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Evaluation of the UK Vaccine Network Project 1.0 (NIHR207661)

Final Report

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Disclaimer

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Executive Summary

The UK Vaccine Network Project 1.0 was a UK government initiative established to strengthen global health security by accelerating the development of vaccines and associated technologies to address epidemic threats in low- and middle-income countries (LMICs). The Project received advisory support on strategic investment in vaccine research and development (R&D) from the UK Vaccine Network (UKVN), a multidisciplinary panel of experts from academia, industry, government and philanthropic sectors, chaired by the Chief Scientific Adviser to the Department of Health and Social Care (DHSC).

In 2015, the UKVN identified 12 priority pathogens with epidemic potential in LMICs. This designation was based on factors such as outbreak risk, disease severity, and the absence of effective vaccines and treatments. The priority pathogens were: Chikungunya virus, Crimean-Congo haemorrhagic fever virus, Ebolavirus, Hantavirus, Lassa virus, Marburg virus, Middle East respiratory syndrome coronavirus, Nipah virus, *Yersinia pestis* (plague), *Coxiella burnetii* (Q fever), Rift Valley fever virus, and Zika virus. In addition, the list included 'Disease X', denoting as-yet unknown pathogens with epidemic potential.

Delivered from 2016 to 2023, UKVN Project 1.0 constituted the first phase of UKVN investments. As one of five components of the UK government's Global Health Security (GHS) programme, it received £134 million in Official Development Assistance (ODA). Its primary objective was to advance the development of vaccine candidates for diseases with epidemic potential and to strengthen vaccine manufacturing capability and epidemiological research.

The UKVN Project 1.0 was comprised of a series of funding competitions managed by delivery partners Innovate UK, the Engineering and Physical Sciences Research Council and the Biotechnology and Biological Sciences Research Council, and the UK's National Institute for Health and Care Research (NIHR)'s Evaluation, Trials and Studies Coordinating Centre (NETSCC) and NIHR's Central Commissioning Facility (CCF). A total of 99 project grants were issued, addressing various stages and areas of vaccine R&D. Funded activities included early- and late-stage preclinical development, clinical development, vaccine manufacturing, and One Health and epidemiological research relevant to vaccinology.

The NIHR, on behalf of the DHSC, has commissioned Technopolis and Triple Line Consulting to conduct an independent impact and process evaluation of the UKVN Project 1.0. The aim of the evaluation was to assess the processes, outcomes and impacts of the Project, identify lessons for the ongoing second phase of the UKVN Project and to inform future iterations of UK Government investments in vaccine R&D. The evaluation was conducted between May 2024 and July 2025.

Methodology

The evaluation employed a theory-based, mixed methods approach, combining quantitative and qualitative data from multiple sources and triangulating findings to minimise data gaps and ensure the validity of conclusions. It included a portfolio analysis of UKVN-funded projects based on final project reports, public monitoring data (e.g., Researchfish) and an online survey. The survey, completed by project leads and partners, was designed to update and harmonise information on project outputs, outcomes and impacts.

A programme of in-depth interviews was undertaken with project leads, and experts not directly involved in the UKVN Project 1.0. Consultations with projects leads, presented as case studies, provided detailed accounts of the impacts and insights derived from project participation. These case studies evidenced the ways in which UKVN-funded activities contributed to advancing technologies along the vaccine development pathway and

strengthening critical research capabilities in the UK and LMICs. Interviews with experts from academia, industry and funding bodies offered external perspectives on the UKVN's added value, its role in addressing R&D barriers and resource prioritisation, and its potential impact in beneficiary countries.

Finally, a cost-benefit analysis was conducted to estimate the global benefits of the first year of the Oxford-AstraZeneca COVID-19 vaccine rollout. This vaccine is based on the ChAdOx platform, the development of which was supported by the UKVN Project 1.0.

Results

The first phase of the UKVN Project 1.0 provided critical funding to strengthen global health security by accelerating the development of vaccines and related technologies to tackle epidemic threats. This independent evaluation assessed the extent to which the objectives and anticipated outcomes of the UKVN Project 1.0, as outlined in the theory of change, were achieved.

Advancing vaccine R&D for 12 priority pathogens.

UKVN Project 1.0 funding delivered significant progress across the vaccine R&D pipeline. Investment was strategically directed towards high-risk, early-stage research where UK organisations had strong scientific capabilities but commercial incentives or access to alternative funding were lacking. This broad, exploratory programme of investment supported the development of a diverse portfolio of vaccine candidates against the 12 priority pathogens. Although resources were spread relatively thinly across the priority pathogens, the MERS-CoV example demonstrated that even a single project can have a meaningful impact in outbreak response. Since 2016, the project has supported the development of 25% of the vaccine candidates targeting these pathogens that progressed to clinical trials. At least five of these vaccine candidates have the potential to become 'Phase II ready', of which two have secured CEPI funding for Phase II trials. Notably, the proportion of funded research at pre-clinical or clinical stages increased from 25% to 67% over the funding period.

Academic institutions and SMEs undertook a range of projects that, collectively, advanced vaccine research across the early development pathway, including discovery research, pre-clinical studies and early-phase clinical trials. To ensure relevance to global health needs, projects were required to align with target product profiles (TPPs) for use in LMICs.

Beyond core vaccine R&D, the portfolio supported complementary upstream and downstream research, including epidemiological studies, development of animal models, zoonotic disease surveillance and work developing serological standards. Platforms technologies and vaccine manufacturing innovations were also supported by UKVN funding.

Benefits for LMIC research communities and wider populations are emerging.

Whilst not mandated, collaboration with local organisations, capacity building and policy engagement in LMICs developed organically where relevant. These activities strengthened local expertise and enhanced vaccine development capabilities in several LMICs. Notable examples included:

- Technology transfer activities for vaccine manufacturing in Vietnam and India
- The development of electronic data collection tools, outbreak models and social science research conducted to support response to the 2018-2020 Ebola outbreak in the Democratic Republic of the Congo

- Formal and informal training activities delivered across several projects, particularly those through the EPSRC manufacturing hubs
- Collaboration with the Nigeria Centre for Disease Control on Lassa Fever surveillance.

Several priority vaccine candidates advanced towards outbreak readiness and stockpiling, including the ChAdOx1 biEBOV and ChAdOx1 MARV vaccines, both recommended for deployment by WHO. In general, vaccine platforms can be developed using priority or exemplar pathogens as 'use cases', with the resulting learnings then applied more broadly across other pathogens. Research on the ChAdOx platform and a MERS vaccine candidate also enabled a rapid pivot during the COVID-19 pandemic, leading to the development of the Oxford-AstraZeneca vaccine, the first COVID-19 vaccine to receive global authorisation.

Whilst substantial additional investment was required to develop this vaccine (as detailed in the cost-benefit analysis section), UKVN funding validated the value of early public investment in disease-agnostic vaccine platforms. Ultimately, a relatively modest investment generated disproportionately high public health and economic returns during the pandemic, particularly for populations in LMICs.

For a funding programme such as the UKVN 1.0, building on existing strengths increases efficiency and reduces risk in achieving short-term outcomes, while maximising the chances of impact. The ChAdOx project portfolio illustrates this point: these projects had already developed the expertise, processes, networks, and advanced regulatory steps, all of which accelerate progress. In the longer run, maintaining a diverse technology portfolio creates opportunities for further innovation and new solutions. The COVID-19 pandemic response demonstrated the value of having multiple vaccine platforms, with some proving better suited to low-cost manufacturing and deployment in LMICs than others.

Support to science and capacity building.

UKVN Project 1.0 supported a range of projects that advanced the scientific and technological foundations of vaccine development and associated research. As evidenced by the research outputs, these projects delivered notable technological innovation and fostered interdisciplinary collaboration. Research activities were highly collaborative, involving over 400 institutions globally, including substantive engagement from researchers based in LMICs. Almost all resulting peer-reviewed scientific publications were made freely available via open access, with nearly one-quarter of these publications including at least one author affiliated with an LMIC institution.

Between 2016 and 2023, the UK vaccine R&D ecosystem matured considerably, with UKVN Project 1.0 contributing significantly to this growth. Strong research clusters emerged or consolidated their activities in vaccine R&D with UKVN 1.0 funding for institutions such as the University of Oxford, the UK Health Security Agency's Porton Down facility and the Pirbright Institute. Collaborative initiatives, including those facilitated through the EPSRC manufacturing hubs, brought together a range of partners to support technological innovation for scalable manufacturing and technology transfer. Capacity building also extended to universities and SMEs across the UK, enhancing national capabilities in vaccine development and production. Importantly, projects outside the 'established research hubs', such as Liverpool and Nottingham, helped to build research base and expands capacity more widely.

An analysis of the UKVN-funded portfolio found that projects exhibited a reasonable degree of complementarity and synergy. Strategic mechanisms for cross-project knowledge exchange were limited, but researchers remained aware of progress across the portfolio due to the small size of the UK vaccine R&D community. As is typical of early-stage research, not all UKVN-funded projects progressed to clinical development, an expected outcome given the

complexity and context-dependence of pathogen biology. Nonetheless, each project contributed to the scientific evidence base (including through negative results) and informed new hypotheses for future research.

The UKVN delivery model was fit for purpose.

The delivery model for UKVN Project 1.0 enabled DHSC to commission research through established funding organisations. Open funding calls broadened participation, attracting researchers from adjacent disciplines. Innovate UK's staged grant model effectively progressed projects from feasibility to larger-scale awards. Delivery partners were flexible in responding to unforeseen challenges, notably granting extensions to projects affected by COVID-19 delays. However, variability in reporting formats and timelines across delivery partners resulted in fragmented data on the outcomes of funding competitions and programme monitoring. This limited the ability to systematically assess performance across the portfolio.

Remaining Barriers to Vaccine R&D

Despite the progress made, several barriers remain that ongoing and future vaccine development funding programmes will need to consider:

1. Operational constraints such as persistent challenges with overseas shipment of biological samples, regulatory complexity, collaboration difficulties and gaps in technical capacity, continue to limit project potential.
2. Access to specialised infrastructure (e.g. high-containment units and challenge trial platforms) is prohibitively expensive and inaccessible. The sale and subsequent decommissioning of the UK's Vaccine Manufacturing and Innovation Centre have further undermined access to critical infrastructure.
3. Commercial pathways for SMEs developing vaccines for LMICs are unclear. Without patentable platform technologies or guaranteed purchase commitments, incentives for investment are weak. In most cases, platforms must be licensable or adaptable to other disease areas to attract commercial interest.
4. Responsibility for funding and maintaining vaccine stockpiles in LMICs is poorly defined, undermining epidemic preparedness.
5. Persistent financial instability in the international development sector limits both the continuity and scale of support for vaccine R&D programmes

To maximise future impact of UKVN 2.0 and other vaccine R&D programmes, the following points may be considered by the DHSC:

Strengthen the strategic focus to support the vaccine R&D pipeline. Future investments should continue to refine the strategic focus to ensure that limited budgets are deployed effectively and maximise benefits for LMICs. Priorities should include:

1. Pathogens and pathogen families where alternative funding sources are limited, such as bacterial pathogens
2. Early discovery, pre-clinical development and Phase I clinical projects that are affordable and provide a strong foundation for later-stage clinical work
3. Areas with an ecosystem prepared for downstream investment, particularly where alignment exists with CEPI's eight priority pathogens and other global initiatives

4. Collaborative investment with other funders (to share risk and enhance feasibility) in a small number of projects where substantial funding could unlock high-impact scientific or translational breakthroughs.

Enhance LMIC leadership and improve pathway to global access. As vaccine candidates progress to clinical phases (e.g. Phase Ib), greater testing and trial implementation in LMIC communities[1] and inclusive LMIC research leadership should be prioritised. Increased technology transfer from UKVN projects to LMICs would support regional manufacturing and strengthen future vaccine sovereignty (see the promotion of voluntary technology transfer in the new Pandemic treaty[2]). The UKVN should also consider requiring patents from UKVN-funded projects to include an equitable and affordable access plan and a commitment to socially responsible licensing.

Support knowledge exchange and capacity building. Collaboration and knowledge sharing across organisations are essential to accelerate vaccine R&D and ensure equitable outcomes. Future investments should explore how established research clusters can provide mentorship to less experienced organisations in the UK and LMICs, facilitating learning via collaboration and training. Future programmes would also benefit from annual cross-project engagement activities to disseminate lessons learned, technical updates and best practices. The UKVN could further mobilise UK regulatory and scientific expertise to provide technical assistance to programme beneficiaries to accelerate vaccine approval timelines.

Strengthen monitoring practices and enable flexible funding approaches. Future programmes should adopt harmonised, low-burden approaches to monitoring and data collection. Standardised templates, designed to minimise burden on beneficiaries, can ensure consistent capture of essential information across diverse projects and support learning during project and programme evaluations. New funding approaches, such as commissioned funding, may be appropriate in cases where the vaccine development pathway is clearly defined. These could include direct grant awards from DHSC to key organisations with established technical capacity and capability. Whilst this depends on sufficient administrative capacity at DHSC, it holds the potential streamline project implementation and reduce unnecessary delays.

UKVN should coordinate more closely with international partners and initiatives. While the UKVN plays a key role as a national forum and advisor on vaccine R&D investments, effective end-to-end planning for vaccine platforms and priority pathogen families requires coordinated collaboration with both domestic and international stakeholders. Strategic partners include UKHSA, which maintains its own priority pathogen list; CEPI; the European Commission's HERA and EDCTP; WHO Collaborative Research Consortia; and selected LMIC-based organisations and initiatives such as AVAREF[3] and Medaccess[4]. These partnerships may support alignment of priorities, facilitate access to complementary expertise and resources and enable joint initiatives to address gaps in critical research infrastructure.

[1] See CERCLE, the LMIC network of clinical trials. https://cerclecoalition.org/

[2] https://www.who.int/news/item/20-05-2025-world-health-assembly-adopts-historic-pandemic-agreement-to-make-the-world-more-equitable-and-safer-from-future-pandemics

[3] https://www.afro.who.int/health-topics/immunization/avaref

[4] https://www.bii.co.uk/en/our-impact/direct-header/medaccess

Preamble

The UK's NIHR, on behalf of the DHSC, has commissioned Technopolis and Triple Line Consulting to conduct an independent impact and process evaluation of the first phase of the UK Vaccine Network (UKVN) Project 1.0 (2016-2023).

The aim of the evaluation was to assess the processes, outcomes and impacts of the UKVN Project 1.0 as well as to identify learnings for the ongoing second phase of the UKVN Project and to inform future iterations of UK Government investments into vaccine R&D. The evaluation was conducted between May 2024 and July 2025.

This final evaluation report provides contextual background to the UKVN Project 1.0, outlines the methodology and its limitations, presents the findings and implications and offers recommendations for DHSC and broader research funding community. Two separate documents accompany this report: a compendium of 18 case studies and appendices with detailed analysis of the data collected.

1 Introduction

1.1 Background to the UK Vaccine Network

The UK Vaccine Network (UKVN) is a UK government initiative established to strengthen global health security by accelerating the development of vaccines and associated technologies to tackle epidemic threats. Set up in 2015 in the context of the Ebola outbreak in West Africa, the UKVN brings together a multidisciplinary expert group to advise the Department of Health and Social Care (DHSC) on strategic investment in vaccine research and development (R&D). The UKVN also functions as a hub for policy support and shared learnings, leveraging coordinated public funding to de-risk early-stage innovation and move vaccine candidates closer to deployment.

The UKVN Project 1.0 (from hereafter referred to as 'UKVN 1.0') is the first phase of UKVN investments that ran from 2016 to 2023. It was one of the five components of the UK government's Global Health Security (GHS) programme and received £134m in Official Development Assistance (ODA) funding.[5] Its overarching goal was to support the development of vaccine candidates for diseases with epidemic potential, as well as manufacturing and epidemiological research.

The primary objective of UKVN 1.0 was to support developing countries in tackling infectious diseases and to promote global health as an international priority, in line with ODA funding criteria for the economic development and welfare of LMICs. As a secondary objective, UKVN 1.0 was expected to reduce global health threats to the UK and improve the UK's vaccine R&D capabilities. The project therefore aligned with several UK government priorities, as well as policies that seek to promote international collaborations (e.g. Global Britain).[6,7]

[5] Based on additional value added through cost extensions, as outlined in the Summary of UKVN Business Cases and Addendums

[6] GOV UK (2016). 2016 Budget documents. https://www.gov.uk/government/publications/budget-2016-documents/budget-2016 Accessed 16 July 2024

[7] UKVN 2019 SR Summary Sheet

1.1.1 UKVN priority pathogens

In 2015, the UKVN expert group developed an investment strategy for vaccine development for epidemic diseases. Using Delphi consensus process, the group identified 12 priority pathogens with epidemic potential in LMICs, based on factors such as outbreak risk, severity and the absence of effective vaccines and treatments. Notably, the 2016 UKVN priority pathogen list was the first of its kind globally and pre-dated but aligned closely with – the World Health Organization's R&D Blueprint. [8]

The 12 priority pathogens identified were Chikungunya, Crimean-Congo Haemorrhagic Fever, Ebola, Hantavirus, Lassa, Marburg, Middle East Respiratory Syndrome, Nipah, Plague, Q Fever, Rift Valley Fever, Zika. In addition, the UKVN list included 'Disease X', referring to unknown pathogens with epidemic potential. The focus of this list was on high-risk pathogens that were unlikely to attract commercial interest from industry due to limited market potential, therefore requiring public sector intervention.[9]

The UKVN recognised critical gaps in the vaccine development pathway for these pathogens, in particular the lack of investment in high-risk early stages, such as Phase 1 clinical trials. It also recognised challenges in conducting Phase 2 and 3 trials for outbreak diseases.[10] For these reasons, the UKVN recommended that the UKVN 1.0 focus on early-stage vaccine development (a historically underfunded area), including:

- Late-stage preclinical and early clinical development of vaccine candidates against the 12 known priority pathogens
- Novel vaccine platform technologies that could be adapted for development of vaccines against emerging diseases[11]
- Vaccine manufacturing technologies to reduce development timelines and improve vaccine equity in LMICs
- Technologies and applied epidemiological research to support effective vaccine development during an outbreak

1.1.2 Overview of the UKVN 1.0

The UKVN1.0 comprised 11 funding competitions managed by four delivery partners:

- Innovate UK
- NIHR
- The Engineering and Physical Sciences Research Council (EPSRC)
- The Biotechnology and Biological Sciences Research Council (BBSRC)

Between 2016 and 2023, the UKVN 1.0 awarded 99 grants, totalling approximately £117.4m (excluding extensions), to support vaccine research and development across a range of scientific disciplines and stages of innovation.

[8] Scoping interviews

[9] Scoping interviews

[10] Scoping interviews

[11] UKVN Original Business Case approved in 2016

Section 3.1 provides a detailed overview of the number of projects funded under each competition, along with associated funding levels and project durations. A summary of delivery partner contributions is provided below.

Between 2016 and 2023, Innovate UK managed seven of the eleven UKVN 1.0 funding competitions, supporting R&D activities from early-stage discovery through to clinical development. It awarded 81 grants, accounting for 62% of the programme's total funding. The NIHR managed two competitions: one through the NIHR Evaluation Trials and Studies Coordinating Centre (NETSCC) and the other through the Central Commissioning Facility (CCF). The first, delivered by NETSCC, supported six clinical-stage projects between 2016 and 2021 to advance vaccine candidates, with a total investment of £12m (10%). The second, managed by the CCF, funded five projects under the 'Epidemiology for vaccinology' competition between 2018 and 2022, with an investment of £4.2m (4%).

EPSRC led the Future Manufacturing Research Hub competition, which funded two large-scale projects between 2016 and 2021. These projects received a combined total of £22.6 million (19%). **BBSRC** managed the 'One Health' competition, supporting five projects from 2018 to 2021 with a total funding allocation of £5.4 million (5%).

UKVN 1.0 provided a diverse and strategically layered series of investments, aligned with the priorities set by the UKVN expert group. The investment supported activities across the vaccine development pipeline, including discovery research, manufacturing capacity, clinical development and epidemiological studies.

