

LANDSCAPE OF EMERGING INFECTIOUS DISEASE RESEARCH AND DEVELOPMENT:





#### **POLICY CURES RESEARCH**

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# LANDSCAPE OF EMERGING INFECTIOUS DISEASE RESEARCH AND DEVELOPMENT: FROM PANDEMIC RESPONSE TO PANDEMIC RESILIENCE

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#### INTRODUCTION

#### Background to the G-FINDER EID survey

Each year since 2007, the G-FINDER survey has provided policy-makers, donors, researchers and industry with a comprehensive analysis of global investment into research and development of new products to prevent, diagnose, control or cure neglected diseases in developing countries, making it the gold standard in tracking and reporting global funding for neglected disease R&D.

In response to the 2014 West African Ebola epidemic, Policy Cures Research began gathering data on R&D targeting emerging infectious diseases (EIDs) alongside neglected disease R&D in the G-FINDER survey. In 2020 we released a report – the first Landscape of Emerging Infectious Disease R&D – based on the data collected over the first five years of the expanded survey. This second Landscape of Emerging Infectious Disease R&D updates the previous report with the funding reported for 2019 and 2020, including the first year of funding in response to the COVID-19 pandemic.

#### Scope of this report

In 2015, the inaugural EID-specific portion of the survey focused exclusively on Ebola R&D. The survey went on to adopt a progressively broader scope over the first three years of the EID survey, meaning that overall funding totals for the early years of our survey are not perfectly comparable to those for 2016 and beyond. A detailed history of the survey's scope expansion is presented in the Methodology section on page 68.

Beginning in 2016, the EIDs covered in the survey have matched the list of priority diseases endorsed by the 2018 World Health Organisation (WHO) research and development Blueprint for action to prevent epidemics ('the Blueprint'), including the addition of SARS-CoV-2 (COVID-19) starting in 2020.

The Blueprint list of priority diseases also includes a 'Disease X', which it defines as 'the knowledge that a serious international epidemic could be caused by a pathogen currently unknown to cause human disease'. In line with the WHO definition, this report uses the Disease X category to capture all 'cross-cutting R&D preparedness that is also relevant for an unknown disease'.

In addition to non-disease-specific EID R&D, which is assigned to Disease X, this report also includes non-earmarked core funding for R&D organisations that work in multiple disease areas, provided that the recipient organisations include Blueprint priority EIDs as a significant focus of their work. This funding is excluded from all disease-specific sections, but is included – as 'Core Funding' – in the figures and analysis presented in the 'Funding to Intermediaries' and 'Funders' sections of the report. For further details on our treatment of core funding, see the Methodology section on page 67.

As in the G-FINDER reports, investments not directly focused on research and development of biomedical products are excluded from our results. This includes activities such as advocacy and behavioural research, which are critical to effecting change, but which are distinct from product development and therefore fall outside the G-FINDER criteria for both EIDs and neglected diseases.

Further details of the methodology employed for this report and the underlying survey can be found in the Methodology section, starting on page 70.

#### Structure of the report

This report is divided into five main parts:

- funding by disease group provides analysis of the funding for each of the priority pathogen families, ordered on the basis of total funding, including a breakdown of funding by product, funding across the various individual diseases and multi-disease categories, and major providers of funding;
- funding by product type examines the division of global funding across vaccines, therapeutics, basic research and vector control and lays out the sources and allocation of funding within each product category;
- funding to intermediaries lists the major providers and recipients of intermediary funding and analyses their contributions;
- 4) **funders of emerging infectious disease R&D** recognises the major providers of EID funding, by sector, nation and organisation, and summarises the distribution of public, private and philanthropic funding across the different disease groups; and
- 5) discussion, where we summarise our main conclusions from an analysis of seven years of EID funding data and identify the key lessons for policy makers in the wake of the COVID-19 pandemic.

#### OVERVIEW OF EID R&D FUNDING

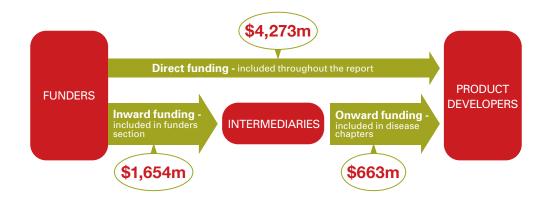
Funding for emerging infectious disease R&D is overwhelmingly driven by outbreaks. Unsurprisingly, 2020 was no exception. But to explain how the COVID-19 pandemic reshaped the funding landscape for emerging infectious disease R&D, it's useful to understand the situation before the pandemic struck.

Between 2014 – when we first began gathering Ebola funding data – and 2018, R&D funding grew more than fivefold. Some of this growth was because we began including a wider range of diseases in our survey. But most – and basically all of it since 2016 – is real, and largely reflects the global response to the West African (2014-2016) and Democratic Republic of Congo (2018-2020) Ebola epidemics, and to the South American (2015-2016) Zika outbreak.

By 2019, the Zika outbreak had passed and case numbers in the DRC Ebola outbreak were reaching their peak. As a result, Zika funding fell further from the peak of \$247m it reached at the height of the outbreak, dropping by nearly \$90m to \$117m. Ebola funding only fell a little, but was just 60% of the level it peaked at in the second year of the West African outbreak, as several strands of research began to wind up. But overall EID funding still rose – by a little – for the fifth year in a row.

This ongoing growth in EID R&D was partly because 2019 was the year when the Coalition for Epidemic Preparedness Innovations (CEPI) began ramping up funding for several of its priority diseases. Mostly, though, funding rose in 2019 because of another big jump in global funding targeting more than one EID – which we capture under the broad heading of 'Disease X'. The Disease X label was coined by the WHO's R&D Blueprint team to account for the – now familiar – idea of preparing for an unknown disease with pandemic potential. For our purposes it includes things like platform technologies to assist in the creation of future vaccines, therapies and diagnostics; fundamental research; and vector control which targets more than one disease. Research designed to tackle multiple and/or mysterious diseases has become *much* more popular since we began tracking it in 2016, growing from just \$43m to \$244m in 2018 and then rising by another \$113m in 2019, when it received more funding than any individual disease.

So, by the start of 2020, global EID funding had already begun to shift from outbreak response to research designed to protect against multiple, lesser-known or entirely novel pathogens. This would prove to be an excellent choice.



The world spent a little under \$2.5 billion over seven years in response to Ebola, and a little under \$3.9 billion in just one year in response to COVID-19. And even this understates the true scale of our R&D response, for two reasons.

First, because it measures only funding actually given to product developers in 2020, ignoring nearly \$1 billion in extra funding that funders (mostly governments) gave to intermediary organisations (mostly CEPI) not spent by the end of 2020. Including this money, as we do in the second half of the report when we focus on who provided funding, pushes the 2020 COVID-19 total to \$4.7 billion.

Second, the total is understated because not everyone will report their investments to G-FINDER. The G-FINDER project was built to track the traditional funders of neglected disease R&D, and we have expanded our organisational coverage along with the areas of R&D we cover, but we know that there are big gaps in our understanding of pharmaceutical industry investment in COVID-19 R&D, and suspect that there are smaller gaps in our coverage of some of the newer public and philanthropic funders who got involved for the first time in 2020. We can't know how big these holes in the data really are, but we can be sure that even the \$4.7 billion figure is a substantial underestimate.

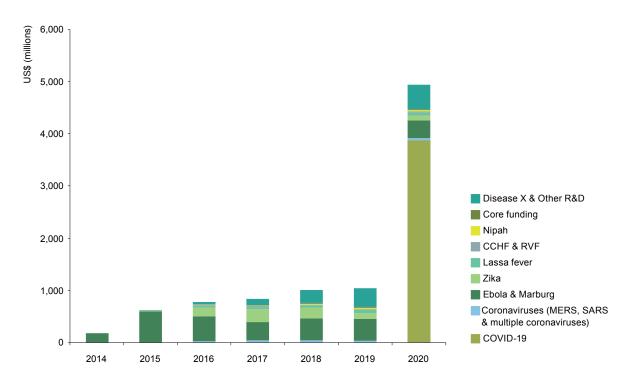


Figure 1. Total funding for emerging infectious diseases 2014-2020

Rather than keep emphasising the size of the COVID response, let's consider what worked, and what didn't.

CEPI was created in 2017 with exactly this scenario in mind, and was able to play a key role in our breakneck development of COVID vaccines. CEPI provided a large amount of funding in 2020 – \$536m in total – but, crucially, it also committed its funding *early*, and to a range of potential vaccines, so that product development could begin immediately and survive attrition from promising-looking candidates. CEPI's previous funding for vaccine platforms provided a head start in the creation of a vaccine, but its ability to allocate its existing reserve of funding immediately was, if anything, even more important.

If CEPI represents the global pandemic response, pooling funding from more than a dozen national governments, the US Biomedical Advanced Research and Development Authority (BARDA)\* represented America's. Like CEPI, BARDA was built for pandemic response, having helped lead the global R&D effort for Ebola and Zika. Also like CEPI, it provided major funding commitments early and often in 2020, backing seven different vaccine candidates and more than a dozen therapeutics. Its \$827m funding total over the course of 2020 made it the largest single funder of COVID-19 R&D.

The real time funding commitment data we gathered shows that, over the first three months of 2020, BARDA announced 80% of the world's funding for COVID-19 therapeutics. This is a great achievement for BARDA, but also something of a failure on the part of the rest of the world. In all, 58% of 2020's COVID funding went to vaccine R&D, more than twice the share for drugs (13%) and biologics (12%) put together. This seems normal for the early years of major outbreaks - we saw much the same for Ebola and Zika - since vaccine trials require far more participants than those for therapeutics. But, since vaccine trials require many more participants than those for therapeutics, vaccine R&D is also much slower than therapeutics R&D. Today, in 2022, we mostly rely on the miracle of vaccination to keep us from dying from COVID-19. But, until the very end of 2020, we relied on drugs. Proven treatments for COVID-19, like the corticosteroid dexamethasone and the antiviral remdesivir, together saved hundreds of thousands of lives in 2020. The treatments we have discovered since, like fluvoxamine and Pfizer's Paxlovid, might have saved hundreds of thousands more. The world ran a lot of studies of repurposed therapeutics in 2020, 2021 and, somehow, also in 2022. But we were still trialling well known compounds in 2022 mostly because we did such a poor job of coordinating and prioritising the trials we did run in 2020. In CEPI, EID vaccine research has a central body to pool funding and coordinate research. We didn't have a similar pre-existing body for therapeutics at the start of the pandemic, and, despite the creation of the COVID-19 Therapeutics Accelerator and the Access to COVID-19 Tools Accelerator, we largely still don't.

COVID-19 wasn't the only disease to benefit from new products. After nearly two years and 2,299 deaths, the DRC Ebola outbreak came to an end in 2020, thanks mostly to the availability of an effective, approved vaccine (initially MSD's Ervebo vaccine, followed by J&J's Zabdeno/Mvabea regimen). Along with two newly-approved biologics and a rapid diagnostic test (as well as many more available under emergency use authorisations), the availability of a vaccine has transformed our ability to contain and eliminate Ebola outbreaks: two subsequent outbreaks in 2021 each killed less than ten people, compared to more than 11,000 during the 2014-2016 West African epidemic.

Following this successful product development, funding for Ebola R&D fell by 20% in 2020, to about half of its 2015 peak, with a substantial portion of the remainder going towards post-registration studies and stockpiling of doses. If the \$2.5 billion total cost of containing Ebola contrasts favourably with the \$3.9 billion for just the first year of COVID-19 R&D, the seven years it took looks somewhat less ideal, especially compared to the warp speed delivery of COVID-19 vaccines. Some of this is due to the difference between the diseases – a multi-year global pandemic provided fertile ground for clinical trials, for example – and some hopefully thanks to what we learned battling Ebola, and from our ongoing research into platform technologies. But the rest is evidence the product development timelines *do* respond to volume of funding and to political will.

Table 1. Disease and product R&D funding 2020 (US\$ millions)

leege or	Basic resear	ch	ines	- dics	Diagnostics V	ector control	Juabecitied	a total	a total
R80 a	Basic.	Drnaz ,	Vaccines	Biologics	Diagne	produc	Tuebo	2019 total	2020 total
Coronavirus disease 2019 (COVID-19)	394.83	506.43	2,237.57	469.37	203.26	-	62.05		3,873.52
Coronaviruses (including MERS, SARS, and multiple coronaviruses)	15.84	8.08	13.69	0.52	0.54	0.33	1.24	38.56	40.24
Middle East Respiratory Syndrome (MERS)	5.52	2.95	8.50	0.52	0.49	0.33	0.43	29.46	18.73
Severe Acute Respiratory Syndrome (SARS)	4.66	1.67	1.18	-	0.05	-	-	6.79	7.56
Other coronaviral R&D in combination with MERS and/or SARS and/or COVID-19	5.66	3.46	4.01	-	<0.01	-	0.82	2.32	13.95
Filoviral diseases (including Ebola, Marburg)	26.59	22.67	138.76	145.42	3.38	-	3.81	410.65	340.63
Ebola	21.90	18.84	105.18	130.80	2.87	-	1.46	349.79	281.04
Marburg	1.91	2.88	17.62	12.21	0.21	-	-	37.79	34.83
Other filoviral R&D in combination with Ebola and/or Marburg	2.79	0.94	15.97	2.41	0.30	-	2.35	23.07	24.75
Zika	43.24	5.43	36.34	3.82	7.27	1.61	1.90	116.59	99.61
Arenaviral haemorrhagic fevers (including Lassa fever)	11.48	2.97	28.22	5.50	0.85	-	2.28	58.94	51.30
Lassa fever	11.07	1.75	27.11	4.66	0.85	-	2.28	56.29	47.72
Other arenaviral R&D in combination with Lassa fever	0.42	1.21	1.11	0.84	-	-	-	2.66	3.58
Bunyaviral diseases (including CCHF, RVF)	6.62	0.65	11.41	3.41	1.48	0.96	0.23	20.48	24.76
Crimean-Congo Haemorrhagic Fever (CCHF)	1.50	0.11	3.72	3.41	0.21	-	0.12	8.31	9.07
Rift Valley Fever (RVF)	2.43	0.24	7.39	-	0.43	0.96	0.11	8.85	11.57
Other bunyaviral R&D in combination with CCHF and/or RVF	2.69	0.30	0.30	-	0.85	-	-	3.31	4.13
Henipaviral diseases (including Nipah)	3.34	0.67	16.80	1.25	-	0.70	0.77	24.09	23.53
Nipah	2.59	0.67	16.80	1.25	-	0.70	0.77	23.19	22.78
Other henipaviral R&D including in combination with Nipah	0.75	-	-	-	-	-	-	0.90	0.75
Disease X & Other R&D								358.07	465.45
Platform technologies								213.20	298.38
Biologics-related platform technologies								46.08	99.76
Vaccine-related platform technologies								60.99	90.65
General diagnostic platforms & multi- disease diagnostics								70.70	66.43
Adjuvants and immunomodulators								24.19	25.27
Drug-related platform technologies								11.24	16.27
Fundamental research								24.18	27.42
Multi-disease vector control products								56.29	59.41
Other R&D								64.40	80.24
Core funding of a multi-disease R&D organsiation^								16.21	16.58
Total EID R&D funding								1,043.59	4,935.62

No reported funding

Category not included in G-FINDER

Category not included in G-FINDER

^ This measure of core funding excludes funding to organisations for which onward funding data is available. Funding from these organisations is included in the categories above and, to avoid double counting, the funding they receive is reported separately in the Intermediaries section of this report.

While most of the funding that went to COVID R&D was new money, the data suggests that the pandemic did partly divert attention, and funding, away from other EIDs. The big 2020 fall in Ebola funding, and a smaller drop for Zika, mostly make sense as part of ongoing post-outbreak trends and the successful completion of Ebola's product development. The falls for a majority of other individual pathogens – a net total drop of \$18m for diseases that had seen their funding increase by \$29m in 2019 – likely reflect shifting priorities, or possibly the disruption of clinical trials by the pandemic.

The areas of highest spending growth in 2020 all seem pandemic-inspired. Funding for multi-coronaviral research grew fivefold, while funding for Disease X in general (up \$113m), and platform technologies in particular (up \$85m) leapt again, much of which was due to a sudden increase in biologics platform funding from the US Department of Defense after the start of the pandemic.

A big share of the drop in 2020's (non-COVID) disease-specific funding was a result of CEPI shifting its outlays in response to the pandemic. Its non-COVID funding dropped by \$25m (-30%) from its peak in 2019. But even after spending 2018 ramping up its funding programmes, and 2020 dealing with an immediate crisis, CEPI has still been able to drastically shift the funding landscape for Lassa fever, Nipah, MERS and Rift Valley fever.

Pre-CEPI, most funding for these diseases was for basic research. Global funding of product development came mostly from the US National Institutes of Health (NIH), and totalled just \$56m, compared to the \$78m CEPI has provided since. Not only has CEPI sharply increased overall funding, it has boosted the share of funding going towards product development by 28 percentage points and, in some cases, provided the first ever meaningful funding for clinical development.

Between them, the NIH and CEPI have provided 82% of the global funding for these four pathogens. The NIH alone provides more than 70% of the world's basic research funding every year, and is responsible for the majority of overall funding for SARS, Marburg, Lassa and MERS.

As with BARDA's dominant role in COVID therapeutics, this is both a great achievement for the organisations in question, and also evidence of a worrying lack of commitment from the many other bodies that presumably also share an interest in preventing future outbreaks of MERS or Lassa fever. It's a level of concentration that places a lot of trust in the judgement – and sustainability – of a small number of organisations, all located far from the low- and middle-income countries where epidemics cause the most harm.

It would be heartening to see CEPI joined by a properly empowered Centre for Epidemic Therapeutics Innovations; and for the newly-established Advanced Research Projects Agency for Health to grow into a fully-realised independent body, backed by a remit to fund the longshot investments the NIH won't. In the meantime, though, we are cautiously optimistic about three features of the recent funding data.

First, funding for COVID R&D was much less concentrated than funding overall. While the names at the top of the list – BARDA, the NIH, and the governments of the UK, Germany and Norway – are all familiar, COVID received funding from 130 different organisations, more than twice as many as provided funding for Ebola over the previous seven years. Many of these organisations were first time funders of EID R&D, and will hopefully keep contributing.

Second, the record amount and share of EID funding from LMICs we saw in 2019 was immediately topped in 2020, evidence of a more geographically diverse funding landscape emerging even prior to the pandemic.

And third, the rush of private sector investment into COVID R&D – not fully captured in our figures – was accompanied in recent years by the first, small amounts of private sector funding for CCHF, Lassa fever and Nipah. Meaning that, with luck, we will enter the next pandemic backed by a broader range of funders supporting a more experienced array of product developers.

How prepared *are* we for the next pandemic? Though it's impossible to judge how our defences will perform against an unknown enemy, much of our spending over the last three years was explicitly devoted to preparing for exactly that. Funding, especially from CEPI, has also poured into the diseases we had largely neglected while we focused on Ebola and Zika, and mostly held steady through the first year of the pandemic. Funding for the half dozen 'Non-Priority' disease areas we track, but exclude from our overall totals, reached a record high in 2019, and remains above its 2018 level. We have created numerous organisations dedicated to pandemic prevention and response, and can only hope that some portion of them, along with the ongoing funding necessary to maintain a healthy product development ecosystem, survives what will hopefully be the long wait for the next Disease X.

We are certainly much more prepared for a pandemic than we were at the beginning of 2014, and more prepared than we were at the beginning of 2020. But we are also, by any reasonable standard, not ready enough. How long will we remember COVID-19 and the millions of people no longer around to remind us? And will we, the people who collectively spent two years washing our hands and disinfecting hard surfaces in response to an airborne coronavirus, learn the broad lessons of pandemic resilience, or just go back to fighting the last war?

Table 2. R&D funding by disease 2014-2020 (US\$ millions)

picease or had area	JS\$ (milli	onsi					C	Sumulativ <sup>8</sup>	2 total	total 020% of the
Rade	2014	2015	2016	2017	2018	2019	2020			
COVID-19							3,874	3,874		78
Coronaviruses (MERS, SARS and multiple coronaviruses)			26	46	44	39	40	195	3.7	0.8
Ebola & Marburg^	178	599	475	350	419	411	341	2,771	39	6.9
Zika		5.3	169	247	206	117	100	844	11	2.0
Lassa fever		9.8	34	35	46	59	51	235	5.6	1.0
CCHF & RVF		2.0	11	21	14	20	25	93	2.0	0.5
Nipah & other henipaviruses			14	13	11	24	24	86	2.3	0.5
Core funding of a multi-disease R&D organsiation			6.6	7.4	20	16	17	67	1.6	0.3
Disease X & Other R&D			43	115	245	358	465	1,226	34	9.4
Platform technologies			16	51	98	213	298	677	20	6.0
Multi-disease vector control products#			20	29	40	56	59	205	5.4	1.2
Fundamental research			6.4	10	21	24	27	89	2.3	0.6
Other R&D			0.6	24	86	64	80	255	6.2	1.6
Total EID R&D funding*	178	616	778	834	1,006	1,044	4,936	9,390	100	100

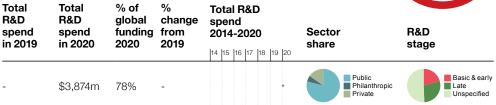
Category not included in G-FINDER

<sup>^</sup> Ebola was the only disease included in the 2014 survey. Value for Ebola in 2014 may include combined filoviral R&D.

<sup>#</sup> The 2016 total for multi-disease vector control products added retrospectively, and likely understates the true funding total.

<sup>\*</sup> Due to significant changes in the survey scope, totals for 2014 and 2015 cannot be directly compared to totals in later years, or to each other.

# COVID-19



FUNDING

million

The figures in this section differ slightly from those included in our Charting the R&D Response to COVID-19 Snapshot report. This is because, while both draw from the same G-FINDER survey data, all the disease-specific analysis in this report includes the funding provided by intermediary organisations, such as CEPI, while the Snapshot instead measures funding to intermediary organisations. The figures here better measure the direct R&D response to COVID-19, while the Snapshot, and the Funders chapter of this report, measure the funder response.

COVID-19 received 78% (\$3,874m) of global EID R&D funding in 2020, dwarfing every previous pandemic response. This represents the largest amount, and the largest share of funding, that any disease has received in any year across all the global health areas covered by the G-FINDER survey.

This figure, though, still understates the total amount of global R&D funding for COVID-19. Several major COVID-19 products were developed by nations, such as China and Russia, or partly self-funded by pharmaceutical companies, like Pfizer and Moderna, for which we lack survey data; meaning that the true COVID R&D funding total is likely even higher than our \$3,874m estimate.

In the seven years since 2014 we have captured just over \$4bn in funding for specific non-COVID EIDs and a further \$1.4bn in EID-focused core funding, Disease X, and other multi-pathogen R&D.

**Unmet R&D needs:** As of April 2022, there were 35 vaccines approved for use by at least one national regulatory authority,¹ ten of which have WHO Emergency Use Listing.² Under the WHO's recently-revised Target Product Profile (TPP), a need remains for vaccines which confer protection against severe disease for at least one year and are active against other coronaviruses and/or potential future variants. Other key attributes of the TPP address LMIC needs, such as non-parenteral administration, higher thermostability, lower frequency of booster doses, and potential coadministration with other vaccines.

