

A DECADE OF R&D FUNDING FOR PLATFORM TECHNOLOGIES

Why platforms matter

During the COVID-19 pandemic, a vaccine candidate based on an mRNA platform was identified in just 42 days.¹ Alongside other COVID-19 vaccines, Moderna's US government-backed vaccine, 'Spikevax', was developed at remarkable speed. Unprecedented levels of funding and streamlining of regulatory processes both contributed to this pace of development; however, much of it can be credited to decades of scientific research into the development of platform technologies.

In fact, the four most widely approved COVID-19 vaccines drew on pre-existing platforms. The Moderna and Pfizer/BioNTech vaccines are based on nucleic acid (mRNA) platforms, and the AstraZeneca/Oxford and Johnson & Johnson vaccines are based on viral-vector (adenovirus) platforms.

While platform technology is not a new concept, it has captured increasing attention in recent years. As we broadly define it, a platform technology is an underlying technology or process that can be adapted for use in product development for more than one product or disease area. While the use of platforms in the rapid development of vaccines against emerging pathogens has recently taken centre stage, the concept is far more wide-ranging. In addition to platform technologies for the creation and delivery of vaccines, we also recognise four other categories: platform technologies related to biologics, drugs, diagnostics, and adjuvants & immunomodulators used to improve vaccine efficacy.

By their very nature, platform technologies can be used across multiple disease areas. Adenovirus-vector platforms, upon which the AstraZeneca/Oxford and Johnson & Johnson vaccines are based, are, for example, commonly used in gene therapy as vectors for cancer treatments. Owing to this versatility, platform technologies allow developers to repurpose R&D for products in robust commercial markets for use against novel pathogens, or in fields like neglected diseases for which no economic incentive exists.

How we measure platform funding

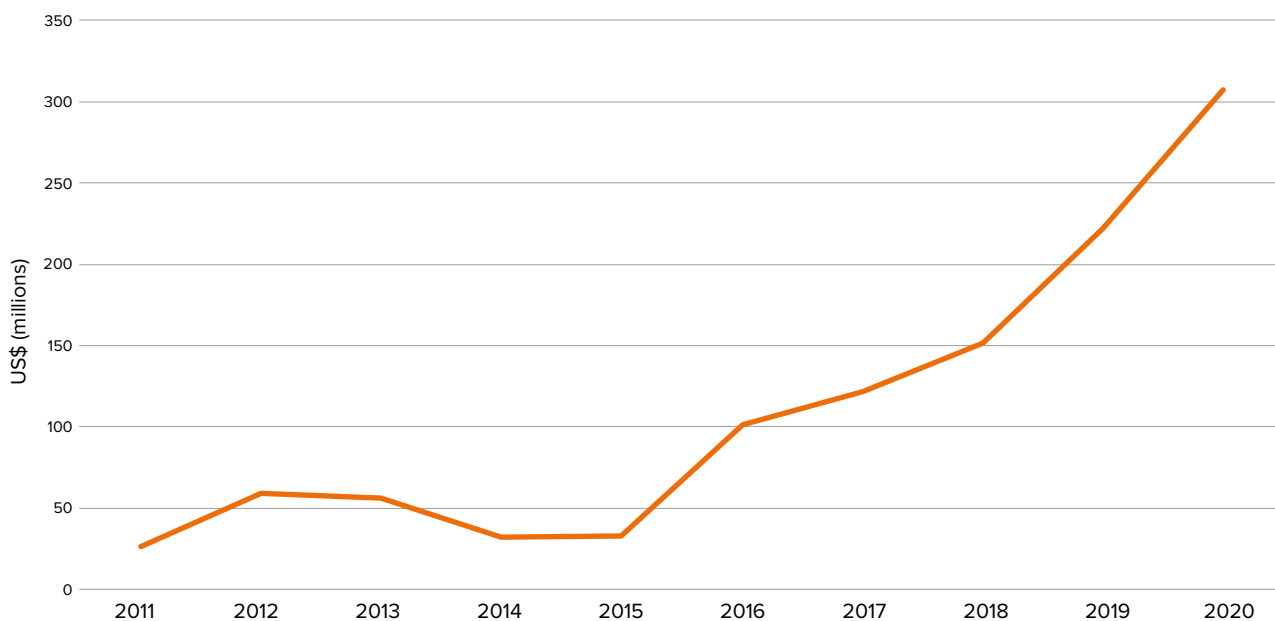
Policy Cures Research collects data on global investment into R&D of platform technologies as part of the G-FINDER survey, which covers funding for R&D targeting neglected diseases (NDs), emerging infectious diseases (EIDs) and sexual & reproductive health (SRH). Our platform technology data therefore reflects this scope, and includes only platform technology investments with potential applications in at least one of these three global health areas.