UKVN 1.0 positioned itself within early-stage vaccine R&D for diseases with epidemic potential, including work on vaccine technologies. It therefore complemented broader vaccine R&D investments, particularly funding designated for late-stage development (e.g. Phase III trials, regulatory processes, distribution and manufacturing), provided by bodies such as the Coalition for Epidemic Preparedness Innovations (CEPI), the EU, Gavi (Gavi, the Vaccine Alliance), and the U.S. National Institute of Allergy and Infectious Diseases. Through DHSC, the UKVN programme also acted as a significant investor in CEPI, contributing £46m between 2018 and 2021, while also coordinating UKVN 1.0 activities to avoid duplication.[12]

1.2 Developments in vaccine R&D and policy

The development of vaccines has traditionally been a lengthy, costly and uncertain process, typically taking 10 to 15 years from conception to regulatory approval. Historical success rates have been low, with only 3.3% of candidates progressing from Phase II to licensure within a decade.[13] A 2018 estimate of the cost of developing a vaccine from preclinical trials through to the end of phase IIa was between US$319m and US$469m (with a wide range from US$137m to US$1.1b), accounting for the likelihood that some vaccine candidates do not succeed.[14]

Emerging infectious diseases (EIDs) pose additional challenges to vaccine development due to the unpredictability of outbreaks, slowing the pace of clinical trials.[15] The COVID-19 pandemic, however, demonstrated that accelerated vaccine development for EIDs is

[12] DHSC & CEPI (2018-2023) UK Vaccine Network – Bilateral Contribution Agreement and Addendum Notices. Available at https://d-portal.org/savi/?aid=GB-GOV-10-UKVN-CEPI Accessed 21 June 2024

[13] MacPherson A *et al* (2020) Probability of Success and Timelines for the Development of Vaccines for Emerging and Reemerged Viral Infectious Diseases. *Ann Intern Med*. 174(3). https://doi.org/10.7326%2FM20-5350

[14] Gouglas *et al* (2018) Estimating the cost of vaccine development against epidemic infectious diseases: a cost minimisation study. *The Lancet Global Health*. 6(12). https://doi.org/10.1016/S2214-109X(18)30346-2 4

[15] Rezza, G & Weaver, SG (2019) Chikungunya as a paradigm for emerging viral diseases: Evaluating disease impact and hurdles to vaccine development. PLOS NTD. https://doi.org/10.1371/journal.pntd.0006919

possible. Facilitated by prior coronavirus research and unprecedented levels of global funding and collaboration, the first COVID-19 vaccine received regulatory authorisation for UK use in December 2020, less than 11 months after the SARS-CoV-2 genetic sequence was published.[16]

Historically, vaccines were produced as whole-pathogen products (live attenuated or inactivated) or as toxoid, subunit and later conjugate formulations, the manufacture of which was dependent on pathogen-specific processes that were often complex to develop and scale.[17] Recently, novel vaccine platforms based on viral vectors, RNA, or DNA have emerged, offering faster adaptation to emerging diseases and improved safety, scalability and reproducibility in manufacturing.

The first of these platform-based vaccines, a viral vector vaccine for Ebola, was approved in 2019.[18] The COVID-19 pandemic further accelerated the development and approval of vaccines using these technologies, reducing timelines from years to months. Challenges remain, particularly to the effective deployment of vaccines based on novel technologies in LMICs, such as the need for ultra-low temperature storage and, in some cases, complex immunisation schedules.[19,20]

Recent pandemics have also spurred policy changes that accelerated vaccine R&D and regulatory processes. The 2014-2016 Ebola outbreak highlighted the need for rapid response mechanisms, leading to WHO's R&D Blueprint for faster epidemic preparedness, which prioritises and streamlines vaccine development and approval for EIDs.[21] The COVID-19 pandemic further demonstrated the effectiveness of these policy changes, such as the use of adaptive trial designs and accelerated regulatory processes. However, policy instruments such as COVAX, a global initiative for equitable vaccine distribution, were unable to ensure equitable access to vaccines for LMICs.[22]

1.3 Challenges to vaccine R&D and access

Significant challenges remain in translating basic research into commercially available vaccines, with many potential innovations stalling at early stages and failing to advance beyond proof of concept. Translational research has to solve scientific and technical challenges (e.g. understanding a disease mechanism, ensuring the stability of vaccine candidates) as well as tackling 'non-scientific' challenges such as insufficient R&D funding, a lack of infrastructure and translational research skills, regulatory and administrative burden,

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[16] Oliver SE *et al* (2021) The Advisory Committee on Immunization Practices' Interim Recommendation for Use of Moderna COVID-19 Vaccine - United States, December 2020. *MMWR Morb Mortal Wkly Rep.* 69(5152). https://doi.org/10.15585/mmwr.mm695152e1

[17] Ghattas M *et al* (2021) Vaccine Technologies and Platforms for Infectious Diseases: Current Progress, Challenges, and Opportunities. *Vaccines* 9(12):1490. https://doi.org/10.3390/vaccines9121490

[18] Wolf J, *et al* Applying lessons from the Ebola vaccine experience for SARS-CoV-2 and other epidemic pathogens. npj Vaccines 5, 51 (2020). https://doi.org/10.1038/s41541-020-0204-7

[19] Ghattas M, *et al*. (2021) Vaccine Technologies and Platforms for Infectious Diseases: Current Progress, Challenges, and Opportunities. *Vaccines* 9(12):1490. https://doi.org/10.3390/vaccines9121490

[20] Zhang, H et al (2024) Single dose recombinant VSV based vaccine elicits robust and durable neutralizing antibody against Hantaan virus. npj Vaccines 9: 28. https://doi.org/10.1038/s41541-024-00814-2

[21] WHO (2016) An R & D Blueprint for Action to Prevent Epidemics – Plan of Action. https://cdn.who.int/media/docs/default-source/blue-print/an-randd-blueprint-for-action-to-prevent-epidemics.pdf Accessed 16 July 2024

[22] Hotez PJ *et al* (2023) COVID-19 vaccines and the pandemic: lessons learnt for other neglected diseases and future threats. BMJ Global Health 8(6):e011883. https://doi.org/10.1136/bmjgh-2023-011883

difficulties collaborating across scientific fields and sectors and a lack of incentives for academic researchers to translate an innovation.[23,24]

This results in innovations getting 'stuck' along the development pathway. The UKVN created a Vaccine Development Process Map to guide early discovery and development scientists through the key stages in vaccine development.[25] The tool highlights potential bottlenecks in the various development phases, focussing on those that may be improved by corrective action or investments by governments, research funders and policy makers.

Compared with High-Income Countries (HICs), LMICs face additional challenges to ensure access to vaccines, related to procurement, distribution, and uptake of vaccines.[26,27,28,29] These include financial constraints, inadequate healthcare infrastructure, complex distribution (e.g., in rural and conflict areas), vaccine hesitancy and few opportunities to build manufacturing and logistics capacity.

Organisations such as the CEPI, Gavi and the European Union (EU) support initiatives that aim to build local manufacturing capacity, thus reducing reliance on vaccine supplies from HICs.[30] The COVID-19 pandemic highlighted the need for Intellectual Property (IP) waivers and technology transfer to improve vaccine access in LMICs.[31] Although a partial IP waiver was agreed upon during the COVID-19 pandemic, it was criticised for not fully addressing the challenges faced by LMICs.

1.4 The international funding landscape for vaccine R&D

Vaccine innovation is primarily concentrated in HICs. Biomedical R&D requires effective coordination between academia, government and industry, with the private sector taking on the later stages of commercialisation and manufacturing.[32] However, the financial incentives for companies to invest in vaccine development for EIDs are limited by the lengthy, costly and risky development process, the sporadic and unpredictable nature of outbreaks and the higher prevalence of disease outbreaks in LMICs where resources and biomedical R&D and manufacturing capacity are strained.

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[23] MRC Translational Research 2008-2018, Evaluation Report (2019). Available at: https://www.ukri.org/wp-content/uploads/2022/01/MRC170122-TranslationalResearchEvaluationReport.pdf Accessed 21 June 2024

[24] Lander & Atkinson-Grosjean (2011) Translational science and the hidden research system in universities and academic hospitals: A case study. *Social Science & Medicine*. 72(4). https://doi.org/10.1016/j.socscimed.2010.11.019

[25] UKVN Working Group 3 focus: "To understand the challenges in vaccine development and the key rate limiting steps for any given vaccine in development."

[26] Reza *et al* (2023) Local distribution infrastructure and robust vaccine manufacturing facilities in LMICs should be prioritised to tackle ongoing and future pandemic risk. *The Lancet Regional Health*. 11(100158). https://doi.org/10.1016/j.lansea.2023.100158

[27] Reza *et* al (2022) Why are vaccination rates lower in low and middle income countries, and what can we do about it? *BMJ*; 378: e069506 https://doi.org/10.1136/bmj-2021-069506

[28] Pugliese-Garcia *et al* (2018) Factors influencing vaccine acceptance and hesitancy in three informal settlements in Lusaka, Zambia. *Vaccine*. 36(37). https://doi.org/10.1016/j.vaccine.2018.07.042

[29] Understanding the behavioural and social drivers of vaccine uptake - WHO position paper – May 2022. Available at: https://iris.who.int/bitstream/handle/10665/354458/WER9720-eng-fre.pdf Accessed 20 June 2024

[30] CEPI 2022-2026 strategy. Available at: https://static.cepi.net/downloads/2023-12/CEPI-2022-2026-Strategy-v3-Jan21_0.pdf Accessed 21 June 2024

[31] Erfani P. *et al* (2021) Intellectual property waiver for covid-19 vaccines will advance global health equity. *BMJ*. 374. https://doi.org/10.1136/bmj.n1837

[32] Sanami *et al* (2017) Translating healthcare innovation from academia to industry. *Advances in Mechanical Engineering*. 9(3). https://doi.org/doi:10.1177/1687814017694114

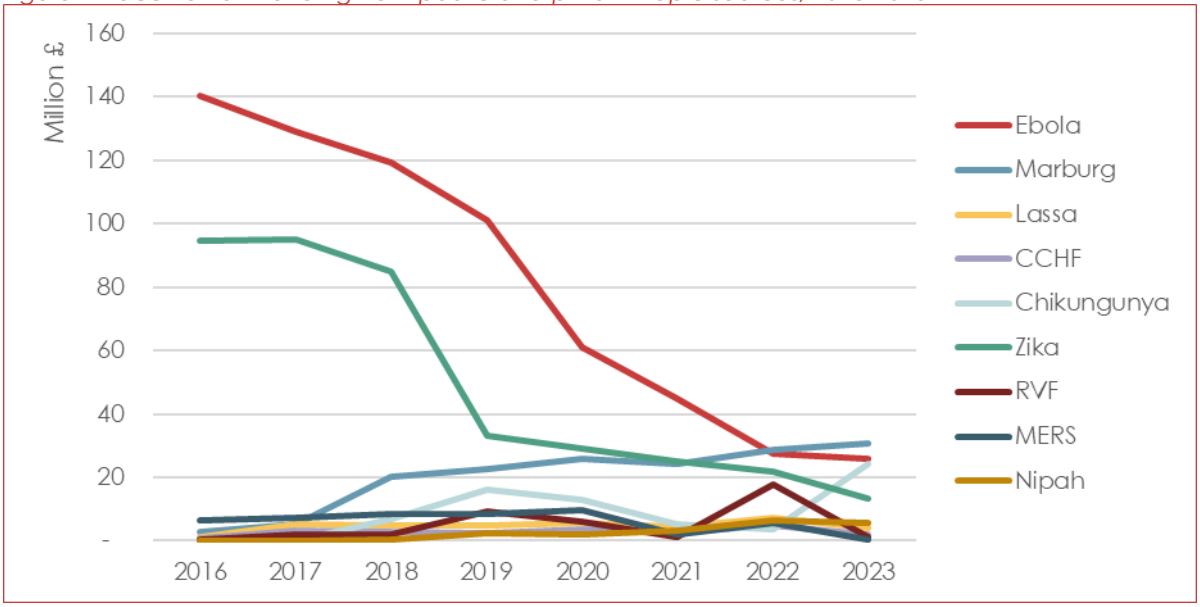
To help alleviate market challenges of vaccine development, international organisations, such as Gavi, undertake market shaping activities to stimulate industry investment in vaccines R&D. For example, Gavi's Vaccine Investment Strategy 2024 identified emerging infectious diseases as a strategic priority, with provisions for future vaccine rollout contingent on readiness and a focus on partnership with CEPI for diseases such as MERS, Nipah and Lassa fever.[33] In addition, public funders and philanthropic organisations support vaccines R&D and capacity building along all stages of the vaccine development pipeline.

The G-FINDER database tracks R&D funding for new products and technologies that address global health challenges.[34] It includes information on R&D funding for all UKVN priority diseases except plague, Hantavirus disease and Q Fever (which are hence not included in the figures reported below).[35]

From 2016 to 2023, G-FINDER reported £1.45 billion in vaccine R&D targeting UKVN priority pathogens for public and philanthropic funders, with public funding accounting for 98% of this figure. Funding levels for vaccines targeting Ebola and Zika were highest, especially over the 2016 to 2020 period (Figure 1), reflecting contemporary outbreaks in West Africa and South America.

Ebola virus research received the largest share of vaccine R&D funding, at £650m (44.9% of funding for UKVN priority pathogens for which G-FINDER holds information), followed by Zika virus (£397m, 27.5%) and Marburg virus (£161m, 11.2%). All other UKVN pathogens each received less than 5% of total funding.

Figure 1 Vaccine R&D funding from public and philanthropic sources, 2016-2023



[33] Investment Strategy 2024, GAVI. https://www.gavi.org/our-alliance/strategy/vaccine-investment-strategy-2024

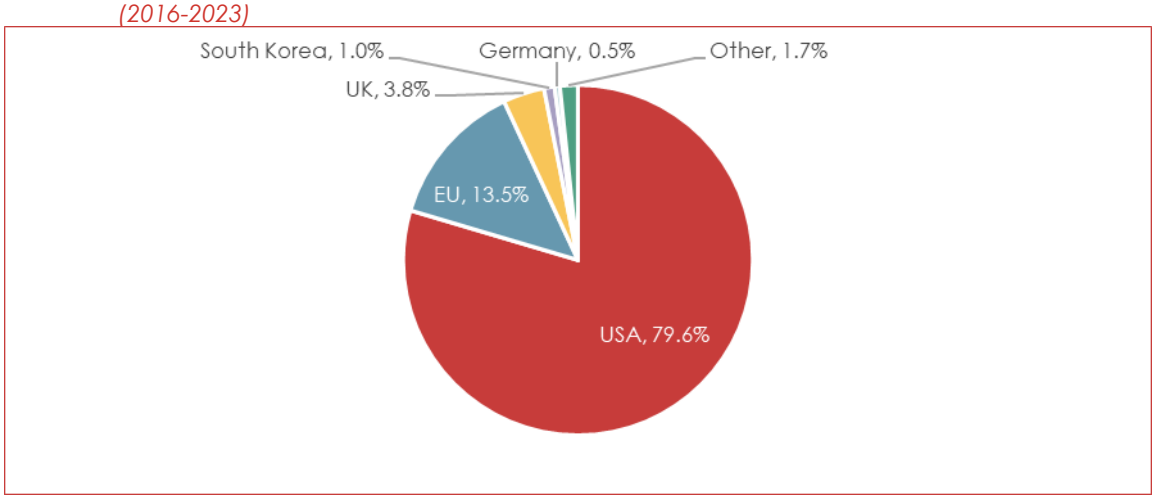
[34] https://gfinderdata.policycuresresearch.org/ Accessed 22 July 2025

[35] G-FINDER reports on Ebola funding from 2014, on Marburg, CCHF, RVF, Lassa and Zika from 2015, on MERS, Nipah and Disease X from 2016, and on Chikungunya from 2018. To maximise comparability, this analysis focusses on 2016-2023 data for investment in vaccine R&D; however, funding for Chikungunya does not include 2016 and 2017 and is hence underreported. https://gfinderdata.policycuresresearch.org/assets/media/pdf/EID_R&D_scope.pdf . Additional detail and caveats of G-FINDER data is available in Appendix H.

Source: G-FINDER database. Public funders' includes funding from Science & Technology agencies, other public government, aid agencies and multilaterals.

Public funding from the United States accounted for the majority for UKVN pathogen vaccine R&D (£1.15bn, 79.6%), Figure 2 most of which supported vaccines targeting Ebola (44%), Zika (31%) and Marburg (14%) viruses (Figure 2). This is followed by contributions from the EU (£194.6m, 13.5%; mainly for Ebola, Chikungunya and RVF vaccines), the United Kingdom (£55.2m, 3.8%), South Korea (£14.1m, 1.0%) and Germany (£7.1m, 0.5%).

Figure 2 Public and philanthropic funding for vaccine R&D targeting UKVN pathogens, per country (2016-2023)



Source: G-FINDER database

Since 2017, G-FINDER has tracked data on funding for EID platform technology development (e.g. adjuvants and immunomodulators, general diagnostic platforms and vaccine-related platform technologies), and for cross-cutting fundamental research on EIDs (e.g. understanding One Health approaches and animal-human disease epidemiology).[36]

Between 2017 and 2023, public and philanthropic funders invested £971 million in platform technologies and £201 million in fundamental research. The majority of funding was provided by the United States (99% and 82% of all funding, respectively), primarily via the US DoD for platform technologies and the US DoD and US NIH for fundamental research. Over the same period, the UK contributed £51 million towards platform technologies and £12 million towards fundamental research.

Among philanthropic funders, the Gates Foundation and Wellcome provided the largest contributions. The Gates Foundation began investing in platform technologies in 2020, providing £60 million between 2020 and 2023. Over the same period, the Gates Foundation and Wellcome contributed £5.3 million and £8 million respectively to fundamental EID research.

1.4.1 Vaccine R&D funders and key initiatives

The high cost and global scope of vaccine R&D encourage frequent collaboration between funders, often through global partnerships and product development partnerships (PDPs).

[36] Impact Global Health (2024). G-Finder. Emerging Infectious disease R&D Scope https://gfinderdata.impactglobalhealth.org/assets/media/pdf/EID_R&D_scope.pdf Accessed 22 July 2025

National governments and philanthropic organisations also provide direct funding for vaccine R&D.

Among **global partnerships**, CEPI plays a key role in the development of vaccines and other biologic countermeasures against epidemic and pandemic threats, ensuring they are accessible to all who need them. CEPI has received more than US$2.6bn from donors, including 35 national governments, the EU and more than ten philanthropic organisations (2017-2023).[37]

CEPI's 2022-2026 strategic aims are based on a projection of US$3.5bn of funding.[38] Its portfolio includes 43 vaccine candidates, including against Betacoronaviruses, Lassa, Nipah, RVF, MERS, Chikungunya and Disease X (i.e. R&D related to epidemic preparedness more generally).[39]

Other global partnerships supporting R&D against UKVN priority pathogens include the European Vaccines Initiative (Nipah virus and Zika virus) and the International AIDS Vaccine Initiative (Ebolavirus, including Sudan ebolavirus, Lassa virus and Marburg virus). Gavi provides funding to enhance health system, immunisation and vaccine manufacturing capacity in LMICs. More detail on the partnerships is available in the full review in Appendix H.

G-FINDER data for 2016–2023 indicate that the largest national contributor to vaccine R&D on UKVN priority pathogens was the US Biomedical Advanced Research and Development Authority (BARDA, £527.6m), followed by the US National Institutes of Health (NIH, £467.8 million), the European Commission (£194.6m), and the US Department of Defense (DoD, £142.1 million). UK funders captured in G-FINDER include Innovate UK (£32m), the Department of Health and Social Care (DHSC, £11.6m), and Wellcome (£11.6m). In South Korea, the majority of vaccine R&D investment (£11.9 million of £14.2 million) was provided by the Samsung Foundation, directed towards MERS vaccine R&D.

Japan is a relatively new entrant in the vaccine R&D sector. For the period 2022–2027, the Japanese government has committed approximately US$8.5b to vaccine research and development. This includes US$400 million through SCARDA to establish new vaccine R&D centres at several universities, US$2.7 billion from other agencies to support vaccine-related start-up, US$1.7 billion to expand vaccine manufacturing capacity and US$2 billion to fund large-scale clinical trials and procure COVID-19 vaccines.[40]

Philanthropic organisations funding vaccine R&D relevant to the UKVN remit include the Bill and Melinda Gates Foundation and Wellcome. Further details of national and philanthropic funders relevant to UKVN's remit are provided in Appendix H.

According to G-FINDER, private sector investment in vaccine R&D targeting UKVN priority pathogens totals nearly £500 million. The majority of this funding has been directed towards Ebolavirus (£387.5 million) and Zika virus (£60.7 million) vaccines in response to respective outbreaks. Investment in Chikungunya virus vaccines (£39.0 million) is also notable and likely reflects progress towards, and attainment of, regulatory approval of two CHIKV vaccines in

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[37] CEPI 2023 investors overview. Available at: https://static.cepi.net/downloads/2024-01/2023_12_20-CEPI-Investors-Overview.pdf Accessed 16 July 2024

[38] CEPI 2022-2026 strategy. Available at: https://static.cepi.net/downloads/2023-12/CEPI-2022-2026-Strategy-v3-Jan21_0.pdf Accessed 21 June 2024

[39] Active CEPI-funded vaccine candidate portfolio by phase, March 2024. https://static.cepi.net/downloads/2024-04/CEPI%20active%20portfolio%20overview%20website_Last%20Updated%204%20Apr%202024.pdf Accessed 5 Aug 2024

[40] Science.org, Japan moves to bolster vaccine R&D after COVID-19 exposed startling weakness. Available at: https://www.science.org/content/article/japan-moves-bolster-vaccine-r-d-after-covid-19-exposed-startling-weakness Accessed 13 August 2024

2024/25 (see section 3.2). By contrast, reported private sector investment in vaccines for other UKVN priority diseases remains relatively low (<£1 million).