There is a need for therapeutics to reduce mortality in hospitalised symptomatic patients with COVID-19, including pregnant women and children under six,<sup>3</sup> preferably a daily oral dose, or a short-course parenteral or inhaled therapy for those requiring ventilation. Only two antivirals have received WHO prequalification<sup>4</sup> – Pfizer's Paxlovid (nirmatrelvir/ritonavir) and Gilead Sciences' Veklury (remdesivir) – both of which are for patients at high risk of hospitalisation. The WHO also conditionally recommends the use of the antiviral molnupiravir developed by MSD (Merck) and two monoclonal antibody therapies – Regeneron's REGENCOV (casirivimab/imdevimab) and GSK's Xevudy (sotrovimab) – early in cases where there is elevated risk of severe disease or hospitalisation.<sup>5</sup>

Two diagnostic TPPs remain unmet: point-of-care tests for prior infection with SARS-CoV-2, and test for prior infection with SARS-CoV-2 suitable for analysing a moderate to high volume of samples. Molecular diagnosis of SARS-CoV-2 is recommended by the WHO and is considered the gold standard for case confirmation. However, it is complicated, costly, and slow to execute and not readily accessible in low-resource settings. As of April 2022, 28 in vitro diagnostics have received WHO Emergency Use Listing, six of which are rapid antigen tests. Though less sensitive, antigen-detecting rapid diagnostic tests are quicker, cheaper and can be used outside of clinical and laboratory settings.

In October 2021 the WHO developed a clinical case definition of post-COVID condition (also known as long-COVID), referring to a variety of symptoms affecting different organs following infection.<sup>8</sup>

pipeline spotlight SK bioscience and GSK are seeking approval for their recombinant protein-based SKYCovione vaccine candidate with GSK pandemic adjuvant, after Phase III trials demonstrated its superiority to AstraZeneca's Vaxzevria; they plan to make the vaccine available through COVAX.9 Veru Inc. has applied for US FDA Emergency Use Authorization for sabizabulin, an anti-inflammatory and antiviral drug to treat hospitalised patients at high risk of acute respiratory distress syndrome following Phase III trials which demonstrated a 55% reduction in mortality.10

After a single year, disbursements for COVID-19 are approaching the total for all other individual EIDs over the last seven years, and now represent more than 40% of all the EID-related funding we have on record.

Table 3, COVID-19 R&D funders 2020

	- millio	ons)
AQ <sup>3</sup> /	15811	020
under	2020	
US BARDA	827	21
US NIH	567	15
CEPI	536	14
German BMBF	525	14
Aggregate industry	503	13
Gates Foundation	171	4.4
Indian DBT	134	3.5
Canadian CIHR	76	2.0
Japanese government (including MOFA and MHLW)	58	1.5
US government contracts	48	1.2
EC	42	1.1
UK NHS	40	1.0
Subtotal of top 12^	3,527	91
Disease group total	3,874	100

The US Biomedical Advanced Research and Development Authority (BARDA)\* was by far the largest provider of COVID R&D funding, accounting for over a fifth (\$827m) of the 2020 total. It was followed by the US National Institutes of Health (NIH), the Coalition for Epidemic Preparedness Innovations (CEPI), the German BMBF and industry, each providing over \$500m. Together, US BARDA and NIH provided over a third (\$1,393m, 36%) of all COVID-19 funding in 2020.

The Gates Foundation was the next largest funder, and the largest philanthropic funder, providing 4.4% (\$171m) of global investment. The Indian DBT, with \$134m, was the only other funder to provide over \$100m.

National funding totals roughly reflect the locations of the leading funders: the US heads the list, having provided 50% (\$1,923m) of the global total, with Germany (\$550m) and Norway (\$537m) each providing 14%. France (\$201m, 5.2%) and India (\$181m, 4.2%) provided the next largest shares, followed by the UK, Canada, Japan and the EC, who were the only other sources to provide over 1% of the total. In all, 130 funders from 31 countries reported having provided funding for COVID-19 R&D in 2020.

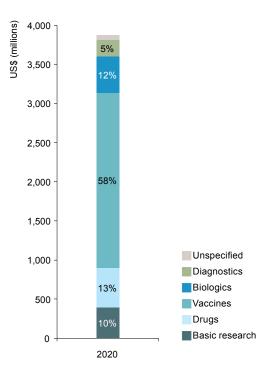
More than half of COVID R&D funding was for vaccines (\$2,238m, 58%), in line with previous epidemic responses for which we have data. The next largest shares were for therapeutics, with drugs receiving 13% (\$506m) and biologics receiving 12% (\$469m), slightly above the 10% (\$395m) share for basic research. Diagnostics research received the lowest share, at just 5.2% (\$203m), although this is still the highest share of investment in diagnostic R&D for any individual pathogen other than Zika.

<sup>\*</sup> Funding attributed to 'BARDA' may also include funding from the budget of its parent entity, the Office of the Assistant Secretary for Preparedness and Response (ASPR).

Among the top funders, CEPI and the BMBF focused nearly exclusively on vaccine research, while BARDA combined its vaccine funding with significant contributions to drug, biologic and diagnostic R&D.

In line with its historic role, the US NIH focused more on basic research, providing over half of global basic research funding. The remaining funding for basic research was more evenly spread between funders, especially compared to vaccine funding, with 70 other organisations funding basic research, and none of them providing even 10% of the global total. The same general pattern holds, though to a lesser extent, across all areas of COVID R&D, with 63 different organisations providing drug R&D funding, and 54 funding diagnostic R&D. Overall, COVID received R&D funding from 130 different organisations, more than twice as many as provided funding for Ebola at any point in the last seven years.

Figure 2. COVID-19 funding by product 2020



While some funders, notably CEPI, do not detail what stage of R&D they are supporting, well over half (\$1,112m, 58%) of the funding that *did* identify an R&D stage went to clinical development, a pattern which we believe broadly holds for CEPI and other providers of stage-unspecified funding as well.

This focus on clinical development differs from the response to the earlier epidemics in our dataset, which typically shows most funding initially flowing to the kinds of basic & early-stage research necessary to identify potential product candidates. In the first full year of the West African Ebola pandemic, for example, clinical development received just over 20% of (stage-specified) global funding; or 33% in the first year of the South American Zika outbreak. This appears to match our real world observations of a rapid advancement of candidates through preclinical and into clinical development within months of their inception, drawing on repurposed platforms – like Oxford's ChAdOx1 – that had been in development long before the pandemic, leading to multiple products receiving WHO Emergency Use Listing less than a year after the virus was widely known to exist.

A little over two-thirds of the overall funding for COVID R&D came from public organisations (\$2,604m), more than 90% of which came from high-income countries. CEPI and other intermediary organisations provided the next largest share, at 15% (\$578m) followed by industry, with 13% (\$503m). Philanthropic sources provided just under 5% of the total (\$189m), mostly from the Gates Foundation.

This represents a similar share of overall philanthropic and industry funding to other EIDs, but a much larger share from intermediaries and low- and middle-income (LMIC) governments and, accordingly, a lower share of high-income country public funding.

## CORONAVIRUSES (INCLUDING MERS, SARS AND MULTIPLE CORONAVIRUSES)



Total R&D spend in 2019	Total R&D spend in 2020	% of global funding 2020	% change from 2019	Total R&D spend 2014-2020	Sector share	R&D stage
\$39m	\$40m	0.8%	4.4%	<b>/</b>	Public Philanthropic Private	Basic & early Late Unspecified

This chapter covers funding for Priority coronaviruses other than COVID-19, including all multi-coronaviral R&D that targets at least one Priority coronavirus. The multi-coronaviral category includes R&D for COVID-19 alongside one or more other coronaviruses. All totals and shares exclude R&D funding that is exclusively for COVID-19.

Funding for 'non-COVID coronaviruses' – Middle East Respiratory Syndrome (MERS), Severe Acute Respiratory Syndrome (SARS), and research on multiple coronaviruses including COVID-19 – totalled \$39m in in 2019, down \$5.8m (-13%) from 2018's total of \$44m. Funding rebounded slightly in 2020, to \$40m, leaving non-COVID coronaviruses as the sixth largest recipient of EID R&D funding – broadly in line with its pre-COVID ranking.

Overall funding has remained relatively stable since 2017, ranging from a high of \$46m in 2017 to a low of \$39m in 2019. This apparent stability, though, conceals big shifts in funding for individual areas of research and development.

Multi-coronaviral R&D dropped to \$2.3m in 2019 (just 6.0% of coronavirus R&D) representing a second year of decline from a peak of \$8.1m in 2017. A COVID-driven rebound in 2020, however, saw a six-fold increase in investment in this area, leaving it with more than a third of all non-COVID coronavirus funding.

**Unmet R&D needs:** Currently, there are no approved drugs or vaccines targeting MERS-CoV or SARS-CoV-1 infections. Research and development for SARS has largely stalled in the absence of further outbreaks and of Target Product Profiles (TPPs) to align R&D activities. An overarching challenge impeding all aspects of MERS research is the weakness of the available animal models in accurately mimicking the disease and severe infections in humans.<sup>11</sup>

The WHO recommends the development of three MERS-CoV vaccine categories: a single dose vaccine for reactive use in outbreak settings, a two-dose vaccine for long-term protection for those at continual high risk (such as healthcare workers and camel handlers), and a reservoir-targeted vaccine for juvenile dromedaries to reduce or prevent viral shedding. Various candidates based on DNA and viral-vector are in the early stage of clinical development. Only two SARS vaccine candidates have ever been tested in humans and no candidate has yet passed Phase I trials. It

Based on the current understanding of MERS pathogenesis, a combination antiviral and antibody therapy would help avoid viral escape, while enabling researchers to learn more about the virus' evolution and immune response in survivors. <sup>15</sup> Based on this approach, a combination of a repurposed drug (lopinavir/ritonavir) and a biologic (IFN- $\beta$ 1b) completed Phase IIb/III trials in 2020. <sup>16</sup> Additionally, a human polyclonal antibody (SAB-301) and a cocktail of human monoclonal antibodies (REGN3048-3051) have completed Phase I trials, while remdesivir, a novel broad-spectrum antiviral with a proven safety profile, is in pre-clinical evaluation.

Creation of an accurate, rapid test to diagnose MERS is rendered challenging by the need for specimens taken from the lower respiratory tract. Consequently, there are currently no point-of-care molecular tests or RDTs available for use outside of research, requiring suspected samples to be sent to a laboratory with biosafety capabilities. To Development of a sensitive, specific, and easily administered diagnostic assay is needed for case confirmation as well as surveillance, epidemiological studies and efficacy assessments in clinical trials. To

pipeline spotlight In 2021, Inovio commenced Phase II trials of their DNA vaccine INO-4700 in Jordan and Lebanon, supported with funding from CEPI.<sup>18</sup> Ardis Pharmaceuticals announced preclinical efficacy of a pan-coronavirus mAb cocktail (AR-701) showing broad reactivity against COVID-19 variants, SARS and MERS in December 2021.<sup>19</sup> A new ultra-rapid real-time RT-PCR test using a mobile PCR device demonstrated a similar sensitivity and specificity to conventional real-time PCR instruments, detecting MERS-CoV RNA within 20 minutes.<sup>20</sup>

MERS funding grew rapidly after its 2016 inclusion in the survey, peaking at \$35m in 2018, when it received 78% of global coronavirus funding. Funding dropped in 2019, and again, sharply in 2020, falling by a total of \$16m and leaving it at just over half of its 2018 peak. Its 2020 share of global non-COVID coronavirus funding, at less than 47%, is equal to its 2016 low. However, some of this post-2018 decline may reflect the lack of 2019 and 2020 disbursement data from the Korea-based International Vaccine Initiative (IVI), which was the third largest funder in 2018, providing \$6.4m in MERS funding.

SARS, on the other hand, has always received far less R&D funding than MERS – a little over a third as much since 2016, when both were included in the survey. Other than a drug R&D-driven peak in 2017, SARS funding has remained relatively low and stable averaging around \$7m a year. It rebounded from a low of \$5.8m in 2018, growing by just under \$1m in both 2019 and 2020, placing it at \$7.6m.

Table 4. Coronaviruses (including MERS, SARS and multiple coronaviruses)
R&D funding 2016-2020

jisea <sup>se</sup> (	15\$ millo	ns)			C	Jumulative 2	2 total 019 % of	10tal 020 % of to
ise	2016	2017	2018	2019	2020			
Middle East Respiratory Syndrome	12	24	35	29	19	120	76	47
Severe Acute Respiratory Syndrome	7.8	13	5.8	6.8	7.6	41	18	19
Other coronaviral R&D in combination with MERS and/or SARS and/or COVID-19	6.1	8.1	3.8	2.3	14	34	6.0	35
Disease group total	26	46	44	39	40	195	100	100

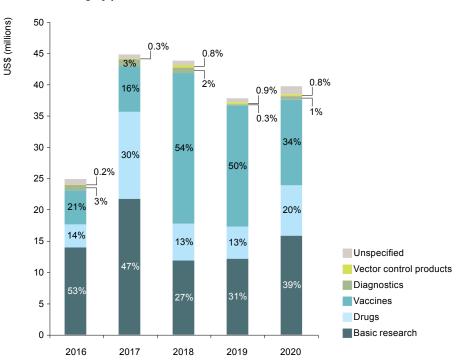
A 2018 spike in **MERS** R&D funding was a result of the first round of funding from CEPI. CEPI's initial \$12m in disbursements made it 2018's top funder, though this was partly thanks to a big drop in funding that year from the US NIH – which was the top MERS R&D funder every year before and since. The \$5.3m fall in overall MERS funding in 2019 came in spite of relatively consistent funding from CEPI, and a \$4.9m (43%) rebound in NIH funding. Alongside a substantial drop in UK DHSC funding – down 85% (-\$1.4m) in 2019 – much of this fall was due to the aforementioned absence of reported funding from the IVI. While we lack data on how closely the IVI's MERS funding mirrored its record 2018 figure of \$6.4m, data on funding *received* by the IVI shows a big drop in its incoming MERS-specific funding in 2019 following the scheduled conclusion of a three-year grant, suggesting that the headline drop is at least partially real.

The larger, nearly \$11m, drop in 2020 MERS funding was almost entirely due to CEPI funding dropping by \$10m, to less than \$100k, effectively placing its non-COVID coronavirus funding on hold and pivoting toward pandemic response. Early 2020 also saw the end of the EC's Zoonotic Anticipation and Preparedness Initiative (ZAPI), leaving it with essentially zero MERS funding in 2020.

CEPI's funding in 2018 and 2019 took the share of MERS funding going to vaccine R&D to 60% over the last three years, up from just 28% in 2017. Remaining changes in the distribution of MERS funding mostly reflect shifts in funding from the US NIH, including a near-250% increase in its vaccine funding in 2019, the cessation of its biologics funding after 2017, and a one-off spike in its drug funding in 2017. Though 2020's MERS vaccine R&D total of \$8.5m is down nearly \$15m from 2018's total of \$23m, it remains the highest total going to any (non-COVID) coronavirus product area.

MERS has received effectively all of the clinical developmental funding for non-COVID coronaviruses since 2016, more than 90% of which has gone to vaccines. In 2019, its funding for clinical development dropped from \$20m to \$2.3m, and to less than \$0.3m in 2020, meaning that product development for non-COVID coronaviruses essentially ceased.

Figure 3. Coronaviruses (including MERS, SARS and multiple coronaviruses) funding by product 2016-2020



Virtually all global funding for **SARS** R&D since 2016 has been provided by the US NIH. Funding from other organisations totalled just over half a million dollars over five years, with no other funding at all in 2019 or 2020. This may slightly overstate the concentration of SARS funding, since the largest non-NIH funder, the German DFG, did not participate in the G-FINDER survey for either 2019 or 2020, after reporting \$0.3m in 2018 funding.

Every year, more than half of the NIH's SARS funding has gone to basic research – peaking at 62% of its total funding in 2020. Nearly two-thirds of the remainder has gone to drug R&D, boosted by a one-off spike in 2017 which accounts for about half of overall SARS drug funding. Vaccine funding – essentially all from the NIH – has averaged around \$1m a year, 12% of the overall SARS total. Diagnostics received about 3.7% of all SARS funding, and effectively none in either 2019 or 2020. There has been no recorded clinical development for SARS since the \$0.2m in NIH-funded vaccine development in 2016.

Nearly 80% of **multi-coronaviral** R&D prior to 2020 was funded by the US NIH, with much of the remainder coming from the German DFG. This picture changed considerably in 2020, with nine organisations providing multi-coronavirus funding for the first time following the outbreak of COVID-19, headlined by \$2.8m in drug R&D funding from the Gates Foundation and \$2.4m split across vaccines and basic research from the Canadian CIHR.

This drove a substantial shift in the distribution of multi-coronavirus funding. Prior to 2020, nearly 90% of multi-coronavirus funding went to basic research, with about half the remainder going to diagnostics R&D. In 2020, the share of basic research funding dropped by more than half to 41%, with most of the remainder divided relatively evenly between drug and vaccine R&D. In fact, nearly 90% of all recorded drug and vaccine funding for multiple coronaviruses took place since the start of 2020.

Table 5. Top coronaviruses (including MERS, SARS and multiple coronaviruses)
R&D funders 2020

	15\$ (millio	ns)			(	cumulative 2	2 total	otal 020% of t	otal
Funder	2016	2017	2018	2019	2020				
US NIH	21	38	20	25	31	135	64	76	
Gates Foundation	-	-	-	-	2.8	2.8	-	6.9	
Canadian CIHR	-	-	0.1	0.3	2.6	3.0	0.7	6.4	
Swiss SNSF	<0.1	0.4	<0.1	0.3	0.8	1.6	0.9	1.9	
German BMBF	-	<0.1	0.5	0.8	0.6	2.0	2.0	1.6	
US BARDA	0.3	0.5	0.5	0.5	0.5	2.4	1.4	1.3	
French ANR	-	-	0.6	-	0.4	1.0	-	1.1	
USAID	-	-	-	-	0.3	0.3	-	0.8	
French ANRS	-	-	-	-	0.3	0.3	-	0.8	
UK DHSC		1.5	1.7	0.2	0.3	3.7	0.6	0.6	
Australian NHMRC	-	<0.1	0.2	0.2	0.2	0.7	0.6	0.6	
Wellcome	-	-	<0.1	0.1	0.2	0.4	0.3	0.5	
Subtotal of top 12 <sup>^</sup>	26	46	44	38	40	194	70	98	
Disease group total	26	46	44	39	40	195	100	100	

Funding organisation did not participate in the survey for this year.

High-income country public funders provided nearly three-quarters of MERS, SARS, & multiple coronavirus funding in 2019 and increased their share to 92% in 2020, more than three-quarters of which came from the US NIH. Philanthropic funders provided the next largest share in 2020 with \$3.0m (7.3% of the total), a significant increase from 2019, consisting mostly of a single \$2.8m multi-coronavirus disbursement from the Gates Foundation to the University of Dundee. Industry has never played a significant role in funding for non-COVID coronaviruses, a trend which continued in 2019 and 2020.

<sup>^</sup> Subtotals for 2016-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative subtotal, the top 12 funders are those with the highest overall totals.

No reported funding

## EBOLA AND MARBURG



Total R&D spend in 2019	Total R&D spend in 2020	% of global funding 2020	% change from 2019	Total R&D spend 2014-2020	Sector share	R&D stage
\$411m	\$341m	6.9%	-17%	<b>/</b>	Public Philanthropic Private	Basic & early Late Unspecified

Funding for filoviral R&D fell slightly in 2019 and then sharply in 2020, dropping by nearly a fifth over the two years. This brought 2020 funding to \$341m, its lowest level since 2014 when funding data was first gathered. Both year's drops were almost entirely due to a big fall in Ebola-specific funding, which decreased by \$17m between 2018 and 2019, and a further \$69m in 2020. This took Ebola's share of filoviral R&D to a record low of 83% in 2020, with Marburg receiving 10% and multiple filoviral R&D the remaining 7% – both record highs.

The US BARDA became the top funder of **Ebola** in both 2019 and 2020, after increasing its funding each year since 2014, and despite repurposing some Ebola programmes to address COVID-19. However, since we prorate BARDA's total programme amounts to estimate its annual contributions, these figures may not fully capture how much COVID changed BARDA's outlays in 2020.

Most of the big net decrease in Ebola funding from its second, DRC-outbreak-driven, peak in 2018 was due to a steep reduction in funding from the US NIH, which cut its Ebola spending by more than \$80m (-60%) over two years. While this drop was spread across many recipients, the largest single decline was a fall of \$26m to Leidos, which had been contributing to the PREVAC West African vaccine trials. Industry funding, having collapsed from nearly \$250m in 2015 to \$60m in 2018, remained fairly stable in comparison – sagging by a further \$14m over two years, with most of the fall coming in 2020.

2019 saw CEPI's first funding for Ebola, \$11.6m in 2019 and another \$6.7m in 2020. Unlike CEPI funding for other EIDs, CEPI's Ebola funding represents only a small proportion of global funding – just 2-3%, compared to 14% for COVID and an average of 43% for its other priority diseases – and is backed by earmarked EC funding rather than supporting a Call for Proposals.

**Unmet R&D needs:** In December 2019, MSD's ERBEVO became the first FDA-approved Ebola vaccine, and is now licensed in four African countries. It was also a vital part of the outbreak response in the North Kivu, DRC Ebola epidemic<sup>21</sup> – the first Ebola outbreak in which a vaccine was widely deployed – being used to vaccinate approximately 300,000. In 2020, the European Medicines Agency (EMA) gave marketing authorisation to Janssen's multivalent heterologous prime-boost vaccine. <sup>22,23</sup> Although vital progress has been made in developing vaccines since the 2014 West African Ebola outbreak, neither approved vaccine has been clinically proven to meet the requirement of providing protection against multiple strains, including the Marburg virus, as set out in the WHO's Ebola vaccine Target Product Profile (TPP).

During the 2014 Ebola outbreak, the absence of bench-top or point-of-care diagnostic tools meant that laboratory-designed tests were the only tool available for confirmatory diagnosis. Since then, the Ebola diagnostics pipeline has improved significantly, with multiple point-of-care (POC) molecular and rapid diagnostic tests (RDTs) now available. The increased speed at which field laboratories with molecular testing capabilities became functional (from months to days) in the 2018-2020 DRC outbreak is testimony to the remarkable progress made in the past seven years. While these developments have indeed been life-saving, to date only one<sup>24</sup> of the available POC diagnostic tests meet the WHO TPP<sup>25</sup> requirements for sensitivity and specificity benchmarks of >98% and >99%. There is therefore a need for continued product development efforts focused on improving existing diagnostic tools and designing novel approaches.