We have collected data on funding for ND-related platform technologies since 2011, however our data collection on EID and SRH platform technologies commenced more recently – in 2016 and 2018 respectively. In order to count as ND-related, platform R&D must be funded by public, philanthropic or not-for-profit entities. We exclude all private sector investment for ND-related platforms on the basis that this investment is unlikely to be primarily *intended* for use in the uncommercial markets which characterise our definition of 'neglected disease'. This precise restriction does not apply to EID or SRH platforms, however all the SRH platforms we include must be suitable for use amongst low- and middle-income country (LMIC) populations. As such, we capture very little of industry's investment in platform technologies, typically including them only once they are ready to be applied to a disease that falls within our survey scope.

ANALYSIS

Funding for platform technologies has increased dramatically over the past decade, rising more than eleven-fold from 2011 to 2020, when it hit a record high of \$307m. Much of this growth occurred in recent years, with a significant jump in funding occurring from 2018 to 2019 (up \$71m, 47%), following the WHO's addition of 'Disease X' – representing unknown pathogens with pandemic potential – to its R&D Blueprint in a move designed to increase focus on platform technologies.

FIGURE 1: **Platform technology R&D funding 2011-2020**



In 2020, when Disease X duly arrived in the form of COVID-19, funding for platform technologies continued to grow rapidly (up \$85m, 38%). The vast majority of this funding (96%) was applicable to EIDs, though substantial portions were also applicable to NDs (41% of the total) and to SRH (22%).

Platform funding in the early years of the survey, which included only investments relevant to NDs, was dominated by the US National Institutes of Health (NIH). Since 2016, though, the US Department of Defense (DOD) has been the largest funder of platform technology R&D, only partly thanks to the inclusion of EID-specific platforms. DOD funding rose from \$1.3m in 2015 to \$38m in 2016, driven largely by its increased funding for general diagnostic platforms. This contributed to a \$68m rise in overall platform technology funding in 2016, with our inclusion of EID platforms accounting for 30% of this growth.