A total of 18 companies are/were involved in the development of the 33 vaccine candidates that entered clinical trials (of which five gained regulatory approval vaccines), targeting seven UKVN priority pathogens (see Appendix H).

1.5 Evaluation objectives

The main objective of the evaluation, as outlined in the commissioning brief, was to undertake an impact and process evaluation of the UKVN Project 1.0 from its inception to-date.

The impact evaluation aimed to assess the extent to which the UKVN 1.0 progressed towards its objectives. The key questions it sought to answer are:

- **EQ1:** To what extent have the intended outcomes and impact on the vaccine development pipeline, as set out in the ToC been observed or are on track to be achieved and why? To what extent and how has the UKVN 1.0 contributed to these outcomes and impacts?
- **EQ2:** How beneficial has this research been for LMIC populations? If this cannot yet be assessed, how likely is this research to benefit LMIC populations?
- **EQ3:** What barriers remain for UKVN funded projects in progressing vaccines down the development pipeline?
- **EQ6:** What additional benefits has UKVN-funded work enabled such as scientific advances and capacity building?

The process evaluation aimed to review the coherence, efficiency and effectiveness of the UKVN 1.0.

- **EQ4:** Has the UKVN allocated resources effectively to priority areas where there are gaps in the R&D landscape?
- **EQ5:** How effective is the UKVN delivery model? Does the current delivery model and the choice and performance of delivery partners allow the UKVN Project to maximise its impact and meet its objectives? Are there opportunities to improve the delivery model or ways of working to improve efficiency/effectiveness?

1.6 This report

This impact and process evaluation focused on assessing the UKVN 1.0 as a whole (i.e. the UKVN Project 1.0 investments made between 2016 and 2023). Analyses of data from individual delivery partners or projects should not be used for comparison.

Section 2 provides a description of the UKVN 1.0 Theory of Change and an overview of the methodology used in the evaluation. Section 3 presents the results and discuss the outcomes and impacts, along with process evaluation of the UKVN 1.0. Section 4 offers conclusions and recommendations based on the evaluation findings.

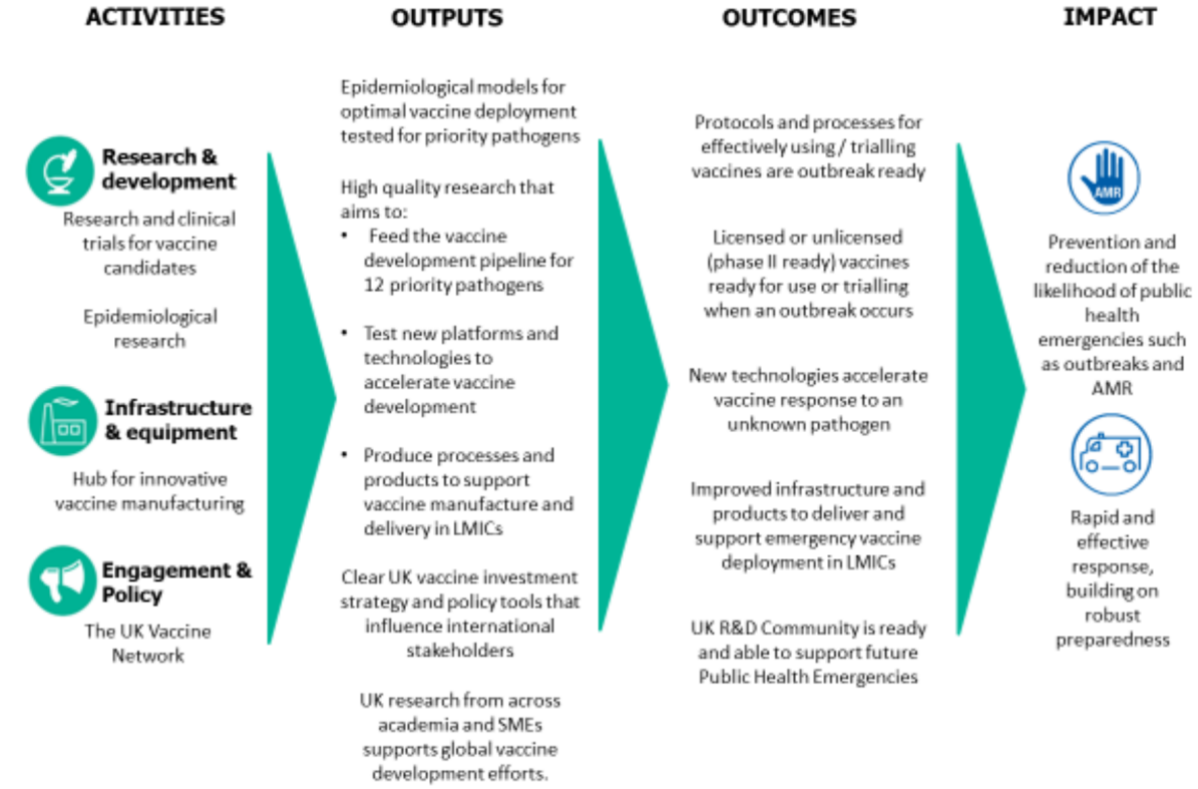
2 Methodology

A theory-based evaluation relies on a Theory of Change (ToC) that outlines expectations of how the UKVN 1.0 was expected to achieve its original objectives through DHSC funding. Testing these assumptions involves collecting and analysing quantitative and qualitative data from various sources and triangulation to minimise data gaps and produce robust conclusions.

2.1 UKVN 1.0 Theory of Change

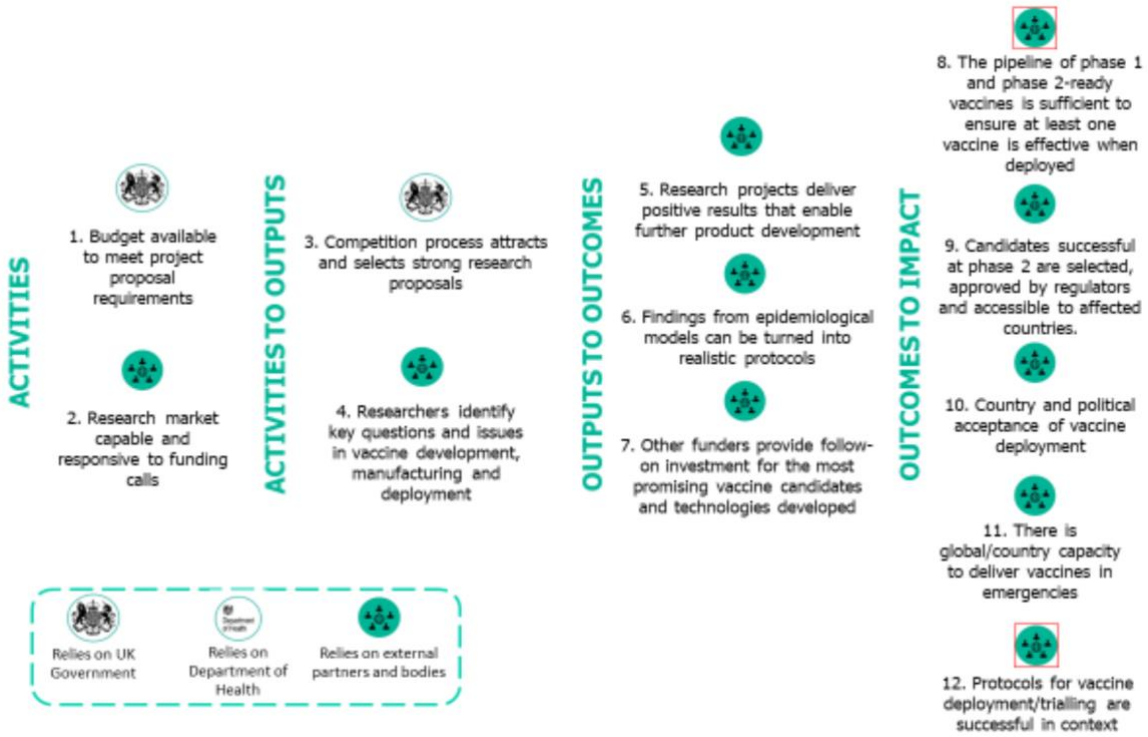
DHSC supplied an established ToC for the UKVN 1.0 as part of the evaluation (see Figure 3 and Figure 4). The ToC indicates that the programme focused on three main areas: vaccine R&D, infrastructure and equipment and engagement and policy. Anticipated outputs included high-quality research, novel platforms and innovative manufacturing processes relevant to the 12 priority pathogens. These outputs were expected to generate trial-ready vaccines, improve deployment infrastructure for LMICs and strengthen the UK R&D ecosystem, ultimately enhancing the prevention of, response to, and resilience against public health emergencies.

Figure 3 UKVN project Theory of Change



Source: UK Vaccine Network Project Annual Review - 2019/20

Figure 4 UKVN project Theory of Change Assumptions

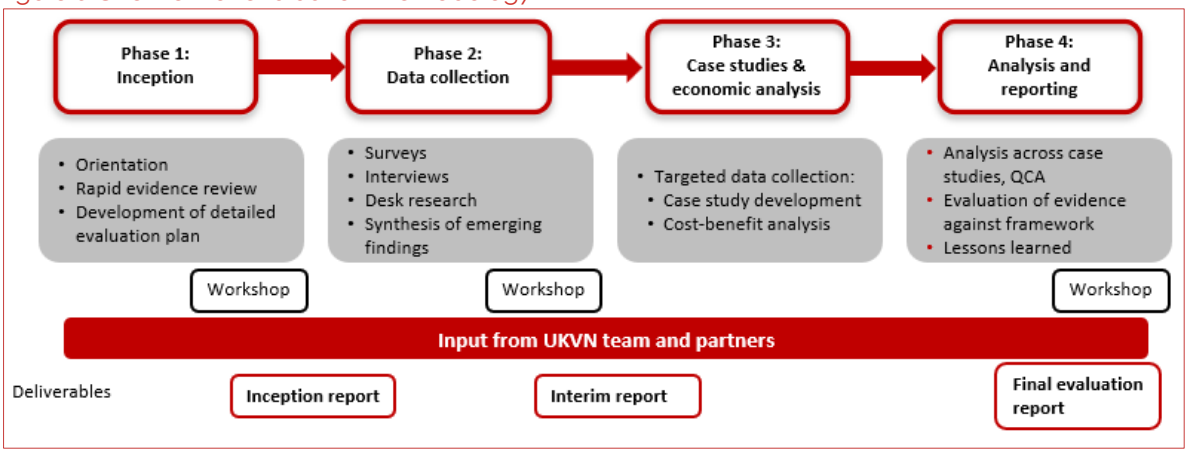


Source: UK Vaccine Network Project Annual Review - 2019/20

2.2 Methods and data sources

The data collection and analysis methods employed in this evaluation aimed to respond to evidence needs for testing the expectations around outputs, outcomes and impact of the UKVN 1.0, as outlined in the ToC. Figure 5 presents an overview of the four evaluation phases and the methods used.

Figure 5 Overview of evaluation methodology



Below we provide an overview of the methods applied and data sources. Appendix A presents a more detailed description of the methods and data sources.

2.2.1 *Orientation and development of detailed evaluation plan*

The orientation phase was initiated with a kick-off meeting between the study team, DHSC and NIHR on 10 May 2024. Following the kick-off meeting, the study team conducted a preliminary analysis of UKVN documentation shared by DHSC and of the UKVN 1.0 portfolio.

Upon receipt of UKVN documentation, the evaluation team conducted an analysis of these documents to gain an understanding of UKVN delivery processes and projects and identify information gaps. A total of 292 documents were shared with and analysed by the evaluation team. A preliminary analysis of these documents supported the development of the data collection tools, to make use of existing data and reduce burden on beneficiaries of the UKVN Project 1.0.

To supplement the knowledge gained from analysis of the UKVN documentation and portfolio, we conducted 10 scoping interviews with 13 individuals previously or currently involved in UKVN Project 1.0. Scoping interviews were conducted between 21 June and 6 August 2024. The interviewees are listed in Appendix A.

Following these activities, we developed an evaluation framework, including evaluation questions (EQs), related indicators and analytical methods/data sources, based on the research questions provided in the commissioning brief, our analysis of the ToC of the UKVN Project, the UKVN log frame metrics and additional lines of enquiries suggested in scoping interviews. This framework has allowed us to develop structured primary data collection tools (see below), building on information in available secondary portfolio data.

2.2.2 *Rapid evidence review*

We conducted a rapid review of the literature in the orientation phase between June and August 2024, capturing the current landscape and key developments since the establishment of UKVN. The review synthesised information gathered through four approaches:

1. Keyword searches of bibliographic databases of peer-reviewed literature, including PubMed and Europe PMC and grey literature from Google searches and snowballing from key documents/reviews. Keywords targeted information on vaccine R&D, UKVN priority pathogens and challenges for vaccine development and deployment in LMICs. Information was triangulated by consulting multiple sources.
2. Targeted searches of websites of government departments, research funders and international organisations.
3. Analysis of the International Clinical Trials Registry Platform (ICTRP, https://trialsearch.who.int/), using keyword searches (Vaccine AND [UKVN priority disease]). Information was triangulated through keyword searches of the peer-reviewed and grey literature (see above).
4. Analysis of the G-FINDER data portal (https://gfinderdata.policycuresresearch.org/) to collect and present information on global funders and funding levels for vaccines R&D from 2014 to 2022 (the most recent period for which data was available). Our database query used product filter 'vaccine' and specific disease filters. G-FINDER does not cover Plague, Q-fever and Hantavirus disease.

In total, the rapid evidence review identified 172 sources of evidence including:

- Individual organisation websites, publications and announcements, including data from manufacturers, funders, initiatives, news outlets, CORDIS (n = 83)
- Scientific journal articles & books (n = 62)

- Policy literature and government initiatives (n = 27)

2.2.3 Portfolio analysis

We compiled a database containing information on the UKVN 1.0 projects, including references, grants value and other details, as well as key outputs such as publications, innovation metrics and vaccine candidates. Both quantitative and qualitative analyses were conducted to assess the UKVN 1.0 outputs, outcomes and early impacts. Preliminary analysis of the portfolio during the inception phase also informed the development of our data collection approach.

The database was populated with information from (1) final project reports; (2) Researchfish; and (3) survey data. We note that there was no harmonised monitoring and reporting system in place for all UKVN-funded projects. The survey allowed respondents to update any information that had changed since they submitted their final project reports or uploaded information to Researchfish, as well as to provide feedback on topics such as team experience.

Project outputs from each data source, such as publication lists and innovation outputs, were compiled and merged, where possible, to ensure that no duplication of reported data occurred.

Final project reports

Final project reports provided narrative and structured information on project activities, outputs and outcomes across the UKVN 1.0 at the time of project completion. Significant variability in the format and detail of these reports between delivery partners and competitors, complicated data extraction efforts. Manual analysis was conducted guided by a thematic framework to capture projects pathogen coverage, objectives, vaccine R&D stages and other key data. This structured review enabled integration with the other data sources of the portfolio analysis.

Researchfish

The latest Research data at the time of the evaluation (March 2024) was extracted from Gateway to Research (GtR) to populate the database of projects with quantitative outputs such as publications, engagement activities and commercial outcomes. Only a subset of projects, specifically those funded via BBSRC and EPSRC (n = 7) reported through GtR. Outputs from these projects were analysed and cross-referenced with final reports and survey data.

2.2.4 Online survey

We conducted two online surveys with (1) successful and (2) unsuccessful applicants to UKVN 1.0 competitions. The surveys aimed to update and expand our knowledge of project outputs, outcomes and impacts. For unsuccessful applicants, the survey aimed to obtain information on how project ideas might have progressed since their application.

The survey was open for 45 days between December 2024 and January 2025. A total of 61 project leads were invited, of whom 33 provided answers (54% response rate). An additional 23 responses were received from project partners invited by project leads. In total, 56 responses (from leads and partners) were collected, covering 39 individual projects. These represented approximately 50% of all UKVN projects and 48 UKVN grants (multiple grants could be linked to the same project, for example through follow-on funding). Only one unsuccessful applicant responded to the survey; this response was excluded from the analysis.

2.2.5 Interviews

A programme of interviews was conducted with experts not directly involved with the UKVN 1.0 but with substantial experience in vaccine R&D across academia, industry and funding

bodies. The aim was to gather external perspectives on the UKVN's added value, its role in addressing R&D barriers and prioritising resources and its potential impact in beneficiary countries. Following consultation with DHSC, 33 invitations were sent and 19 interviews were completed with representatives across16 organisations.

2.2.6 *Cost-benefit analysis*

A cost-benefit analysis was conducted to estimate the global benefits of the first year of the Oxford-AstraZeneca COVID-19 vaccine rollout. The vaccine is based on the ChAdOx platform, whose development was supported by the UKVN 1.0. The analysis assessed the number of deaths prevented and hospitalisations reduced and estimated the proportion of these benefits attributable to the UKVN's investment. These attributed benefits were then compared to the UKVN's funding to estimate a return on investment, with additional consideration given to the platform's broader potential beyond COVID-19.

2.2.7 *Case studies*

A total of 18 case studies were produced to capture in-depth insights into the impact and learning generated by the UKVN 1.0. The case studies served as examples, tracing how UKVN funded activities have enabled outcomes, such as advancing technologies along the vaccine development stages or fostering critical research capabilities in the UK and in LMICs.

Case studies were selected using a set of selection criteria, including (1) funding size, delivery partner and research competitions; (2) type(s) of organisations involved; (3) type(s) of outcomes and impact as set out in the ToC; (4) coverage of evaluation questions; (5) availability of evidence and access to key informants; (6) pathogen coverage. An initial long list of case studies was iterated and agreed with DHSC.

Information for the case studies was collected through targeted online searches and in-depth interviews with project leads. A list of project leads interviewed for case studies is provided in Appendix A. The final list of case studies, along with the full case study narratives, is provided in the accompanying case studies file developed for this evaluation final report.

2.3 Limitations

Several limitations affected the robustness of the findings.

First, the UKVN 1.0 encompassed a diverse portfolio of projects, spanning multiple disciplines, technology areas and timelines. This heterogeneity constrained the ability to take a programmatic view of the portfolio.

Second, the early-stage nature of research and innovation activities funded through the UKVN 1.0 meant that many projects, while completed at the time of the evaluation, continued beyond it through follow-on work; as a result, not all intended outcomes or longer-term impacts were yet visible or could be captured in the evaluation.

Third, the portfolio analysis faced limitations in data coverage and quality. Final project reports, Researchfish submissions and survey responses varied in completeness and accuracy, with potential under- or overreporting of activities and achievements. Analysis of the final reports was further constrained by inconsistent structures, qualitative focus, and lengthy narrative content. The technical complexity and diversity of funded projects also made it difficult to assess precise R&D progress. Nevertheless, in most cases, it was possible to form a high-level view that provided a clear indication of progress and direction.

Moreover, many final project reports were submitted shortly after project closure, reflecting the situation at closure, up to eight years before the evaluation. Although efforts were made to triangulate more recent data from various sources, this was not possible for some projects due

to the missing survey responses. In these cases, the evaluation relied primarily on final reports to capture achievements during the funding period, which may underestimate the full impact of the UKVN 1.0.

Fourth, there were considerable challenges regarding data collection and stakeholder engagement. Survey responses were obtained for approximately half of all projects, constrained by staff turnover, outdated contact information and limited participant availability. These challenges are inherent to retrospective evaluations conducted several years after project completion and are not unique to this evaluation. For case studies, interviews were often restricted to project leads, as it proved difficult to reach other project partners. Broader engagement with partners could have offered additional perspectives on collaboration and capacity building.

Finally, the cost-benefit analysis was constrained by gaps in available data. Limitations included incomplete information on R&D costs, assumptions around vaccine effectiveness and difficulties in tracking funding sources for vaccine procurement (further details are provided in Appendix E).

3 Results

This section is structured as follows: first, an overview of the UKVN 1.0 programme portfolio is provided (see Appendix B for further details); second, results are presented in relation to the outcomes and impacts outlined in the UKVN ToC; and finally, findings from the process evaluation of the UKVN 1.0 are reported.