While no TPP for a Marburg virus diagnostic test currently exists, the WHO Ebola/Marburg Research and Development Roadmap<sup>26</sup> points to the need for similar rapidly deployable multiplex POC diagnostic tests, effective against both filoviruses, with rapid turnaround times and needing minimal laboratory infrastructure.

pipeline spotlight A Phase I trial has been launched by the University of Oxford, for a new ChAdOx1 biEBOV vaccine candidate effective against both Zaire and Sudan Ebola virus species. <sup>27</sup> It seeks to establish the safety and immunogenicity of the new candidate for subsequent studies. In October 2020, the US FDA approved Inmazeb (REGN-EB3), the first biologic candidate for treating Zaire Ebola virus. <sup>28</sup> A second biologic – Ebanga (Ansuvimab-zykl) was approved in December of the same year. <sup>29</sup>

Table 6. Ebola & Marburg R&D funding 2014-2020

Djeease \	15\$ millio	ue)					C	Cumulative	3 total	total 1020 % of to
Disc	2014	2015	2016	2017	2018	2019	2020			
Ebola	178	567	427	309	367	350	281	2,478	85	83
Marburg	-	19	27	26	36	38	35	180	9.2	10
Other filoviral R&D in combination with Ebola and/or Marburg	-	13	21	16	16	23	25	112	5.6	7.3
Disease group total	178	599	475	350	419	411	341	2,771	100	100

Of the other major funders of Ebola R&D at the 2015 peak of the West African epidemic, the US DOD continued its decline, dropping by a further \$18m (-66%) between 2018 and 2020, while the EC – its funding already 85% below its peak by 2018 with the conclusion of Innovative Medicine Initiative's Ebola + program – saw its funding rebound slightly, to just under \$10m. While BARDA's vaccine funding declined alongside the global total, the overall rise in its Ebola funding was thanks to a jump in its biologics R&D, going mostly to Regeneron (up \$50m in 2020).

This increase in BARDA's biologics funding capped four consecutive years of growth and took biologics R&D to \$131m – a near majority (47%) of Ebola funding in 2020. The increase came as BARDA's funding pivoted from Mapp Biopharmaceutical's ZMapp to Regeneron's REGN-EB3, after the latter demonstrated superior efficacy and safety in 2019's PALM trial. But some portion of the increased contract value BARDA and Regeneron agreed to in 2020 may cover BARDA's stockpiling of REGN-EB3 doses, meaning its actual R&D spending may be substantially lower than our figures suggest.

Table 7. Top Ebola & Marburg R&D funders 2020

,	JS\$ (millo	ns)					(	cumulative	2 total	otal 020% of the
Funder	2014	2015	2016	2017	2018	2019	2020			
US BARDA	30	70	70	81	132	158	165	706	38	48
US NIH	67	109	151	134	156	117	73	805	28	21
Aggregate industry	37	247	141	63	61	62	47	657	15	14
US DOD	12	71	42	18	54	40	26	263	9.7	7.8
EC	4.9	49	50	38	7.6	9.9	9.9	169	2.4	2.9
Sabin Vaccine Institute	-	-	-	-	-	0.2	7.6	7.7	<0.1	2.2
CEPI			-	-	-	12	6.7	18	2.8	2.0
US CDC	-	6.8	5.1	3.4	2.7	3.8	2.9	25	0.9	0.9
EDCTP	-	-	-	<0.1	0.1	6.4	0.9	7.5	1.6	0.3
Inserm	5.8	3.5	1.2	3.4	2.1	0.9	0.6	17	0.2	0.2
UK MRC	1.3	17	-	-	-	0.6	0.5	19	0.1	0.2
Innovate UK	-	-	-	0.8	0.7	0.5	0.4	2.3	0.1	0.1
Subtotal of top 12^	177	592	471	349	417	410	340	2,756	99.8	99.8
Disease group total	178	599	475	350	419	411	341	2,771	100	100

Funding organisation did not participate in the survey for this year.

<sup>^</sup> Subtotals for 2014-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative subtotal, the top 12 funders are those with the highest overall totals.

<sup>-</sup> No reported funding

Ebola vaccines, on the other hand, saw a fifth consecutive year of decline from their peak of \$407m in 2015. The big drop in 2020 funding was due to a large decrease in Phase III vaccine funding, partly offset by a smaller shift towards post-registration studies. This reflects the US FDA's approval of MSD's ERVEBO vaccine in December 2019 and European Medicines Agency (EMA) approval of J&J's Ebola vaccine regimen in mid-2020, and suggests the decline in spending represents a genuine reduction in unmet need.

Like vaccines, funding for Ebola diagnostics peaked – at \$21m – in 2015. Funding then fell every year, until a slight (\$0.3m) rebound in 2020, leaving it at \$2.9m.

Basic research reached its highest funding level in 2018 at \$61m and fell in both 2019 and especially in 2020, leaving it only a little higher than its \$20m total in the first year of the pandemic. While most of the drop was due to reduced funding from the US NIH – responsible for nearly 90% of basic research funding over the last five years – 2020 also saw a cessation of Ebola basic research funding from the US CDC and from industry.

As with basic research, Ebola drug funding reached its peak after the West-African pandemic – growing by \$19m to \$46m in 2018 thanks to a one-off \$22m spike in US DOD funding for an early-stage antiviral programme that appears to have since wound-down. Funding from the NIH, the other major supporter of drug R&D, also dropped (by \$11m) in 2019, contributing to record low drug funding in 2019, which stayed essentially unchanged in 2020.

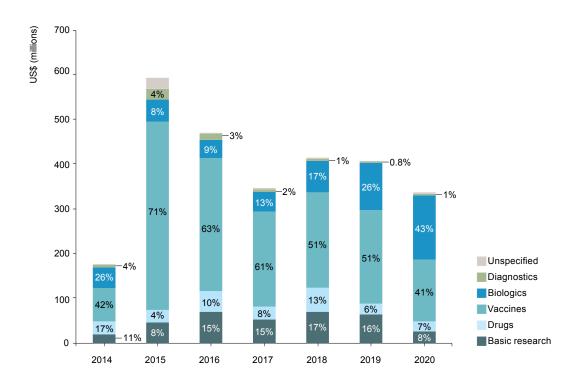


Figure 4. Ebola & Marburg funding by product 2014-2020

Like Ebola, funding for **Marburg** R&D also declined between 2018 and 2020, increasing by \$1.4m in 2019, only to drop by \$3.0m in 2020. But Marburg-specific R&D funding has largely retained the bump in funding it experienced in 2018, its average of \$36m of the last three years more than 50% higher than over the preceding three.

This enduring increase in Marburg R&D funding comes in spite of the ongoing falls from its top funder – the US NIH. The NIH had been responsible for 99% of Marburg funding over its first three years of inclusion in the G-FINDER survey, but only around half of the total funding since 2018. This shift is mostly thanks to a 2018 vaccine funding stream from the US DOD, and the first full year of a new US BARDA biologic funding to Mapp Biopharmaceutical in 2020 for the 'pan-Marburg Medical Countermeasure', which more than doubled funding for biologics R&D.

**Multi-filoviral** funding grew sharply in 2019 to a then-record-high \$23m, before rising further, to \$25m, in 2020. These shifts in multi-filoviral funding mostly reflect spikes in US NIH biologics and vaccine funding in 2019 – which took its overall funding to a record high – followed by the ramp up in BARDA-backed onward funding from the Sabin Vaccine Institute in 2020 for its combined Ebola and Marburg vaccine programme, which made it the largest funder of multi-filoviral R&D in 2020.

The vast majority (82% in 2020) of overall funding for Ebola & Marburg R&D continued to come from the high-income country public sector, primarily US government organisations and the EU. The share of philanthropic funding, which made up 7.4% of the initial, 2014 wave, has fallen every year since, down to almost nothing in 2020. Industry's contributions peaked at 41% in 2015, falling to 14% by 2020.

# ZIKA Sotal Total % of % Total R&D

Total R&D spend in 2019	Total R&D spend in 2020	% of global funding 2020	% change from 2019	Total R&D spend 2014-2020   14   15   16   17   18   19   20	Sector share	R&D stage
\$117m	\$100m	2.0%	-15%		Public Philanthropic Private	Basic & early Late Unspecified

Funding for Zika R&D continued to fall in both 2019 and 2020, declining by a total of \$107m (-52%) to a little under \$100m in 2020 – its lowest level since the start of the 2016 epidemic. Much of the fall occurred in 2019, with a \$90m drop continuing the decline from its peak of \$247m in 2017. In 2020, Zika was the third-highest funded EID in the G-FINDER survey, with a 2.0% share of global funding.

Much of the fall in total Zika funding over the previous two years was driven by declines in funding from the top two funders, US BARDA and the US NIH. BARDA's funding fell \$55m in 2019 (-69%) driven by a \$49m reduction in vaccine R&D funding, while the smaller \$8.1m drop in 2020 was mostly due to its reduced funding for diagnostics. These reductions meant that BARDA was responsible for the majority of the big 2019 drop in global Zika funding, and a little under half of the smaller fall in 2020. BARDA's funding has dropped by nearly 85% from its peak of almost \$100m in 2017, when it was the top funder of Zika R&D and provided two-fifths of global funding, with a focus on clinical development of vaccines and diagnostics. This left the US NIH as the largest funder of Zika R&D in both 2019 and 2020, as it was in 2016, in the early stages of the South American epidemic.

**Unmet R&D needs:** Research is ongoing for potential therapies and vaccines to prevent Zika virus infection and Congenital Zika Syndromes (CZS). However, further investigation of epidemiology, clinical manifestations, and long-term sequelae of CZS is urgently needed.<sup>30</sup>

The ideal prospective vaccine should be appropriate for both endemic and outbreak settings and have an excellent safety profile in pregnant and lactating women. The most advanced candidate is a DNA vaccine (VRC 705), which completed Phase II trials in October 2019.<sup>30</sup> Multiple additional vaccine candidates are currently in Phase I trials.<sup>31</sup> While the Zika vaccine pipeline has progressed significantly, the low incidence and unpredictable nature of the outbreaks, diversity of clinical manifestations and infeasibility of trials using CZS as the primary endpoint make it difficult to conduct late-stage efficacy trials. Alternative approaches, such as accelerated regulatory pathways with immune correlates or animal rule, Controlled Human Infection Models or surrogates as endpoints are under consideration.<sup>30</sup>

Ideal treatments for Zika should be suitable for both therapeutic use for treating intra-uterine infection and prophylactic use, including prevention of mother to child infections. Even with the potential licensure of a Zika vaccine, drugs can play a valuable preventive role in areas of low endemicity. Currently, two biologics – a human monoclonal antibody (Tyzivumab) and an immunoglobulin (ZIKV-IG/NP-024) – are the only therapeutics in clinical development.<sup>30</sup> The single biggest challenge in developing Zika therapeutics is the discovery of an agent which is not teratogenic but which can prevent congenital Zika infection.<sup>30</sup>

The diagnostic pipeline for Zika has improved since 2015, with multiple point-of-care (POC) or near-POC molecular and serological assays already approved by the US FDA and WHO under both emergency use and standard pathways. However, none of the FDA approved PoC tests adequately addresses multiplexing with other co-endemic and cross-reacting flaviviruses, such as dengue and Chikungunya. <sup>32, 33</sup>

Aedes mosquito control programmes in Zika-affected countries must overcome urban outdoor transmission and high levels of infestation. Several recent field studies have confirmed reduced incidence of arboviral diseases after implementation of Wolbachia-based microbial control, while as-yet-unvalidated modelling studies suggest high efficacy of genetic manipulation.<sup>34</sup>



Two repurposed drugs, Asunaprevir and Simeprevir, have exhibited potent antiviral activities in *in vitro* studies<sup>35</sup> while another broad-spectrum antiviral, Galidesivir, is undergoing preclinical evaluation in macaque apes.<sup>36</sup> Biologics Tyzivumab and ZIKV-IG/NP-024 have successfully completed Phase I trials and are under further clinical development.<sup>37</sup> In 2021, an RNA vaccine, mRNA-1893, entered Phase II trials.

The \$27m drop (-31%) in US NIH funding in 2019 was a result of its lower funding for basic research and vaccines R&D, with a relatively small \$0.9m recovery in 2020 thanks to slight increases in funding for basic research and biologics. Much of the remaining fall in Zika funding resulted from the near-halving of European Commission funding in 2020 (-\$4.6m, -49%), mostly in basic research as the ZIKAlliance project neared an end. In fact, all of the top Zika R&D funders during its peak in 2017 have reduced their funding, including a near-cessation of industry funding (down 97% since 2017) and the end of funding from the Gates Foundation and the Brazilian FINEP.

Zika still enjoys a long tail of smaller funders, though, with 34 different entities providing at least some funding in 2020 – broadly in line with the 35 funders it had in 2017, at the peak of the South American outbreak, and more than any individual pathogen other than COVID-19. Some of these historically smaller funders have increased their contributions in recent years. The US DOD, for example, has increased its funding every year since it began funding Zika R&D in 2017, reaching nearly \$3m in 2020 – up from just \$0.3m in 2017 – going mostly toward biologics and early-stage vaccine R&D.

There was \$0.8m in new 2020 funding for vaccine clinical development from Indian ICMR which offset the \$0.6m decline in its basic research budget. It has now provided \$4.2m over the last two years, after a gap in its Zika R&D programmes in 2018, and accounted for nearly 80% of 2020's LMIC public funding. Funding from Brazilian public organisations, which made-up two-fifths of the pre-outbreak total and peaked at \$9.3m in 2016, fell sharply in 2020, as several organisations ceased providing funding.

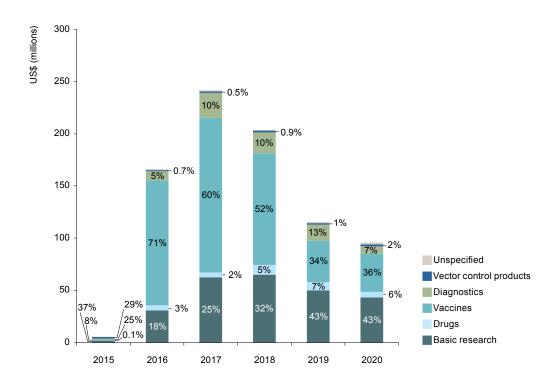


Figure 5. Zika funding by product 2015-2020

The big falls in overall funding since 2018 drove sustained contractions across almost every product area. While funding for all product categories fell between 2018 and 2019, by far the largest drop was for vaccines (down \$67m, -63%). In 2020, the biggest reduction was in diagnostics R&D (down \$8.0m, -52%) – after falling by \$5.0m in 2019 – driven by an 84% reduction in US BARDA funding from \$13m in 2018 to \$2.0m in 2020.

Despite its steady decline since 2017, the amount of funding for Zika diagnostic R&D stands out relative to other EIDs, accounting for over half of the global share of non-COVID disease-specific diagnostics R&D funding, possibly due to rising interest in the development of multi-disease diagnostics targeting Zika along with dengue and Chikungunya.

Funding for basic research also fell, but less steeply than product-specific funding. Having peaked at \$65m in 2018, basic research decreased in both 2019 and 2020, falling by a total of \$22m (-34%), mostly in 2019.

Though it remained small in absolute terms, funding for biologics R&D recovered in 2020, after falling to a low of \$1.2m in 2019 – just over a fifth of its 2017 peak. The growth in biologics funding was due to a 2020 rebound in funding from the US NIH and the ramp-up of two US DOD programmes, including one aimed at preventing Zika in pregnant women, and the first ever reported funding for clinical development of Zika biologics.

Zika-specific vector control funding has remained consistently low – between \$1m and \$2m every year. The low level of Zika-specific VCP funding is because most R&D targeting the *Aedes aegypti* mosquito – the primary vector for Zika – is categorised as multi-disease vector control, since it also targets the spread of dengue and Chikungunya. While the *level* of Zika VCP funding has remained consistent, its *share* of Zika funding has changed radically over the life of the South American outbreak: from nearly a third of all funding prior to the epidemic, to just 0.5% at its peak, to a little over 1.6% of the total for 2020.

Table 8. Top Zika R&D funders 2020

, d	JS\$ (millio	ns)				C	Jumulative 2	3 total 2019 % Of	otal
Funder	2015	2016	2017	2018	2019	2020			
US NIH	-	82	66	86	60	60	354	51	61
US BARDA	-	50	100	77	24	16	265	20	16
EC	-	2.7	11	11	9.4	4.8	38	8.0	4.8
Innovate UK	-	1.3	4.4	3.6	3.3	3.2	16	2.8	3.2
US DOD	-	-	0.3	1.0	2.1	3.0	6.3	1.8	3.0
Indian ICMR	-	0.5	0.6	-	1.6	2.5	5.2	1.4	2.6
Aggregate industry	0.6	8.8	40	11	2.2	1.3	64	1.9	1.3
Institut Pasteur	1.2	2.0	2.9	1.4	2.1	1.2	11	1.8	1.2
Inserm	-	-	-	0.3	0.6	1.1	2.0	0.5	1.1
French ANR	-	-	-	-	-	0.7	0.7	<0.1	0.7
UK MRC	1.3	0.1	0.1	0.2	0.8	0.7	3.2	0.7	0.7
German BMBF	-	-	<0.1	<0.1	0.7	0.6	1.4	0.6	0.6
Subtotal of top 12^	5.3	168	242	200	111	95	768	95	95
Disease group total	5.3	169	247	206	117	100	844	100	100

<sup>^</sup> Subtotals for 2014-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative subtotal, the top 12 funders are those with the highest overall totals.

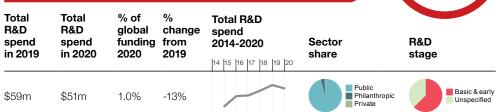
<sup>-</sup> No reported funding

Both basic & early-stage research and clinical development reached their respective peaks – of \$125m and \$105m – in 2017. While basic & early-stage research funding remains comparatively robust thanks to relatively consistent basic research funding, funding for all early-stage product research – other than drug R&D – declined steeply from its peak. With the end of the South American outbreak, funding for clinical development declined even more sharply, its share of Zika funding falling from 42% in 2017-2018 to 24% in 2019-2020.

In 2015, prior to the South American outbreak, public funding from HICs and LMICs was roughly equal, with each sector providing about \$2.2m. Yet their shares rapidly diverged as public HICs responded to the epidemic with a \$196m peak in 2017 while LMIC funding peaked at just \$10m in 2016 followed by a slow, inconsistent decline. Though there was increased investment from public LMICs in 2019 (\$3.4m, 83%), thanks to a resumption of funding from the Indian ICMR, it was offset by a decline from Brazilian funders in 2020 (-\$4.4m, -58%) leaving its funding close to its pre-2016 level.

Private sector investment, mostly from MNCs, fell from \$40m in 2017 to \$0.9m in 2020, while SME funding resumed in 2020 with \$0.4m for biologics R&D, after all-but-ceasing in 2017.

## LASSA FEVER



QAD FUNDING

million

Funding for Lassa fever and other arenaviruses continued to experience strong growth in 2019 – rising by \$12.5m (27%) to an all-time high of \$59m, before dropping by \$7.6m (-13%) to \$51m in 2020. Of this, more than 90% went exclusively to Lassa fever, with the remainder going to multi-arenavirus R&D.

As with the rapid growth in 2018, changes in CEPI's **Lassa fever** vaccine funding accounted for much of the movement in 2019 and 2020. CEPI's funding grew to \$27m in 2019 (up by \$6.1m, 29%), before dropping by \$5.7m (-21%) to \$21m in 2020. This left Lassa fever funding more than two-thirds above its pre-CEPI peak in 2017, reflecting the transformative impact of CEPI's entry into the funding landscape. With CEPI's funding focused exclusively on Lassa fever, multiple arenaviruses received a record low 4.5% share of funding in 2019 (\$2.7m), before rebounding slightly to 7.0% (\$3.6m) in 2020.

In total, CEPI disbursed \$69m between 2018 and 2020 towards the development of a Lassa fever vaccine, along with \$0.3m in funding for Nigeria-based basic research and another \$0.9m of diagnostics funding to FIND, which we capture based on FIND's onward funding. CEPI has been the leading funder of Lassa fever R&D every year since it began providing funding, its contributions accounting for a little under half of global funding and just over 80% of vaccine R&D. The scale of CEPI's funding also shifted the focus of funding away from basic research – which received the majority of global funding every year until 2018 – towards vaccines.

**Unmet R&D needs:** There is currently no approved vaccine for Lassa fever, resulting from the unique challenges Lassa poses:<sup>38</sup> genetic heterogeneity,<sup>39</sup> poorly-understood correlates of infection, the potential for immune-mediated neurological complications, and the requirement of simultaneous cell- and antibody-mediated response for optimal protection. The WHO's Lassa fever vaccine Target Product Profile for preventive use recommends a homologous vaccine which confers protection for at least three years, is safe for healthy adults and children, and provides coverage against Lassa virus lineages I to IV. Three investigational vaccines based on different platforms (DNA, measles virus vector and vesicular stomatitis virus vector) have progressed to clinical trials,<sup>39-41</sup> but none which meet the requirement for protection across all four lineages.

Easy-to-use diagnostic tests are needed for accurate detection, ideally across the disease spectrum and for multiple lineages. Most available RDTs and immunoassays are limited to research use, while the three existing CE-IVD marked molecular tests require a laboratory with bio-containment capabilities. Zalgen's commercially-available ReLASV® Antigen Rapid Test<sup>42</sup> underwent field evaluation in 2018, performing better than currently available qPCR tests<sup>43</sup> and signaling a promising advancement in Lassa diagnosis, though one that detects only three of the four known lineages. A novel, species-neutral, Double Antigen Binding Assay was recently found to have detection specificity of 83.3% from oral fluid samples.<sup>44</sup>

Ribavirin, in conjunction with supportive therapy, is the current mainstay of Lassa pre- and post-exposure prophylaxis (PrEP/PEP) treatment, despite inconclusive evidence of its efficacy as PEP. Ribavirin is most effective when given intravenously and within the first six days of illness, leaving an unmet need for a stable oral therapeutic agent which is effective against multiple lineages.

More studies are needed on the mechanism of action, indications and optimal routes of administration of the current ribavirin-based treatment, which is backed by only one, non-randomised, study. A better understanding of ribavirin could open up new avenues for discovering new therapies, including combination treatments with newer candidates.

pipeline spotlight In 2021, following positive Phase I trial results, the International AIDS Vaccine Initiative (IAVI) plans to advance its Lassa vaccine candidate, rVSV $\Delta$ G-LASV-GPC LASV, which is based on FDA approved technology, into Phase IIb clinical trials,<sup>41</sup> making it the most advanced vaccine candidate in the pipeline. In 2021, Kineta Inc also announced positive Phase I trial results for the world's first oral Lassa virus entry inhibitor LHF-535.<sup>45</sup>

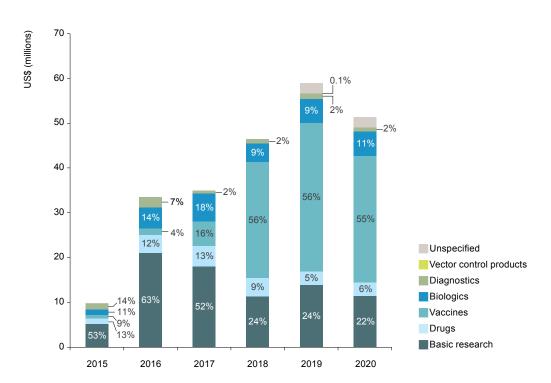
Table 9. Lassa fever R&D funding 2015-2020

Djsease \	15\$ (millio	ns)				(	Sumulative 2	ot9 % of	ozo % of tot
Disc	2015	2016	2017	2018	2019	2020			
Lassa fever	8.8	25	28	43	56	48	210	95	93
Other arenaviral R&D in combination with Lassa fever	1.0	8.4	6.6	3.3	2.7	3.6	25	4.5	7.0
Disease group total	9.8	34	35	46	59	51	235	100	100

CEPI's vaccine disbursements support a portfolio of six recombinant viral vector and nucleic acid candidates. Of these, IAVI's candidate,  $rVSV\Delta G$ -LASV-GPC, has received consistent funding since 2018 – including \$7.5m in 2020 alone. In 2021, the EDCTP and CEPI announced they would jointly support its Phase IIb clinical trials in West Africa, which we anticipate leading to further increases in reported funding over the coming years.