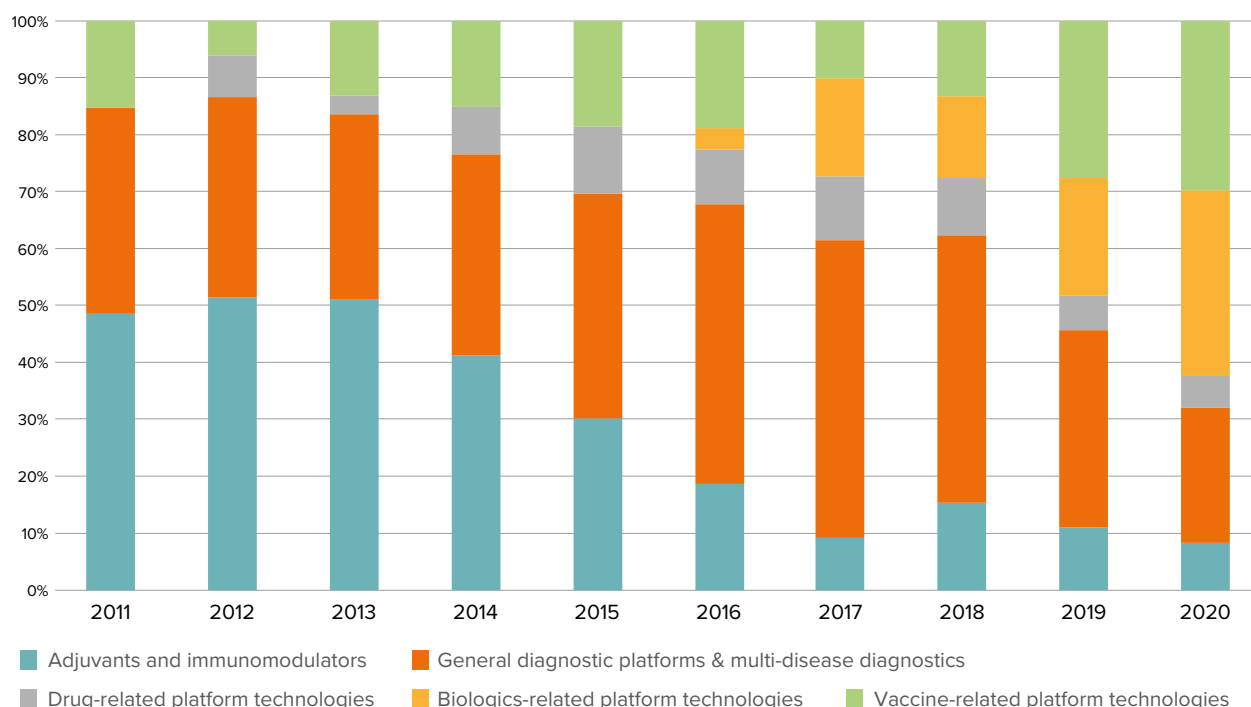
From 2016, the DOD's contributions continued to grow, reaching \$173m in 2020, when it accounted for 56% of total platform funding. More than four-fifths of the DOD's funding in 2020 concentrated on EID-specific platforms, of which over two-thirds was focused on biologics-related platform technologies.

In 2020, the US DOD contributed more than three times as much as the next largest funder, the Bill & Melinda Gates Foundation whose funding rose to \$50m (up \$13m, 36% from 2019). In contrast to the DOD's EID focus, just 0.6% of Gates Foundation funding was directed towards platforms applicable to EIDs only, with their funding going mostly to vaccine-related platform technologies applicable to all global health areas.

Taken together, the US NIH, the DOD, and the Gates Foundation contributed over three-quarters of total funding over the ten years to 2020. In contrast to the other two major funders, which have steadily increased the share of their expenditure going to platforms, the share of NIH funding going to platforms has grown only slowly, rising broadly in line with its overall contributions to global health R&D.

Figure 2, below, shows that the big increases in platform funding have not benefited all categories of platform technology equally:

FIGURE 2: **Platform technology R&D funding by technology type 2011-2020**



Adjuvants and immunomodulators received the largest share of platform technology funding up until 2015, largely thanks to the NIH, which directed just under four-fifths of its pre-2015 funding to this category.

In the second half of the decade, and after our survey scope expanded to include EID platforms, the landscape started to shift. Funding for diagnostic platforms experienced strong growth in the four years to 2019, alongside smaller, but still substantial, increases in funding for both vaccine- and biologics-related platform technologies. Funding for all three areas grew further in 2020, but the lion's share of the growth in platform funding flowed to biologics platforms, making them, at \$100m, the top-funded category with just under a third of the overall total.

Funding for the remaining categories remained flat, but, thanks to the marked rises in funding for other platform technologies, drug-related platforms received less than 10% of total platform funding in 2020, as did adjuvants and immunomodulators.

Vaccine-related platform technologies

Vaccine-related platform technologies include common mechanisms, such as expression systems or delivery vectors such as viral vector and nucleic acid-based platforms, which can be employed for multiple target vaccines. This category also includes technologies purely focusing on delivery of finished products, such as vaccine microarray patches.