3.1 Overview of the UKVN 1.0 portfolio of projects

The UKVN 1.0 supported a portfolio of 99 project grants delivered between 2016 and 2023. As illustrated in the Table 1 below, the UKVN 1.0 initiated 11 funding competitions managed through five delivery partners. Each competition focused on different stages and areas of vaccine R&D, covering early- and late-stage preclinical development, clinical development, vaccine manufacturing, as well as One Health and epidemiology research for vaccinology. In total, the UKVN 1.0 provided £117.4m in funding.[41]

Table 1 Overview of UKVN Project 1.0 portfolio

Delivery partner	Research competition	Date range of projects	Average project duration (years)	No. of grants	Approx. total grant value (% of total)
BBSRC	'One Health' competition	2018-21	3.9	5	£5.4m (5%)
EPSRC	Future Manufacturing Research Hub competition	2018-23	5.5	2	£22.6m (19%)
Innovate UK	Vaccine Development Competition (£10m): Stage 1, Stream 1 – smaller awards to support proposals that are at an earlier stage of development	2016-17	1	15	£6.2m (5%)
	Vaccine Development Competition (£10m): Stage 1, Stream 2 – larger awards for projects that are at a	2016-19	3	5	£4.6m (4%)

[41] This figure excludes additional allocations for project extensions outlined in the business cases, which bring the total investment to approximately £134 million.

	more advanced stage of development and are likely to go into Phase I first-in-human trials within the next 12 months				
	Vaccine Development Competition: Stage 2, Stream 1 – further, larger awards for projects successful at Stage 1, Stream 1 and ready for more advanced development	2018-22	3.5	4	£8.6m (7%)
	Development of candidate vaccines and vaccine platform technologies at the preclinical stage (£25m)	2017-18	1	22	£9.6m (8%)
	Development of candidate vaccines and vaccine platform technologies at the preclinical stage (£25m) - Stage 2	2018-22	3.8	7	£14.1m (12%)
	Development of candidate vaccines and vaccine platform technologies at the clinical stage (£35m)	2017-22	4.4	7	£20.7m (18%)
	Vaccines for epidemic diseases (Small Business Research Initiative)	2022-23	1.2	21	£9.3 (8%)
NIHR (CCF)	Epidemiology for Vaccinology competition	2018-22	3	5	£4.2 (4%)
NIHR (NETSCC)	Development of vaccine candidates - UKVN NETSCC Intramural Proposals. Projects supported through MRC/BBSRC Centres of Excellence	2016-21	4.3	6	£12m (10%)
Total				**99**	**£117.4m**

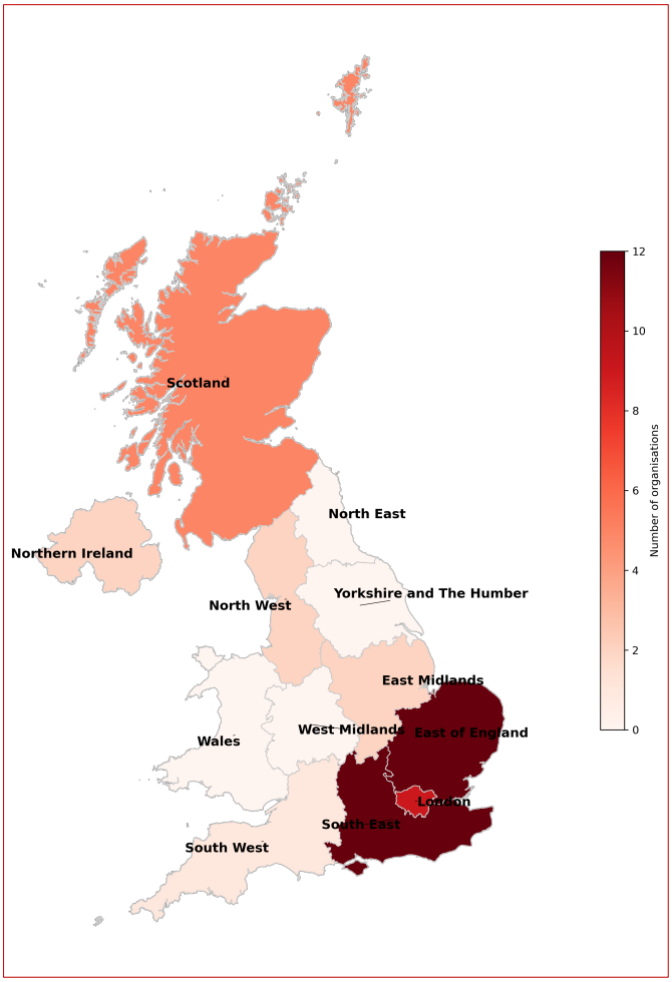
Innovate UK awarded the vast majority of grants (n = 81), representing approximately 62% of the total grant value for the UKVN 1.0. Innovate UK's funding competitions followed a staged approach to vaccine funding, with a series of interconnected competitions over the span of the UKVN 1.0. These included Stage 1 and Stage 2 funding streams, designed to support projects at different levels of technological maturity. This phased approach aimed at enabling promising vaccine candidates to progress along the various R&D stages and ensure a diversified investment approach.

At least 164 applications for funding were submitted across all competitions. This figure is likely an underestimate due to gaps in the available data.

3.1.1 Type of organisations funded by the UKVN 1.0

A total of 48 unique organisations were associated with project leads, of which 24 academic organisations (University / Research Institute), 22 companies and 2 UK executive agencies, the Medicines and Healthcare products Regulatory Agency (MHRA) and UK Health Security Agency. All organisations were based in the UK, with the exception of Themis Bioscience GmbH (Austria), MRC Uganda Virus Research Institute (Uganda) and Vaxinano (France).

Figure 6 Geographical distribution of funded organisations in the UK



As shown in Figure 6, most UK organisations were based in the South East of England, East of England and London.

Academic organisations were awarded approximately £83.8 million across all competitions (71% of all funding), companies £28 million (24%) and UK executive agencies £5.6 million (5%).

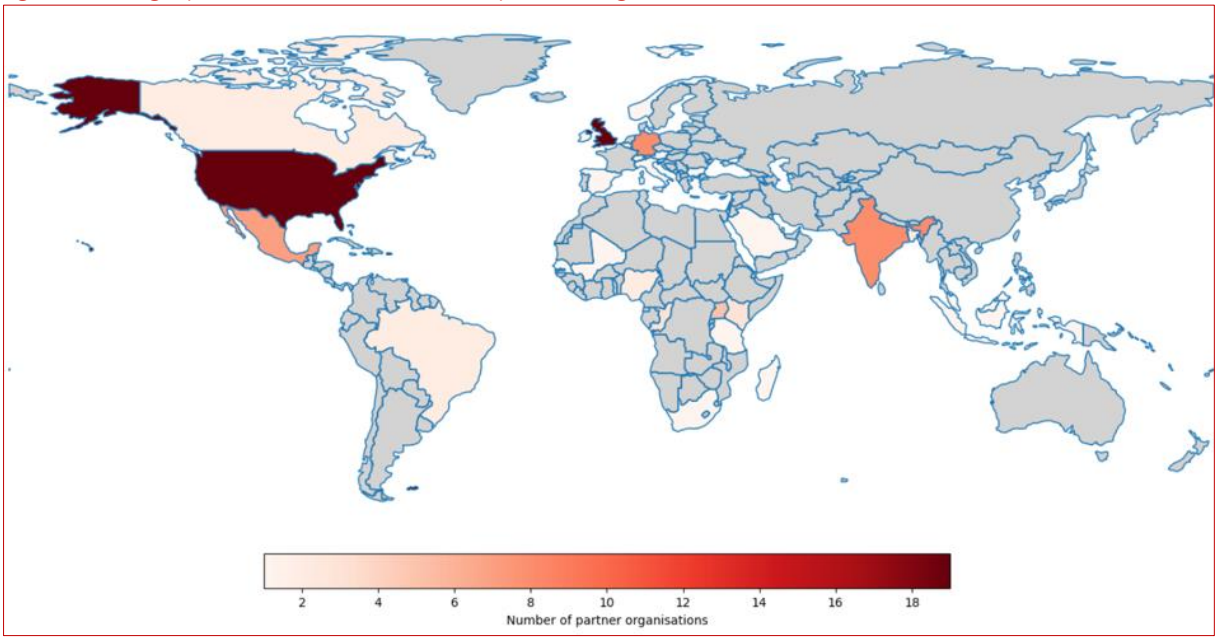
A total of 20 organisations were awarded more than one grant. A relatively small group of organisations (n = 11) led more than half of the 99 grants, accounting for nearly 60% of the UKVN budget (approximately £66.7 million from the total of £117.4 million).

A total of 186 unique partner organisations were identified across 94 of the 99 UKVN grants (95%). On average, each grant involved three to four partner organisations. Companies accounted for nearly 40% of all partners (n=73), including biotech firms, consultancies and law firms.

Partner organisations also included universities (n = 51, 27%) and research institutes (n = 39, 21%). The remaining partner organisations included hospitals, manufacturing facilities, government agencies, NGOs and others. At least 44 partner organisations were identified as project leads in other UKVN projects, suggesting close collaboration across UKVN portfolio.

Approximately three-quarters of partner organisations were based in high-income countries (n = 139, 74%), of which most are based in the UK (n = 85), followed by the USA (n = 19) and Germany (n = 8). The remaining 44 organisations with identified country affiliations were based in LMICs, most of them in the African continent (n = 19), including Uganda (n = 5), Nigeria (n = 3) and Kenya (n = 2); Asia (n = 16), primarily in India (n = 8) and North America (Mexico, n = 7) were also represented. Figure 7 provides a map of partner organisations' location.

Figure 7 Geographical distribution of UKVN partner organisations



Note: Partners based in the United Kingdom (n = 85) are not fully represented in the colour scale to improve visibility of other countries.

3.2 Progressing vaccine candidates for use or trialling in outbreaks

This section outlines the progress of UKVN projects focussed on vaccine candidates for the 12 UKVN priority pathogens along the vaccine development pathway. Referred to collectively as 'vaccine R&D' projects, their progress is mapped against R&D phases and stages as set out in the UKVN Vaccine Development Process Map for human vaccines (see Table 2).[42]

Table 2 Vaccine R&D phases and stages

Phase	Stage	Stage title	Stage description
Pre-clinical discovery	1	Host immunology / Pathogen biology	Characterise host immune mechanisms and pathogen structure or behaviour
	2	Challenge models / Antigen design / Vaccine type	Use infection models to test and optimise antigens that induce a protective response Select the vaccine platform or modality (e.g., mRNA, vector, subunit, VLP)
	3	Antigen testing / Immune response / Immunisation strategy	Evaluate antigen immunogenicity and plan dosing, routes and schedules
Pre-clinical development	4	Strain development / Formulation / QC	Develop antigen strain, create stable formulation and ensure quality control
	5	Animal studies / Immune response analysis	Test safety and efficacy in animals and analyse immune outputs
	6	Process / Scale-up / GMP	Scale production under Good Manufacturing Practice for clinical use

[42] UK Vaccine Network (2024). Vaccine Development Process Maps. https://www.vaccinedevelopment.org.uk/human.html Accessed on 1 May 2025.

Clinical development	7	Safety testing / Approvals	Safety management planning, clinical study design and ethical/regulatory approvals
	8	Phase 1 trial	First-in-human study primarily assessing safety and basic immune response
	9	Scale-up / Safety reporting	Expand manufacturing and monitor safety data collected during clinical trials
	10	Phase 2 trial	Evaluate immunogenicity and preliminary efficacy in a larger population

Source: UKVN Vaccine Development Process Maps

The analysis included 64 UKVN 1.0 grants, grouped into 48 projects. Each project typically aligned with one vaccine candidate, may have received several linked or consecutive UKVN 1.0 grants and was led by the same team (for more detail and a full list of projects, see Appendix G).

All 12 UKVN 1.0 priority pathogens are emerging zoonotic pathogens and were grouped into four categories based on shared clinical presentation, dominant transmission ecology and vaccine R&D challenges:

Viruses causing viral haemorrhagic fevers (VHF): **Ebola, Marburg, Lassa and Crimean-Congo Haemorrhagic Fever (CCHF) viruses**. These cause acute febrile illness with multisystem involvement; haemorrhagic manifestations occur variably and case-fatality rates are often high (varying by pathogen and setting). At the start of the UKVN, VHF vaccine R&D required BSL-4 or equivalent high-containment manufacturing and ultra-cold chain distribution, raising costs far above those for typical viral platforms.

Mosquito-borne arboviruses: **Chikungunya, Zika and Rift Valley Fever (RVF) viruses**. These viruses produce acute febrile illness, often accompanied by rash, arthralgia or myalgia, with Rift Valley fever also associated with ocular, hepatic, and haemorrhagic complications. Outbreaks are short, explosive and geographically unpredictable, hindering reliable Phase III site selection. For RVF, livestock serve as amplifying hosts; effective control therefore requires coordinated animal and human vaccination.[43]

Respiratory and rodent-borne viruses: **MERS-CoV, Nipah virus and Hantaviruses**. These are transmitted primarily via respiratory exposure (MERS, Nipah) or aerosolised rodent excreta (hantaviruses). Outbreaks are sporadic and limited in size but associated with high lethality, rendering conventional Phase III efficacy trials unfeasible. Vaccine development strategies thus emphasise broad antigen coverage to mitigate the risk of emergent coronavirus or henipavirus variants.

Bacterial pathogens: ***Yersinia pestis* (plague) and *Coxiella burnetii* (Q fever)**. These bacterial pathogens present challenges distinct from viral targets. Antigenic variability and complex immune correlates of protection necessitate adjuvanted, multicomponent vaccines. Live-pathogen research generally requires BSL-3 facilities, though recombinant antigen production can be conducted under lower containment.

3.2.1 Progress of UKVN 1.0 R&D projects and contribution to the global vaccine pipeline

Summary of achievements at vaccine R&D project portfolio level

[43] Fawzy M, Helmy YA (2019) The One Health Approach is Necessary for the Control of Rift Valley Fever Infections in Egypt: A Comprehensive Review. Viruses 11(2):139. doi: 10.3390/v11020139

- R&D progression across all 12 priority pathogens, with the proportion in pre-clinical or clinical development rising from 25% to 67% over the funding period
- At least 17 projects (27% of portfolio) have received further funding
- At least five candidates have the potential to become 'Phase II ready' in the short term; two of the projects have secured funding for Phase II trials
- Since 2016, 53 new vaccine candidates for priority pathogens have entered clinical development globally; the UKVN 1.0 supported 25% of these candidates (13), second only to the USA (43%, 23)
- All UK-developed candidates for UKVN priority pathogens in clinical trials received UKVN funding (10), except one (ChAdOx1 NipahB). Prior to 2016, none of the candidates entering clinical development had been developed in the UK.
- UKVN 1.0 contributed a significant share of global public/philanthropic vaccine R&D funding for CCHF (40.5%), with smaller but notable shares for Nipah (14.9%) and RVF (11.9%); global shares for Zika, Ebola and chikungunya were lower.

Progress of UKVN 1.0 vaccine R&D project portfolio

Projects targeting all 12 priority pathogens advanced along the vaccine development pathway. Table 3 shows how the maturity of the portfolio advanced during the UKVN 1.0 funding period, with a shift towards later-stage development: of the 64 projects[44], 48 (75%) started in discovery phase and 16 in pre-clinical or clinical development (25%). By the end of the project funding, 43 (67%) had progressed into pre-clinical and clinical development. While 21 projects (33%), had advanced stages within the discovery phase. This trend was consistent across all 12 priority pathogens. A more detailed analysis for each pathogen is presented in the sections below.

Table 3 Progress of UKVN 1.0 vaccine R&D projects along development pathway

Pathogen group	Disease	Number of projects	% of projects in pre-clinical and clinical phases at project start	% of projects in pre-clinical and clinical phases at project end	Number of projects in clinical development at project start → project end
Viruses causing haemorrhagic fevers	Ebola	6	0%	67%	0 → 1
	Marburg	6	0%	67%	
	Lassa	5	0%	40%	
	CCHF	6	67%	83%	0 → 2*
Mosquito-borne arboviruses	Chikungunya	8	63%	75%	2 → 4
	Zika	14	29%	79%	1 → 5
	RVF	5	40%	60%	1 → 2*

[44] This figure includes a count for each pathogen targeted by multivalent or multi-pathogen projects, i.e. some projects are counted multiple times.

Respiratory and rodent-borne viruses	MERS	3	33%	67%	1 → 1
	Nipah	3	0%	33%	
	Hanta	1	0%	100%	
Bacterial pathogens	Plague	4	0%	50%	0 → 1
	Q fever	3	0%	67%	

*Includes a vaccine candidate for veterinary use entering field trials. Multivalent vaccine candidates are counted against each targeted pathogen. Source: Survey, final project reports, interviews, desk research.

<15% of candidates
15% - 50%
>50% of candidates

At least 17 projects have received further funding to advance 19 vaccine candidates (including two projects that received two awards to develop candidates targeting different pathogens). Most follow-on funding was provided by UKVN 2.0, supporting 13 of 18 candidates. Other funders include CEPI (2 awards, for Phase II clinical trials), the European Union and the US Department of Defense (development of a UKVN 1.0-supported platform to target malaria).

At least five UKVN 1.0 vaccine candidates have the potential to become 'Phase II ready' in the short term, having completed Phase I trials with positive results. Of these, two have secured funding from CEPI for Phase II trials (ChAdOx RVF; ChAdOx MERS). None of the UKVN 1.0 projects have yet led to a licensed vaccine.

Global landscape of vaccine candidates in clinical development

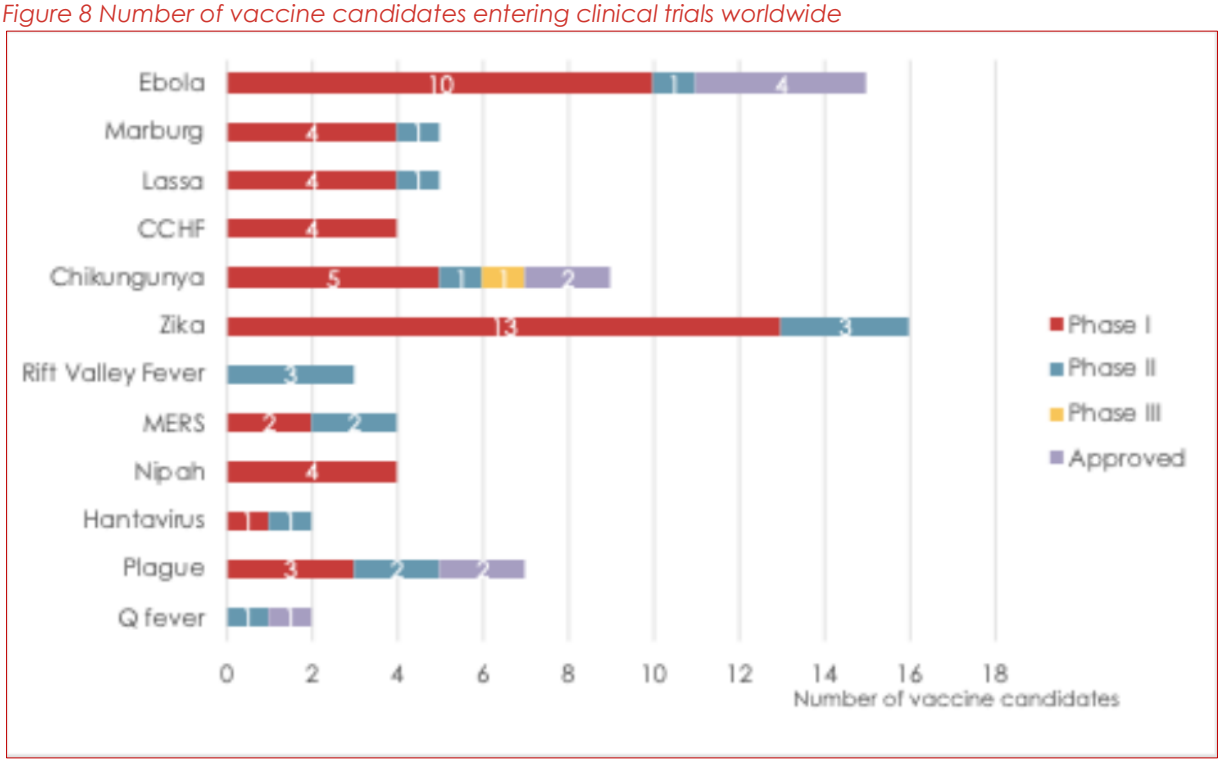
Worldwide (including in the UK), a total of 75 vaccine candidates targeting one or more of the UKVN 1.0 priority pathogens have entered clinical trials (Figure 8), with 53 candidates entering since the start of the UKVN 1.0 in 2016 (Figure 9)[45]. Overall, Ebolavirus and Zika virus vaccines account for the largest pipelines, with 15 candidates each.