In contrast to CEPI's heavy focus on vaccines, the US NIH – now the second largest funder of Lassa R&D – spread its funding across all product categories. Diagnostic R&D has traditionally relied heavily on NIH funding, with the NIH providing 95% of all Lassa diagnostic funding between 2015 and 2019. However, from a peak of \$1.9m in 2016, its funding has trended downwards, to a low of \$0.4m in 2020. Consequently, the NIH share of diagnostic funding fell to 51% in 2020, also partly thanks to a record \$0.3m from FIND in the second year of its Lassa fever response.

Figure 6. Lassa fever funding by product 2015-2020



Lassa drug funding continued to decline, reaching a five-year low of \$1.8m in 2020 thanks to reduced contributions from both Wellcome and the US NIH – the only two funders of Lassa drug R&D. However, Wellcome's steady stream of investment to Kineta, supplemented by funding from the US NIH, helped to progress its antiviral drug LHF-535 through Phase Ib clinical trials in the first half of 2020.

While the US NIH and CEPI continued to fund the lion's share of Lassa fever R&D in 2020, their combined share of total funding dropped from 94% in 2018 to 86% in 2020. This was partly due to reductions in each organisation's 2020 funding, and partly to increased funding from France's Inserm, the German BMG – a new Lassa funder in 2020 – and the US DOD, which saw its Lassa-specific contributions rise from an initial \$26k in 2018 to \$2.3m in 2020. Between them, these three funders contributed \$5.0m in 2020, up from \$3.0m in 2019 – providing a heartening increase in the diversity of Lassa funding.

Table 10. Top Lassa fever R&D funders 2020

, od ,	58 millions)						Cumulative total 2000 % of total 2000 % of total		
Funder	2015	2016	2017	2018	2019	2020			
CEPI		-	-	21	27	21	69	46	42
US NIH	9.1	26	31	23	25	21	135	42	41
US DOD	-	-	-	<0.1	1.8	3.4	5.2	3.0	6.7
Inserm	-	-	-	-	2.2	1.7	3.9	3.8	3.3
Wellcome	-	0.9	2.0	1.9	1.5	1.1	7.4	2.6	2.1
German BMG	-	-	-	-	-	1.0	1.0	<0.1	2.0
US CDC	-	1.9	0.4	0.4	0.8	0.8	4.3	1.3	1.6
FIND	-	-	-	-	0.5	0.3	0.8	0.8	0.7
German DFG	-	3.3	0.2	0.2		0.2	3.9	<0.1	0.4
Aggregate industry	-	-	-	-	<0.1	0.2	0.2	<0.1	0.3
Institut Pasteur	0.6	0.7	1.1	<0.1	-	0.1	2.5	<0.1	0.2
Japan Society for the Promotion of Science (JSPS)				-	<0.1	<0.1	0.1	0.1	<0.1
Subtotal of top 12^	9.8	34	35	46	59	51	233	100	100
Disease group total	9.8	34	35	46	59	51	235	100	100

Funding organisation did not participate in the survey for this year.

Reported funding from the West African nations where Lassa fever is endemic remains a gap in our G-FINDER data; however, 2019 did see the first ever reported funding *to* West Africa-based recipients, including a \$147k grant from FIND to Nigeria's Irrua Specialist Teaching Hospital and, in 2020, \$242k from Inserm to The Alliance for International Medical Action in Senegal.

Encouragingly, there was – for the first time – some industry funding reported in 2019 and 2020, from two private sector funders beginning early-stage vaccine R&D, though their contributions amounted to less than \$200k across both years.

<sup>^</sup> Subtotals for 2015-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative subtotal, the top 12 funders are those with the highest overall totals.

No reported funding

Like Lassa fever prior to the commencement of CEPI's funding, **multi-arenavirus** funding remains heavily reliant on the US NIH, which has been responsible for more than two-thirds of funding since its inclusion in the survey. Almost all remaining funding has come from two other US organisations – the CDC and the DOD. The CDC's contributions peaked at \$1.9m in 2016 and have remained well below that level since, though they rebounded slightly in 2019 and 2020. The US DOD only began funding in 2019 and on average has contributed over \$1.0m each year since then, helping to offset reductions in NIH funding – which were partly driven by the 2018 conclusion of its multi-arenaviral biologics research.

The US DOD's multi-arenavirus funding has gone almost entirely to vaccine R&D, which consequently saw more than 80% of its total funding in the last two years. This surge in vaccine funding, along with a rebound in NIH drug R&D, drove the share of multi-arenavirus funding going to basic research to record lows in 2019 and 2020 – down to just 12% after averaging 50% in 2015 and 2016.

Almost all the global funding for Lassa fever and other arenaviral R&D over the last three years was provided by CEPI or by high-income country governments. Philanthropic funding, almost exclusively from Wellcome, accounts for almost all of the remainder – 3.0% of the total since 2018. Private sector funders reported investment in arenaviral R&D for the first time in 2019, but to date their contributions total less than \$200k over the last two years.

#### CRIMEAN-CONGO HAEMORRHAGIC FEVER AND RIFT VALLEY FEVER



Total R&D spend in 2019	Total R&D spend in 2020	% of global funding 2020	% change from 2019	Total R&D spend 2014-2020	Sector share	R&D stage
\$20m	\$25m	0.5%	21%		Public Philanthropic Private	Basic & early Late Unspecified

Global funding for bunyaviral research and product development reached \$25m in 2020, rising by \$4.3m (21%) from 2019. Despite this growth, bunyaviral diseases received the second smallest share of global EID funding in 2020, falling below 1% for the first time since 2015 thanks to the influx of COVID funding.

Funding for all three priority bunyaviral areas grew in 2019 and 2020, with overall funding rising by nearly three-quarters (\$11m) between 2018 and 2020, though multi-bunyaviral funding remained safely below its 2017 peak, a decline that mostly reflected a shift to pathogen-specific vaccine and biologics R&D investments.

Apart from a dip in 2018, funding for both Crimean-Congo Haemorrhagic Fever (CCHF) and Rift Valley Fever (RVF) has seen steady, year-on-year growth. In 2019 and 2020, most of the growth in overall bunyaviral funding was driven by the first disbursements from CEPI and significant increases in US NIH funding.

**Unmet R&D needs:** Standardised models of non-human primates susceptible to CCHF infection are needed for a better understanding of disease pathogenesis and immunology while offering insights for developing therapeutics and vaccines.

In the absence of approved drugs, CCHF case management relies on supportive care. Off-label use of ribavirin, a broad-spectrum antiviral, lacks sufficient supporting evidence and there are no CCHF therapeutic candidates in clinical development. Broadly neutralising and non-neutralising mAbs, along with favipiravir, a small molecule drug, have shown potential in pre-clinical studies. Randomised controlled trials of favipiravir and ribavirin, and further development of novel biologics are urgently needed.<sup>46</sup>

An inactivated, mouse brain-derived CCHF vaccine has been used in Bulgaria since 1974; but safety concerns, instability and a lack of efficacy trials make it unsuitable for global use.<sup>47</sup> KIRIM-KONGO-VAX, an inactivated vaccine, is the only candidate currently in clinical development.<sup>48</sup> Effective CCHF vaccines targeting humans and animal reservoirs are urgently needed.

CCHF detection currently involves direct isolation or molecular tests, each requiring sophisticated facilities. The WHO highlights three urgent R&D needs: clinically validated and quality assured RT-PCR, ELISA Assay for reference laboratories, and RDTs for near-patient settings. 49

As with CCHF, supportive therapy is the only option for managing patients with severe RVF. While no RVF drug candidates have reached clinical development, a chemotherapeutic agent, mitoxantrone, 50 and two broad-spectrum antivirals – a non-nucleoside inhibitor (favipiravir) and a nucleoside analogue (BCX4430) – are in pre-clinical development. As RVF can cause encephalitis and miscarriages, an ideal therapeutic candidate should cross the blood-brain barrier and be usable in pregnant women.

The WHO's draft RVF Target Product Profile calls for three vaccines: one for reactive/emergency use, one for long term protection for high-risk populations, and an animal vaccine for prevention of transmission. There are several veterinary vaccines in routine use, albeit with concerns about their safety, effectiveness and the potential for reassortment with wild strains. <sup>52</sup> To date, only two RVF vaccine candidates, one inactivated (TSI GSD 200) and one live-attenuated (MP12), both developed by the US DOD, have undergone human testing. Candidates based on novel approaches such as DNA and viral vectors remain in the pre-clinical stage.

There are no validated point-of-care molecular tests in late-stage development, and no validated commercial serology assays for use in humans.



A team of researchers at CIRAD Réunion have developed the first specific rapid detection test for RVF virus. This first-line lateral flow immunochromatographic strip test is able to identify all strains of the RVF virus and has demonstrated high specificity and sensitivity during validation, offering a promising first-line, on-site diagnostic assay for use in resource-limited settings.<sup>53</sup>

Table 11. CCHF & RVF R&D funding 2015-2020

jieease (	15\$ millio	ue)				C	Jumulative	2 total 2019 % of	ozo% of to
)ise	2015	2016	2017	2018	2019	2020			
Rift Valley Fever (RVF)	1.1	2.8	4.9	4.8	8.9	12	34	43	47
Crimean-Congo Haemorrhagic Fever (CCHF)	0.8	2.7	9.1	6.8	8.3	9.1	37	41	37
Other bunyaviral R&D in combination with CCHF and/ or RVF	<0.1	5.4	6.7	2.6	3.3	4.1	22	16	17
Disease group total	2.0	11	21	14	20	25	93	100	100

A little under two-thirds of the post-2018 growth went to **RVF**, which grew from \$4.8m in 2018 to nearly \$12m in 2020. This growth pushed RVF's share of total bunyaviral R&D funding in 2020 to 47%, its highest level since 2015. **CCHF** R&D, which saw its funding grow by only \$2.3m in the two years to 2020, fell to 37% of overall bunyaviral disease funding, down from a peak of 48% in 2018, while multi-bunyaviral R&D received the remaining 17% (\$4.1m) – roughly in line with its three-year average.

The faster, CEPI-driven growth of RVF led to a shift in the allocation of bunyaviral funding relative to both the early years of the survey, when funding tended to be evenly split between CCHF and RVF, and to 2018, which saw a record share going to CCHF.

The funding landscape has changed radically since 2018, thanks to the combined effects of a steep rise in US NIH funding, the first disbursements from CEPI, the first substantial LMIC public funding, and notable declines from most other funders.

Much of the overall growth between 2018 and 2020 was due to increased funding from the US NIH – consistently the biggest funder of bunyaviral R&D – which increased its funding across all three bunyaviral R&D areas between 2018 and 2020 by a total of \$7.7m, nearly doubling its 2019 total funding to a record high of \$12m in 2020, leaving it responsible for nearly half of overall bunyaviral funding. Most of the remaining funding growth was directed specifically towards RVF, and came in the form of CEPI's initial disbursements under its vaccine programme, totalling nearly \$12m across 2019 and 2020.

Aside from CEPI and the US NIH, almost all the major pre-2019 bunyaviral R&D funders reduced their contributions by 2020, headlined by a \$1.5m drop from the UK DHSC (-59% between 2018-2020) as the initial funding under its adenovirus vaccine and livestock reservoir targeted vaccine (RTV) wound-up. Ongoing CCHF and multi-bunyaviral funding from the US DOD dwindled to nearly nothing – just \$70k across both years – while the apparent cessation of multi-bunyavirus funding from the German DFG (down from \$0.7m in 2018) actually reflects its absence from the last two G-FINDER surveys, meaning that our headline figures probably slightly understate the true level of funding.

The only other substantial increase from ongoing funders came from Wellcome, which significantly increased its funding for three ongoing multi-bunyaviral basic research programmes starting in 2019, with funding nearly doubling to \$0.9m. We also saw, starting in 2019, a new stream of CCHF funding from the Indian ICMR – its first ever contribution to bunyaviral R&D and the first substantial funding from an LMIC government.

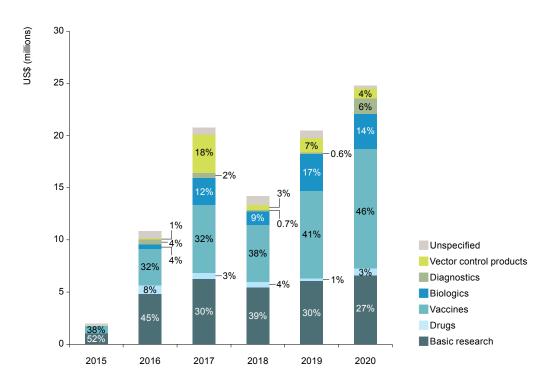


Figure 7. CCHF & RVF funding by product 2015-2020

Though funding for bunyaviral basic research and drugs R&D has remained steady over the last five years, the last two years of investment show notable increases in vaccines, biologics, and diagnostics R&D. Funding for vaccine R&D doubled between 2018-2020 (up \$6.0m, 110%), diagnostics R&D saw a ten-fold increase in 2020 (up \$1.5m, 1138%), and biologics R&D more than doubled in 2019 (up \$2.2m, 164%).

The rise in vaccines R&D was mostly focused on CEPI- and NIH-funded basic & early-stage research into CCHF and RVF vaccines, totalling \$8.4m in 2020. CCHF also saw increased vaccine funding between 2018 and 2020, mostly thanks to the first significant vaccine funding from the US NIH and a 2020 increase in Innovate UK's funding for two Phase I vaccine studies, including one based on Oxford University's ChadOx platform, and the first ever industry funding for bunyaviral R&D. Most of the overall increase in CCHF funding went to biologics, thanks to a substantial increase in the US NIH funding under its ongoing monoclonal antibody research (up \$2.2m, 169% between 2018 and 2019).

The 2020 increase in bunyaviral diagnostics R&D funding was mostly the result of new US NIH funding to a suite of arboviral and emerging infectious disease research centres and networks, while the 2019 expansion in biologics R&D funding was driven by \$2.2m in new NIH-funded CCHF early-stage research projects.

The rise in **multi-bunyaviral funding** was thanks to rebounding US NIH funding for basic research – which remained well below its 2017 peak – and especially diagnostics, which saw a \$0.7m increase in 2020, taking its share of multi-bunyaviral funding from an average of less than 3.0% to 21% in 2020.

There was little clinical development in any area of bunyaviral R&D in the first two years of the survey. This changed in 2017, when UK DHSC vaccine and vector control funding drove a peak in the share of clinical development for CCHF (36% in 2017), while clinical development for RVF peaked a year later, at 38% of funding (\$1.8m) in 2018. With the Innovate UK's UK Vaccine Network grants winding down, and CEPI's funding currently focused on early-stage research, both pathogens saw their share (but not always the amount) of clinical development decline each year from their respective peaks, with CCHF falling to 15% in 2020 and RVF all the way to 9.3%. There has never been any reported clinical development for multi-bunyaviral products.

Table 12. Top CCHF & RVF R&D funders 2020

,	JS\$ (millio	ns)				(	umulative	2 total	otal 020% of to
Funder	2015	2016	2017	2018	2019	2020	ĺ		
US NIH	1.4	4.5	5.3	4.5	6.7	12	35	33	49
CEPI		-	-	-	5.4	6.2	12	26	25
Innovate UK	-	0.7	3.3	1.0	1.3	1.3	7.5	6.3	5.2
EC	0.2	1.2	1.9	1.9	1.9	1.3	8.3	9.1	5.1
UK DHSC	-	<0.1	4.2	2.6	2.1	1.1	10	10	4.3
Wellcome	0.2	0.8	0.7	0.5	0.9	0.9	4.0	4.5	3.7
Indian ICMR	-	-	-	-	0.7	0.7	1.4	3.2	3.0
Institut Pasteur	0.2	0.1	0.5	0.8	0.3	0.3	2.2	1.5	1.2
Canadian CIHR	-	0.2	0.4	0.2	0.2	0.2	1.2	1.2	0.8
Burroughs Wellcome Fund				0.1	0.1	0.1	0.4	0.7	0.6
Swedish Research Council	-	-		-	<0.1	0.1	0.2	0.4	0.5
German BMBF	-	-	-	-	<0.1	<0.1	0.1	0.3	0.3
Subtotal of top 12^	2.0	11	21	14	20	25	82	99	99
Disease group total	2.0	11	21	14	20	25	93	100	100

Funding organisation did not participate in the survey for this year.

High-income country governments consistently contribute the largest share of bunyaviral R&D funding, however, 2019 and 2020 brought a notable rise in public LMIC funding and first-time investment from industry.

Philanthropic funding grew by three-quarters between 2018-2019 (up \$0.5m, 76%) – driven by a rise in funding from Burroughs Wellcome Fund and Wellcome – but the slight fall from 2019 (-\$89k, -7.7%) was due to the lack of reported funding from Fondation Mérieux, which led to an absence of philanthropic-funded CCHF R&D for the first time ever. The small amount of new industry funding came from SMEs, totalling \$126k in 2019-2020.

<sup>^</sup> Subtotals for 2015-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative subtotal, the top 12 funders are those with the highest overall totals.

<sup>-</sup> No reported funding

# NIPAH AND HENIPAVIRAL DISEASES



Total R&D spend in 2019	Total R&D spend in 2020	% of global funding 2020	% change from 2019	Total R&D spend 2014-2020	Sector share	R&D stage
\$24m	\$24m	0.5%	-2.3%		Public Private	Basic & early Unspecified

Total funding for Nipah & henipaviral disease R&D more than doubled in 2019, a \$13m increase taking it to \$24m, or 2.3% of pre-COVID global EID funding. A very slight (2.3%) drop in 2020 saw total funding fall to \$24m – still nearly 85% higher than its average level over the first three years in the survey.

The big ongoing increase in Nipah-specific funding in 2019, combined with slight declines in funding for other henipaviruses, mean that the vast majority of henipaviral R&D funding now targets Nipah virus specifically. The share of funding going to other henipaviral R&D has now fallen from a peak of 22% in 2016, to a little over 8% across 2017 and 2018, to just 3.2% in 2020.

The big 2019 rise in Nipah-specific funding was mostly thanks to CEPI's contributions to **Nipah** R&D, jumping from an initial \$2.1m in 2018 to \$13m in 2019. CEPI's Nipah funding increased by a further \$1.5m to \$14m in 2020, leaving it responsible for nearly two thirds of global Nipah funding.

These disbursements represent the first three years of CEPI's funding for four different Nipah vaccine candidates, under ongoing agreements ultimately scheduled to distribute up to \$100m. These include up to \$25m for the development of HeV-sG-V, which in March 2020 became the first Nipah vaccine candidate to reach first-in-human trials.

The remaining changes in total Nipah funding were largely caused by the US NIH, the main funder of Nipah R&D prior to CEPI's involvement. NIH funding rebounded in 2019, rising by \$2.5m (42%) before falling by \$2.7m to a record low \$5.6m in 2020. Between them, CEPI and the NIH accounted for around nine-tenths of Nipah-specific funding in both 2019 and 2020.

**Unmet R&D needs:** In the absence of an approved drug, Nipah virus case management relies on supportive care and off-label use of ribavirin, an anti-viral. Nipah infection often involves the central nervous system; therefore, an ideal therapeutic agent should be capable of crossing the blood-brain barrier. Additionally, new drugs are needed for post-exposure prophylaxis. A few small-molecule and biological approaches have been explored; however, the evidence for antivirals such as remdesivir and favipiravir so far is limited to early-stage research using animal models.<sup>54</sup>

The WHO draft Nipah virus vaccine Target Product Profile recommends that an ideal vaccine should have a reactive use-case profile – rapid protection, single dose, high efficacy, thermostability and provision of protection against both strains of Nipah. The current vaccine pipeline is made up of mostly pre-clinical candidates, with only two candidates having entered clinical trials. Almost all candidates are monovalent – targeting either the Bangladesh or Malaysia strain.<sup>55</sup>

Even in the absence of an effective vaccine, timely and accurate detection can help in deploying effective non-pharmaceutical countermeasures, such as Malaysia's targeting of animal-to-human spill-over. Developing an appropriate diagnostic test is challenging due to poorly understood disease kinetics (in cerebrospinal fluid, saliva and other fluids), cross-reactivity with different strains, especially in animals, and high rates of false-negative results from IgM serology-based tests. Consequently, there are currently no accurate point-of-care molecular tests or RDTs available, with specialised laboratories required to handle the isolation of Nipah virus in suspected samples.



A monoclonal antibody, m102.4, remains the only novel therapeutic to undergo human trials.<sup>56</sup> Molbio Diagnostics received approval from the Indian regulators for a molecular test based on its TruNat platform to detect Nipah.<sup>57</sup> In 2022, PHV02, a recombinant vesicular stomatitis virus based vaccine, became only the second candidate to enter clinical trials.<sup>58</sup>

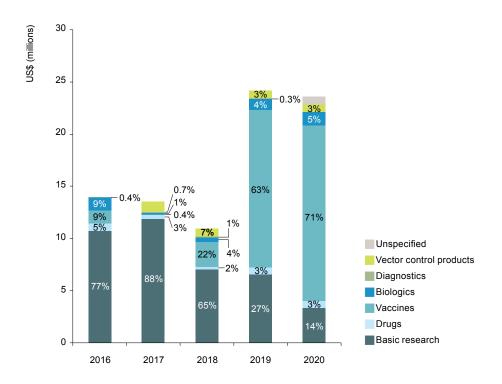
Table 13. Nipah & henipaviral disease R&D funding 2016-2020

Disease \	128 (Willio	us)			Criminative total 5050 % of total				
Disc	2016	2017	2018	2019	2020				
Nipah	11	12	10	23	23	79	96	97	
Other henipaviral R&D including in combination with Nipah	3.0	1.1	0.9	0.9	0.7	6.7	3.7	3.2	
Disease group total	14	13	11	24	24	86	100	100	

Much of the remaining funding came via a new stream of funding from India – which is subject to sporadic Nipah outbreaks – via the Indian Council of Medical Research (ICMR), totalling \$1.4m over the last two years and making it the sole source of LMIC funding. Innovate UK continued to provide the only funding for Nipah vector control, in the form of an ongoing \$0.8m per year project targeting vaccination of porcine reservoirs. US DOD funding rose to \$0.6m in 2020 – up from a low of just \$50k in 2019 – as it ramped-up funding for a new vaccine project.

Between 2016 and 2017, nearly 85% of Nipah funding went to basic research. CEPI's identification of Nipah among its initial Calls for Proposals, and its initial disbursements in 2018 saw this picture start to shift – the share of funding for basic research falling to 62%, and vaccines' share rising from less than 1% to 24% in 2018.

Figure 8. Nipah & henipaviral disease funding by product 2016-2020



Since then, the big increases in CEPI's role over the last two years have taken the share of R&D funding going to vaccines to nearly 75% in 2020. Basic research has seen an ongoing decline in both its amount and share of funding, with the absolute reduction almost entirely due to a gradual and ongoing \$8.1m fall in US NIH basic research funding since its 2017 peak. Funding from the NIH has shifted instead towards vaccines (a total of \$3.5m in 2019 and 2020), biologics (totalling \$1.7m) and drugs (\$1.3m), each of which saw the substantial increases in 2019 largely sustained into 2020.

The increase in NIH biologics funding came alongside 2020 growth in an ongoing biologics programme from the US CDC, driving a third straight year of growth in Nipah biologics funding.