Vaccine-related platform technologies experienced strong funding growth from 2018 to 2020, rising from \$20m to hit an all-time high of \$91m (up 359%). More than 60% of this growth was due to increased contributions from existing funders – the Gates Foundation and the US DOD. The Gates Foundation – the top funder over this three-year period – more than tripled its contributions from 2018 to hit \$30m in 2020. The US DOD's funding increased even more rapidly, growing to \$9.2m in 2019 (up \$8.5m, 1,185% from 2018), and again to \$25m in 2020 (up \$16m, another 170%).

Vaccine-related platforms were increasingly focused on improving rapid response capabilities to novel and emerging pathogens. Virtually all of the reported vaccine-related platform funding in 2020 was applicable to EIDs, with half applicable to EIDs alone. The US DOD contributed to this trend, and much of its rise in funding was due to EID-specific investments in platform capabilities at its Medical Countermeasures Advanced Development Manufacturing Facility. Nevertheless, a sizeable portion of the Gates Foundation's funding was designed to improve vaccination coverage in low resource settings – in 2020, the Foundation made four disbursements totalling \$4.3m to developing single-dose vaccines which we treat as applicable to all global health areas.

Some of the growth in the two years to 2020 was also due to new funding streams from two new organisations founded in 2017: Open Philanthropy and the Norway-based Coalition for Epidemic Preparedness Innovations (CEPI). CEPI disbursed a total of \$26m in 2019 and 2020 in support of three vaccine platforms – Imperial College London's self-amplifying RNA (saRNA) vaccine platform, University of Queensland's 'molecular clamp' platform and CureVAC's mRNA platform. The RNA Printer: Open Philanthropy made its first contribution to vaccine platform R&D in 2020, directing \$6.5m to Icosavax's virus-like particle platform – intended to be adapted into a COVID-19 vaccine.

High-income country (HIC) governments and philanthropic funders accounted for just under 80% of total funding over the ten-year period. While overall contributions from intermediary organisations were relatively static, the primary funders shifted over time with the rise and fall of funding from product development partnerships like PATH and the International Vaccine Institute (IVI) in the first half of the decade, and, starting in 2019, from CEPI.

While \$2.3m of public LMIC funding from India was reported in 2016, its funding trended down over three consecutive years to reach a low of \$91k in 2019, before rebounding slightly to \$0.5m in 2020 – supplemented by \$20k of funding from Tunisia.

In 2016, the Gates Foundation gave \$0.8m to Sanofi to explore the feasibility of using Micropellet technology to develop thermostable novel combination vaccines. This technology was then tested in a proof-of-concept yellow fever vaccine.²

Biologics-related platform technologies

Biologic-related platform technologies include processes or platforms capable of producing bio-therapeutics such as monoclonal antibodies or siRNA-based technologies, which can be adapted for more than one pathogen.

All captured R&D of biologics-related platform technology was directed specifically at EIDs. Biologic platform funding grew for five consecutive years from 2016 – when EID platform technologies were first included in the survey – rising from \$3.7m to \$100m in 2020. The largest single increase in funding occurred from 2019 to 2020, with a rise of \$54m (116%).

More than 99% of overall funding and the majority of 2020's record growth came from the US DOD. The DOD has increasingly focused its pandemic preparedness approach on biologics-related platforms, shifting funding from within ongoing programmes away from drug-based approaches to biologics. Nearly two-thirds of the DOD's biologics platform funding in 2019 and 2020 went to a Pandemic Prevention program designed to improve its capabilities in rapidly discovering and maturing antibody technologies to counter emerging viral threats. This program was originally scheduled to receive \$24m in 2020, but saw its budget unexpectedly increased to \$65m during 2020, seemingly in response to COVID-19.

The DOD's COVID-19 response drew upon capabilities developed in its Pandemic Prevention programme, as DOD researchers extracted antibodies from COVID-19 positive blood samples in just three weeks, after which they were soon replicated and manufactured for use in clinical trials.

