governments and philanthropic organizations rapidly injected billions of dollars into the SARS-CoV-2 vaccine development pipeline with the intent to quickly mitigate the health, societal, and economic impact of the COVID-19 pandemic. A total of over $6.7 billion in awarded funds from publicly available sources, spread among 1,439 grants, were identified that addressed coronavirus vaccine development from 2020 to 2025 (**Figure 1**). Most research dollars allocated to the analyzed grants were for grants that originated in 2020 alone (51%; 480 grants), when the vast majority (99.5%; 450 grants) focused specifically on ancestral SARS-CoV-2 and specific SARS-CoV-2 variants, as opposed to vaccines designed to provide broader protection. The rapid creation and deployment of vaccines, particularly mRNA vaccines, which were designed to specifically prevent SARS-CoV-2 infection, disease, and mortality, were unprecedented scientific triumphs, made possible by early and robust funding. These vaccines proved highly effective at preventing severe COVID-19, especially as caused by early SARS-CoV-2 strains.

Figure 1. Coronavirus vaccine funding over time. Global research funding dollars (USD, in millions) from publicly available sources allocated to all coronavirus vaccine research (**total**), and broadly protective coronavirus vaccine (**BPCV**) research by year. Data labels indicate total number of grants per year.

The surge of initial SARS-CoV-2 vaccine R&D funding enabled development and delivery of COVID-19 vaccines by the end of 2020. However, as variants such as Delta and Omicron emerged in 2021 and 2022, the limitations of first-generation vaccines, particularly related to breadth and durability of protection in the face of viral evolution, became apparent. As such, a second wave of investment commenced, one focused not just on ancestral SARS-CoV-2 and emerged variants, but on broader protection from future SARS-CoV-2 variants and other coronaviruses with the potential to cause significant human disease. Forty percent of all coronavirus research funding from publicly available sources in 2022 was awarded to projects with direct relevance to BPCV development (**Figure 1**), with this 2022 BPCV funding representing 42% of all BPCV grant funding from 2020 to 2025. The pivot to BPCV research marked a maturation of the funding strategy, driven by the high probability that the next pandemic could again arise from the Coronaviridae virus family, which has produced three highly pathogenic human viruses within the past 25 years: SARS-CoV-1 (severe acute respiratory syndrome; SARS), MERS-CoV (Middle East respiratory syndrome; MERS), and SARS-CoV-2 (coronavirus disease 2019; COVID-19).

Sharp Contraction in Funding (2023-2025)

While 2021 and 2022 saw continued high levels of coronavirus-related research funding, with 2022 exhibiting a particular focus on BPCV development, by 2023 momentum had slowed. Research investments in 2023 accounted for only 7.4% of total vaccine research, development, and implementation funds allocated during the 6-year study period (**Figure 1**). By 2024, the decline was more acute, with approximately 1.7% of all funding during the study period allocated to coronavirus research. Similarly, research with direct relevance to BPCV development peaked in 2022 with USD ~$199 million awarded (37 grants), whereas 2023 and 2024 saw only $99 million (30 grants) and $35 million (14 grants) granted, respectively (**Figure 1**). In 2025, overall coronavirus vaccine funding was especially low, with only $35 million (21 grants) awarded; only 72.6% of that ($25.6 million; 2 grants) was directed toward BPCV development. The dramatic drop in BPCV-directed grants, in particular, likely reflects multiple factors: overall coronavirus vaccine funding attrition, sustained protection from current vaccines against severe disease from emerging SARS-CoV-2 variants, a shift towards mRNA platforms for rapid pandemic response, and potential for cross-protective immunity from current vaccines against novel coronaviruses. The use-case view of BPCVs has also evolved, and while a recent modelling study found that a stockpile of an effective pan-sarbecovirus vaccine could have prevented millions of COVID-19-related deaths,[5] the practical challenges of sustaining such a large enough stockpile to respond to a rapidly spreading respiratory pathogen has to be weighed against the demonstrated capacity of manufacturers, particularly using mRNA platforms, to rapidly design and produce updated vaccines for novel coronaviruses. However, the value of pre-emptively developing a vaccine that could be rapidly manufactured at large scale and deployed remains, especially if effective, globally equitable manufacturing capacity is in place.

Potential Impact of Coronavirus Vaccine R&D Funding Trends on Addressing Future Coronavirus Threats

With the end of the COVID-19 public health emergency, attention has shifted. Shifting trends in political priorities, growing anti-vaccine sentiments, and competing global crises have redirected resources.[6,7] Yet the threat of SARS-CoV-2 resurgence by a variant with greater immune escape or the emergence of a novel coronavirus with pandemic potential remains. The lack of sustained investment risks leaving the global community more vulnerable to the potentially devastating effects of future coronavirus pandemics. Notably, this lack of preparedness extends beyond coronaviruses to other respiratory viruses with pandemic potential. For example, a similar analysis of Pandemic Pact data on influenza vaccine R&D shows a similar trend of funding contraction over the same time-period (**Figure 2**).