Following the cessation of NIH funding for the only known Nipah diagnostic programme in 2019, there was no funding at all for diagnostics in 2020.

Funding for **henipaviruses other than Nipah** continued its ongoing decline from a peak of \$3.0m in 2016, dropping by a further 17% (-\$0.2m) to just \$0.7m in 2020 after remaining basically unchanged in 2019. Its decline mostly reflects the conclusion of US NIH vaccine research after 2016 and the gradual falls in basic research funding from both the NIH and the Swiss SNSF. Only three organisations – the NIH, SNSF and the US DOD – provided any funding for other henipaviral R&D in 2020, and all of it went to basic research.

While there is no reported product development for other henipaviruses, CEPI's most advanced Nipah vaccine candidate – HeV-sG-V – began its life as a potential vaccine against Hendra, another priority henipavirus, and remains in veterinary use against Hendra in Australia, where it was created. Its journey suggests that broader henipaviral R&D may one day benefit from candidate-identification spillovers from Nipah-specific investments.

Table 14. Nipah & henipaviral disease R&D funders 2020

رامد	5\$ millo	uel			(	Cumulative total 2020 % of total			
under	2016	2017	2018	2019	2020				
CEPI	-	-	2.1	13	15	30	54	62	
US NIH	11	12	6.5	9.0	6.1	45	37	26	
Indian ICMR	-	-	-	0.6	0.8	1.4	2.6	3.3	
Innovate UK	-	0.8	0.7	0.7	0.7	2.9	2.9	3.0	
US DOD	<0.1	<0.1	0.3	<0.1	0.7	1.1	0.3	2.8	
US CDC	-	0.1	0.1	0.2	0.4	0.9	0.7	1.8	
Swiss SNSF	-	0.2	0.2	0.2	0.2	0.9	0.9	0.8	
Inserm	-	-	0.1	0.2	<0.1	0.4	0.7	0.4	
Japan Society for the Promotion of Science (JSPS)			-	-	<0.1	<0.1	<0.1	<0.1	
Aggregate industry	-	-	<0.1	<0.1	<0.1	0.1	0.3	<0.1	
Disease group total	14	13	11	24	24	86	100	100	

Funding organisation did not participate in the survey for this year.

There continues to be very little investment in Nipah & other henipaviruses from small pharmaceutical and biotechnology companies, and almost no reported multinational pharmaceutical company investment. This lack of private sector interest, alongside the absence of philanthropic funding, means that essentially all funding for the disease group currently comes from CEPI, high-income country governments, and the Indian ICMR.

<sup>-</sup> No reported funding

# DISEASE X & OTHER R&D



Total R&D spend in 2019	Total R&D spend in 2020	% of global funding 2020	% change from 2019	Total R&D spend 2014-2020	Sector share	R&D stage
\$358m	\$465m	9.4%	30%		Public Philanthropic Private	Basic & early Late Unspecified

Along with the seven Blueprint disease groups, the WHO has prioritised R&D preparedness for 'Disease X', which represents 'a pathogen currently unknown to cause human disease'. Funding for Disease X includes the following categories:

**Fundamental research** covers cross-cutting studies to increase understanding of multiple EIDs, which is not yet directed towards a specific technology. It includes research on disease surveillance and epidemiology, animal spill-over events, and pathogen biology. Viral surveillance studies in bats, for example, led to the 2018 discovery of Bombali virus, a new species of Ebolavirus. Pathogenesis studies using prototype viruses help define target antigens and develop assays; for example, understanding of molecular structures across the flavivirus family was instrumental in rapid translational research during the recent Zika outbreak

**Vaccine platforms** include technologies and processes that allow the generation of immunogens applicable to multiple pathogens. Pre-existing safety and immunogenicity data and validated manufacturing practices allow rapid production and testing of platform-based vaccines. In 2020, a COVID-19 vaccine candidate based on an mRNA platform was identified in just 42 days – an industry record. Other technologies include viral vector- and nucleic acid-based ('plug and play') platforms. Self-amplifying mRNA technology is being investigated in early-stage clinical trials<sup>59</sup> for the development of second generation COVID-19 vaccines, while a pan-coronavirus vaccine technology based on the Ferritin platform<sup>60</sup> is entering Phase I clinical trials.<sup>61</sup> The most advanced platform-based EID vaccine candidates include a prime/boost viral vector-based Ebola vaccine (Ad26.ZEBOV/MVA-BN-Filo) and several COVID-19 vaccines.

**Adjuvants and immunomodulators** are compounds or structures formulated to improve efficacy or duration of vaccine immunogens. Adjuvants play a key role in sub-unit or purified antigen-based vaccines, which lack immunostimulant properties. Current adjuvants have several drawbacks, such as inability to induce a cellular immune response. Adjuvants in development include MATRIX-M,<sup>62</sup> which has been successfully combined with the R21 malaria vaccine candidate and is undergoing Phase III trials,<sup>63</sup> and GLA-SE, a TLR4 agonist which has been combined with ID93 TB vaccine candidate in a successful Phase III trials.<sup>64</sup>

**Biologics- and drug-related platforms** are adaptable technologies used for developing gene- and immune-based therapies. Current therapeutics platforms in development include DNA- and RNA-based monoclonal antibody (mAb) platforms and human polyclonal antibodies from transchromosomic bovine systems. As well as true platforms, this category also includes new delivery drug technologies and devices to simplify administration and broad-spectrum antivirals.

Delivery technologies in development<sup>65</sup> include nanoparticle-based drug delivery systems and controlled release formulation technologies such as PLGA micro- and nanoparticles, in situ gelling and liquid crystal formulations.

Broad-spectrum antivirals are small molecule compounds which inhibit essential machinery of multiple virus families. The pipeline includes favipiravir, an RNA-dependent RNA polymerase inhibitor, UV-4B, an alphaglucosidase inhibitor and nitazoxanide, an antiprotozoal agent recently investigated in late-stage clinical studies for use in treatment of COVID-19<sup>66</sup> and influenza. <sup>67</sup>

**General diagnostic platforms** are rapidly adaptable tools for detecting pathogens for which commercial diagnostic tests are unavailable. During recent Ebola and Zika outbreaks, diagnostic platforms allowed rapid development of field-appropriate tests. Platform-based diagnostics include molecular (reference or point-of-care test), high-throughput testing based on real-time PCR and lateral flow rapid diagnostic assays. Diagnostic tests in development based on these technologies include real-time RT-PCR kits, RT-LAMP, antigen and antibody-based assays, and cartridge-based point-of-care molecular tests. Most recently, eRapid<sup>66</sup> – a low-cost, affinity-based electrochemical sensing platform able to detect and quantify a broad range of viral biomarkers, has been developed and licensed for use in COVID-19 diagnosis.

The **multi-disease vector control** category captures funding targeting vectors capable of transmitting several different diseases. These include altering mosquito populations using genetic tools and sterile insect technique, chemical and genetic screens to identify molecules targeting *Aedes aegypti* mosquitoes, and *Aedes*-targeted Attractive Targeted Sugar Baits.

Funding for Disease X continued its rapid rise, reaching \$465m in 2020, a more than tenfold increase since 2016, when it was first included in the survey. Disease X funding has now grown by more than \$100m for three consecutive years, leaving it as the second biggest area of EID R&D spending every year since 2018. In 2019, prior to the COVID-driven influx in global EID spending, it received more than a third of global EID R&D funding, up from just 5.5% in 2016.

The \$113m (46%) 2019 increase in Disease X funding was driven by a \$115m increase in platform technology funding. Funding for platforms grew a further \$85m in 2020, making them largely responsible for the \$107m increase in 2020's Disease X funding. In fact, the eighteen-fold growth in platform funding has been responsible for two-thirds of the growth in overall Disease X funding since 2016, pushing their share of Disease X funding from 38% in 2016 to 64% in 2020.

The other major area of growth has been fundamental research, which has nearly tripled from \$10m in 2017 to \$27m in 2020. Multi-disease vector control R&D has also grown, but far more slowly than overall Disease X funding, with sharp (41%) growth in 2019 slowing (to 5.5%) in 2020. As a result, the share of Disease X funding going to multi-disease VCP has fallen every year, from 46% in 2016 to 13% in 2020.

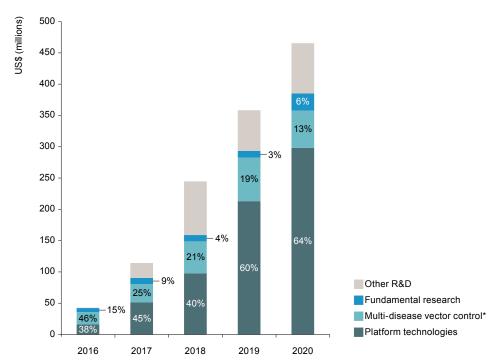


Figure 9. Disease X & Other R&D funding by product 2016-2020

Funding for **platform technologies** has been increasing every year since its inclusion in 2016, rising by \$282m in the five years to 2020. The majority of funding for platform technologies in 2020 went towards biologics (\$100m, 33% of platform funding) and vaccine-related platforms (\$91m, 30%), thanks to significant increases for each category in both 2019 and 2020, jointly accounting for around three-quarters of total platform growth. Most of the remaining growth went to diagnostic platforms, which more than doubled theirs funding in 2018 and then again in 2019, including the first substantial platform funding from Open Philanthropy, before dropping slightly in 2020.

<sup>\*</sup> The 2016 total for multi-disease vector control only includes Aedes aegypti control funding previously allocated to Zika, and likely understates the true funding total.

The massive growth in platform funding over the past two years mostly reflects sustained increases from the existing top funders. The US DOD – the top platform funder in both 2016 and 2017 – increased its \$37m in funding in 2018 by \$70m in 2019, and by another \$65m in 2020. These increases made the DOD by far the largest funder of platform technologies – providing nearly four times as much as the next largest funder in 2020 – and responsible for a majority of global platform funding in both 2019 and 2020, as well as more than 99% of funding for biologics platforms.

The big increases in biologic and vaccine-related platform technologies over the past two years, along with the sharp (\$50m) 2019 increase in diagnostic platform funding were also primarily due to new and increased funding from the US DOD.

Funding from the Gates Foundation – heavily focused on vaccine platforms – also grew by a total of \$32m between 2018 and 2020, more than tripling its funding and leaving it as the second biggest platform funder in 2020. US NIH funding grew relatively gradually after its big – adjuvant focused – increase in 2018, rising by 16% over two years to \$28m. The US NIH was responsible for just under half of all adjuvant and immunomodulator funding over the three years to 2020, and the relatively slow growth in NIH platform spending contributed to the relative stability of adjuvant funding in 2019 and 2020.

Two new funders began funding EID platforms in earnest in 2019: CEPI, which disbursed \$16m in 2019 and a further \$9.9m in 2020, and Open Philanthropy, with \$10m in 2019 and \$14m in 2020, together accounting for most of the remaining growth in funding.

Table 15. Platform technology funding 2016-2020

platform ogy	JS\$ (millo	ua)			C	Cumulative total 2020 % C				
'ec''	2016	2017	2018	2019	2020					
Biologics-related platform technologies	3.7	22	22	46	100	193	22	33		
Vaccine-related platform technologies	1.7	10	20	61	91	183	29	30		
General diagnostic platforms & multi- disease diagnostics	1.7	8.9	20	71	66	168	33	22		
Adjuvants and immunomodulators	2.6	4.4	22	24	25	79	11	8.5		
Drug-related platform technologies	6.4	6.1	14	11	16	54	5.3	5.5		
Total platform funding	16	51	98	213	298	677	100	100		

Funding for **multi-disease vector control** increased slightly in 2020, following a \$16m increase in 2019. The US NIH has been the top funder of multi-disease VCP R&D since 2018, with ongoing increases in its funding (up around \$10m in each of the last two years) taking its share of multi-VCP funding from 22% in 2017 to 52% in 2020. The US DOD – a top-two funder each year since multi-VCP was included in the survey – is responsible for 16% of the total funding over time, consistently providing around \$8.1m a year under its Deployed Warfighter Protection programme.

Wellcome has provided a total of \$22m, focused on *Aedes aegypti* control, making up 11% of global funding since 2017. The Gates Foundation and industry provide much of the remaining funding, though both saw their contributions fall substantially in 2020. Multi-VCP also enjoys an increasing array of smaller funders, rising from 26 separate funders in 2019 to 31 in 2020 – far more than for most individual pathogens.

Funding for **Fundamental research** relevant to multiple EIDs increased by \$11m in 2018 and sustained this high level of funding over the next two years. A narrow majority of investment in fundamental research over the last three years has come from the US DOD, almost exclusively via its Preventing the Emergence of Disease programme. But the rise in overall funding since 2018 is largely the result of steep rises in disbursements from the US NIH (up \$8.1m, 426% from 2018 to 2020). A new funding stream for viral pathway identification from the EC, worth \$1.2m in 2020, offset a \$1.3m (-73%) drop from the Gates Foundation, as its funding to UCLA for investigating the antibody profiles of Ebola victims came to an end.

The unspecified multi-EID funding we include under **Other R&D** has fluctuated in the past few years, decreasing by \$22m in 2019 before rising by \$16m in 2020. Since 2018, the majority of funding for R&D for more than one EID has come from France's Inserm, through a single grant which covers R&D for Ebola, Marburg and Lassa fever, but which cannot be apportioned between the individual diseases. But, with Inserm's funding having risen for the last two years, the slight \$5.9m decline (-6.9%) in Other R&D since its peak in 2018 actually reflects the aftereffects of a one-off 2018 spike in unspecified disbursements from two other funders: a jump in hard-to-categorise research from the US NIH and in the EDCTP's funding for its Pan-African Network for EIDs.

Table 16. Top Disease X & Other R&D funders 2020

N. Carlotte	JS\$ (millic	ns)			(	Sumulative 2	total 2019 % of	ozo% of tota
Tunder	2016	2017	2018	2019	2020			
US DOD	9.7	41	59	132	196	437	37	42
US NIH	4.4	24	52	52	76	209	15	16
Gates Foundation	8.7	8.5	19	43	53	132	12	11
Inserm	1.2	3.4	43	44	46	138	12	9.9
Open Philanthropy		1.6	0.1	10	14	26	2.8	3.0
CEPI	-	-	-	16	9.9	26	4.6	2.1
Innovate UK	1.6	8.5	7.4	9.8	9.5	37	2.7	2.0
EC	-	3.0	3.5	5.3	9.0	21	1.5	1.9
Wellcome	0.2	2.7	7.4	8.9	8.8	28	2.5	1.9
UK MRC	0.3	1.8	5.3	6.1	7.8	21	1.7	1.7
Aggregate industry	0.1	1.0	9.2	5.1	4.8	20	1.4	1.0
EDCTP	-	3.1	6.5	1.2	3.5	14	0.3	0.8
Subtotal of top 12^	43	105	225	336	439	1,109	94	94
Disease group total	43	115	245	358	465	1,226	100	100

Funding organisation did not participate in the survey for this year.

Overall, around three-quarters of Disease X & other R&D funding came from the public sector in high-income countries in both 2019 and 2020, a large proportion of which was from US government agencies. The philanthropic sector accounted for the majority of the remaining funding (16%), of which the Gates Foundation was the primary funder. Outside of multi-disease VCP, the private sector reports very little cross-cutting R&D which is primarily focused on EIDs.

<sup>^</sup> Subtotals for 2016-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative subtotal, the top 12 funders are those with the highest overall totals.

<sup>-</sup> No reported funding

#### **NON-PRIORITY PATHOGENS**

Policy Cures Research collects global investment data on several emerging infectious disease pathogens which are not included in the WHO R&D Priority Blueprint, and which are therefore excluded from all the figures presented elsewhere in this report. These 'Non-Priority' pathogens include other arenaviral haemorrhagic fevers, bunyaviral diseases, coronaviral diseases and filoviral diseases which are not formally identified as R&D priorities by the WHO. We also collect data on Chikungunya and emergent non-polio enteroviruses (including EV71, D68), both of which were considered for inclusion in the WHO R&D Blueprint in 2018, but which were not granted priority status at that time.

Of these non-priority pathogens, **Chikungunya** has consistently received the highest level of funding since it was included in the survey in 2018. In that first year, reported funding for Chikungunya totaled \$34m. It rose by 55% to \$53m in 2019, before decreasing to \$44m in 2020. Both the 2019 growth and subsequent decline were largely driven by changes in a new stream of vaccine funding from CEPI, which totaled \$22m in 2019 and \$13m in 2020. Unlike the WHO, CEPI does identify Chikungunya as one of its priority targets. The total amount CEPI has directed towards Chikungunya was more than the amount it has dedicated to several of its other priority pathogens, behind only COVID-19 and Lassa fever. With a total of \$131m in funding over the three years since it was included in the survey, Chikungunya has received much more funding than several WHO priority pathogens, and more than MERS and SARS put together.

The influx of CEPI's vaccine-specific funding meant that more than half of Chikungunya funding was directed towards vaccines from 2019 onwards. Prior to 2019, basic research received the largest share of funding at 37% (\$13m). Funding for biologics was the next-largest category, at 25% (\$8.5m), most in the form of self-funded industry R&D. Almost no funding – just \$0.5m in total – has been dedicated to VCPs that exclusively target Chikungunya; most of its VCP funding is captured under our multi-disease VCP category, since its mosquito vector, *A. Aegypti*, also transmits other pathogens, including Zika.

Overall, the US NIH has been the top funder of Chikungunya R&D, contributing an average of \$18m each year across multiple product areas. Governments of low- and middle-income countries affected by Chikungunya have contributed 6.2% of global funding between 2018 and 2020, the highest such share for any EID over that period.

With Chikungunya accounting for a clear majority of all non-priority funding, much of the remainder has gone to non-priority bunyavirus R&D, covered by the survey since 2016. This includes a total of \$6.2m for **Severe Fever with Thrombocytopenia Syndrome** (SFTS) and \$45m for other non-priority bunyaviruses, almost exclusively **Hantavirus**. The US NIH provides about 60% of both SFTS and other bunyaviral funding, with more than 10 other organisations – including several based in South America and Korea – providing at least some funding for non-priority bunyaviruses.

**Emergent non-polio enteroviruses** are the only other non-priority area to receive more than \$10m in total funding, with a total of \$25m since their inclusion in 2018. More than half of this came in 2020 thanks to a big increase from the US NIH, which has provided nearly four-fifths of the total.

The US NIH plays an even more dominant role in the remaining non-priority disease areas covered by the G-FINDER survey: **arenaviruses other than Lassa fever, coronaviruses other than MERS, SARS and COVID-19** and **filoviruses other than Ebola and Marburg** together account for just \$14m in total funding, of which the NIH provided 90%.

# **FUNDING BY PRODUCT**

In 2020, vaccine R&D continued to receive more funding than all other products combined, accounting for 50% of total EID funding. This figure rises to 55% if we exclude core funding and other funding which does not specify a product area – as we will continue to do throughout this section.

Biologics received the second largest share at 15%, slightly more than drugs and basic research, which respectively made up 12% and 11% of global funding. Diagnostics received just 5.9% of total funding; only vector control products (VCPs), with 1.3%, received less.

Although accurate, these figures are heavily influenced by the magnitude of COVID-19 funding in 2020, and closely resemble the proportions for the 80% of global funding which went to COVID-19. Since we discuss the distribution of COVID-19 funding elsewhere in the report, in the remainder of this section we instead focus on the product allocation of funding *not* devoted to COVID-19.

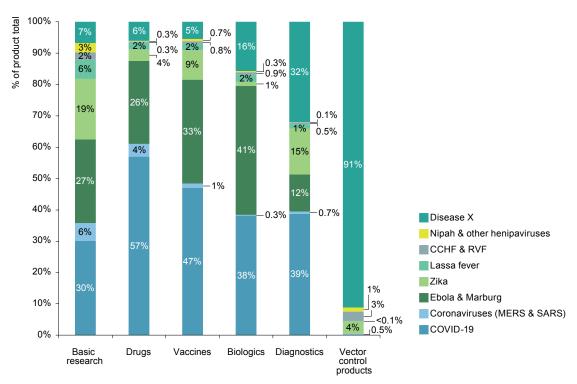


Figure 10. Product funding by disease (2014-2020)^

If we restrict our analysis to the years 2016-2019, when the survey scope remained relatively consistent, the only areas to experience meaningful growth were biologics funding and the non-disease-specific funding included under the heading of Disease X. Prior to and but for the emergence of COVID-19, disease-specific vaccine, drug and diagnostic R&D funding all saw substantial reductions, with only funding for disease-specific vector control remaining consistent, but extremely low – totaling less than \$20m in the five years to 2020. Only basic research failed to follow its preexisting trend in 2020: disease-specific basic research was basically unchanged from its 2016 level in 2019, but, like almost every other disease-specific product area, non-COVID basic research fell sharply (by \$46m) in 2020, as funding pivoted to COVID-19.

<sup>^</sup> This figure shows total funding from funders and intermediaries to product developers for the period 2014 to 2020. Funding which did not specify a product is excluded.

The proportion of funding dedicated to vaccines trended steadily downward from a peak of 72% in 2015 to 43% in 2019. Excluding the spike in funding associated with COVID-19, this trajectory would have continued in 2020, falling to a low of 38% of non-COVID funding. This overall trend was driven by steep reductions in Ebola & Marburg and Zika vaccine funding, down \$286m and \$112m from their respective peaks, leaving these disease groups with a record low share (48%) of the non-COVID vaccine funding in 2020. Substantial rises in funding for vaccine-related platform technologies targeting Disease X, and lesser increases in vaccine funding for almost all other disease areas were not enough to offset these post-outbreak declines.

The share of funding dedicated to biologics grew from 10% in 2017 to 17% in 2019. In 2020, non-COVID biologics saw an acceleration of their previous growth, with biologics R&D rising to 27% of non-COVID funding in 2020. Disease X and Ebola & Marburg were behind much of this increase, receiving 94% of non-COVID-19 biologics funding, though this may include some non-R&D funding in the form of BARDA's stockpiling purchases of Regeneron's REGN-EB3 Ebola antibody, as a lack of granular BARDA reporting makes its purchases difficult to distinguish from late-stage product development.

The US government – encompassing US NIH, US DOD and US BARDA – made up 98% of all pre-COVID biologics funding, and continued to provide a similar share of the non-COVID funding in 2020. The COVID-19 pandemic unearthed a new pool of funders for COVID-specific biologics R&D, lowering the US government share of overall biologics funding to 73%. But the *recipients* of COVID-19 biologics funding remained relatively concentrated, with just two biotechs receiving more than half of 2020 biologics funding and the top five recipients accounting for 82% of the total funding for biologics – compared to 40% for the top five identified recipients of vaccine funding.

While three-quarters of 2020 basic research funding went to COVID-19, the remainder was divided a little more evenly than other product areas. A total of 27% of non-COVID basic research funding went to the four least-funded disease groups – arenaviruses, non-COVID coronaviruses, bunyaviruses and henipaviruses – which together received just 8.8% of non-COVID global funding. The US NIH provided basic research funding to every *individual* disease area and, on average, contributed over 70% of basic research funding each year – including 56% of COVID-19 basic research funding.

Setting aside funding for COVID-19, the share of drug R&D was just 5.3% of the global total, down slightly from its pre-COVID average of 8.6%. While the majority of COVID-19 drug R&D focused on clinical development & post-registration studies, only 1.6% (\$0.9m) of other drug R&D had advanced beyond basic & early-stage research, with all reported clinical development targeting Ebola or Zika.