Nine vaccines targeting UKVN priority pathogens have been approved by regulators; of these, six were approved after 2016. Five are approved only in Russia, China (Ebola, plague) and Australia (CCHF). Prior to 2016, 22 candidates had entered clinical development or reached regulatory approval. Half of these targeted Ebola virus (11, with 9 entering in 2014/15), followed by candidates for *Y. pestis* (5), *Coaxiella burnetii* (2) and one candidate each for Marburg virus, CCHFV, chikungunya virus and hantavirus.[46]

[45] One candidate, AGS-v PLUS, broadly targets mosquito-borne diseases and is included in both the Zika and chikungunya virus categories where vaccine candidates are grouped by specific pathogens. However, it is counted only once in the total number of candidates at the overall vaccine pipeline or UKVN portfolio level.

[46] Approved vaccines that entered first-in-human studies prior to 2016 include: three EBOV (two approved in Russia/China only), one chikungunya, one plague (approved only in Russia/China), and one Q fever vaccine (approved only in Australia).

Figure 8 Number of vaccine candidates entering clinical trials worldwide



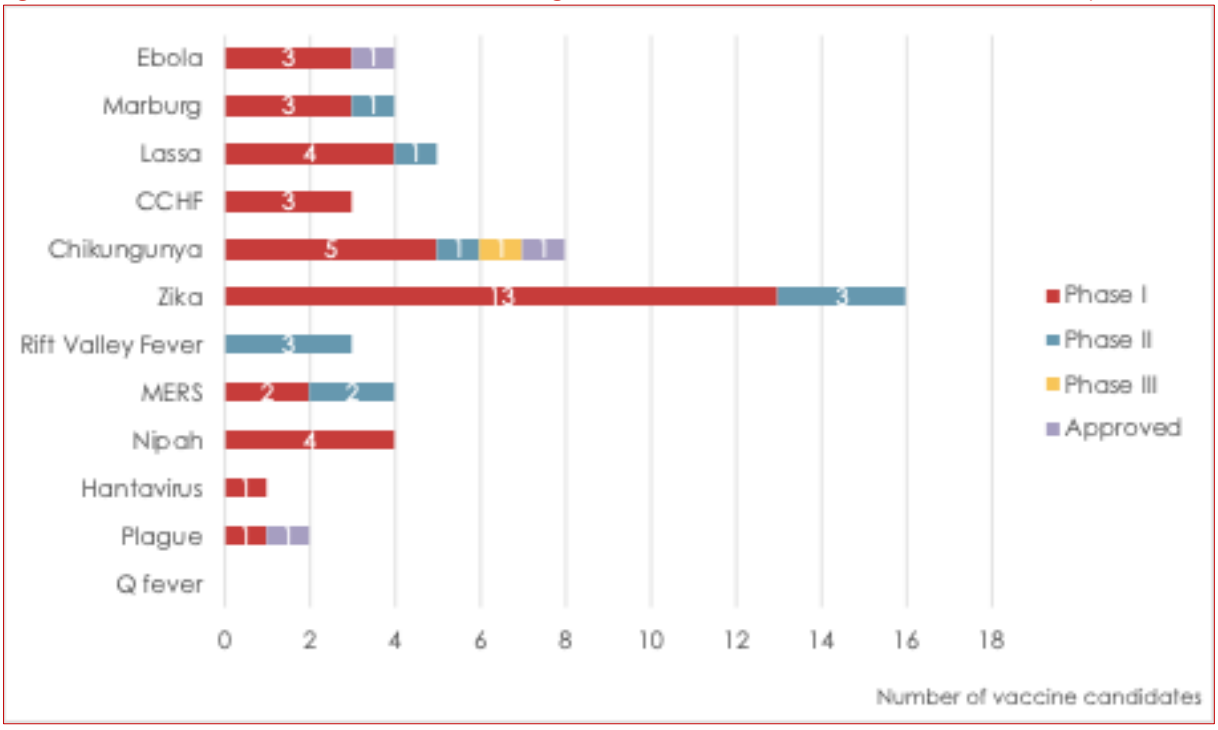
Source: WHO ICTRP, literature review

Of the 53 vaccine candidates that have entered clinical development since 2016, 38 have entered or completed, a Phase I trial (72%), 11 (21%) have reached Phase II and one has advanced to Phase III (Figure 9). Three vaccines (6%) that started first-in-human studies in or after 2016 received regulatory approval, targeting Ebola virus (EBOV strain), chikungunya virus and *Yersinia pestis* (plague).[47] The pathogen with the largest number of candidates entering clinical development is Zika (16), reflecting that the start of the UKVN 1.0 coincided with the 2015–16 Zika outbreaks.

A quarter of the candidates (13 of 53, 25%) were developed in the UK, the second highest after the USA (43%, 23 of 53) and far ahead of the 'next' country, Austria (8%, 4 of 52). None of the 22 vaccine candidates entering clinical development prior to 2016 had been developed by a UK developer.

[47] The plague vaccine was approved in 2024 in Russia only; the year of first-in-human administration of this candidate is unclear.

Figure 9 Number of vaccine candidates entering clinical trials worldwide between 2016 and April 2025



Source: WHO ICTRP, literature review

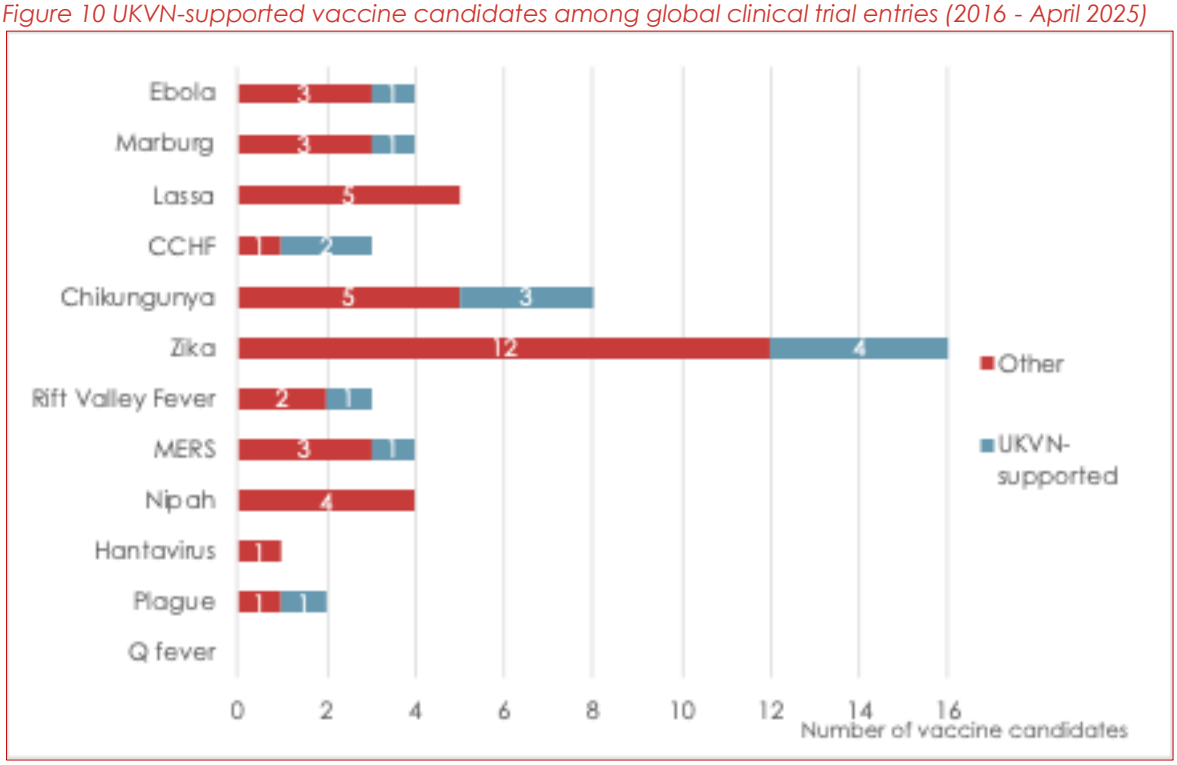
UKVN 1.0 contribution to global pipeline of vaccines in clinical development

The UKVN 1.0 supported 13 vaccine candidates entering clinical trials (as part of the UKVN 1.0-funded project or subsequently), against eight priority pathogens. This represents a quarter of candidates entering clinical development for UKVN 1.0 priority pathogens between 2016 and April 2025 (25%, 13 of 53) (Figure 10).

The UKVN 1.0 contribution is particularly high for CCHF (2 of 3 candidates entering clinical trials worldwide) and led to one of few candidates targeting plague (1 of 2) and RVF (1 of 3). Vaccine candidates that entered clinical development for Lassa, Nipah and Hantavirus were not supported by the UKVN; no Q fever candidates have entered clinical trials since 2016.

The UKVN 1.0 played a key role in supporting UK developers: all UK-developed vaccine candidates for UKVN priority pathogens in clinical trials received UKVN funding (10), except one (ChAdOx1 Nipah, supported by CEPI).

Figure 10 UKVN-supported vaccine candidates among global clinical trial entries (2016 - April 2025)



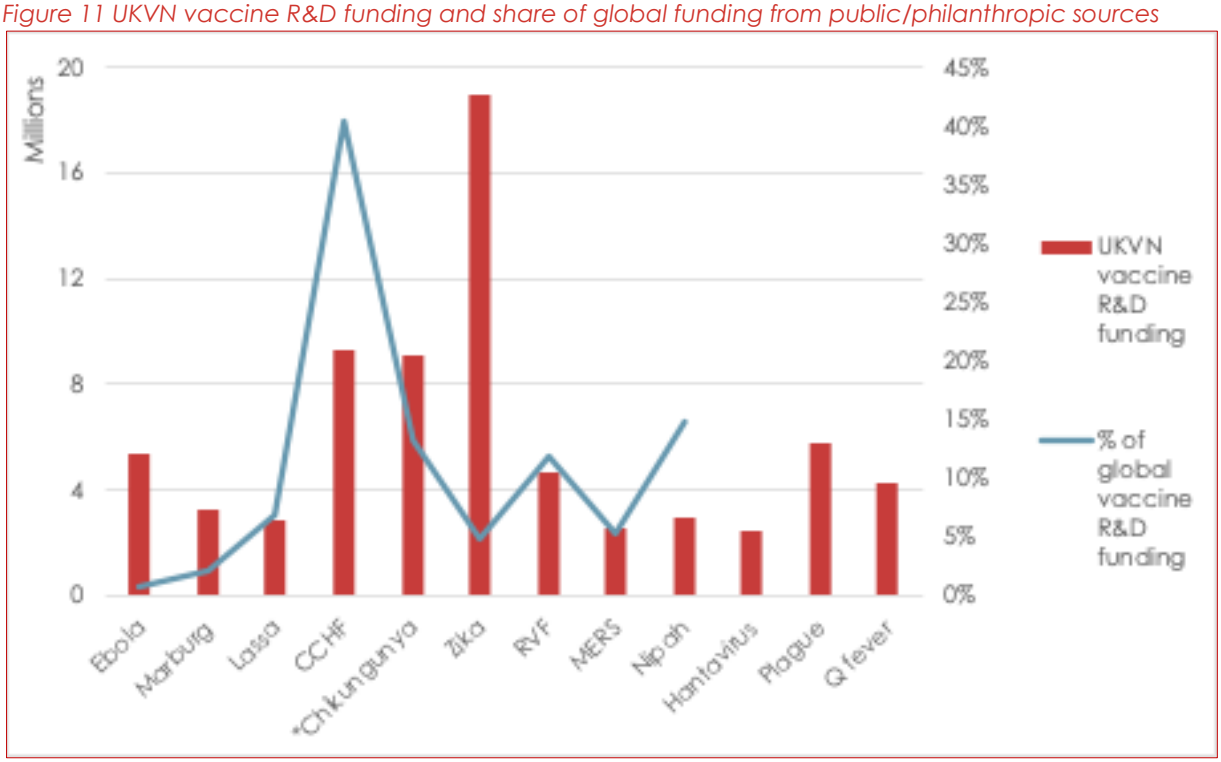
Source: WHO ICTRP, literature review

The UKVN 1.0 vaccine R&D portfolio received a total of £72.0 million in funding.[48] The largest amount went to projects targeting Zika virus (£19m / 26.3%, also targeted by the largest number of projects), followed by projects targeting CCHF and chikungunya (approx. £9m, 13%), Ebola virus (£6.8m, 7.5%) and plague (£5.7m, 8.0%) (Figure 11).

Compared to vaccine R&D funding from public and philanthropic sources captured by G-FINDER, the UKVN 1.0 vaccine R&D portfolio represents a large share of global funding for projects targeting CCHF (40.5%) and, to a lesser degree, for Nipah (14.9%) and RVF (11.9%). While funding for Zika and Ebola projects was relatively high (26.3% and 9.2% of the portfolio, respectively), the global share was below 5%. G-FINDER data for chikungunya vaccine R&D is only available from 2018, the actual UKVN share of global funding is hence lower than presented here. For a detailed analysis of vaccine R&D investment for each of the priority pathogens and caveats of G-FINDER data (see Appendix G).

[48] This figure only represents funding for projects focussed on progressing vaccine candidates. Funding for projects developing multivalent candidates was split by the number of target pathogens before allocating funding to pathogens.

Figure 11 UKVN vaccine R&D funding and share of global funding from public/philanthropic sources



*G-FINDER data only available from 2018. UKVN figures do not include pathogen-specific funding for tools, assays, and data underpinning vaccine R&D. Source: UKVN 1.0 portfolio data, G-FINDER data portal

3.2.2 *Vaccine R&D progress per UKVN priority pathogen*

As explained above, the 12 UKVN 1.0 priority pathogens were grouped into four categories that share clinical presentation, dominant transmission ecology and vaccine R&D challenges, (1) viruses causing viral haemorrhagic fevers: Ebola, Marburg, Lassa and CCHF viruses; (2) Mosquito-borne arboviruses; (3) Respiratory and rodent-borne viruses: MERS-CoV, Nipah virus and Hantaviruses and (4) Bacterial pathogens.

3.2.2.1 Viruses causing viral haemorrhagic fevers: Ebola, Marburg, Lassa and CCHF viruses

The UKVN vaccine R&D portfolio for Ebola, Marburg and Lassa viruses included mostly multivalent vaccine candidates, targeting multiple pathogens in various combinations. This section first provides overviews of Ebola, Marburg and Lassa fever vaccines and their global clinical trial contexts. This is followed by an analysis of UKVN-funded vaccine R&D projects relevant to these diseases and progress achieved.

Ebola virus (EBOV/SUDV)

Zaire Ebola virus (EBOV) and Sudan Ebola Virus (SUDV) cause haemorrhagic fever in humans, with an average fatality rate of approximately 50%.[49,50,51] The viruses can spill over to humans from their natural reservoir, fruit bats, through close contact with infected animals and then

[49] WHO (2025) Ebola Disease. https://www.who.int/news-room/fact-sheets/detail/ebola-disease Accessed 01 May 2025

[50] WHO (2025) Disease Outbreak News. Sudan virus disease – Uganda. https://www.who.int/emergencies/disease-outbreak-news/item/2025-DON555 Accessed 01 May 2025

[51] WHO (2025) Marburg Virus Disease. https://www.who.int/news-room/fact-sheets/detail/marburg-virus-disease Accessed 01 May 2025

spread person-to-person through contact with bodily fluids. EBOV and SUDV have caused multiple high-mortality outbreaks in Africa, including the large 2013–2016 West African EBOV epidemic which led to around 11,500 deaths.[52]

A total of 15 vaccines targeting EBOV and/or SUDV have been evaluated in clinical trials (Table 4). Of these, eleven had entered clinical development prior to 2016, reflecting strong R&D activity after the start of the West African Ebola outbreak in 2013. Most of the vaccines (10 of 15) are based on viral vector platforms.

Four Ebola virus (EBOV) vaccines have received regulatory approval, two of which (Ervebo, Merck; Zabdeno/Mvabea, Johnson & Johnson) are WHO-prequalified for broader global use. However, none provide protection against Sudan virus (SUDV).[53] Five SUDV vaccine candidates are currently in clinical development.

Table 4 Ebola virus vaccine candidates in clinical trials globally (EBOV and SUDV)

Vaccine platform category	Target	Developer	Clinical trial phase
Viral vector	EBOV	Merck (US)	Approved
	EBOV	Johnson & Johnson (US)	Approved
	EBOV	CanSinoBio (CN)	Approved (China)
	EBOV	Gamaleya Research Inst (RU)	Approved (Russia)
	SUDV	Sabin Vaccine Inst (US)	Phase II
	EBOV, SUDV	Sabin Vaccine Inst (US)	Phase I
	EBOV	Auro Vaccines LLC (US)	Phase I
	EBOV	Johns Hopkins (US)	Phase I
	EBOV, SUDV	**University of Oxford (UK)**	Phase I
	SUDV	IAVI	Phase I
Inactivated/live-attenuated	EBOV	University of Tokyo (JP)	Phase I
Protein-based subunit	EBOV	Novavax (US)	Phase I
DNA	EBOV, SUDV	NIAID (US) VRC-EBODNA023	Phase I
	EBOV, SUDV	NIAID (US) VRC-EBODNA012	Phase I
	EBOV	Inovio (US)	Phase I

Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidate.

Marburg Virus (MARV)

Like EBOV and SUDV, Marburg virus (MARV) is a zoonotic filovirus that causes viral haemorrhagic fever in humans, with case fatality rates averaging around 50%. First recognised in 1967, MARV has since been responsible for outbreaks in the Democratic Republic of the Congo, Angola, Equatorial Guinea, Uganda, Rwanda, and Tanzania.[54]

Prior to 2016, one MARV vaccine candidate, based on a DNA platform, had advanced to clinical development (Table 5). Since 2016, four additional vaccine candidates have entered clinical trials, all based on viral vector platforms; one progressed into a Phase II clinical trial.

[52] Kyobe Bosa H et al (2024) The west Africa Ebola virus disease outbreak: 10 years on. The Lancet Global Health 127: e1081 - e1083

[53] Gavi (2025). Vaccines profiles: Ebola. https://www.gavi.org/vaccineswork/vaccine-profile-ebola Accessed 01 May 2025

[54] WHO (2025) Disease Outbreak News. Marburg virus disease– United Republic of Tanzania https://www.who.int/emergencies/disease-outbreak-news/item/2025-DON559 Accessed 01 May 2025

Table 5 Marburg virus vaccine candidates in clinical trials globally

Vaccine platform category	Target	Developer	Clinical trial phase
Viral vector	MARV MARV, EBOZ MARV MARV	Sabin Vaccine Institute (US) NIAID (US) **University of Oxford (UK)** Public Health Vaccines LLC (US)	Phase II Phase I Phase I Phase I
DNA	MARV	NIAID (US)	Phase I

Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidate.

Lassa virus (LASV)

LASV is a zoonotic arenavirus that causes Lassa fever, an acute haemorrhagic illness.[55,56] First recognised in 1969, LASV has since caused numerous outbreaks, particularly in Nigeria, Sierra Leone, Liberia and Guinea. Its primary reservoir is the multimammate rat (Mastomys natalensis), with human infection typically occurring through contact with food or household items contaminated with rodent excreta. Secondary human-to-human transmission also occurs, particularly nosocomial (healthcare) settings.

Annually, LASV is estimated to affect 2 million people, causing between 5,000 and 10,000 deaths in West Africa.[57] While the overall case-fatality rate is around 1%, mortality climbs to 15-20% among hospitalised patients and 50% in severe outbreaks or late-pregnancy infections.[58]

Prior to 2016, no LASV vaccine candidates were in clinical development (Table 6). Since 2016, five monovalent LASV vaccine candidates have entered clinical trials.[59] One candidate is in a Phase II trial.

Table 6 LASV vaccine candidates in clinical trials globally

Vaccine platform category	Developer	Clinical trial phase
Viral vector	IAVI Themis/Merck (AT/US) Emergent Biosolutions (US)	Phase II Phase I Phase I
DNA	Inovio (US)	Phase I (discontinued)
Inactivated/viral vector	University of Maryland (US)	Phase I

Source: WHO International Clinical Trials Registry Platform, literature review.