The observed decreased investment in BPCV development, in particular, weakens preparedness for the next coronavirus pandemic. First-generation COVID-19 vaccines were highly effective in the short-term against early SARS-CoV-2 strains, but their main weakness became apparent once viral evolution accelerated. Much of the neutralizing antibody response was directed toward immunodominant Spike protein epitopes that are highly mutable. Omicron demonstrated the scale of this problem by escaping a large fraction of existing neutralizing antibodies,[8] and later XBB-lineage variants showed that convergent receptor-binding domain mutations could further increase antibody evasion while maintaining or enhancing ACE2 binding fitness.[9] Future coronavirus threats are unlikely to be limited to continued SARS-CoV-2 drift. Coronavirus emergence has already occurred repeatedly across distinct betacoronavirus subgenera. Mechanistically, the spillover risk is reinforced by receptor plasticity and the existence of pre-emergent animal coronaviruses with human-cell infectivity: ACE2 binding is an ancestral and evolvable property of sarbecoviruses,[10] SARS-CoV-2-related bat viruses capable of hACE2-dependent replication in human cells are already known,[11] and merbecoviruses with human receptor usage and human organoid infectivity have now been identified in pangolins and bats.[12,13] These observations argue that preparedness efforts against future coronavirus threats should prioritize vaccines targeting conserved, functionally constrained coronavirus epitopes with breadth across zoonotic lineages, rather than relying only on strain-matched vaccines.

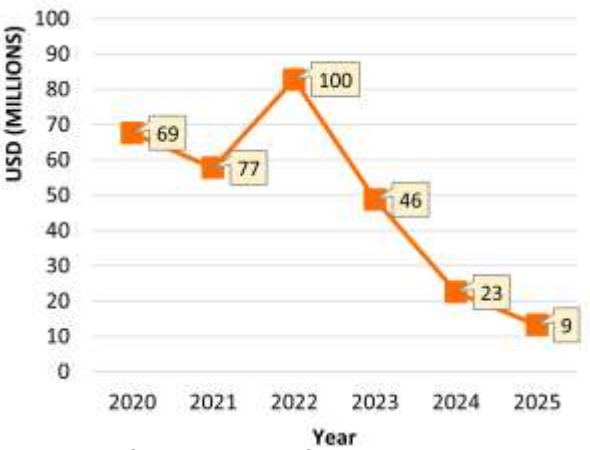

Figure 2. Influenza vaccine funding over time. Total global research funding dollars (USD, in millions) from publicly available sources allocated to influenza vaccine research by year. Data labels indicate total number of grants per year.

The global coronavirus research trends depicted here reveal that long-term pandemic preparedness against future coronavirus threats is limited by short-term funding gaps. The rise of anti-vaccine sentiment and shifts in government funding priorities create additional challenges. Furthermore, recent policy changes (particularly in the United States) resulting in cuts to government research funding, especially vaccine R&D, undermine long-term commitments needed for future of coronavirus vaccine development and diminishes pandemic preparedness. For example, the United States contributed nearly $2.5 billion from publicly available sources (746 grants) to coronavirus vaccine R&D from 2020 to 2023, with ~$127 million (94 grants) of that directed towards BPCV development, representing ~37% and ~31% of all funding, respectively, to that point (**Figure 3**). In 2024, however, the U.S. contributed just ~$51 million (58 grants) to coronavirus vaccine R&D (~$36 million to BPCV R&D; 9 grants), and just ~$6 million (11 grants; $0 to BPCV R&D) in 2025.

The boom-and-bust cycle of pandemic R&D funding described here is not unexpected or unprecedented. For example, based on a similar analysis of Pandemic Pact data, there was a substantial surge in monkeypox (mpox) vaccine R&D funding, coinciding with the global outbreak beginning in 2022,[14] with funding peaking at ~$169