Diagnostics experienced strong funding growth from 2018 to 2019, rising from \$48m (5.3% of overall funding) to an all-time high of \$91m (9.5%). Much of this increase was due to funding for general diagnostic platforms & multi-disease diagnostics captured under Disease X, which more than tripled from 2018 to 2019 to account for 78% of diagnostic funding in 2019. Excluding COVID-19, funding for diagnostics dropped only slightly, by \$11m, in 2020 – still sitting substantially above its pre-2019 level thanks to the rapid rise in diagnostic platform funding. Funding for pathogen-specific diagnostics, beyond the 94% which went to COVID-19, continued its three-year decline, falling to just \$14m, more than half of which went to Zika.

VCPs were the only product area that, understandably, didn't receive any COVID-19 funding. Instead, VCP R&D continued to be dominated by Disease X, which has captured more than 90% of VCP funding since 2016. Around 70% of Disease X VCP funding was concentrated on the *A. Aegypti* mosquito, which is known to transmit Zika, dengue, Chikungunya and Yellow fever.

# **INTERMEDIARIES**

## Funding to intermediaries

Intermediary organisations can take many forms, from product development partnerships (PDPs) to multilateral initiatives such as CEPI or the European and Developing Countries Clinical Trials Partnership (EDCTP). Fundamentally, though, they all provide a coordinating mechanism for pooling funding from different organisations which, individually, may lack the resources to conduct R&D at the requisite speed and scale.

Intermediary organisations have long played a significant role in the landscape of R&D for neglected diseases such as malaria and tuberculosis. But until relatively recently this wasn't true for EIDs; there was no funding to intermediaries reported in 2014, and only limited funding – totalling less than \$15m – in 2015 and 2016, reflecting the absence of intermediary organisations focused on EID R&D prior to the West African Ebola outbreak.

This changed following the 2017 establishment of CEPI, which lead to the subsequent rapid growth in intermediary funding. Total funding to intermediaries grew by 50% in 2018 and by another two-thirds in 2019 to reach \$260m, before exploding to \$1.7bn in 2020 as a huge range of new and continuing funders relied on CEPI as the key plank of their response to the COVID-19 pandemic.

Prior to 2020, the top five funders of EID intermediaries were the Norwegian Ministry of Foreign Affairs (MFA) with a cumulative total of \$111m, the German BMBF (with \$94m), the Japanese Government (\$78m), the Gates Foundation (\$66m) and the UK DHSC (\$50m), who between them accounted for three-quarters of global intermediary funding. The vast majority (93%) of their funding went to CEPI, with only the BMBF and the DHSC providing meaningful funding to non-CEPI intermediaries.

In 2020, the COVID pandemic led to an influx of new funding, and of new funders. Fifty three organisations provided intermediary funding for the first time in 2020, more than doubling the total number of funders as overall funding rose by a factor of six. Most of the top pre-pandemic funders further increased their contributions, including the DHSC, which rose to first place with disbursements to CEPI totaling \$318m, the BMBF (\$280m, including \$268m to CEPI), the MFA (\$247m) and the Japanese Government (\$121m). They were joined in 2020 by the Saudi Ministry of Finance, which gave \$140m to CEPI and an additional \$1.5m to FIND – its first reported contributions to EID R&D. All of the top seven funders of intermediaries in 2020 were high-income country governments, with no LMIC governments or private sector entities and just two philanthropic organisations – Wellcome and the Gates Foundation – appearing among the top funders.

CEPI has been the top recipient of funding to intermediaries every year since its foundation in 2017, receiving between 80% and 90% of total intermediary funding every year since.

The vast majority of CEPI's pre-2020 funding came in the form of non-earmarked core funding. The sole exceptions were \$9.5m in 2019 earmarked RVF funding from the EC and \$6.1m in Ebolaspecific funding from the EC and the Paul Allen Foundation, which together accounted for just 3.7% of CEPI's pre-2020 funding.

Funders' approaches shifted considerably in 2020, with 88% of CEPI's 2020 funding receipts specifically designated for COVID-19 R&D. CEPI's core funding actually fell from its peak in 2019, dropping by \$26m (-14%), as did the small ongoing funding streams designated for Ebola and RVF.

Overall, CEPI received \$423m in funding prior to 2020 and disbursed \$118m, leaving it with a substantial amount of cash-on-hand even after its set up and operating expenses – estimated at around \$25m in 2019 – are taken into account. CEPI disbursed another \$595m over the course of 2020, compared to the \$1.5bn it received, leaving it with significant residual funding for the second year of the pandemic, and beyond, most of which is earmarked for COVID-19 R&D. The CEPI Board has also redirected part of its existing core funding to its COVID-19 response, and has left open the possibility of further such reallocations in the future.

Funding to non-CEPI intermediaries has traditionally been less focused on unearmarked core funding, which averaged 41% over the life of the survey and fell to a record low of 31% in 2019.

Prior to 2020, disease-specific funding for non-CEPI intermediaries was mostly for MERS (30% of the disease-specific total), multi-disease VCP (21%) and platforms (17%). While core funding to non-CEPI intermediaries rose sharply in 2020, most of their overall increase, and a narrow majority of their total funding, went specifically to COVID, leaving the share of unearmarked core funding largely unchanged at 32%.

The Foundation for Innovative New Diagnostics (FIND) was, aside from CEPI, the largest beneficiary of 2020's increase in intermediary funding, receiving \$46m in COVID-specific funding. Thanks to the resulting shift in its portfolio to include more EID-specific R&D, we also began recognising the core funding FIND receives – \$46m in 2020 – as funding for both EIDs and neglected diseases. This new approach led to a big increase in the share of FIND's funding included in this report.

The ACT-A accelerator, a new partnership launched in April 2020 in response to the pandemic, was the third largest recipient of funding to intermediaries, receiving \$20m in R&D-focused funding from the Swiss SDC. This relatively small sum reflects the fact that most of ACT-A's involvement in R&D ultimately took the form of facilitating other funders' direct grants to product developers, which are captured elsewhere in our funding data.

The Sabin Vaccine Institute, which participated in the G-FINDER survey for the first time in 2019, reported receiving significant 2020 funding for Ebola and Marburg vaccine development from the US BARDA and ATI, placing it among the top five recipients.

Several intermediaries have begun receiving EID-specific funding since 2018: IAVI received funding directed to five different EIDs since 2019, while DNDi and MMV both received funding for COVID-19 in 2020.

Figure 11. EID funding flows 2014-2019

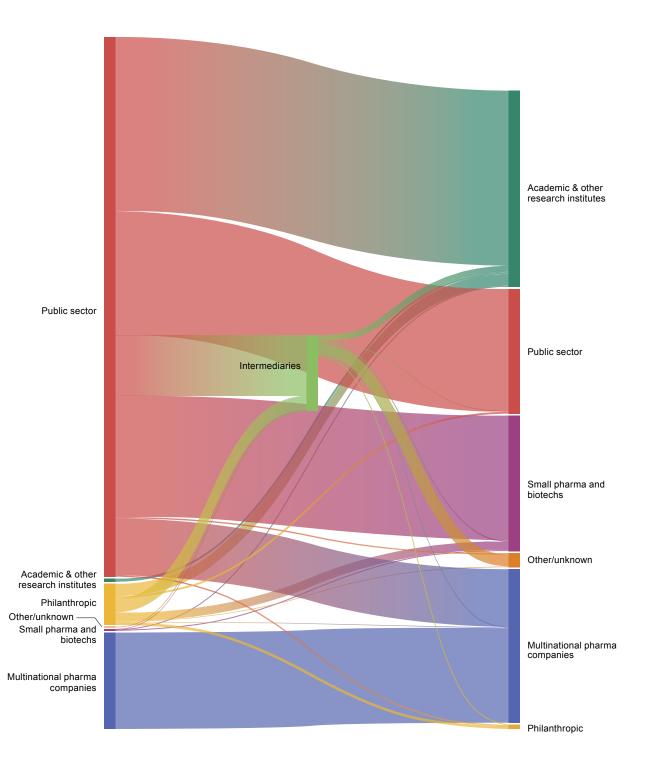
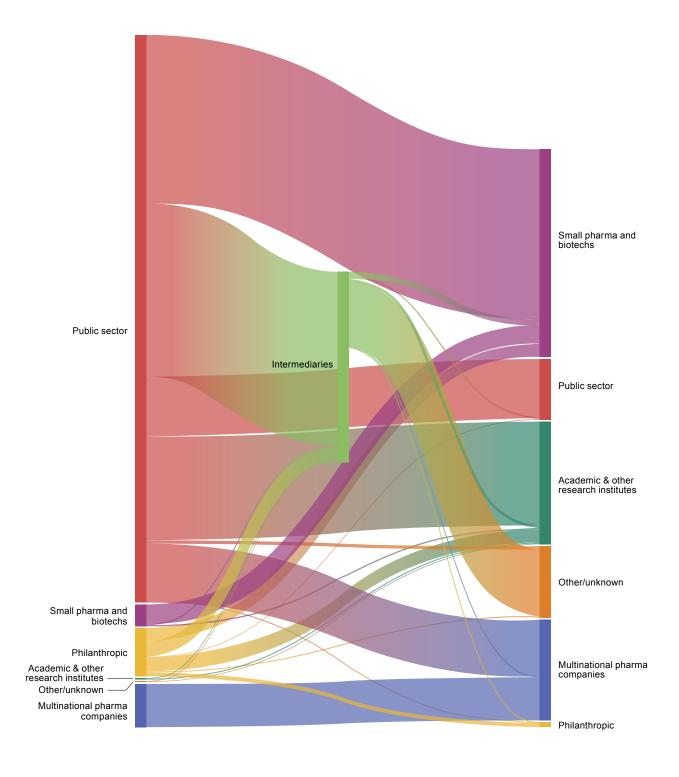


Figure 12. EID funding flows 2020



## Funding from intermediaries

Total funding from intermediaries ('onward funding') has been steadily increasing since 2015 and unsurprisingly reached an all-time high in 2020.

CEPI is the main provider of intermediary funding, allocating most of its pre-2020 funding via a series of Calls for Proposals targeting Lassa, MERS, Nipah, RVF, platform technologies and Chikungunya – the last of which is not currently recognised as a priority pathogen in the WHO Blueprint and which is therefore excluded from the figures in this report.

In 2020, CEPI massively increased its disbursements and shifted them heavily towards COVID-19, while reducing its funding to almost every other area. Since CEPI does not report the size of its contributions to individual recipients, we have only a partial picture of how CEPI has allocated its funding, allowing us to monitor disbursements across different diseases, but not recipient organisations or candidates' progress through the pipeline.

Prior to 2020, a little over 40% of CEPI's disbursements went to Lassa fever, with MERS, Nipah, Ebola and vaccine platforms each accounting for between 10 and 20%. In 2020, more than 90% of CEPI's funding was directed to COVID-19 vaccine candidates (\$536m), with Lassa (\$21m) and Nipah (\$15m) together receiving 61% of the remainder.

Pre-pandemic funding from intermediaries other than CEPI was mostly split between hard-to-categorise 'Other R&D' (26%), MERS (23%), Ebola (20%), and platform technologies (19%). Like CEPI, these other intermediary funders pivoted to COVID in 2020, with 62% of their disbursements targeting COVID. The core funding provided by non-CEPI intermediaries rose tenfold (up \$7.6m) in 2020, likely also in response to the pandemic. Most of their remaining funding went to platform technologies or the Sabin Vaccine Institute's BARDA-backed vaccine programme for Ebola and Marburg.

The second largest provider of onward funding, in 2020 and overall, was the Foundation for Innovative New Diagnostics (FIND), which has provided small amounts of EID-relevant funding every year since 2015, averaging \$1.4m, before providing \$24m in COVID diagnostic funding in 2020.

Behind FIND and the EDCTP – which has devoted a small share of its mostly neglected disease focused funding to programmes targeting Ebola and Disease X – is the RIGHT Fund, which provided its first ever funding for EID R&D in 2020 – a total of \$9.3m split between core funding to Korean product developers and a number of smaller, platform-focused investments. The fund, established in 2018, is a tripartite Public-Private Partnership between the Government of Korea, Korean life sciences companies, and the Gates Foundation. Almost half of its 2020 funding was provided as core funding to a Korean University and EuBiologics, a Korean Biotech, with the remainder divided between platform technologies and COVID-19.

The European Vaccine Initiative (EVI), which began providing funding data in 2018, and has increased its funding every year since, providing a total of \$6.6m (5.9% of non-CEPI onward funding) mostly via core funding grants to a wide range of European recipients.

The International Vaccine Institute (IVI), is a PDP mostly backed by core funding from the governments of South Korea, Sweden, India, and Finland. They have reported a total of \$9.6m in MERS vaccine funding, peaking at \$6.4m in 2018 and supporting a significant share of global MERS R&D. While we lack data showing the funding they provided in 2019 and 2020, this programme appears to have concluded in 2019, leading to the April 2020 publication of positive Phase 1/2a clinical trial data for the INO-4700 MERS vaccine.

# **FUNDERS**

Contributions from funders to EID R&D saw continued growth in 2019, rising by 9.0% (\$100m), before quintupling – to \$5.9bn – in 2020 in response to the COVID pandemic.

Funding in both years continued to be dominated by high-income country public organisations, which rose to a record high share of 85% in 2019. But a COVID-driven rebound in private sector funding and an influx of LMIC funding reduced the HIC share of 2020 funding to just under 80% – a four year low. This first year of the pandemic saw record contributions from every sector, heavily skewed towards COVID-19 R&D, while non-COVID funding remained largely unchanged.

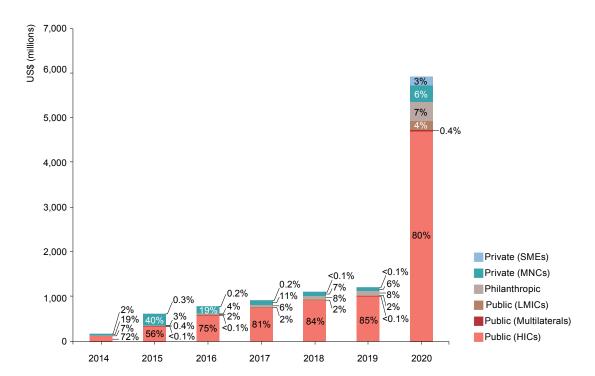


Figure 13. Total funding by sector 2014-2020

# Top funders of EID R&D

In 2020, the US Biomedical Advanced Research and Development Authority (BARDA),\* the US National Institutes of Health (NIH) and the German Federal Ministry of Education and Research (BMBF) were the top three funders of EID R&D, their combined investment of \$2.7 billion representing nearly 45% of all funding. BARDA alone provided just over \$1 billion – easily the largest ever contribution from any single funder.

The top five funders of EID R&D (which includes the aggregate total for industry and the UK Department of Health and Social Care, alongside the aforementioned BARDA, NIH and BMBF) provided nearly 61% of all 2020 global funding. But this represents a meaningful reduction in the degree of concentration among the top funders relative to 2019 – when the top five funders provided two-thirds of the global total – thanks to the diversity of COVID funding.

<sup>\*</sup> Funding attributed to 'BARDA' in this report may also include funding from the budget of its parent entity, the Office of the Assistant Secretary for Preparedness and Response (ASPR).

Table 17. Top EID R&D funders 2020

_	JS\$ (millio	ns)					(	Sumulative 2	3 total	total 2020 % of the	ota
Tunder	2014	2015	2016	2017	2018	2019	2020				
US BARDA	30	70	120	182	209	183	1,017	1,811	15	17	
US NIH	67	119	304	312	350	299	847	2,297	25	14	
German BMBF	-	1.5	5.0	23	34	36	808	908	3.0	14	
Aggregate industry	37	248	150	104	82	69	562	1,252	5.7	9.5	
UK DHSC			0.3	9.4	35	35	355	435	2.9	6.0	
Gates Foundation	13	8.6	14	35	42	64	281	458	5.3	4.7	
Norwegian Ministry of Foreign Affairs	-	-	-	11	16	84	247	359	6.9	4.2	
US DOD	12	71	54	61	115	176	240	728	15	4.1	
Japanese government (including MOFA and MHLW)				26	26	25	179	257	2.1	3.0	
EC	4.9	49	55	59	32	49	174	423	4.1	2.9	
Saudi Ministry of Finance							141	141	-	2.4	
Indian DBT	-	-	-	0.6	9.9	9.6	135	155	0.8	2.3	
Subtotal of top 12^	177	607	742	860	1,018	1,091	4,986	9,224	90	84	
Total EID R&D funding*	178	617	786	930	1,108	1,207	5,926	10,753	100	100	

Funding organisation did not participate in the survey for this year. Any contributions listed are based on data reported by funding recipients and so may be incomplete.

Unsurprisingly, the vast majority of the funding provided by the top funders in 2020 was directed to COVID-19 R&D, going mostly to vaccines. COVID received 84% of the top five funders' contributions in 2020, with about half of the remainder (\$294m, 8.2%) going to Ebola & Marburg. The remaining funders of EID R&D focused a little less on COVID, which received 71% of their funding, and more on Disease X, which accounted for 16% of funding outside the top five, compared to just 2.4% of the top five funders' 2020 contributions.

Of the top five funders, the US NIH has historically been the single most important funder of EID R&D, providing nearly a third of all global funding for the 2014-2018 period. In 2019, despite a \$51m decline in its investment, the US NIH remained by far the largest funder of EID R&D. While the NIH did increase its funding significantly in 2020, BARDA's funding grew much more rapidly, making it the top global funder of EID R&D for the first time.

BARDA's funding was mostly directed to COVID biologics and vaccines, with some continued support to Ebola and other filoviral diseases and a smaller amount for Zika. The majority of BARDA funding likely went to clinical development & post-registration studies, while the NIH continued in its role as the largest single funder of basic & early-stage research.

<sup>^</sup> Subtotals for 2014-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative total, the top 12 funders are those with the highest overall totals.

<sup>-</sup> No reported funding

<sup>\*</sup> Due to significant changes in the survey scope, totals for 2014 and 2015 cannot be directly compared to totals in later years, or to each other.

The US DOD, the third largest funder in 2019, devoted just 3.1% of its 2020 funding to COVID. Though it substantially increased its funding for other EID areas, especially platform technologies, its funding grew much less sharply than that of several other organisations. It remained the second largest funder of non-COVID R&D in 2020, behind only the NIH.

After seeing its funding drop sharply in 2019 with the conclusion of the DRC Ebola outbreak, industry's aggregate funding increased by a factor of eight in 2020, making them the 4th largest funder with an industry-wide total of \$562m - more than doubling their previous peak during the West African Ebola pandemic. Most industry investment in 2020 went to vaccine, drug and biologics R&D for COVID-19.

The Norwegian Ministry of Foreign Affairs (MFA), which directs its EID funding almost exclusively to CEPI, also saw a large increase in their funding, becoming the 7th largest funder in 2020.

The Saudi Arabian Ministry of Finance, which made its first ever recorded contributions to EID R&D, appears as the 11th overall funder in 2020. As with Norway, nearly all of its 2020 EID funding was invested via contributions to CEPI.

The largest funder from the philanthropic sector was the Gates Foundation, which increased its funding more than fourfold in 2020 and remained the sixth largest funder overall, as it has been every year since 2016.

The Indian Department of Biotechnology of the Ministry of Science and Technology joins the list of top funders for the first time in 2020, and is the only low- and middle-income country (LMIC) organisation among the top 12, driven primarily by funding for COVID-19.

## **Public funding**

The majority of EID R&D funding each year comes from public funders. Public funders have provided more than 80% of overall funding since 2014, their share ranging from a low of 57% in 2015 – thanks to an influx of private sector Ebola funding – to a high of 87% in 2019.

Almost all of this public funding (96% of the total) comes from high income country (HIC) government organisations. However, the share of funding provided by LMIC governments has risen almost every year; after reporting no funding at all in 2014, LMIC public funding hit a record high of 2.0% of the global total (\$24m) in 2019, before rising further, to 3.6% (\$213m) in 2020. This growth in LMIC funding, which continues to come mostly from India and Brazil, partly reflects the changes in our survey scope since 2014, particularly the 2015 inclusion of Zika, which received 41% of all LMIC funding prior to 2020.

Funding from public multilaterals makes up only a small proportion of public EID funding – just 0.2% of the global total – and includes meaningful funding from just three organisations: the UN, Unitaid and the WHO, 95% of which came in 2020.

In 2019, as in every previous year, the majority of public funding was invested in either Ebola, Zika or Disease X, which together received 74% of the total in the six years to 2019. In 2020, though, COVID-19 alone received 79% of public funding, absorbing all of the \$3.9bn net increase in 2020. While public funding for Disease X continued its rapid growth (up by \$75m, 25%), there were further drops for both Ebola and Zika.

Core funding from public funders continued to rise in 2019, jumping by a further \$79m (64%) to \$202m – nearly a fifth of overall public funding. But it fell sharply in 2020, dropping by 26% (down \$52m) to \$150m – just 3.0% of the massively-increased public total. Both the 2019 rise and the 2020 fall were due to changes in public funders' core funding for CEPI, which received \$172m in 2019 (85% of the total) but just \$85m (56%) in 2020. This reflected a shift among public funders towards earmarking their funding to CEPI specifically for COVID, rather than providing it as untied core funding, as they mostly had prior to 2020. CEPI's overall public funding actually grew by more than \$1bn in 2020, most of which is captured as funding for COVID.

Table 18. Public R&D funding by disease group 2014-2020

Disease or Legional Control of the C	15\$ millo	ns)					(	Jumulative 2	2 total 2	otal 020% of the
DR&D a	2014	2015	2016	2017	2018	2019	2020			
COVID-19							3,928	3,928	-	79
Coronaviruses (MERS, SARS and multiple coronaviruses)			26	44	26	29	37	162	2.7	0.7
Ebola & Marburg	127	334	326	283	358	336	294	2,059	32	5.9
Zika		4.7	154	203	192	116	103	773	11	2.1
Lassa fever		9.8	33	33	24	30	28	157	2.9	0.6
CCHF & RVF		1.8	10	20	14	23	23	91	2.2	0.5
Nipah & other henipaviruses			14	13	8.7	11	9.0	57	1.1	0.2
Core funding of a multi- disease R&D organisation			11	77	123	202	150	563	19	3.0
Disease X & Other R&D			32	99	198	298	373	1,001	29	7.5
Platform technologies			14	45	76	153	225	514	15	4.5
Multi-disease vector control products			13	29	31	41	50	164	4.0	1.0
Fundamental research			4.4	8.4	18	21	25	78	2.0	0.5
Other R&D			0.6	17	73	83	73	246	7.9	1.5
Total public funding*	127	350	606	773	943	1,046	4,946	8,791	100	100

Ebola was the only disease included in the 2014 survey. Value for Ebola in 2014 may include combined filoviral R&D. Marburg, CCHF & RVF, Lassa fever and Zika were added in 2015. Coronaviruses, Nipah & henipaviruses and Disease X were included in 2016. Multi-disease vector control products were first included in 2017. Value for multi-disease vector control products in 2016 was added retrospectively and likely understates the true total. COVID-19 was included in 2020.

A high proportion of public funding for EIDs, both pre- and post-COVID, comes from US government agencies, headlined in 2020 by the US BARDA, with 21% of total public funding, and, over the longer term, by the US NIH, which had been the top public funder every year prior to 2020. Overall funding from US-based organisations accounted for 44% of public funding in 2020, by far the largest share of any country. Funding from the US DOD rose for a fourth consecutive year in 2020, but less rapidly than that of other major funders, as it spent just 3.1% of its 2020 total on COVID, focusing instead on another big increase in platform funding, including a \$40m unscheduled increase in its biologic platform funding made during 2020.