General diagnostic platforms & multi-disease diagnostics

General diagnostic platforms are standalone plug-and-play platforms that can work with disease-specific assays. This category also includes multi-disease diagnostics: multiplex diagnostic technologies capable of detecting multiple pathogens or biomarkers simultaneously.

From an average of \$15m in the years prior, funding for general diagnostic platforms & multi-disease diagnostics jumped to \$50m in 2016 (up \$37m, 285% from 2015) and continued to rise to \$77m in 2019, before dropping slightly to \$73m in 2020.

There were two main drivers of the 2016 jump: a twenty-four-fold rise in US DOD funding combined with a four-fold rise in Gates Foundation funding, which hit \$29m and \$12m respectively. While 23% of the DOD's growth in 2016 was driven by the new inclusion of EID platforms in our survey, its funding continued to grow over the subsequent years, reaching \$47m in 2019. That year also saw the first contribution from Open Philanthropy – a total of \$18m to Sherlock Biosciences across 2019 and 2020 for the development of a platform designed to identify any human virus.

Open Philanthropy's 2019 funding propelled it to become the second highest funder of that year, surpassing the Gates Foundation, the US NIH and the European Commission (EC) – the three major non-DOD funders prior to 2019.

Compared to other platform technologies, general diagnostic platforms had the greatest diversity in funding, with a total of 55 different funders over the ten-year span. There were multiple public LMIC funders from different regions, including Africa, though their percentage share of funding remained low – averaging just 1.6%. Similarly, there were several philanthropic funders, including recent contributions from Open Philanthropy and Fondation Mérieux – though their share of total funding declined from a Gates Foundation driven peak of 49% in 2013 to an average 19% in the following years.

Intermediary organisations were responsible for 6.9% of overall funding, mostly thanks to PATH, FIND and – more recently – the GHIT Fund. The majority remainder of total funding came from public HIC funders, most of it from the US DOD.

From 2015 to 2019, the EC disbursed \$1.8m to R&D of a platform designed to non-invasively and rapidly diagnose tropical diseases on-site by breath sampling. This technology has been used to design non-invasive breath tests for gastric cancer, diabetes mellitus, chronic kidney disease and COVID-19.^{3–5}

Drug-related platform technologies

Drug-related platform technologies include broad-spectrum therapeutic countermeasures, including small molecule and host-directed antimicrobial drugs, and drug delivery technologies and devices such as long-acting and subcutaneous drug delivery systems.

Over the past decade, funding for drug-related platform technologies has slowly trended upwards – from no funding reported in 2011 to a peak of \$17m in 2020. While 62% of the 2020 funding was applicable to EIDs only, funding was also captured for drug-related platforms applicable to NDs and SRH – including the only funding for platforms applicable to SRH alone.

The US DOD was the top funder from 2018 to 2020, though its contributions dropped by one-fifth from \$11m to \$9.0m (-\$2.2m, -20%) over that period. In contrast, disbursements from the Gates Foundation – the second largest funder – rebounded from a low of \$1.0m in 2018 to \$5.0m (up \$4.0m, 383%) – with more than 70% of this rise driven by funding of R&D designed to enable less frequent drug dosing.

The Gates Foundation also funded R&D to improve paediatric formulations and oral drug delivery technologies. In contrast, the US DOD's focus was more singular, with its funding predominantly directed towards R&D of broad-acting antivirals to counter EIDs. However, both organisations – alongside other funders including the Swiss National Science Foundation (SNSF) and the EC – disbursed funding for R&D of nanoparticle-based drug-delivery.

In 2012, there was a one-off spike in public LMIC funding with \$4.0m contributed by the Indian Department of Biotechnology (DBT) and Indian Council of Medical Research (ICMR), driving the LMIC share of funding to 93% of the total. However, in the past five years, funding from LMICs has only averaged \$183k each year, or 1.3% of the global total.

A total of fifteen public HIC funders contributed 59% of total funding across the decade, and philanthropic funders contributed around half of this amount.