UKVN-funded projects and contributions

[55] WHO (2024). Lassa Fever. https://www.who.int/news-room/fact-sheets/detail/lassa-fever Accessed 01 May 2025

[56] GOV UK (2025). Guidance Lassa fever: origins, reservoirs, transmission and guidelines https://www.gov.uk/guidance/lassa-fever-origins-reservoirs-transmission-and-guidelines Accessed 01 May 2025

[57] Chaudary M et al (2025) Burden of Lassa fever disease in pregnant women and children and options for prevention. Vaccine 43: 126479. https://doi.org/10.1016/j.vaccine.2024.126479

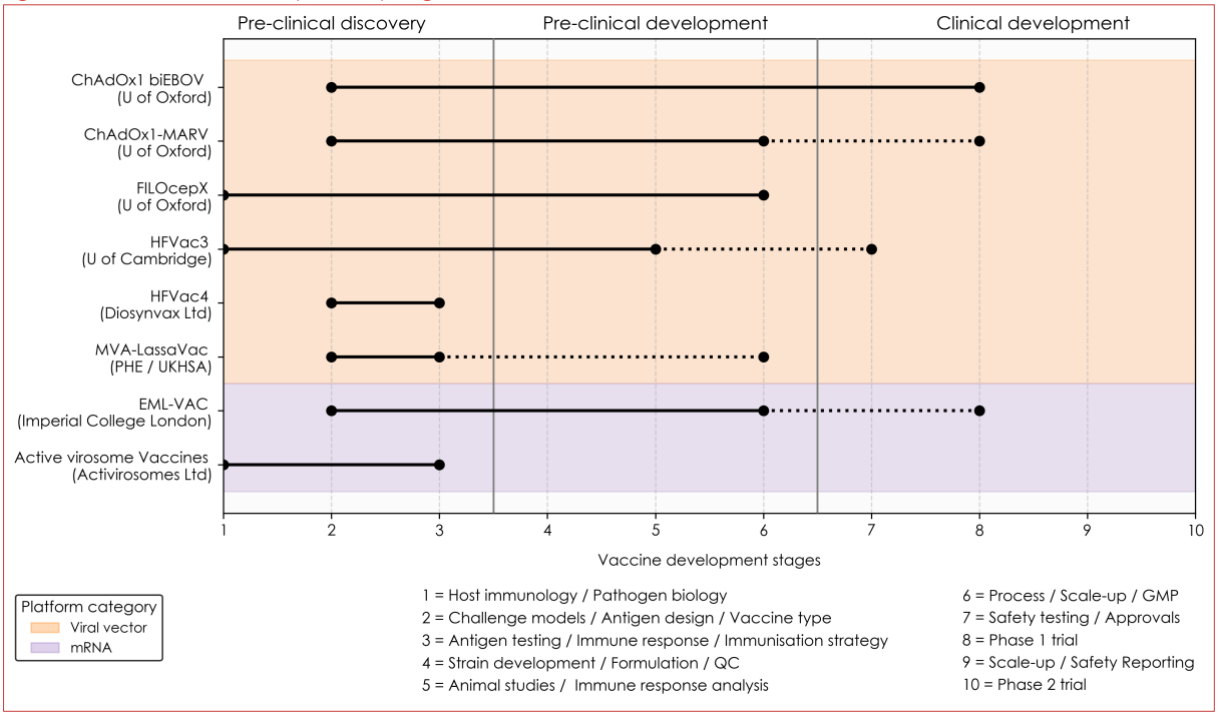
[58] Buba MI et al (2018) Mortality Among Confirmed Lassa Fever Cases During the 2015-2016 Outbreak in Nigeria. Am J Public Health. 108(2):262-264. doi: 10.2105/AJPH.2017.304186

[59] Fierce Biotech (2022). Inovio drops Lassa, MERS vaccines as clinical data fall short, gutting infectious disease pipeline https://www.fiercebiotech.com/biotech/inovio-drops-lassa-mers-vaccines-clinical-data-fall-short-gutting-infectious-disease Accessed 01 May 2025

The UKVN supported eight vaccine R&D projects, mainly multivalent vaccine candidates in various combinations with each other and with other targets (see Appendix G). The projects received a total of £11.6 million, representing 16% of all UKVN vaccine R&D funding. A further project delivered Phase IV trials on the persistence of immunity after vaccination with an approved EBOV vaccine and the impact of a booster dose. By pathogen, £5.4 million (7.5% of UKVN vaccine R&D funding) was allocated to EBOV/SUDV; £3.3 million (4.6%) to MARV and £2.9 million (4.0%) to LASV.

Figure 12 provides an overview of R&D progress. Most projects focussed on viral vector-based candidates (6 of 8) and all started in the discovery phase.

Figure 12 Vaccine development progression for EBOV, SUDV, MARV and LASV



Black lines indicate the development stage at the start and end of the UKVN 1.0-funded project. Dotted lines show development after the end of the UKVN 1.0 award (funding secured, ongoing). Source: Survey, final project reports, interviews and desk research.

At least five projects moved from the discovery phase into pre-clinical development and one candidate completed a Phase I clinical trial (ChAdOx1 biEBOV).

At least four projects continue development of their candidates with funding from UKVN 2.0:

- University of Oxford: Clinical development of candidates for MARV and SUDV (see case study Box 1)
- Imperial College London: Clinical development of a multivalent candidate targeting EBOV, MARV and LASV
- DIOSynVax Ltd: Development of GMP manufacturing processes and a clinical trial plan for HFVac3, a candidate targeting SUDV, MARV and LASV
- UKHSA: Progress towards clinical trials of LassaVac, a candidate for LASV

Two vaccine candidates were recognised for their potential in outbreak response: The WHO recommended deployment of ChAdOx1 biEBOV, alongside other candidates, in the 2022

SUDV outbreak and initiation of a Phase I trial of the ChAdOx1-MARV vaccine following MARV outbreaks in 2023 and 2024.[60] (see case study Box 1).[61,62]

In summary, the UKVN 1.0 has made important contributions to the development of VHF vaccines. The urgency of the West Africa Ebola outbreak and the large number of key organisations active in the response, including WHO, Gavi and large pharmaceutical companies. In 2016, vaccine candidates were already in development and/or used in field trials under emergency protocols. Against this backdrop, UKVN 1.0 focused on filling key gap: advancing vaccines for non-Ebola filoviruses and multivalent candidates (in line with WHO target product profile[63]) and supporting research to guide effective vaccine use.

The UKVN projects have already delivered outcomes for EBOV, SUDV and MARV, including trial-ready vaccines and outbreak-ready protocols. Going forward, these hold potential for real world impact, pending trial results and - in the case of evidence to inform vaccination protocols - publication of findings and active engagement with policy makers. For LASV, continued development with follow-on funding for three vaccine candidates holds potential.

Box 1 Novel multivalent vaccines against haemorrhagic fevers

Viral haemorrhagic fevers (VHFs), including those caused by Ebola, Marburg and Lassa viruses, pose a major threat to public health in LMICs. Where vaccines exist, they target a single virus, which limits their suitability for immunisation in high-risk populations. The project 'Novel multivalent vaccines against haemorrhagic fevers' funded by UKVN/Innovate UK (£3.6 million, 2017–2023) aimed to develop single-dose multivalent vaccines using viral vector platforms.

The team, led by Prof Teresa Lambe at the University of Oxford, developed and tested several multivalent vaccine candidates in animal models. Two bivalent vaccines, ChAdOx1 EBOZ & SUDV (later named biEBOV) and ChAdOx1 MARV & LASV, were prioritised for further development. The biEBOV vaccine demonstrated safety and strong immune responses in Phase I trials in the UK and progressed to Phase Ib trials in Tanzania. While ChAdOx1 MARV & LASV did not proceed to clinical trials due to challenges with combining the two antigens, it informed the development of a monovalent Marburg vaccine, ChAdOx1-MARV.

A major achievement of the project was the WHO's recommendation of the biEBOV and ChAdOx1-MARV vaccines in response to outbreaks in 2022, 2023 and 2024. The team rapidly transferred vaccine production to the Serum Institute of India, enabling timely manufacture and shipment to support outbreak control in Uganda and Tanzania. Additionally, training and local engagement ensured trial readiness and strengthened local capabilities for future outbreak responses, e.g. at the Ifakara Health Institute in Tanzania.

However, non-human primate studies completed after the conclusion of the project suggested limited protection from the bivalent biEBOV vaccine, likely due to antigenic competition (where the presence of one antigen reduces the immune response to another). As a result, the team paused biEBOV's development and shifted focus toward development of a monovalent SUDV vaccine candidate while the multivalent approach is being re-

[60] WHO (2024). WHO Technical Advisory Group – candidate vaccine prioritization. https://cdn.who.int/media/docs/default-source/blue-print/who-tag-cvp-report-marburg-trial-for-tag-cvp-review.pdf Accessed 01 May 2025.

[61] WHO (2022) Ebola. Uganda, 2022. https://www.who.int/emergencies/situations/ebola-uganda-2022 Accessed 01 May 2025.

[62] WHO (2022) Global health agencies outline plan to support Ugandan government-led response to outbreak of ebola virus disease https://www.who.int/news/item/03-11-2022-global-health-agencies-outline-plan-to-support-ugandan-government-led-response-to-outbreak-of-ebola-virus-disease Accessed 01 May 2025.

[63] "It is preferable from a public health perspective for multivalent vaccines to be available for prophylactic use, rather than multiple monovalent vaccines" WHO (2016) WHO Target Product Profile for multivalent filovirus vaccines: providing long-term protection to high-risk populations.

assessed. The UKVN 2.0 is providing support for development of both, a monovalent SUDV vaccine and clinical development of the ChAdOx1-MARV candidate.

Crimean-Congo Haemorrhagic Fever

Crimean-Congo haemorrhagic fever (CCHF) is a tick-borne viral disease that produces a severe fever in humans.[64] As well as through tick bites, the virus (CCHFV) can be transmitted to people via livestock and through close contact with infected persons. Fatal in up to 40% of cases, CCHF leaves many survivors deeply fatigued for weeks or months.

Each year, around 10,000-15,000 people fall ill with CCHF. Globally, it is estimated that 10,000–15,000 cases of CCHF occur annually, resulting in approximately 500 deaths. Three billion people, many of them farm workers in LMICs, live within endemic regions, which stretch from sub-Saharan Africa through the Balkans and Middle East to Central and South-West Asia[65,66]. In recent years, rising temperatures associated with climate change have facilitated the northward expansion of the tick vector, leading to autochthonous human cases in Spain (2022) and Portugal (2024).[67]

One vaccine candidate entered clinical trials prior to 2016 (supported by Tubitak, Türkiye's public funding agency), and three after (Table 7).

Table 7 CCHFV vaccine candidates in clinical trials globally

Vaccine platform category	Developer	Clinical trial phase
Viral vector	**UKHSA** **University of Oxford**	Phase I Phase I
DNA	Karolinska Institutet (SE)	Phase I
(no data)	Tubitak (TR)	Phase I

Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidates.

UKVN-funded projects and contributions

The UKVN 1.0 funded six vaccine R&D projects targeting CCHFV, with one project focussed on a multivalent candidate for VHFs (Figure 13). These projects received £9.3 million, accounting for 12.9% of UKVN vaccine R&D funding.

Three projects progressed the same vaccine candidate, MVA-GP CCHF, for different uses (livestock / human) and to facilitate its deployment in low-resource settings (room temperature stable-formulation). The projects were highly collaborative (see section 3.1.1), involving partners from across public research organisations, academic institutions and SMEs.

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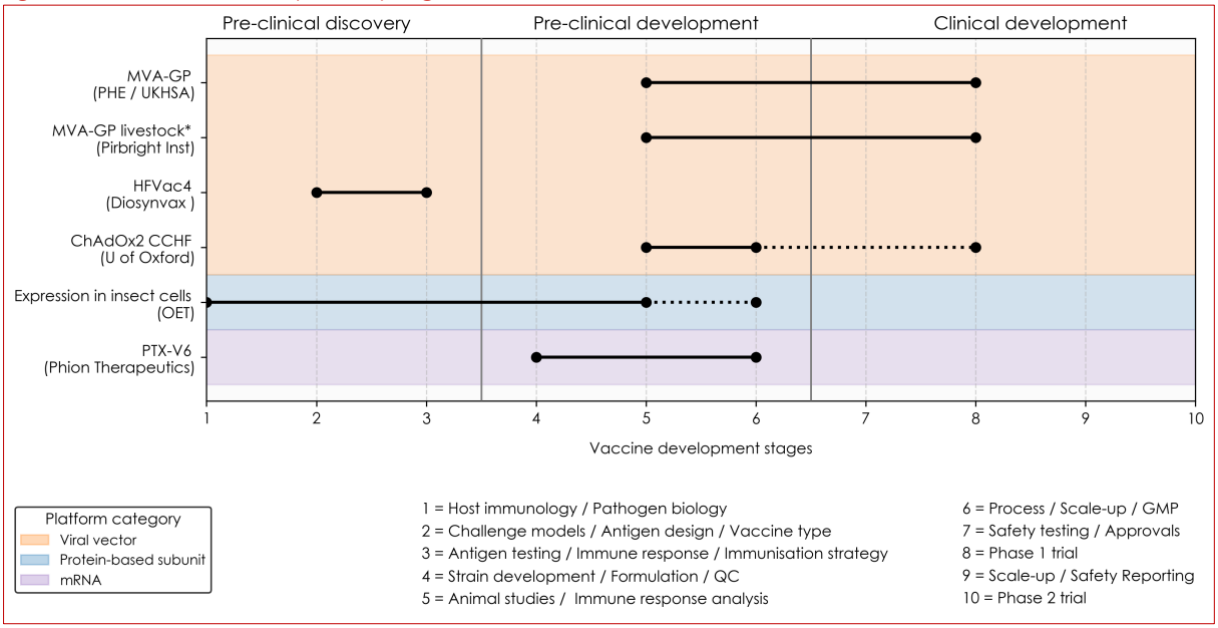
[64] World Health Organization. Crimean-Congo haemorrhagic fever fact sheet. 2025. Available at: https://www.who.int/news-room/fact-sheets/detail/crimean-congo-haemorrhagic-fever Accessed 01 May 2025.

[65] GOV UK (2024). Guidance Crimean-Congo haemorrhagic fever: origins, reservoirs, transmission and guidelines. https://www.gov.uk/guidance/crimean-congo-haemorrhagic-fever-origins-reservoirs-transmission-and-guidelines Accessed 01 May 2025

[66] ECDC Factsheet for health professionals about Crimean-Congo haemorrhagic fever. Updated Dec 2023. https://www.ecdc.europa.eu/en/crimean-congo-haemorrhagic-fever/facts/factsheet

[67] Celina SS et al (2023) Mapping the potential distribution of the principal vector of Crimean-Congo haemorrhagic fever virus Hyalomma marginatum in the Old World. PLoS NTD, https://doi.org/10.1371/journal.pntd.0010855

Figure 13 Vaccine development progression for CCHFV



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project. Dotted lines show development after the end of the UKVN 1.0 award (funding secured, ongoing). Source: Survey, final project reports, interviews and desk research. MVP-GP livestock (Pirbright Institute) shown at Phase 1 for R&D illustration; as a veterinary vaccine, it progressed to livestock field trials, not human trials.

In summary, the UKVN 1.0 has made an important contribution to the development of CCHFV vaccines. It supported two of the four vaccine CCHFV candidates that have entered clinical development globally; a third candidate advance by UKVN 1.0 has secured UKVN 2.0 funding to reach the stage of readiness for clinical trials. Globally, the UKVN 1.0 provided a substantial share of CCHFV vaccine R&D funding (approx. one third according to G-FINDER[68]).

The projects were underpinned by extensive collaboration between different project teams, combining expertise in CCHF, vaccine development and manufacturing. Going forward, the groups are likely to benefit from this network of collaborators to bridge gaps in expertise and coordinate research efforts to avoid duplication.

Box 2 Development of an economically viable CCHF virus vaccine

Crimean-Congo haemorrhagic fever (CCHF) is the most widespread tick-borne viral disease affecting humans, with case fatality rates reaching 40%. Despite its public health impact, no globally approved human vaccine exists. A UKVN-funded project led by Oxford Expression Technologies Ltd (OET) is addressing this gap by developing a novel protein subunit vaccine using its baculovirus-insect cell expression platform, flashBAC™.

With £2.76 million funding from the UKVN, the project team developed vaccine candidates based on CCHF virus glycoproteins. The project established a new insect cell, enabling safe, clinical-grade protein production. Preclinical studies in mice demonstrated immune responses and the vaccine formulation was optimised to remove the need for ultra-cold supply chain. This makes the candidate well suited to manufacture and deployment in LMICs, where cold chain infrastructure is limited.

[68] The UKVN 1.0 portfolio analysis of funding for vaccine R&D per disease, and the funding captured in G-FINDER, could not be compared directly, likely due to different inclusion criteria and potentially to under-reporting.

With UKVN 2.0 support, the project is advancing towards GMP-scale production and a planned Phase 1 trial. The project has strengthened OET's capabilities and contributed to commercial success of the cell line, having enabled OET to grow substantially and expand their work through new global partnerships with multiple vaccine development companies and consortia.

3.2.2.2 Mosquito-borne arboviruses: Chikungunya, Zika and Rift Valley fever viruses

Chikungunya Virus

Chikungunya virus (CHIKV) is a mosquito-borne virus that causes acute febrile illness and prolonged joint pain.[69],[70] Although rarely fatal, infection can result in chronic rheumatologic sequelae, with persistent or relapsing joint pain lasting months to years, and less commonly neurological or ocular complications. The virus has caused large-scale outbreaks in Africa, Asia and, more recently, in the Americas following its introduction to the Caribbean in 2013. Between 2011 and 2020, an estimated 18.7 million cases occurred globally, with economic costs approaching US$5 billion, largely attributable to chronic sequelae.[71]

Eight CHIKV vaccine candidates have entered in clinical trials; with one already in clinical development at the start of the UKVN (Table 8). Two vaccines reached regulatory approval in 2024/25, Valneva's IXCHIQ® and Bavarian Nordic's VIMKUNYA™ vaccine.[72,73] One vaccine candidate, Themis' MV-CHIK, underwent Phase II trials but development was discontinued as part of a "routine pipeline prioritisation".[74] Of the five vaccine candidates that remain in clinical development, one is currently in a Phase II/III study, while the remaining four are in Phase I trials.

Table 8 CHIKV vaccine candidates in clinical trials globally

Vaccine platform category	**Developer**	**Clinical trial phase**
Viral vector	**Themis/Merck (AT/US)** **University of Oxford (UK)**	Phase II - discontinued Phase I
Inactivated/Live-attenuated virus	Valneva (Austria/France) Bharat Biotech (IN) Human Biologicals Institute (IN) Najit Technologies Inc (US)	Approved Phase II/III Phase I Phase I

[69] de Lima Cavalcanti TYV et al (2022) A Review on Chikungunya Virus Epidemiology, Pathogenesis and Current Vaccine Development. Viruses 14(5):969. doi: 10.3390/v14050969

[70] Bettis AA et al (2022) The global epidemiology of chikungunya from 1999 to 2020: A systematic literature review to inform the development and introduction of vaccines. PLoS Negl Trop Dis.16(1):e0010069. doi: 10.1371/journal.pntd.0010069.

[71] de Roo AM et al (2024) The global health and economic burden of chikungunya from 2011 to 2020: a model-driven analysis on the impact of an emerging vector-borne disease: BMJ Global Health 2024;9:e016648.

[72] Bavarian-Nordic (2025). Bavarian Nordic Receives U.S. FDA Approval of Chikungunya Vaccine for Persons Aged 12 and Older. https://www.bavarian-nordic.com/media/media/news.aspx?news=7053 Accessed 13 May 2025

[73] Valneva Receives EMA's Positive CHMP Opinion for its Chikungunya Vaccine (31 May 2024). Available at: https://valneva.com/press-release/valneva-receives-emas-positive-chmp-opinion-for-its-chikungunya-vaccine/ Accessed 25 July 2024; Valneva Receives Marketing Authorization in Europe for the World's first Chikungunya Vaccine, IXCHIQ (1 July 2024). Available at: https://valneva.com/press-release/valneva-receives-marketing-authorization-in-europe-for-the-worlds-first-chikungunya-vaccine-ixchiq Accessed 14 August 2024

[74] Fierce Biotech (2023). Merck admits defeat in race with Valneva to get first chikungunya vaccine to market https://www.fiercebiotech.com/deals/merck-admits-defeat-race-valneva-get-first-chikungunya-vaccine-market Accessed 13 May 2025

Protein-based subunit	**ConserV Bioscience (UK)**	Phase I
Particle-based subunit (VLP)	Bavarian Nordic (US)	Approved
mRNA	Moderna Inc (US)	Phase I

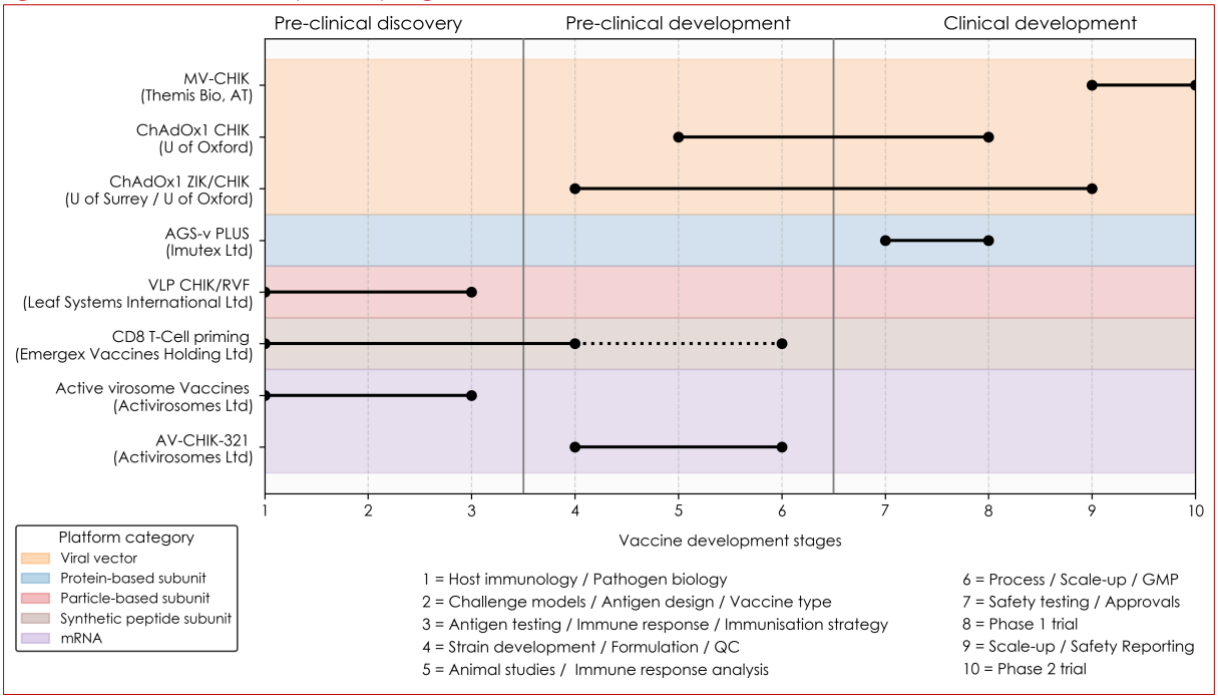
Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidates.