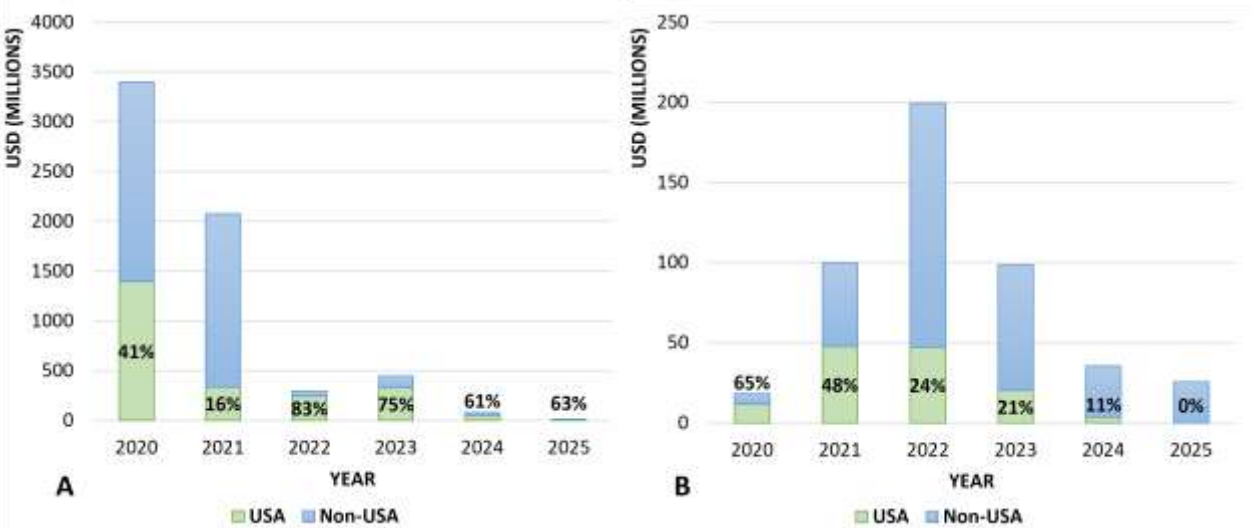

Figure 3. U.S. share of coronavirus vaccine funding by year. The share of total global awarded research funds (USD; in millions) from publicly available sources toward **A)** non-broadly protective and **B)** broadly protective coronavirus vaccine development distributed by the U.S. vs other countries.

million in 2023, and then sharply contracting to ~$79 million in 2024, and ~$32 million in 2025 (**Figure 4**). The loss of funding is particularly perilous in the context of respiratory viral families like coronaviruses, however, that continue to spill over from zoonotic origins and pose threats to global human health.

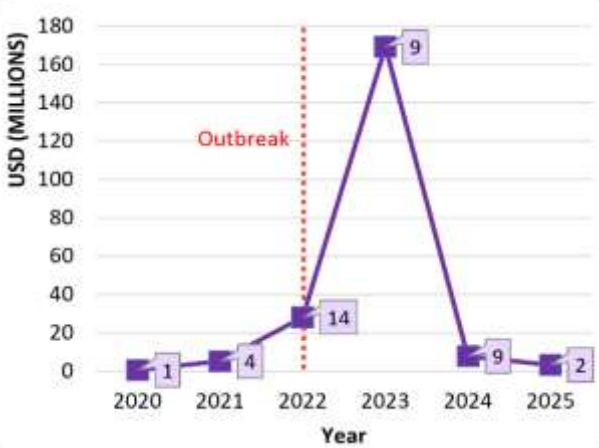

Figure 4. mpox vaccine funding over time. Total global research funding dollars (USD, in millions) from publicly available sources allocated to mpox vaccine research by year. Data labels indicate total number of grants per year. The 2022 mpox outbreak is denoted.

Limitations

Notably, the grants included in this analysis are constrained by the completeness of the Pandemic PACT database, which is compiled from publicly available sources. Incomplete or missing entries may limit our ability to fully characterize the research objectives of all grants. To mitigate this limitation, the Pandemic PACT team employs a rigorous extraction and validation process that combines human review with machine annotation to ensure that all available information is used to classify research grants.[15] Nonetheless, some grants may not be captured, although given the large number of grants included, any such omissions are unlikely to significantly affect the overall funding patterns described below. Moreover, this analysis only captures awarded grants, and therefore the recent actions by the US government in 2025 to cut previously awarded funding was not captrured.[16] This analysis also does not include industry investment in the private sector; Pandemic PACT includes only publicly available grant information on governmental, foundation, and philanthropic funding mechanisms; hence, the private vaccine research landscape is beyond the scope of these analyses/insights. However, it should be noted that the lack of publicly available information on commercial research spending limits the funding comparisons.

Conclusion: A Call for Sustained Commitment

Our analysis illustrates a clear pivot from reactive to proactive funding during the mid-pandemic years, followed by a return to near pre-pandemic levels once the crisis is over. To enable effective responses to the next coronavirus pandemic threat, sustained and globally diversified investment in coronavirus vaccine research is necessary over time, including during inter-pandemic periods. With the tools, scientific expertise, and institutional frameworks now in place, the opportunity exists to build on prior investment and save lives.

Author Contributions

DF analyzed and interpreted the data and wrote the manuscript. RF and AN built and refined the database, and edited the manuscript. DF, ES, JO, AU, AJM, TL, NV, and EJM contributed to project ideation and manuscript editing. EL oversaw the project and edited the manuscript.

Acknowledgments

This study was funded by a grant from the Coalition for Epidemic Preparedness Innovations (CEPI). The funder played no role in study design, data collection, analysis and interpretation of data, or the writing of this manuscript. Pandemic PACT is funded by Wellcome [226543].

Competing Interests:

The authors declare no competing interests.

Data Availability

The datasets analyzed during the current study are available in the Pandemic PACT database, (https://www.pandemicpact.org/grants). Secondary datasets generated during the current study are available from the corresponding author on reasonable request.

Code Availability

The underlying code for this study (the custom Microsoft Excel Visual Basic for Applications [VBA] macro) is available on reasonable request from the corresponding author. All software and code for the Pandemic PACT database is open source and made available via GitHub under the MIT license.

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