From 2014 to 2018, the EC provided \$2.3m of funding to the CYCLON HIT project, which investigated cyclodextrins – a nanotechnology-engineered carrier for antibiotics and drugs. In 2017, this technology was tested in delivering antibiotics directly to the lungs to treat MDR tuberculosis.⁶

Adjuvants and immunomodulators

Adjuvants and immunomodulators are substances used as part of a vaccine regimen to enhance or modulate the immune response.

Funding for adjuvants and immunomodulators has remained relatively consistent over the past ten years. On average, \$20m of funding was captured each year – peaking at \$30m in 2012, dropping to \$9.8m in 2015 before partially recovering to \$25m in 2020.

Much of the year-on-year fluctuations in funding levels were due to shifts in funding from the US NIH. As the largest funder, the NIH contributed more than half of the ten-year total, with the Gates Foundation contributing another 22%. The number of other funders has fallen in the last two years, with only seven total funders in 2019 and 2020. Over this time, the only new funder of adjuvant and immunomodulator R&D was the South African Medical Research Council (SAMRC), which provided \$63k of funding in 2019 and a similar amount in 2020.

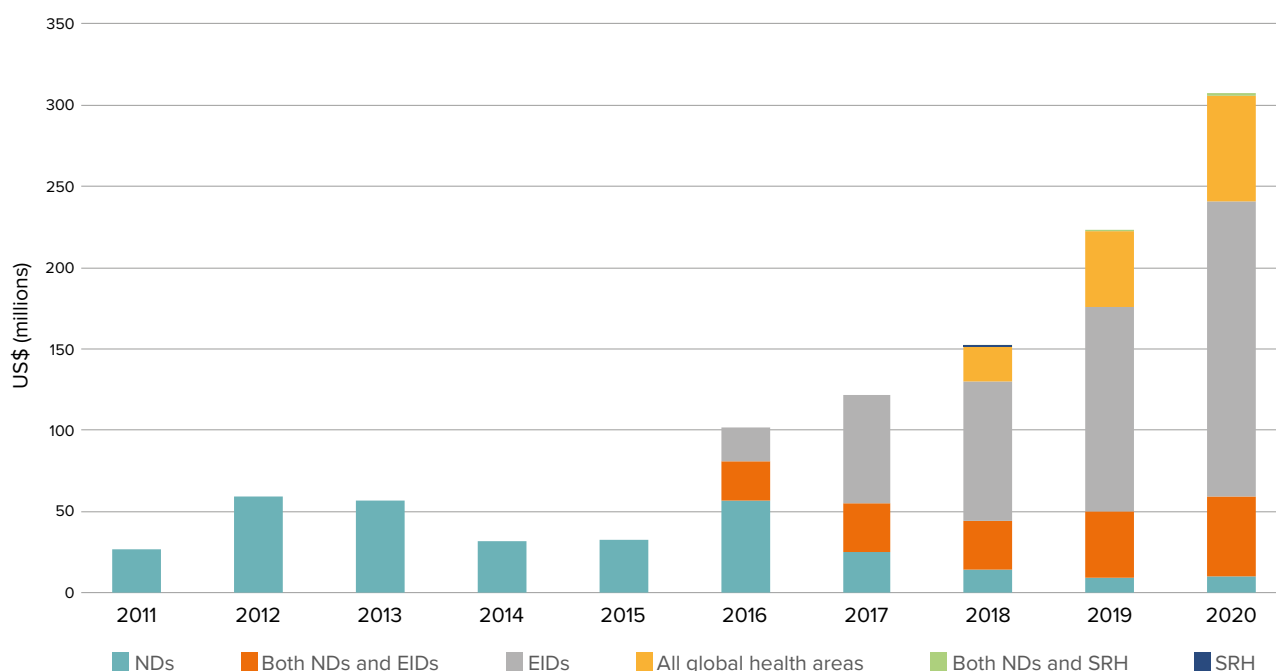
With the US NIH and the Gates Foundation dominating the funding landscape, along with smaller contributions from the EC and the DOD, public HIC and philanthropic funders accounted for 79% of total funding across the decade – rising as high as 98% in 2019.