UKVN-funded projects and contributions

The UKVN 1.0 funded eight vaccine R&D projects targeting CHIKV, allocating a total of £9.1 million, 12.6% of the vaccine R&D project portfolio (Figure 14). Five of the eight projects targeted additional pathogens alongside CHIKV or were more broadly protective (e.g. immune response to mosquito bites).

The portfolio was diverse, with candidates based on five different platform categories and at various stages across the development pathway. Two projects focussed on ChAdOx1-based candidates (CHIKV/co-administration of CHIKV and Zika candidates). Three projects started in early discovery, exploring novel strategies, e.g. to lower manufacturing costs or enhance delivery methods. Most projects were led by SMEs (6 of 8).

Figure 14 Vaccine development progression for CHIKV



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project. Dotted lines show development after the end of UKVN 1.0 award (funding secured, ongoing). Source: Survey, final project reports, interviews and desk research.

The ChAdOx CHIK and ChAdOx ZIKA/CHIK candidates advanced from pre-clinical development stages into clinical development.

At least two projects have secured follow-on funding to advance their vaccine candidates:

- Emergex (now Gylden Pharma) secured funding from UKVN 2.0 to prepare their CHIKV vaccine candidate for clinical trials (further pre-clinical development/ GMP manufacture)[75]
- Imutex (now ConserV Bioscience) received UKVN 2.0 funding to extend their vaccine AGS-v PLUS, combining two components: one that stimulates an immune response to mosquito bites, the other specifically targeting CHIKV and ZIKV antigens (see case study Box 3).[76] In addition, the company secured support from the US Department of Defense to target malaria using the same platform.[77]

In summary, UKVN 1.0 made important contributions to the development of CHIKV vaccines. It supported three of the nine CHIKV vaccine candidates in clinical development globally and funded a Phase I trial of an innovative vaccine approach designed to protect against mosquito-borne diseases more broadly. The portfolio was diverse, advancing candidates across multiple platforms and exploring novel approaches to vaccine production and delivery suited for use in resource-limited settings.

Going forward, the CHIKV portfolio has potential to deliver benefits. Several vaccine candidates advanced along the development pathway and at least two projects secured follow-on funding. Partnerships established through the UKVN-funded project have also led to sustained international collaborations and funding for continued development of the vaccine candidate from international sources (e.g. see case study 'Vaccine against mosquito-borne diseases', AGSv-Plus / US Department of Defence).

Box 3 Vaccine against mosquito-borne diseases

Mosquito-borne diseases like Zika, chikungunya and Rift Valley Fever, affect over 700 million people globally each year. While vaccine development typically targets individual pathogens, UKVN-funded projected let by Imutex Limited (part of the SEEK Group) took a novel approach to develop a vaccine that targets mosquito saliva to disrupt disease transmission at the source.

A £3.6m million UKVN award supported clinical development of AGS-v PLUS, a multivalent vaccine designed to trigger immune responses against salivary proteins injected by mosquitos during feeding. The team, in collaboration with the University of Maryland and support from the US National Institute of Allergy and Infectious Diseases, completed a Phase 1 trial assessing safety and immunogenicity. Results showed the vaccine was well tolerated and generated immune response.

The trial also found that vaccinated participants' blood reduced mosquito fertility and lowered in vitro Zika virus infectivity, providing early proof of principle for this transmission-blocking approach. Findings were published in a peer-reviewed journal and presented at international conferences.

SEEK established ConserV Bioscience Limited to lead further development. The team has secured additional funding from UKVN 2.0 and the US Department of Defence to advance

[75] UKRI Gateway to Research (2025). Preclinical development of A CD8 T-Cell Priming Vaccine Against Chikungunya Virus https://gtr.ukri.org/projects?ref=10084550 Accessed 13 May 2025

[76] UKRI Gateway to Research (2025). A novel vaccine approach combining mosquito salivary antigens and viral antigens to protect against Zika, chikungunya and other arboviral infections. https://gtr.ukri.org/projects?ref=10083718 Accessed 13 May 2025

[77] Conserv Bioscience (2024). ConserV Bioscience in collaboration with Walter Reed Army Institute of Research awarded a grant by CDMRP to evaluate a novel malaria vaccine candidate https://conservbio.com/news/conserv-bioscience-in-collaboration-with-walter-reed-army-institute-of-research-awarded-a-grant-by-cdmrp-to-evaluate-a-novel-malaria-vaccine-candidate/ Accessed 13 May 2025

AGS-v Plus, including combination studies with malaria, Zika and Chikungunya vaccine candidates.

Zika virus

Zika virus disease is caused by the Zika virus (ZIKV), a mosquito-borne flavivirus related to the dengue and yellow fever viruses. First identified in 1947, ZIKV remained mostly confined to Africa and Asia until outbreaks occurred in the Pacific and Americas from 2007 onwards.[78] It gained global attention during the 2015–16 South American outbreaks, infecting around 1.5 million people. The virus was linked to congenital Zika syndrome, such as microcephaly, in about 5–15% of infants born to infected mothers. In adults, ZIKV can cause Guillain-Barré Syndrome, a rare disorder leading to muscle weakness, paralysis and potentially long-term disability.

The 2015-16 ZIKV outbreak strongly increased the search for a vaccine and resulted in 16 candidates entering Phase I clinical trials from 2016 (with 15 from 2016 to 2019) (Table 9). However, case numbers have declined sharply since the 2015-16 outbreak, disrupting ongoing Phase II trials.[79,80]

Table 9 ZIKV vaccine candidates in clinical trials globally

Vaccine platform category	Developer	Clinical trial phase
Viral vector	**University of Oxford (UK)** **Themis/Merck (MV-ZIKA) (AT/US)** Themis/Merck (MV-ZIKA-RSP) (AT/US) Janssen Vaccines/Johnson&Johnson (NL/US) **University of Liverpool (UK)**	Phase I Phase I Phase I Phase I Phase I
Inactivated/Live-attenuated virus	Takeda (JP) NIH NIAID (US) Bharat Biotech International (IN) Valneva (US) University of Vermont (US)	Phase II (status: terminated) Phase I Phase I Phase I Phase I
Protein-based subunit	Imutex Ltd/ConserV Bioscience (UK)	Phase I
DNA	NIH NIAID (US) (VRC-ZKADNA090) NIH NIAID (US) (VRC-ZKADNA085) Inovio/US Army (US)	Phase II Phase I Phase I
mRNA	Moderna (mRNA-1893) (US) Moderna (mRNA-1325) (US)	Phase II Phase I

Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidate.

UKVN-funded projects and contributions

The UKVN 1.0 supported fourteen ZIKV vaccine development projects, with £19.0 million in funding, representing 26.3% of the UKVN vaccine R&D portfolio (Figure 15). Six projects targeted more than one pathogen.

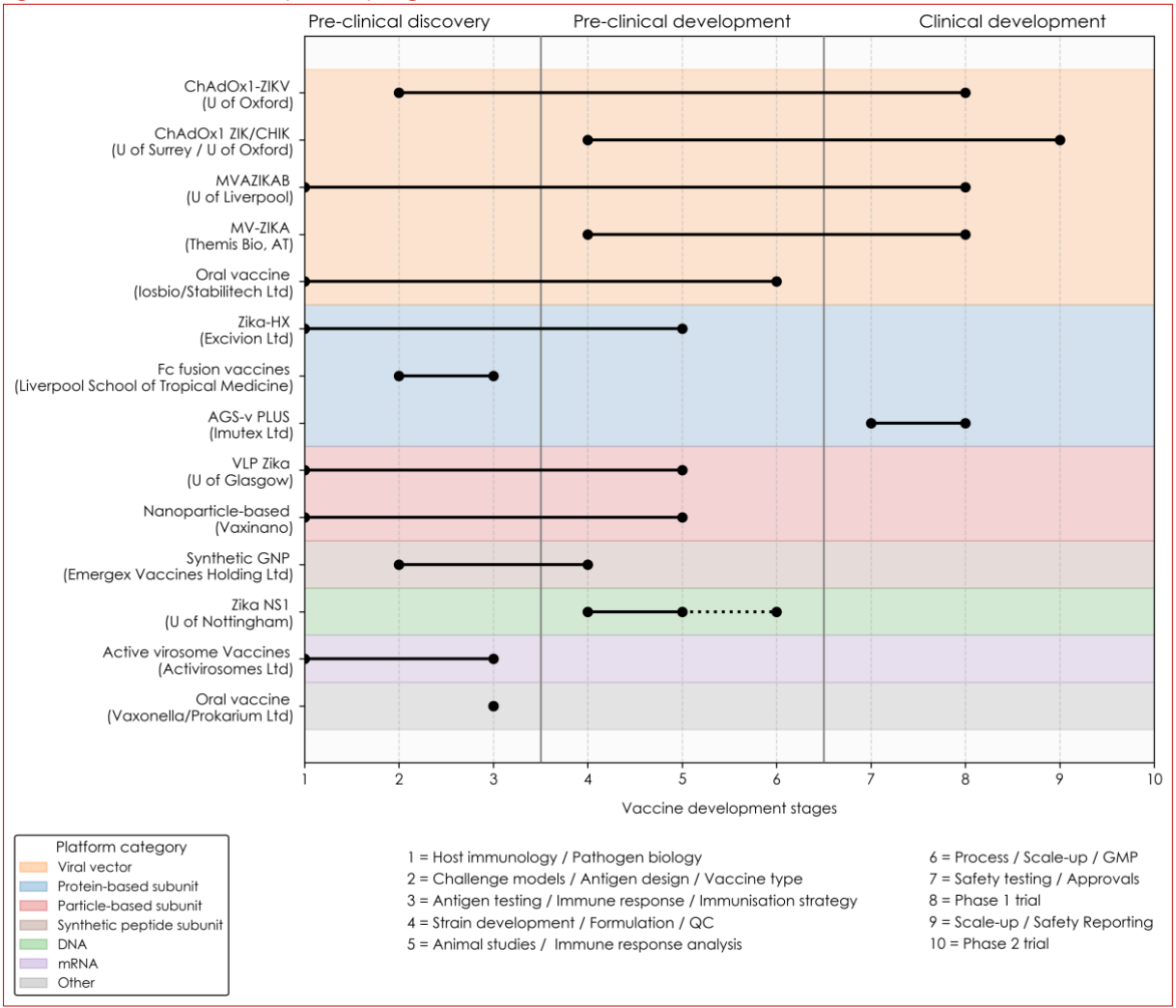
[78] World Health Organization. Zika virus. *World Health Organization.* 2022. Available at: https://www.who.int/news-room/fact-sheets/detail/zika-virus

[79] Woodson, S.E., Morabito, K.M. Continuing development of vaccines and monoclonal antibodies against Zika virus. npj Vaccines 9, 91 (2024). https://doi.org/10.1038/s41541-024-00889-x

[80] Adis Insight (2024). TAK 426 Drug Profile. https://adisinsight.springer.com/drugs/800047679 Accessed 13 May 2025

Projects developed vaccine candidates across seven vaccine platform categories, with a cluster of five projects focussed on viral vector candidates. Most candidates started in the discovery phase (10 of 14). Project leadership was split evenly between academia and SMEs (7 each).

Figure 15 Vaccine development progression for ZIKV



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project. Dotted lines show development after the end of the UKVN 1.0 award (funding secured, ongoing). Source: Survey data, final project reports, interviews and desk research.

Five candidates were evaluated in clinical trials, with two projects advancing candidates from discovery into clinical development (see also case study Box 4). Other projects also progressed their candidates, e.g. at least five candidates advanced from discovery to pre-clinical development and two from pre-clinical development into clinical trials.

At least three ZIKV vaccine R&D projects secured follow-on funding:

- A £1.86 million UKVN 2.0 award supports pre-clinical testing and scale-up studies for a DNA vaccine candidate, led by the University of Nottingham.[81]
- Imutex (now developed by ConserV Bioscience) received funding from UKVN 2.0 to extend the design of their vaccine (see CHIKV above, case study Box 3.[82,83] The company has also received funding from the US Department of Defense to develop a combination targeting malaria.[84]
- Further development of Themis' MV-ZIKA vaccine candidate is supported by the European Union via the ZIKAVAX consortium.[85] Informed by results of the UKVN-funded MV-ZIKA trial, the viral vector-based candidate was modified to improve protection (now called MV-ZIKA-RSP) and was tested in a Phase I trial.[86,87]

In summary, the UKVN 1.0 funded a diverse portfolio of ZIKV vaccine candidates, across platform categories and stages of development, led by academia and SMEs. At least three projects have continued development of ZIKV candidates supported by follow-on funding, indicating potential for future impact. For some lead organisations, no evidence of continued R&D targeting ZIKV vaccines was (publicly) available (e.g. ZIKV candidates by Vaxinano, iosBio). The decrease in Zika cases since the 2015/16 outbreak may have shifted priorities.

Box 4 A phase I study of recombinant poxvirus Zika vaccines

Zika virus, a mosquito-borne flavivirus, emerged as a global health concern during the 2015-16 outbreaks in South America, when it was linked to severe birth defects and neurological complications. In response, the WHO designated Zika a priority to disease to accelerate vaccine development.

A £4.3 million UKVN grant via Innovate UK Small Business Research Initiative (SBRI) competition in 2017 enabled a team led by the University of Liverpool to progress a novel Zika vaccine based on the MVA viral vector platform through pre-clinical testing in a mouse model, manufacturing to GMP standard and a Phase 1 clinical trial.

Despite several project implementation challenges, including an unstable initial vector construct, manufacturing setbacks and delays due to the COVID-19 pandemic, the team successfully developed a stable candidate, MVAZIKAB, completed preclinical studies and produced vaccine vials for a Phase 1 trial. While delays meant that the project closed before clinical testing, the team was able to begin a Phase 1 trial in 2023. Early trial data suggest the

[81] University of Nottingham (2023). Funding boost for research into fast-tracking rapidly deployable vaccines https://www.nottingham.ac.uk/news/fast-tracking-vaccines-grant Accessed 13 May 2025

[82] UKRI Gateway to Research (2025). A novel vaccine approach combining mosquito salivary antigens and viral antigens to protect against Zika, chikungunya and other arboviral infections. https://gtr.ukri.org/projects?ref=10083718 Accessed 13 May 2025

[83] Conserv Bioscience (2024) ConserV Bioscience ARBO-SAL project has been awarded UK Aid funding by the UK Vaccine Network, delivered by Innovate UK. https://conservbio.com/news/conserv-bioscience-arbo-sal-project-has-been-awarded-uk-aid-funding-by-the-uk-vaccine-network-delivered-by-innovate-uk/ Accessed 13 May 2025

[84] Conserv Bioscience (2024) ConserV Bioscience in collaboration with Walter Reed Army Institute of Research awarded a grant by CDMRP to evaluate a novel malaria vaccine candidate https://conservbio.com/news/conserv-bioscience-in-collaboration-with-walter-reed-army-institute-of-research-awarded-a-grant-by-cdmrp-to-evaluate-a-novel-malaria-vaccine-candidate/ Accessed 13 May 2025

[85] European Vaccine Initiative (2021). A safe, effective and affordable Zika Vaccine https://www.euvaccine.eu/post/a-safe-effective-and-affordable-zika-vaccine Accessed 13 May 2025

[86] European Vaccine Initiative (2021). A safe, effective and affordable Zika Vaccine https://www.euvaccine.eu/post/a-safe-effective-and-affordable-zika-vaccine Accessed 13 May 2025

[87] Kurup D et al (2022) Measles-based Zika vaccine induces long-term immunity and requires NS1 antibodies to protect the female reproductive tract. NPJ Vaccines ;7(1):43. doi: 10.1038/s41541-022-00464-2

vaccine is safe and elicits an immune response. The project has also led to a patent application (pending).

This was the first time the project team advanced a vaccine candidate into clinical development, establishing key capabilities for future vaccine R&D at the University of Liverpool and its NHS partner facility. The team is now applying for further funding to progress the MVAZIKB candidate and adapt the MVA platform for other pathogens. The proposed projects include a MVAZIKB Phase II trial in Brazil and a collaboration with researchers in Malawi to co-develop MVA-based vaccines.

Rift Valley Fever

Rift Valley Fever virus (RVFV) is a mosquito-borne zoonotic phlebovirus that causes an acute febrile illness in humans, which can progress to severe complications including haemorrhagic fever, hepatitis, retinitis and encephalitis.[88] RVFV primarily affects livestock, such as sheep, goats and cattle, where infection leads to high mortality and abortion rates. The virus is endemic across sub-Saharan Africa, with recurrent outbreaks in East African countries such as Kenya and Tanzania, and has also been reported outside the region, including in the Arabian Peninsula.[89]

Since 1986, US Army personnel entering RVFV endemic areas have been offered a vaccine.[90] A 2011 publication referring to this candidate stated that "the trial data support the safety and immunogenicity of the inactivated RVF vaccine"; no further information was found. Since 2016, two further RVFV vaccine candidates have entered clinical trials (Table 10).

Table 10 RVFV vaccine candidates in clinical trials globally

Vaccine platform category	Developer	Clinical trial phase
Viral vector	**University of Oxford (UK)**	Phase II
Inactivated/live-attenuated virus	US Army Medical Research Institute of Infectious Diseases Wageningen Bioveterinary Research (NL)	Administered since 1986 Phase I/IIa

Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidate.

UKVN-funded projects and contributions

The UKVN 1.0 supported five RVFV vaccine R&D projects, including two projects targeting multiple pathogens (RVFV/CHIKV; RVFV/Q Fever), allocating £4.7 million in funding, 6.5% of UKVN vaccine R&D funding (Figure 16).[91]

Projects started across R&D stages, with three in the discovery phase. Three of the five projects developed viral vector-based vaccines, with two projects focussing on the same vaccine candidate (ChAdOx1-RVF) for clinical and for veterinary use (see case study Box 5 and Box 6). Two other projects advanced novel, low-cost approaches to manufacturing.