Germany became the second largest national funder of EID R&D in 2020. Its funding – 97% of which came from the BMBF – increased more than tenfold, reaching \$832m, almost all of which was for COVID-19. Public funding from the UK also increased, for the fourth consecutive year, in 2020 (\$511m), 69% of which came from the UK DHSC, and public funding from Norway and Japan also increased significantly in 2020 (up \$164m and \$154m, respectively).

Funding from India, by far the largest LMIC funder in 2020, was predominantly for COVID-19 – a total of \$166m, which left India responsible for more than three-quarters of 2020 LMIC funding. Prior to 2020, a majority of India's funding had come as intramural funding for the various research institutes operated by the Indian Council of Medical Research (ICMR). Much of this funding came via a relatively substantial Zika R&D programme, which reached \$2.7m in 2020, following a brief gap in 2018. Funding from Brazil also increased in response to the pandemic (up \$15m), in a landscape previously dominated by its funding for Zika R&D. While Zika funding from Brazil had rebounded to \$5.9m in 2019, rising by \$1.9m following an ongoing post-outbreak fall, it dropped to just \$0.4m in 2020.

<sup>-</sup> No reported funding

<sup>\*</sup> Due to significant changes in the survey scope, totals for 2014 and 2015 cannot be directly compared to totals in later years, or to each other

Table 19. Top public R&D funders 2020

	JS\$ (millio	ue)					(	Sumulative 2	total 2019 % of	10tal 020 % of to
Tunder	2014	2015	2016	2017	2018	2019	2020			
US BARDA	30	70	120	182	209	183	1,017	1,811	17	21
US NIH	67	119	304	312	350	299	847	2,297	29	17
German BMBF	-	1.5	5.0	23	34	36	808	908	3.4	16
UK DHSC			0.3	9.4	35	35	355	435	3.4	7.2
Norwegian Ministry of Foreign Affairs	-	-	-	11	16	84	247	359	8.0	5.0
US DOD	12	71	54	61	115	176	240	728	17	4.9
Japanese government (including MOFA and MHLW)				26	26	25	179	257	2.4	3.6
EC	4.9	49	55	59	32	49	174	423	4.7	3.5
Saudi Ministry of Finance							141	141	-	2.9
Indian DBT	-	-	-	0.6	9.9	9.6	135	155	0.9	2.7
Canadian CIHR	-	-	1.2	2.0	1.1	1.1	80	85	0.1	1.6
UK FCDO	1.4	-	-	-	0.8	1.0	71	74	<0.1	1.4
Subtotal of top 12^	127	348	583	731	899	982	4,294	7,673	94	87
Total public funding*	127	350	606	773	943	1,046	4,946	8,791	100	100

Funding organisation did not participate in the survey for this year. Any contributions listed are based on data reported by funding recipients and so may be incomplete.

# Philanthropic funding

The philanthropic sector provided 7.0% of global EID funding in 2020, broadly in line with its share in previous years. This is in sharp contrast to their commitments to neglected diseases, where they have provided a fifth of global funding over the last 14 years. While philanthropies' share of global funding remained largely unchanged, the *amount* of funding they provided rose sharply in 2020, in line with overall funding, increasing by \$325m, or 353%.

Philanthropic EID funding has increased each year since 2014, largely as a result of increasing funding for platform technologies and rising core funding to CEPI. Philanthropic funding for Ebola peaked in 2015, and has received just 3.2% of the sector's funding in the years since. Almost half of philanthropic funding in the years leading up to 2020 went instead towards Disease X, mostly focusing on platform technologies. This focus on platform technology continued in 2020, when 19% of philanthropic funding went to Disease X; but most of the new funding was invested in COVID R&D. Philanthropic funding to MERS and other coronaviruses also increased in 2020 (up \$4.3m), although this mostly served to offset a drop in 2019, with a net increase of just over a million dollars since 2018.

<sup>^</sup> Subtotals for 2014-2019 top 12 reflect the top funders for those years, not the contributions of the 2020 top funders. For the cumulative total, the top 12 funders are those with the highest overall totals.

<sup>-</sup> No reported funding

Due to significant changes in the survey scope, totals for 2014 and 2015 cannot be directly compared to totals in later years, or to each

Table 20. Philanthropic R&D funding by disease group 2014-2020

Difference of	JS\$ (millio	ns)					C	jurnulative	otal 2	10tal 1020% of the
Rate	2014	2015	2016	2017	2018	2019	2020			
COVID-19							240	240	-	58
Coronaviruses (MERS, SARS and multiple coronaviruses)			3.6	2.5	3.8	0.7	5.0	16	0.7	1.2
Ebola & Marburg	13	19	7.8	3.8	0.8	3.5	5.5	54	3.8	1.3
Lassa fever		-	0.9	2.0	2.1	1.5	1.1	7.6	1.7	0.3
CCHF & RVF		0.2	0.8	0.8	0.7	1.2	1.1	4.7	1.2	0.3
Zika		-	6.3	5.1	2.9	0.6	0.4	15	0.6	<0.1
Core funding of a multi- disease R&D organisation			-	25	41	22	86	175	24	21
Disease X & Other R&D			10	14	31	63	77	196	68	19
Platform technologies			1.3	6.1	17	43	60	127	47	14
Multi-disease vector control products			6.9	2.2	7.8	14	9.7	40	15	2.3
Fundamental research			2.0	2.0	2.7	2.9	2.0	12	3.2	0.5
Other R&D			-	3.8	3.8	3.2	5.7	16	3.5	1.4
Total philanthropic funding*	13	20	30	54	83	92	417	707	100	100

Ebola was the only disease included in the 2014 survey. Value for Ebola in 2014 may include combined filoviral R&D. Marburg, CCHF & RWF, Lassa fever and Zika were added in 2015. Coronaviruses and Disease X were included in 2016. Multi-disease vector control products were first included in 2017. Value for multi-disease vector control products in 2016 was added retrospectively and likely understates the true total. COVID-19 was included in 2020.

As in previous years, the largest share of philanthropic funding came from the Gates Foundation, which provided 61% of all philanthropic funding over the six years to 2019, and 67% in 2020. The Foundation has increased its funding for EID R&D every year since 2015. It provided an additional \$22m in 2019 – taking its total to \$64m – before a fourfold increase in 2020. This additional funding was spread across all areas of COVID R&D, ranging from \$13m for biologics to \$82m for vaccines. A smaller (\$13m) increase in its vaccine platform funding took it to nearly double its 2019 high, and offset the declines in its adjuvant and VCP funding – both of which had spiked in 2019.

Wellcome, the second largest philanthropic funder every year, saw its EID funding drop by nearly 60% in 2019 (down \$19m), mostly due to a scheduled drop in its contributions to CEPI, which had accounted for nearly two-thirds of its 2018 spending. Wellcome's funding to CEPI, and its overall contributions, rebounded sharply in 2020, both rising by \$61m while its other funding streams remained relatively stable.

Each of the top three philanthropic EID funders (Gates, Wellcome, and Open Philanthropy) increased their funding in 2020. Along with an influx of new funders in 2020 – 15 organisations provided at least a million dollars in 2020, up from just four in 2019 – this brought the total increase in philanthropic funding to \$325m, more than four times 2019's then-record total.

The last two years saw the first significant EID funding from Open Philanthropy, which has rapidly increased its contributions since its formation in 2017, providing \$10m in 2019 and \$25m in 2020. Prior to 2020, all of Open Philanthropy's investment in EID R&D went towards Disease X, while in 2020 it expanded its portfolio to include disease-specific funding for COVID-19 and Zika.

Other than CEPI, the largest recipients of philanthropic EID funding were industry organisations – primarily funded by the Gates Foundation – which collectively received a quarter of 2020's philanthropic funding.

<sup>-</sup> No reported funding

<sup>\*</sup> Due to significant changes in the survey scope, totals for 2014 and 2015 cannot be directly compared to totals in later years, or to each other.

## Private funding

In 2019, private sector funding continued its decline from its Ebola-driven peak in 2015, falling to a low of \$69m – just 6% of overall EID funding. However, overall industry funding rebounded strongly in 2020, reaching \$492m, an eight-fold increase that still left it accounting for only 9.5% of global EID funding.

These figures likely represent a significant underestimate of private sector funding for COVID-19 due to a lack of survey participation from key industry organisations responsible for several registered COVID-19 vaccines and therapeutics. Even with these omissions, the big increase in 2020 was entirely due to an influx of COVID R&D funding: 90% of all industry investment into EIDs in 2020 went towards COVID, similar to the combined shares for Ebola, Zika and Disease X in previous years. Non-COVID funding from the private sector fell for the fifth year running, dropping by another \$16m (-23%) mostly thanks to further cuts in Ebola vaccine funding. This follows the approval of two private sector backed Ebola vaccines and the resulting shift to post-registration studies.

Table 21. Private sector R&D funding by disease group 2014-2020

١	JS\$ (millio	ns)					C	cumulative 2	a total	020% of to
Funder	2014	2015	2016	2017	2018	2019	2020			
COVID-19							508	508	-	90
Coronaviruses (MERS, SARS and multiple coronaviruses)			0.1	-	0.2	0.1	0.2	0.6	0.2	<0.1
Ebola & Marburg	37	247	141	63	61	62	47	657	89	8.3
Zika		0.6	8.8	40	11	2.2	1.3	64	3.1	0.2
Lassa fever		-	-	-	-	<0.1	0.2	0.2	<0.1	<0.1
CCHF & RVF		-	-	-	-	0.1	<0.1	0.1	0.1	<0.1
Nipah & other henipaviruses			-	-	<0.1	<0.1	<0.1	0.1	0.1	<0.1
Disease X & Other R&D			0.3	1.0	9.2	5.1	4.8	21	7.4	0.9
Platform technologies			0.3	0.3	3.2	1.2	2.4	7.4	1.7	0.4
Multi-disease vector control products				0.8	3.9	3.9	2.4	11	5.6	0.4
Other R&D			-	<0.1	2.1	-	-	2.1	-	-
Total private sector funding*	37	248	150	104	82	69	562	1,252	100	100

Ebola was the only disease included in the 2014 survey. Value for Ebola in 2014 may include combined filoviral R&D. Marburg, CCHF & RVF, Lassa fever and Zika were added in 2015. Coronaviruses, Nipah & henipaviruses and Disease X were included in 2016. Multi-disease vector control products were first included in 2017. Value for multi-disease vector control products in 2016 was added retrospectively and likely understates the true total. COVID-19 was included in 2020.

Historically, the vast majority of industry funding has come from multinational pharmaceutical companies (99% in the five years prior to 2020), however in 2020 they accounted for only two-thirds of private sector funding, thanks to the increasingly significant role played by smaller pharmaceutical and biotechnology companies (SMEs). Nearly all of this new SME funding was for COVID, and skewed towards R&D for biologics; but there were also smaller, new SME funding streams for other EID areas, headlined by \$2.4m in multi-disease VCP funding from a first-time survey participant.

<sup>-</sup> No reported funding

<sup>\*</sup> Due to significant changes in the survey scope, totals for 2014 and 2015 cannot be directly compared to totals in later years, or to each other.

Thirty six different companies reported providing EID funding in 2020, up from a low of just seven in 2019. Of these, 27 reported EID funding for the first time in 2020. Between them, the top three 2020 funders accounted for 83% of total private sector funding. This indicates a far more diversified funder base than at the peak of the Ebola epidemic in 2016, when three entities were responsible for 94% of all reported funding. Two-thirds of the 2020 increase in private sector funding – \$323m – came from companies with a significant track record of EID funding, while the remainder was provided by funders relatively new to EID R&D.

Almost half (46%) of industry's funding in 2020 was invested in vaccine R&D, and around a quarter to drugs and a quarter to biologics. This is a major shift from previous years, where the vast majority of funding was for vaccines (an average of 95% in the six years to 2020) and reflects major increases across all three product areas, rather than any decline in vaccine funding. All of the increase in industry's vaccine funding went to COVID, while vaccine funding for other diseases declined, driven by further falls in Ebola and Zika vaccine R&D.

In 2020, 82% of industry's vaccine funding, 99.7% of its biologics R&D, and 99.4% of drug spending went to COVID-19. Of the remainder, the majority of vaccine and drug funding went to Ebola, and most biologics funding to Zika. Industry's Ebola drug funding dropped in 2019, but increased again in 2020, while Zika drug funding fell even lower.

# **DISCUSSION**

#### Funding for R&D has given us the means to avert future Ebola epidemics

Thanks to the seven years of investment in Ebola R&D since the beginning of the West African epidemic in 2014, we now have two registered Ebola vaccines, two approved biologics and an approved rapid diagnostic test. Additional products might be cheaper, better meet the needs of particular populations or provide improved protection against secondary strains and related pathogens. But the incremental improvements we are now investing in are relatively minor.

Our progress since 2014 can be measured in lives saved. More than 11,000 people died over the course of the West African epidemic, creating an economic and social burden estimated at over \$50bn. The next outbreak, in 2018 in North Kivu province in the Democratic Republic of Congo (DRC) led to another 2,299 deaths before it was brought under control, in mid-2020, with the help of more than 300,000 doses of the then newly approved rVSV-ZEBOV-GP vaccine. When Ebola struck in North Kivu again in February and October of 2021, each outbreak lasted less than three months, and each caused just six fatalities.

No doubt some of this improvement is attributable to prior immunity and improved response; but much of it reflects the availability of real options for detection, prevention and treatment. Those recurrent outbreaks remind us not to become complacent, but the effectiveness of the 2021 response should be replicable elsewhere, and largely end the pandemic threat posed by Ebola.

How much did our success against Ebola cost us?

Total spending on Ebola R&D between 2014-2020 was a little under \$2.5bn. Of this, about \$1.2bn was disbursed during and immediately after the 2014-2016 West African epidemic, with the remainder spent between 2017 and 2020, peaking again in 2018 at the start of the DRC outbreak.

If we had mobilised this level of funding – a little under two-thirds of the one-year total disbursed for COVID R&D – during the initial epidemic, could the initial DRC outbreaks have been largely averted? Our COVID response, which saw registered vaccines administered nine months after the WHO declared a pandemic, provides proof of concept. But the response to COVID was not just better funded than Ebola's, it also built on much improved funding infrastructure and major investments in platform technology between 2014 and 2020. And, thanks to COVID's transmissibility and our early policy failures, product development took place in a target rich environment for product trials and duly enrolled tens of thousands of participants worldwide. On the other hand, there was considerable duplication and likely some waste associated with the speed and scale of the COVID response, with many funders seeking to reinvent the wheel and many researchers conducting underpowered, duplicative trials of the same candidates.

Does the much faster rate of product development for COVID simply represent differences between the pathogens, or advances in R&D infrastructure? Or did the very different levels of funding we chose to provide reflect – and reinforce – a difference in the urgency of our response. It is obvious why the world didn't respond to Ebola the way it responded to COVID, but the ultimate costs of even a 'small' epidemic dwarf the costs of finding a cure quickly.

#### The size and speed of the R&D response to COVID-19 is unprecedented

Reported global funding for COVID R&D in 2020 was \$4.7bn, of which \$3.9bn was disbursed to product developers. Even these figures likely understate the true total, thanks to big gaps in industry's reporting, but they still dwarf funding for previous epidemics. The full amount of COVID R&D funding is likely more than the \$4.8bn funders provided for all EID-related R&D over the preceding six years.

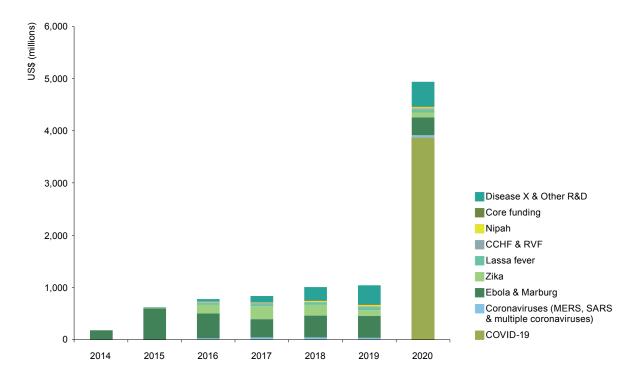


Figure 14. Total funding for emerging infectious diseases 2014-2020

#### Speed is vital and failures are inevitable

The exponential growth of outbreaks like COVID means that small increases in the speed of product development can save many lives. Dexamethasone, the first widely-administered pharmaceutical intervention for COVID, reduces mortality among mechanically ventilated patients by 36% and is estimated to have saved 650,000 lives over the second half of 2020. Completing the RECOVERY trial, which identified dexamethasone as an effective therapy, even a week earlier would have saved tens of thousands of lives in the pandemic's first wave.

Even in smaller outbreaks, where the lives lost to delays are fewer, the initial wave of a pandemic may also prove to be the *only* window for product development. When the West African Ebola epidemic ended, so did the still ongoing product trials it had enabled, slamming shut the window on product development and leaving candidates at best frozen, or at worst needing to restart trials during the next outbreak.

So while research and development can only form part of the global response to a novel pathogen, every part of that response must be optimised for speed. For R&D funding, that means immediate, credible commitments, ideally drawing on pre-existing relationships and pre-existing platforms. Funders' reserves of credibility and cash-on-hand can function as a kind of platform to accelerate product development, giving developers the means to begin work immediately.

To see how the early response to COVID matched these aspirations, we can zoom in on the early months of the pandemic, using the funding announcement data we gathered at the time.\*

CEPI, which still held a substantial share of its pre-2020 core funding as the pandemic began, was one of the first organisations in the world to announce a funding commitment in response to COVID-19, on the 23rd of January 2020. By the end of that month it had committed \$28m, making it responsible for just under half of all announced funding by that point.

<sup>\*</sup> This month-by-month data tracks funding commitments rather than the disbursement data cited elsewhere in this report, see our COVID R&D Tracker page for details.

The US BARDA announced *its* first funding commitment on the 18th of February and by the end of March it had committed \$367m – or 44% of all R&D funding commitments announced in the first quarter of 2020. Both organisations were able to leverage their existing relationships with product developers, their financial flexibility, and perhaps pandemic-ready organisational cultures, to play dominant roles early in the global COVID response. BARDA went on to become by far the largest single funder of COVID R&D by the end of 2020, disbursing an estimated \$827m, or 18% of the global total, while CEPI's 2020 disbursements of \$536m made it the third largest provider of funding to product developers, behind only BARDA and the US NIH.

Scale as well as speed of funding matters because exponential growth turns differences in efficacy into big differences in outcomes. COVID has benefited from a wide range of therapeutics and vaccines with varying levels of efficacy and practicality against COVID and its variants. An R&D investment strategy which bets exclusively on a single approach or candidate would have cost millions of lives. Many of our early guesses about what would work were wrong, and subsequent vaccines have demonstrated the trade-off between efficacy, adaptability, scalability and ease of distribution. But having enough funding to explore a range of options saved lives, and even more choices might have saved still more.

#### Do our epidemic responses focus too heavily on vaccines?

As in the early years of previous epidemics, well over half the 2020 R&D funding for COVID went to vaccines (58% of the total). About a quarter went to therapeutics, split more-or-less evenly between drugs (13%) and biologics (12%), with 10% for basic research and 5.2% to diagnostics. While vaccines have proved incredibly effective at reducing the lethality of COVID and, gradually, bringing the pandemic under control, even with record levels of funding their development and large-scale deployment takes time. The speed of an initial response directly determines number of cases and number of deaths, and drug trials require an order of magnitude fewer participants than those for vaccines. So supplementing the vital project of vaccine discovery and testing with earlier, better coordinated trials of repurposed therapeutics could have saved hundreds of thousands of lives.

The first two approved interventions against COVID were remdesivir – a known antiviral which completed trials for use with COVID in late April 2020 – and the generic corticosteroid dexamethasone, in June. Meanwhile, poor quality trials and insufficient coordination between researchers has led to application of ineffective treatments like ivermectin and hydroxychloroquine, while seemingly effective treatments like fluvoxamine – which demonstrated a point estimate of 22% reduced mortality in a large Brazilian study – still lack sufficiently transferable evidence to achieve wide registration.

Because of their lower recruiting requirements, therapeutics trials, especially for repurposed compounds, have significant speed and cost advantages over novel vaccine trials, and can represent a huge return on early investment. The trials for the Pfizer and AstraZeneca vaccines each had more than 20,000 participants in their intervention arms, while intervention arms in successful trials for remdesivir, Pfizer's novel therapeutic Paxlovid and fluvoxamine all required well under a thousand participants.

But while COVID vaccine funding was first announced in mid-January, the first meaningful funding for COVID therapeutics R&D – around \$4m from the Japanese government – didn't come until the 13th of February, weeks after CEPI's first vaccine grant. In the first three months of 2020 more than 80% of global funding commitments for COVID therapeutics were announced by BARDA, and just 5.6% by the newly established COVID therapeutics accelerator (CTA).

The lack of an incumbent peak body empowered to support therapeutic R&D, mirroring CEPI's role in vaccine development, undoubtedly exacerbated a pre-existing tendency to focus on vaccines over drug and biologics R&D. The role played by the CTA proved short-lived. It, and its functional successor, the Access to COVID-19 Tools Accelerator (ACT-A), ultimately served more as coordinating entities for its contributing funders' therapeutics investments than as free-standing providers of funding. The CTA, or something like it, will need to be recreated largely from scratch when the next pandemic hits, again slowing our therapeutics response by weeks or months.

#### CEPI's creation has transformed the funding landscape for its priority diseases

While CEPI played a key role in the response to COVID, its pre-pandemic funding to other, less recognised pathogens is arguably even more significant. CEPI identifies six priority diseases, in addition to vaccine platforms for use against Disease X. Along with its contributions to consortiumled Ebola R&D, it has made independent calls for proposals in relation to five of them: Lassa fever, Nipah, MERS, Rift Valley fever and Chikungunya – a non-WHO-priority pathogen not captured in our headline figures and therefore excluded from this analysis.

Since 2019, when its disbursements began in earnest, CEPI has provided 22% of global MERS R&D funding, 46% of Lassa fever, 57% of Rift Valley Fever and 60% of Nipah funding. Together with the US NIH – either the largest or second largest funder of each of these areas – these two organisations are responsible for 89% of global funding across these four pathogens.

CEPI's funding for its priority diseases peaked in 2019, prior to a shift in its disbursements toward COVID R&D. If we look only at that year, to get a sense of CEPI's 'peacetime' contributions, we see CEPI provided a clear majority of product development – not just vaccine development – funding for Lassa (67%), Nipah (75%) and RVF (84%), along with nearly half (46%) of the total for MERS.

Prior to CEPI's creation, funding for these diseases focused on basic research, which received 54% of their overall funding in the years to 2017, and as much as 84% in the case of Nipah. Global funding of product development for these diseases totalled just \$57m – mostly from the US NIH – over this period, less than half the \$132m provided by CEPI. Not only has CEPI sharply increased global funding for all these priority diseases, it has boosted the share of their funding going towards product development by 30 percentage points and, in some cases, provided the first ever meaningful funding for clinical development.