The contributions of intermediary organisations were concentrated in the first half of the decade, accounting for 67% of funding in 2014 and waning significantly since. PATH's funding peaked at \$2.6m in 2014, steadily declining before disappearing entirely in 2020. However, some of the drop in intermediary funding is artefactual and likely overstated – the Seattle-based Infectious Disease Research Institute, contributed an average of \$6.3m each year up until 2015, after which it did not participate in the survey.

From 2011 to 2014, Infectious Disease Research Institute (IDRI), now rebranded as Access to Advanced Health Institute (AAHI), provided \$24m of self-funding to progress its adjuvant portfolio. Its 3M-052-Alum adjuvant formulation is currently being used in a COVID-19 vaccine undergoing phase I clinical trials in Thailand.⁷

Platform technology funding by global health area

FIGURE 3: **Platform technology R&D funding by global health area 2011-2020[^]**



[^]ND platform technologies have been included in the survey since 2011. EID and SRH platform technologies were added to the survey in 2016 and 2018 respectively.

Funding for **emerging infectious disease** platforms accounted for much of the overall growth in platform technology funding. In the five years of its survey inclusion, its funding grew from \$44m in 2016 to \$296m in 2020 – when 96% of captured funding was applicable to EIDs, and 59% was specifically for EID-related technologies.

Given almost all the platform technologies we captured were applicable to EIDs, the changes in funding for EID platforms largely mirrors the overall changes in platform technology funding described earlier in the report. Funding grew for all types of platform technology, but especially for biologics- and vaccine-related platforms.

Neglected disease platform technology funding was captured over the entire ten-year period. Its funding fluctuated around an average of \$51m up until 2019, when it suddenly jumped to \$97m, before increasing sharply again, to \$125m, in 2020. Less than 10% of this funding over the past two years was applicable to NDs alone.

The focus of ND platform funding was slightly different to that of EID platforms. From 2016 onwards, general diagnostic platforms & multi-disease diagnostics captured 46% of the funding for platforms applicable to NDs alone, compared to 29% for EID-specific platforms. Diagnostics also represented the largest share of broader platform funding applicable to NDs each year since 2016, though their share of ND-relevant platform spending dropped from 61% in 2017 to 40% in 2020, as funding for vaccine-related platforms grew.

Sexual & reproductive health platform technologies have been included in the survey only since 2018. Over this three-year period, funding has grown from \$22m in 2018 to \$66m in 2020 (up \$44m, 203%). The overwhelming majority of this funding was directed towards platforms also applicable to EIDs and NDs. Only \$2.6k of SRH-specific platform funding was reported, coming from Wellcome for the development of a novel vaginal drug delivery design.

Overall, the small amount of SRH platform investment is unsurprising – outside of HIV and other infectious STIs, SRH comprises a diverse group of health issues, rendering platform technologies less relevant to this area.

PROVING PLATFORMS WORK: THE PANDEMIC'S SILVER LINING

Over the period we have tracked funding into emerging infectious diseases, we have observed a clear pattern of reactive funding to individual disease outbreaks. Funding for Ebola and Zika rose and fell in parallel with their largest outbreaks; both dwarfed by the COVID-19 response, which by conservative estimates led to a \$3,847m injection of R&D funding in 2020 alone.

Alongside this pattern of increasing funding in response to individual outbreaks, funders have begun to pay increasing attention to the need to look forward and shift towards investment in pandemic preparedness, including platform technologies. In the same way that many of the platform technologies we employed against COVID-19 were developed in response to diseases like HIV, their successful adaptation to a previously unknown pathogen serves as proof-of-concept for their application to other EIDs, or to the next Disease X. Indeed, the final step in developing a platform that can be successfully applied to many diseases, is to successfully apply it to one – providing the proof-of-concept necessary for it to be used more broadly.

Until recently, for example, Johnson & Johnson's adenovirus type 26 (Ad26) vector platform had not been used in any successfully registered vaccines. It was backed by decades of research and had been used in several investigational vaccines, including vaccines against HIV, malaria and respiratory syncytial virus.⁸ Then, in response to Ebola and COVID-19 Johnson & Johnson was able to swiftly develop, test and register two vaccines using the platform – Ad26.ZEBOV and Ad26.COV2.S.

In a similar vein, the VSV vector platform was successfully used for the first time in Merck's Ebola vaccine, having undergone research since the 1990s.⁹ The mRNA vaccines which headlined our novel response to COVID-19, were underpinned by a similarly extended history of research.¹⁰ These platform technologies, which had for years showed promise as the future of vaccine technology, were only finally validated in response to Ebola and COVID-19, stimulating increased interest in their application to other areas.

In some cases, though, the COVID-19 pandemic unearthed platforms' shortcomings. The potential for adenovirus vector platforms to cause rare cases of thrombosis with thrombocytopenia syndrome (TTS) was revealed only once the platform was used to create a vaccine administered to an unprecedented number of individuals. Similarly, recipients of the COVID-19 vaccine based on the University of Queensland's molecular clamp platform were found to return false-positive HIV tests, halting further trials. Even these high-profile failures give us a clearer idea of what tools we actually have available in preparation for the next pandemic, and how their defects, once known, can be managed. Phase III trials of an adenovirus-vectored HIV vaccine are now monitored for cases of TTS, for example. And the molecular clamp is being reworked without the use of HIV protein fragments, improving upon its previous design and hopefully readying it for the next emerging infectious disease threat.

As we look to the future, platform technology R&D continues to be critical in ensuring we have reliable, adaptable technologies that can be immediately leveraged to respond to the next Disease X. The use of platforms in the COVID-19 R&D response has contributed to this goal, validating several platform technologies – and providing benefits that may ultimately be seen in other diseases and fields of research.

Methodology

Challenges in defining platform technology funding:

To be captured as funding for platform technologies in the G-FINDER survey, funding must be directed towards R&D activities which have a stated objective to develop a technology or process that can be adapted for use in product development for more than one disease area – meaning the R&D must not yet be directed toward a specific disease or product.

Often, though, a platform is a spillover from the development of a specific product, and is identified as a platform only when it is later adapted to another disease. We don't count product development specifically for, say, HIV, that ultimately produces a viable platform for use against Ebola as 'platform funding' and, as a result, we tend to undercount the true level of platform investment.

Certainly, there are many instances where a technology or process is considered for its potential as a platform from initial conception. However, while the *initial* research may be disease or product agnostic, proof-of-concept will often occur by applying the platform to a specific disease or product. Depending on how this stage of R&D is described, this may be captured as late-stage funding for platform technologies, or it may instead be categorised as funding for the specific disease and product area.

Onward funding:

In this analysis, we include all funding to product developers, including funding from Product Development Partnerships and other intermediaries like CEPI. To avoid double-counting, we therefore excluded all funding given to these intermediaries, even where it has been earmarked for use in platform R&D.

Limitations in our survey coverage:

The G-FINDER survey targets only those organisations which are active in funding ND, EID or SRH R&D. When considering the versatility of platform technologies and their applications in vastly different fields, this presents a challenge in data collection as we do not survey organisations with a focus outside our global health areas. Therefore, it is likely that we fail to capture funding for platforms which are primarily intended for diseases outside of our scope, but which may have applications for those that we *do* cover.

Secondly, it is important to acknowledge that much platform technology R&D is carried out by the private sector. Despite this, we exclude private sector investment into ND platforms, as our definition of 'neglected' requires the existence of market failure – that there is insufficient commercial incentive to attract R&D from private industry. We therefore exclude a potentially significant amount of private sector funding for platforms, which may ultimately find applications for neglected disease, on the basis that this investment is not primarily *intended* for use in uncommercial markets. While this restriction does not exist for EID and SRH platforms, we remain hesitant about treating commercial investments as *primarily* motivated for use in either of these areas. As a result, it is likely that we significantly undercount private sector platform development with the potential to be used against EIDs and NDs.

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