#### Is the funding landscape too centralised?

Above, we point to the role of well-resourced funding bodies which can build ongoing relationships with developers and immediately make large contributions in response to new threats. CEPI, for example, has worked effectively as a means of coordinating and consolidating R&D funding from smaller funders who could not, by themselves, hope to evaluate or support a wide portfolio of products. But, on the other hand, the resulting concentration in various areas of EID funding means we are delegating a big share of decision making to a small number of organisations.

Like CEPI, the US NIH plays a dominant role in the EID funding landscape, specialising, unlike CEPI, in basic research. It provides basic research funding to every individual disease area and contributed over 70% of basic research funding each year since 2014. It is also the primary and, in some years, the only meaningful supporter of R&D in several areas, providing 99% of global SARS funding over the life of our survey, 70% of Marburg funding, 60% of MERS and 56% of Lassa fever.

Meanwhile, as outlined above, CEPI's vaccine funding for its chosen pathogens now accounts for much of the product development funding in several previously neglected areas.

The world would obviously be much worse off without these dominant funders. And, clearly, there is a balance to be struck between centralising major investment decisions in a way that allows commitments to be made at an efficient scale while avoiding wasteful duplication, and allowing that centralisation to create a single point of failure in our pandemic response.

The EID funding landscape needs to strike the right balance to ensure that, alongside these few dominant players, we also foster a varied ecosystem of funders who may have different priorities – therapeutics rather than vaccines, say – or different approaches to decision making; different CEPIs, but not fewer.

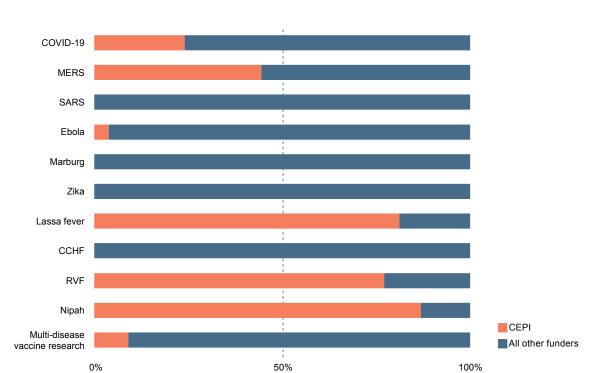
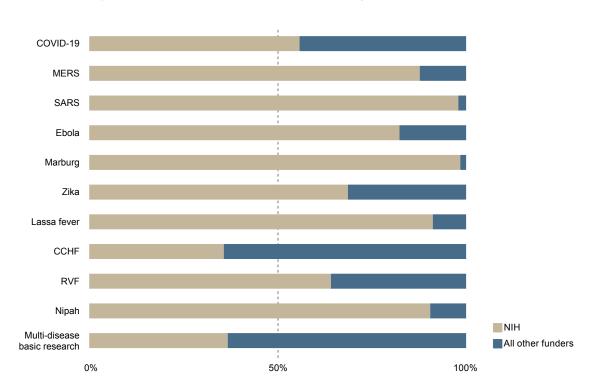


Figure 15. CEPI share of vaccine R&D funding 2018-2020





A particular concern raised by the concentration of the funding landscape is its lack of geographical diversity, and the limited role given to, or being assumed by, LMIC funders – especially those in endemic nations. Recognising and containing outbreaks requires an understanding of the needs and concerns of affected communities. By concentrating R&D decision making in Washington and Oslo, big funders have to import or ignore these LMIC perspectives, then export clinical trial capabilities to nations with little or no involvement in setting R&D strategy. It is heartening, then, to see a record amount and share of global funding from LMIC governments in 2019, and again in 2020, in what we hope represents an ongoing trend.

Another potential source of diversity is the wave of first-time funders ushered in by COVID. The funding landscape benefits when there are both big, reliable funders who can make big grants quickly, and a longer tail of smaller funders who can tack against the prevailing wind, and focus on pathogens and technologies that otherwise slip between the cracks. Hopefully many of these first time funders will continue to contribute towards pandemic resilience after COVID has passed.

A third hopeful trend is the slight rise in private sector funding, not just for COVID, but in several traditionally neglected EIDs. The full role of the private sector remains a big gap in our understanding of the EID R&D landscape, since many companies engaged in significant R&D activity are unwilling to share their funding data. Based on what we *do* know, though, while private sector funding for Ebola and Zika is far below its outbreak-driven peaks, the last three years have seen the first, small amounts of private funding for CCHF, Lassa fever and Nipah, hopefully forming the basis for growth in private sector contributions over time.

#### How do we achieve pandemic resilience?

Research and development cannot do much in the early weeks of a Disease X epidemic. But while policy responses and non-pharmaceutical interventions buy us time, it is crucial that we use it wisely, with a system for product development that can begin while there are still hundreds, rather than millions of cases.

Our eventual success against both Ebola and COVID relied heavily on platform technologies, and the big increases in funding across most platform categories even prior to the current pandemic suggest a growing commitment to being better prepared for the next one.

But when COVID-19 was first detected, the global R&D infrastructure had pivoted almost entirely away from the coronavirus research that followed MERS and SARS outbreaks, in favour of a focus on Ebola and Zika. In 2020, understandably, attention and funding were mostly focused on COVID – though overall non-COVID funding remained stable thanks to another increase in Disease X funding.

As we deal with the ongoing effects of COVID-19, it's important to remember that, like the current pandemic, the next one may arrive from an unexpected source, and the distribution of R&D funding should reflect that uncertainty. This means ensuring a broad funding (and funder) base, especially for basic research and for smaller pathogens, and nimble product developers with immediate access to platforms and funding.

By these standards, it is not ideal that basic research funding is down 40% from its 2017 peak for the priority areas without recent outbreaks. But, thanks in part to CEPI, *overall* funding for these pathogens has risen sharply since 2016, rising by \$71m to \$203m in 2019 before remaining relatively stable (down \$3.5m) in 2020. While funding for most multi-pathogen research dropped, almost all individual priority pathogens have seen increased funding since 2016 – SARS being the sole exception.

Funding has also increased for almost all of the non-priority pathogens we cover: they saw their collective funding rise from \$57m in 2018 to \$80m in 2019, before dropping to \$70m in 2020, accompanied by increases in most areas of Disease X funding. Funders seem to have recognised the importance of preparing for outbreaks of unknown or little-known pathogens in concert with the immediate threat of COVID-19.

To maintain an R&D sector that is capable of efficiently absorbing the kinds of funding spikes generated by Ebola, Zika and especially COVID, it is important that funders maintain their support even when the threat of infectious disease no longer seems quite so immediate. Boom-bust funding cycles, like those that characterised our response to epidemic coronaviruses, are an inefficient way to support R&D, requiring suddenly engaged funders to rebuild relationships, capacity and experience each time.

In this context, the panoply of organisations founded specifically in response to COVID-19 is unlikely to be optimised for responding to the *next* pandemic, and may dilute support from the organisations most likely to still be active when the next pandemic arrives. We still lack a genuine 'CEPI for therapeutics', and CEPI itself carried hundreds of millions in earmarked COVID funding into 2021, but failed to raise even half the funding it requested for its five year plan for long term pandemic preparedness.

We are undoubtedly much more prepared for a pandemic than we were at the beginning of 2014, and more prepared than we were at the beginning of 2020. But we are also, by any reasonable standard, not ready enough. How long will we remember COVID and the millions of people no longer around to remind us? And will we, the people who collectively spent two years washing our hands and disinfecting hard surfaces in response to an airborne coronavirus, learn the broad lessons of pandemic resilience, or just go back to fighting the last war?

# **METHODOLOGY**

## Reading this report

#### TREATMENT OF DISEASE GROUPS

Individual Blueprint priority diseases are organised into disease groups within the report's structure based on their shared viral family. While individual disease breakdowns are presented in each disease group chapter, most tables aggregate funding based on the total for a disease group, and funding targeting multiple EIDs including at least one Blueprint priority pathogen is included in the totals for that pathogen's disease group. So, for example, Ebola virus disease and Marburg virus disease are grouped together in the 'Ebola & Marburg' disease group for the purposes of identifying top funders and measuring funding for individual technologies, along with any filoviral disease R&D which targets Ebola and/or Marburg alongside other filoviruses.

In order to avoid overwhelming the measures of funding for priority coronaviruses other than COVID-19, we have split the coronaviruses analysis in two sub-chapters: one focused exclusively on COVID-19 and another ('MERS, SARS & multiple coronaviruses') dedicated to the other two priority coronaviruses – which also covers funding which targets more than one priority coronavirus.

#### FUNDING TO AND FROM INTERMEDIARIES

A significant portion of EID R&D funding flows from funders to product developers via intermediary funding organisations like the European and Developing Countries Clinical Trials Partnership (EDCTP) and the Coalition for Epidemic Preparedness Innovations (CEPI). To avoid double counting, the figures in the annual G-FINDER Neglected Disease report include only funding flowing to intermediaries ('inward funding') and exclude the flow of funding from intermediaries to product developers ('onward funding').

This report adopts a different approach to intermediary funding which allows us to report both inward and onward intermediary funding in separate sections of the report. All figures included in the individual disease chapters are based on the aggregate of funding disbursed directly to product developers (including self-funding) *and* onward funding flowing *from* intermediaries. Funding totals reported in the Funders section of the report, on the other hand, instead list the aggregate of direct funding and inward funding flowing *to* intermediaries.

This means that funding totals in the individual disease chapters include payments to product developers disbursed by CEPI and other intermediaries in that year, but not any funds given to those intermediaries – even if they were earmarked for a specific pathogen – since including both flows would result in double counting. Conversely, the Funders section of the report *does* include contributions provided to CEPI by its funders, but does not include CEPI (or any other intermediary) as a funder of EID R&D, since all their onward funding is excluded from Funder totals. As a result, the totals reported in the Funders and Disease sections of the report relate to different measures of global funding and differ by almost \$1bn in 2020 as the initial wave of COVID-19 funding to intermediaries outstripped their first year of disbursements.

#### YEARS

Throughout the text, references to years refer to the financial year in relation to which data was gathered, rather than the year in which the survey took place.

A small amount of COVID-19 funding (around \$3m) was reported in the 2019 survey by two organisations – Australia's Medical Research Future Fund and the Canadian Institutes of Health Research – whose 2019 fiscal year spanned the early part of 2020. In order to avoid confusion, we have incorporated this funding into the 2020 total, meaning that our figures include more than a full year of funding from these organisations.

#### ANNUAL CHANGES IN SURVEY PARTICIPATION

Annual changes in funding mentioned in this report are based on funding reported by all survey participants in each year, and may include artefactual changes resulting from differences in survey participation. In instances where these differences materially influenced the apparent year-on-year change, this is indicated in the text and a 'participation-adjusted' estimate based on the change in funding from consistent survey participants is provided.

#### COUNTRY GROUPINGS

For brevity, we use the terms 'LMICs' and 'developing countries' to denote low- and middle-income countries, and 'HICs' to denote high-income countries, as defined by the World Bank.

#### DISEASES INCLUDED IN THIS REPORT

The scope of this report includes all emerging infectious diseases and disease groups included in the WHO list of Blueprint priority diseases: Crimean Congo haemorrhagic fever (CCHF), Ebola virus disease, Lassa fever, Marburg virus disease, Middle East respiratory syndrome (MERS), Nipah and henipaviral diseases, Rift Valley fever (RVF), severe acute respiratory syndrome (SARS), SARS-CoV-2 (COVID-19), and Zika. COVID-19 was added to both the list of Blueprint Priority Pathogens and the survey scope starting in 2020.

This report follows the WHO in adopting a 'Disease X' priority area to capture all 'cross-cutting R&D preparedness that is also relevant for an unknown disease', representing R&D targeting multiple pathogen families or as-yet-unknown pathogens. The activities included under Disease X funding are technologies which can potentially be applied to a range of diseases, but have not yet been attached to a specific product for a specific disease, including R&D for adjuvants and immunomodulators, diagnostic platforms, delivery devices, broad-spectrum antivirals and multi-disease vector control products (VCPs) intended to target EIDs, as well as fundamental research focusing on EIDs. The Disease X & Other R&D chapter of the report also captures any other grants which cannot be allocated to a single EID, including grants which do not specify a single pathogen or product category.

Research and development aimed at more than one emerging infectious disease is also included, provided at least one of the intended targets is a priority pathogen. Non-disease-specific expenditure is included as part of funding for Disease X or under core funding for EID-focused research institutions.

#### TYPES OF RESEARCH INCLUDED

This report quantifies EID R&D investments into two overarching categories, each broken down into a number of further categories:

- Basic & early-stage research, including:
  - Basic research
  - · Discovery and pre-clinical development
- Clinical development, including:
  - Baseline epidemiology in preparation for product trials
  - Clinical development and field evaluation
  - Post-registration studies of new products, including Phase IV/pharmacovigilance studies, and operational research for diagnostics

A detailed explanation of what types of R&D activities are included in each of these categories is provided in the G-FINDER EID R&D scope document.

The purpose of this report is to track and analyse global investment in the research and development of new health technologies for emerging infectious diseases. The G-FINDER survey does not, and is not intended to, capture investment in the entire spectrum of EID research. Many research activities that are extremely important for global health are excluded because they are not related to the development of new tools for emerging infectious diseases; this includes health systems and operations/implementation research (for example, research into health systems or policy issues, or research into the programmatic delivery of non-product interventions, or existing health technologies), and sociological, behavioural and epidemiological research not related to the development of new health technologies. We also exclude investment into non-pharmaceutical tools such as untreated bed nets and personal protective equipment, or interventions such as safe burial. General therapies such as painkillers or nutritional supplements are also excluded, as these investments cannot be ring-fenced to emerging infectious disease treatment only. Investment that is not research-related is similarly excluded: although we recognise the vital importance of activities such as health programme delivery, advocacy, routine disease surveillance programmes, community education and general capacity building to address emerging infectious diseases, investment in these activities falls outside the scope of this report.

A comprehensive explanation of all inclusions, exclusions and restrictions in the detailed EID R&D scope document, and a matrix summarising the scope for EIDs and technologies is available from <a href="https://www.policycuresresearch.org/rd-needs-for-global-health/">https://www.policycuresresearch.org/rd-needs-for-global-health/</a>.

## Survey methodology

#### HISTORICAL CHANGES TO THE SURVEY SCOPE

Although maintaining a consistent scope is important in order to allow analysis of multi-year funding trends, the scope of the G-FINDER EID survey has evolved since its inception in 2015 and will continue to change in response to further updates of the WHO R&D Blueprint priority pathogens and expert consensus.

The G-FINDER survey first included questions about EID expenditure in 2015, covering grants made in 2014. This first year of the EID survey only covered R&D spending on Ebola virus disease, including grants targeting multiple filoviral diseases including Ebola.

The survey of 2015 funding (the second year in which EID funding was included), was expanded to include five additional diseases, mostly African viral haemorrhagic fevers: Marburg, CCHF, RVF and Lassa fever, as well as Zika. The expanded scope also captured R&D targeting multiple filoviruses, bunyaviruses, or arenaviruses as well as R&D focused on filoviruses other than Ebola and Marburg and bunyaviruses other than CCHF and RVF.

2016 marked the third year of EIDs' inclusion in the G-FINDER survey, adding R&D spending on coronaviral diseases (including MERS and SARS), and henipaviral diseases (including Nipah). 2016 also saw the inclusion of several kinds of non-disease-specific ('Disease X') funding and core funding for multi-EID organisations.

These changes in scope mean that, although funding totals for 2014 and 2015 are reported alongside those for 2016 and beyond, these figures include funding for a significantly different set of diseases and are not directly comparable. The comparatively small totals for the new scope additions in their respective initial years of inclusions in the survey suggest that the extent to which overall reported funding in each year of the EID survey has been inflated by scope expansion is relatively slight and that our headline totals for 2014 and 2015 do not greatly understate total funding in those years.

In 2017 (the fourth EID survey year), the scope of Disease X and core funding expenditure was expanded to include the full value of funding intended to support research applicable to *both* neglected diseases and EIDs, including core funding, platform technologies and other R&D, which would previously have been prorated between neglected disease and EID funding totals. Funding for R&D targeted *exclusively* at neglected diseases continues to be dealt with in the G-FINDER Neglected Disease report and is excluded from the figures presented here.

As part of the inclusion of combined EID and neglected disease funding, a new category, multi-disease vector control products, was created to capture funding for R&D not targeted at one specific vector-borne disease. The new category captures funding for VCP R&D where the targeted vector transmits both neglected diseases and EIDs. For example, the Aedes aegypti mosquito transmits both the dengue virus (a neglected disease) and Zika (an EID). For funding reported in 2017 and beyond, the full value of this kind of funding is included under the category of multi-disease vector control products. The vast majority of pre-2017 multi-disease vector control funding, almost all of which was for Zika, has also been retrospectively reassigned based on this approach, eliminating the artefactual drop in Zika VCP R&D between 2016 and 2017 which appeared in the previous report.

#### IDENTIFICATION OF SURVEY RECIPIENTS

As new diseases have been added to the survey scope, organisations known to be active in these areas have been identified and invited to participate in the G-FINDER survey.

In 2014 (the first year EIDs were included in the survey), the survey recipients were existing G-FINDER participants in the neglected disease survey supplemented via a search for organisations engaged in Ebola R&D.

In 2015, following expansion of the survey to collect R&D investment in additional African viral haemorrhagic fevers and Zika, the survey recipient database was expanded to capture organisations engaged in or funding these types of R&D.

In 2016, as the survey was expanded to reflect the Blueprint list of priority pathogens, several organisations known to be active in EID R&D were approached to participate in the survey based on their attendance at the first scientific meeting of the Coalition for Epidemic Preparedness Innovations.

The survey of 2020 funding was expanded to invite a large number of funders identified via our real-time tracking of COVID-19 funding announcements. The relatively low level of actual participation from these newly identified funders contributes to our conclusion that our headline estimate of COVID-19 R&D funding is likely to be substantially lower than the true total. In order to compensate for the lack of participation from several major funders of COVID-19 R&D, we also incorporated funding from key non-participating funders reported by the Global Research Collaboration for Infectious Disease Preparedness (GLOPID-R).

#### DATA COLLECTION

The G-FINDER survey operates according to two key principles: capturing and analysing data in a manner that is consistent and comparable across all funders and diseases; and presenting funding data that is as close as possible to 'real' investment figures.

G-FINDER was originally designed as an online survey. An online survey platform was developed to capture grant data and is still used by the majority of survey participants. An offline grant-based reporting tool is also available. Industry (pharmaceutical companies and biotechnology firms) investment in R&D is not grant-based, so a version of the reporting tool has been tailored for these participants. Instead of grants, companies enter the number of staff working on emerging infectious disease programmes, their salaries, and direct project costs related to these programmes. Companies are required to exclude 'soft' figures such as in-kind contributions and costs of capital.

For some organisations with very large datasets, the online survey and equivalent offline reporting tool are difficult to use. The G-FINDER team was therefore asked to use publicly available databases to identify the relevant funding. For the US National Institutes of Health (NIH), grants are collected using the Research Portfolio Online Reporting Tools (RePORTER) and the Research, Condition and Disease Categorization (RCDC) process. For the Biomedical Advanced Research and Development Authority (BARDA), relevant programmes are identified using the international and domestic 'Project Maps' retrieved from the Medical Countermeasures website (supplemented by keyword searches) and annual funding estimated based on prorated committed project values listed on the USASpending.gov website categorised as being funded by the Office of the Assistant Secretary for Preparedness and Response, BARDA's parent body.1 Information on funding from the US Department of Defense (DOD) is collected using the Defense Technical Information Center's 'DOD investment budget search' tool. Funding from the European Commission (EC)2 is retrieved from the Community Research and Development Information Service (CORDIS) public database and Innovative Medicines Initiative's (IMI) online project list. Supplementary data is provided by the EC. Information about the R&D projects funded by Innovate UK is extracted from spreadsheets available on its website.

All participating organisations are asked to only include disbursements (or receipts), rather than commitments made but not yet disbursed. Where we lack access to disbursement schedules, as with most of the datamined organisations listed above, we prorate total value of funding across the portion of the projected grant period which fell in the relevant fiscal year.

#### VALIDATION

All entries are verified against the inclusion criteria. Cross-checking is conducted using reconciliation reports – which match investments reported as disbursed by funders with investments reported as received by intermediaries and product developers – followed by manual grant-level review of the report outputs. Any discrepancies are resolved by contacting both groups to identify the correct figure. For grants from the US NIH, funding data is supplemented and cross-referenced with information received from the National Institute of Allergy and Infectious Diseases (NIAID).

Industry figures are reviewed against industry portfolio information held by Policy Cures Research and against full-time equivalent (FTE) and direct costs provided by other companies. Costs that fall outside the expected range, for example above average FTE costs for clinical staff, are queried with the company and corrected.

### OTHER R&D

Over the life of the survey, around 2.7% (\$255m) of funding has been reported to the survey as 'unspecified', usually for multi-disease programmes where funds could not easily be apportioned by disease. This funding is included in the report under the heading of 'Other R&D', with a narrow majority of the total resulting from \$133m in funding from France's Inserm, which covered a range of EIDs and could not be accurately apportioned between the target pathogens. A proportion of funding for some individual diseases was also 'unspecified' as to product, including when funders reported a grant for research into Zika basic research and drugs without apportioning funding to each product category. The existence of these two kinds of 'unspecified funding' means that reported funding for some diseases and products will be slightly lower than their actual funding, with the difference being included as 'Other R&D' funding in the Disease X chapter.

A further 6.9% (\$738m) of global funding was given as core funding to R&D organisations, such as CEPI, that work in multiple disease areas. As this funding could not be accurately allocated by disease it is reported as unallocated core funding, but included in non-disease-specific measures of Blueprint priority pathogen spending in the Funders section of the report, since this is the focus of recipient organisations. In cases where grants to a multi-disease organisation were earmarked for a specific disease or product, they are included under the specific disease-product area in the Funders section of the report, while disbursements from intermediary organisations are included in individual disease chapters - see 'Funding to and from Intermediaries', above.

<sup>1</sup> This means that funding attributed to 'BARDA' in this report may also include funding from the broader Office of the Assistant Secretary for Preparedness and Response (ASPR) budget.

The term 'EC' used here and throughout the report refers to funding from the European Union budget that is managed by the European Commission or related European Union partnerships and initiatives, such as the European & Developing Countries Clinical Trials Partnership (EDCTP) and Innovative Medicines Initiative (IMI).

#### DATA AGGREGATION

All pharmaceutical industry funding data is aggregated and anonymised for confidentiality purposes. Rather than being attributed to individual companies, pharmaceutical company investment is instead reported according to the type of company, with a distinction made between multinational pharmaceutical companies (MNCs) and small pharmaceutical and biotechnology firms (SMEs).

#### INFLATION ADJUSTMENTS

Funding data is adjusted for inflation and converted to US dollars (US\$) to eliminate artefactual effects caused by inflation and exchange rate fluctuations, allowing accurate comparison of annual changes. All funding data in this report is in 2020 US\$.

#### LIMITATIONS

While the survey methodology has been refined over the past decade, there are limitations to the data presented, including survey non-completion, time lags in the funding process, an inability to disaggregate some investments, and non-comparable or missing data. Data for some significant public funders, most notably the US NIH and BARDA, draws mostly on prorated publicly reported project totals rather than reported annual disbursements.

#### SUPPLEMENTARY MATERIALS

A detailed methodology is available at:

https://www.policycuresresearch.org/g-finder

All of the data behind the G-FINDER EID report is available through our data portal:

https://gfinderdata.policycuresresearch.org

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