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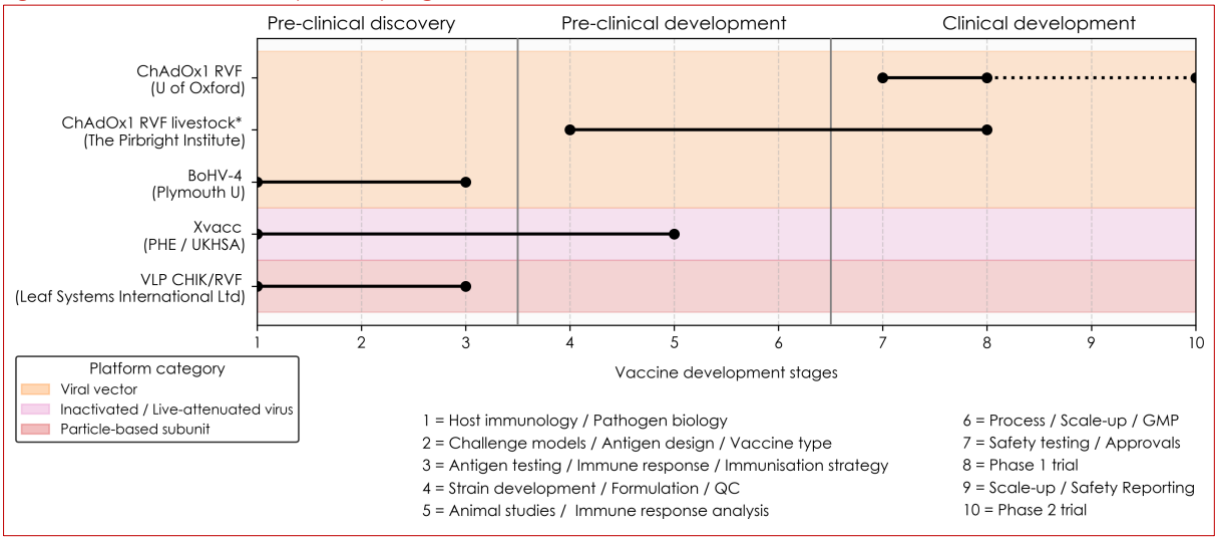
[88] WHO (2024) Rift Valley Fever, https://www.who.int/news-room/fact-sheets/detail/rift-valley-fever. Accessed 23/5/25

[89] Ndishimye P et al (2024) Rift Valley Fever outbreaks in the East African Community: insights from ProMed Data (2010-2024) Front. Public Health 12:1298594. doi: 10.3389/fpubh.2024.1298594

[90] Rusnak JM et al (2011) Immunogenicity and safety of an inactivated Rift Valley fever vaccine in a 19-year study. Vaccine 29: 3222-3229. https://doi.org/10.1016/j.vaccine.2011.02.037; The ICTRP first entry for TSI-GSD 200 is from 2018, but the vaccine is reported to have been tested since 1986.

[91] The end point for "ChAdOx1 RVF livestock", a vaccine for veterinary use which progressed to field trials, is indicated as 'clinical development, Phase I trial'.

Figure 16 Vaccine development progression for RVFV



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project. Dotted lines show development after the end of the UKVN 1.0 award (funding secured, ongoing). ChAdOx1 RVF livestock (Pirbright Institute) shown at Phase 1 for R&D illustration; as a veterinary vaccine, it progressed to livestock field trials, not human trials. Source: Survey, final project reports, interviews and desk research.

The five projects advanced the development stage of their respective RVFV vaccine candidates. At least one project secured follow-on funding to advance the vaccine candidate: CEPI allocated US$3.7 million for a Phase II clinical trial of ChAdOx1 RVF in Kenya.[92] In addition, the UKVN 2.0 is funding UKHSA to progress the manufacturing technology that had underpinned their RVFV candidate (rapid and precise inactivation of viruses through X-ray irradiation) for the development of a ZIKV vaccine.

In summary, the UKVN 1.0 made important contributions to the development of a RVFV vaccine, supporting one of only two vaccine candidates currently in active clinical development globally (ChAdOx RVF), for a Phase I clinical trial as well as a livestock field trial. Going forward, this vaccine candidate has the potential to yield benefits to LMICs in the short- to medium-term. The results are promising - field studies showed it to be effective in livestock and it is currently in a Phase II trial. As veterinary vaccines face fewer regulatory hurdles, a livestock vaccine could be available within the next years, although production processes would need to be adjusted to lower vaccine cost.[93]

At the same time, the limited number of vaccine candidates supported by the UKVN poses a risk to the portfolio's overall impact. Of the four candidates supported, the evaluation team could only find evidence of continued development and follow-on funding for the ChAdOx1 RVF candidate.

Box 5 Advanced development of a safe and effective Rift Valley Fever vaccine for livestock

Rift Valley Fever (RVF) is a viral disease caused by the Rift Valley Fever Virus (RVFV), mainly transmitted to humans and livestock by mosquitoes. RVF leads to high fatality rates (up to

[92] CEPI (2024). Promising human Rift Valley fever vaccine to enter Phase II clinical trials in Kenya https://cepi.net/promising-human-rift-valley-fever-vaccine-enter-phase-ii-clinical-trials-kenya Accessed 13 May 2025

[93] Michael James Francis (2022) Considerations for rapid development and licencing of conventional and platform technology veterinary vaccines, Avian Pathology 51:2, 107-112. DOI: 10.1080/03079457.2022.2046703

90%) in young livestock and abortion in pregnant animals. Besides economic losses to farmers, outbreaks in animals are linked to the disease spreading to humans

A £2.36 million UKVN grant enabled researchers from the Pirbright Institute, led by Prof George Warimwe, the University of Oxford and Kenyan partners - the International Livestock Research Institute (ILRI) and the KEMRI-Wellcome Trust Research Programme (KWTRP) -, to advance development of the ChAdOx1-RVF vaccine candidate for use in livestock. Preclinical studies had already demonstrated that a single dose of the ChAdOx1 RVF vaccine candidate provided full protection against RVFV in mice, sheep, goats and cattle.

After producing the vaccine to GMP standards, the team showed that a reduced dose of ChAdOx1-RVF still protected animals from RVF, was safe in pregnant livestock and, in a 700-animal Kenyan field trial, triggered stronger immune responses than the only currently licensed livestock vaccine against RVFV, the Smithburn vaccine.

The project strengthened Kenyan research capacity through training for conducting field trials in compliance with veterinary Good Clinical Practice (vGCP) standards. This catalysed investments in both personnel and infrastructure, enhancing the institute's ability to conduct further livestock vaccine studies in the future. At the same time, ILRI and KWTRP played a key role in the trial delivery, including sourcing trial animals, overseeing daily operations and trial monitoring. Proactive communication with the local regulator was essential to the study: Because Kenya classified the viral-vector vaccine as a Genetically Modified Organism (GMO) under plant-oriented rules, the vaccine trial was the first to fit into this framework, requiring close coordination between the researchers and national regulators.

The team is currently improving the manufacturing process to bring costs down to veterinary-vaccine levels and engaging with animal-health companies and Kenyan regulators to secure local licensing.

Box 6 Phase I studies of a novel chimpanzee adenovirus Rift Valley Fever vaccine

Rift Valley Fever (RVF) is a viral disease caused by the Rift Valley Fever Virus (RVFV), mainly transmitted to humans and livestock by mosquitoes. In humans, RVF symptoms range from mild illness to severe haemorrhagic syndrome, which can have fatality rates of up to 50%.

A £2.18 million UKVN award enabled a team from the University of Oxford, led by Prof Pontiano Kaleebu and the MRC/UVRI Uganda Research Unit to advance development of the ChAdOx1-RVF vaccine candidate.

After producing ChAdOx1-RVF to GMP standards, the team conducted Phase I trials in the UK and Uganda. The trial results showed that the vaccine was well tolerated and generated immune responses across all dose levels. This promising finding secured a US$3.7 million grant from CEPI to advance development in a Phase II study in Kenya.

Among the challenges encountered by the research team was the insufficient genetic stability of the first vaccine batch, which had to be addressed and caused a delay to the project. However, the setback provided valuable insights, leading to a revised method for incorporating transgenes into the ChAdOx1 vector platform. This improved approach was subsequently used in the development of other vaccine candidates, including the Oxford/AstraZeneca COVID-19 vaccine and has played an important role in advancing scalable manufacturing of ChAdOx1-vectored vaccines.

Next, the team will complete the Phase II trial in Kenya and, along with supporting non-human-primate work, pursue emergency use authorisation via the "Animal Rule", a pathway designed for diseases that are too sporadic to undergo conventional Phase III trials.

3.2.2.3 Respiratory and rodent-borne viruses: MERS-CoV, Nipah virus, Hantavirus

Middle East Respiratory Syndrome (MERS)

Middle East Respiratory Syndrome (MERS) is caused by the zoonotic MERS coronavirus (MERS-CoV), primarily transmitted through contact with infected camels.[94] MERS can lead to acute respiratory distress and death in the most severe cases. The virus was identified in Saudi Arabia in 2012 and has since become endemic in camels in the region. Human cases are reported across the Middle East, Africa and South Asia, with nearly 1000 deaths from 2021 to 2024.[95,96]

Four vaccine candidates have been evaluated in humans, all entering clinical development after 2016 (Table 11). One candidate progressed to a Phase II trial; however, its development was discontinued due to a poor immune response.[97]

Table 11 MERS-CoV vaccine candidates in clinical trials globally

Vaccine platform category	Developer	Clinical trial phase
Viral vector	Gamaleya Research Institute (RU) Universitätsklinikum Hamburg-Eppendorf (DE) **University of Oxford (UK)**	Phase I/II Phase I Phase I
DNA	Inovio/US Army (US)	Phase II (discontinued)

Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidate.

UKVN-funded projects and contributions

The UKVN 1.0 funded three vaccine R&D projects targeting MERS-CoV, including one project developing a pan-coronavirus vaccine and one project targeting development of two vaccines using the same formulation technology (MERS, plague) (Figure 17). In total, the UKVN provided £2.5 million, representing 3.5% of its vaccine R&D funding. Each project focussed on a different platform category and started in different stages of development.

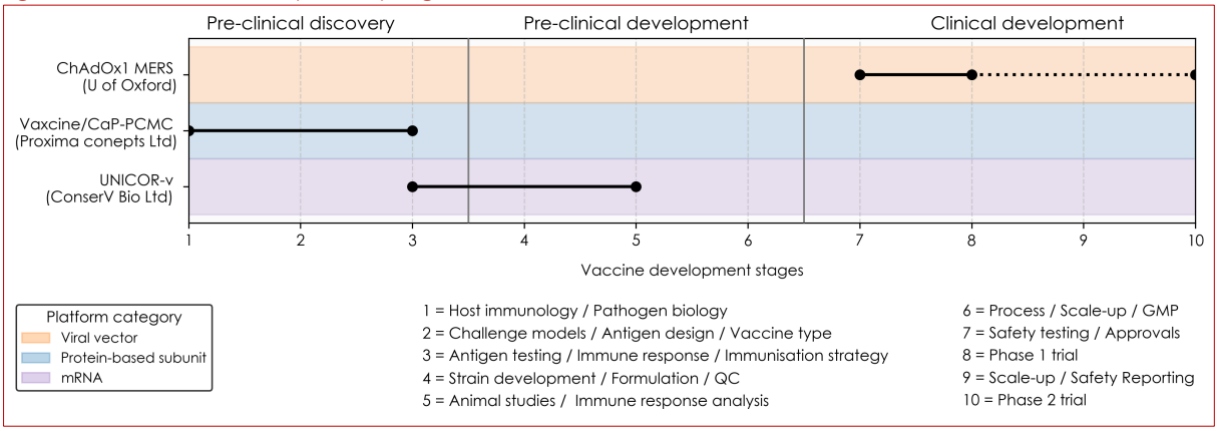
[94] Killerby ME, Biggs HM, Midgley CM, Gerber SI, Watson JT. Middle East Respiratory Syndrome Coronavirus Transmission. Emerg Infect Dis. 2020;26(2):191-198. doi:10.3201/eid2602.190697

[95] Zaki, A.M., Van Boheemen, S., Bestebroer, T.M., Osterhaus, A.D. and Fouchier, R.A., 2012. Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. *New England Journal of Medicine*, *367*(19), pp.1814-1820

[96] World Health Organization. Middle East respiratory syndrome coronavirus (MERS-CoV). World Health Organization website. Published December 2019. Available here. Accessed February 14, 2025

[97] Fierce Biotech (2022). Inovio drops Lassa, MERS vaccines as clinical data fall short, gutting infectious disease pipeline https://www.fiercebiotech.com/biotech/inovio-drops-lassa-mers-vaccines-clinical-data-fall-short-gutting-infectious-disease Accessed February 14, 2025

Figure 17 Vaccine development progression for MERS-CoV



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project. Dotted lines show development after the end of the UKVN 1.0 award (funding secured, ongoing). Source: Survey, final project reports, interviews and desk research.

All three projects advanced their vaccine candidates, with one project moving from pre-clinical discovery to pre-clinical development.

At least two of the three projects secured follow-on funding:

- The ChAdOx1 MERS vaccine received funding from CEPI, including for a Phase II study[98] (see Box 7 and case study 'Phase I studies of a novel chimpanzee adenovirus MERS')
- ConserV Bio Ltd secured a UKVN 2.0 award for their pan-coronavirus vaccine candidate to test the antigens developed with UKVN 1.0 funding in different vaccine platforms[99]

In summary, the UKVN 1.0 supported a small portfolio of only three MERS-CoV vaccine R&D projects. This included clinical development of the ChAdOx1 MERS candidate, one of four vaccine MERS-CoV candidates globally that have entered clinical trials. Findings from this project contributed to the speed of development of the Oxford-AstraZeneca COVID-19 vaccine (see Box 7 and case study 'Phase I studies of a novel chimpanzee adenovirus MERS'), delivering real-world benefit (see Cost benefit analysis, section 3.5). This illustrates that advances in R&D, enabled by UKVN 1.0 funding, can accelerate outbreak responses and save lives.

Going forward, there is a clear pathway to benefit for LMIC populations if the ChAdOx1-MERS candidate demonstrates efficacy in the upcoming Phase II trials. CEPI has already committed to funding its continued development, stockpiling and the transfer of manufacturing capabilities to LMICs.

Box 7 Phase I studies of a novel chimpanzee adenovirus MERS

Middle East Respiratory Syndrome (MERS) is caused by the MERS coronavirus (MERS-CoV), primarily transmitted to humans through contact with infected camels. MERS can lead to

[98] CEPI (2023) New partnership aims to advance vaccine against MERS coronavirus. https://cepi.net/new-partnership-aims-advance-vaccine-against-mers-coronavirus Accessed 13 May 2025

[99] Conserv Bioscience (2024). ConserV Bioscience pan-coronavirus project has been awarded UK Aid funding by the UK Vaccine Network by Innovate UK. https://conservbio.com/news/conserv-bioscience-pan-coronavirus-project-has-been-awarded-uk-aid-funding-by-the-uk-vaccine-network-by-innovate-uk/ Accessed 13 May 2025

acute respiratory distress and death in severe cases. Human cases have been reported across the Middle East, Africa and South Asia, with 943 deaths from 2021 to 2024.

A £2.05 million UKVN grant enabled a team at the University of Oxford, led by Prof Sarah Gilbert and partners at King Abdullah International Medical Research Centre, Saudi Arabia, to advance a viral-vectored vaccine against MERS-CoV for human use, ChAdOx1-MERS.

The team manufactured the vaccine candidate to GMP standard and showed that a single dose was safe, well tolerated and immunogenic in Phase I trials in the UK and Saudi Arabia. Given the similarities between the MERS-CoV and SARS-CoV-2 viruses, knowledge gained from this research contributed to the rapid development of the Oxford-AstraZeneca Covid-19 vaccine in 2020. For example, the ChAdOx1 MERS Phase I dose studies informed early dose selection for the ChAdOx1 Covid-19 vaccine, streamlining the path to clinical trials.

Funded by CEPI, the University of Oxford team are currently conducting a Phase I trial of ChAdOx1-MERS, focussing on efficacy of the vaccine in older adults. An additional US$34.8 million were provided by CEPI to conduct a Phase II trial of the vaccine candidate in the Middle East. If the trial results are positive, CEPI will provide further funding to create a reserve of 100,000 doses for rapid deployment in future MERS outbreaks, as well as facilitate technology transfer to a regional manufacturer to supply LMICs.

Nipah Virus

Nipah virus (NiV) is a zoonotic pathogen that can cause severe, frequently fatal respiratory and neurological disease.[100,101] NiV is carried by Pteropus fruit bats and infects humans primarily through bat-contaminated date-palm sap or via infected livestock, including pigs and horses. Direct pig-to-human transmission was responsible for the first NiV outbreaks in Malaysia and Singapore in 1998–99, with nearly 300 human cases and over 100 fatalities.[102] Outbreaks have also been reported in Singapore, Bangladesh, India and the Philippines, with an average mortality rate of 60% (up to 95 % for the Bangladesh strain).

From 2020, four vaccine candidates entered clinical trials (Table 12), three supported by CEPI.

Table 12 Nipah virus vaccine candidates in clinical trials globally

Vaccine platform	Developer	Clinical trial phase
Viral vector	Public Health Vaccines/NIH NIAID (US) University of Oxford	Phase I Phase I
Protein-based subunit	Auro Vaccines (US)	Phase I
mRNA	Moderna Inc (US)	Phase I

Source: WHO International Clinical Trials Registry Platform, literature review.

UKVN-funded projects and contributions

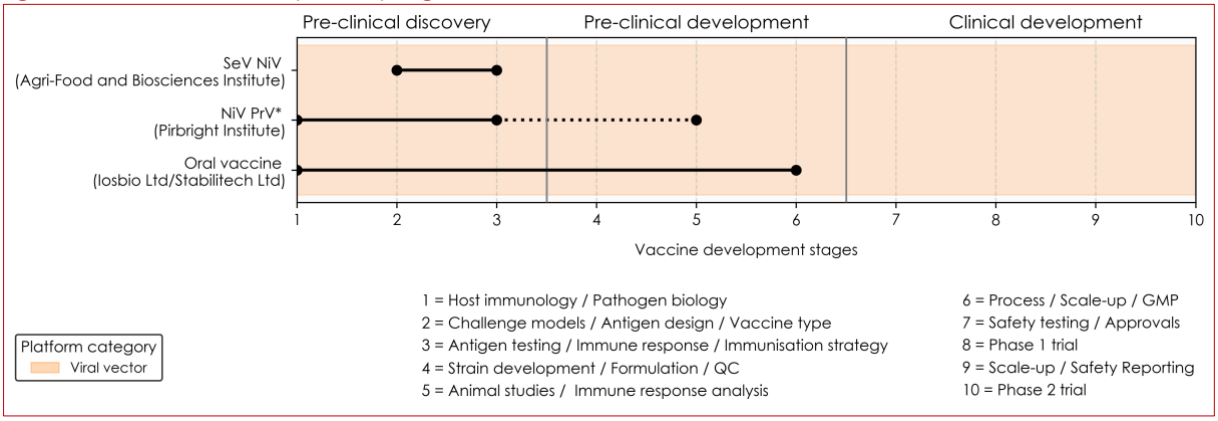
[100] Rodrigue V et al (2024) Current progress towards prevention of Nipah and Hendra disease in humans: A scoping review of vaccine and monoclonal antibody candidates being evaluated in clinical trials. Trop Med & Int Health 29: 354-364. https://doi.org/10.1111/tmi.13979

[101] Sharma V et al (2018) Emerging trends of Nipah virus: A review. Reviews in Medical Virology 29:e2010. https://doi.org/10.1002/rmv.2010

[102] McLean RK & Graham SP (2019) Vaccine Development for Nipah Virus Infection in Pigs. Front Vet Sci 6. https://doi.org/10.3389/fvets.2019.00016

The UKVN 1.0 funded three vaccine R&D project targeting NiV with a total of £3.0 million (4.1% of UKVN vaccine R&D funding) (Figure 18). All projects started in the discovery phase and focussed on viral vector-based candidates, each with a distinct emphasis, e.g. a vaccine platform that is safe and effective in both pigs and humans; development of an oral vaccine.

Figure 18 Vaccine development progression for NiV



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project. Dotted lines show development after the end of the UKVN 1.0 award (funding secured, ongoing). Source: Survey, final project reports and desk research.

All three projects advanced their vaccine candidates, with one candidate moving from discovery into pre-clinical development. At least one project secured follow-on funding: The Pirbright Institute received a UKVN 2.0 award to further develop its candidate for veterinary use, targeting both NiV and pseudorabies virus.[103,104]

In summary, the UKVN 1.0 funded a small portfolio of three NiV vaccine R&D projects and led to UKVN 2.0 follow-on funding for a veterinary vaccine candidate. This candidate has potential to benefit LMICs, particularly as livestock vaccines face fewer regulatory barriers. Controlling animal outbreaks, especially in pigs, could reduce human infection risk. However, the small portfolio size and high R&D risks jeopardise overall impact. No evidence was found that development of the other two NiV vaccine candidates is being continued.

Hantaviruses

Hantaviruses are rodent-borne pathogens that can cause two severe human illnesses: hantavirus pulmonary syndrome (HPS) in the Americas and haemorrhagic fever with renal syndrome (HFRS) in Europe and Asia. Humans are usually infected by inhaling aerosolised urine, faeces or saliva from rodent carrier species, although person-to-person spread has been recorded in South America.[105] Every year, almost 200,000 people are affected by Hantaviruses globally, with a case fatality rate of 1–15% for HFRS and up to 40–60% for HCPS.

[103] The Pirbright Institute (2025). Research project A bivalent vaccine to reduce the risk of Nipah virus outbreaks https://www.pirbright.ac.uk/our-science/research-projects/bivalent-vaccine-reduce-risk-nipah-virus-outbreaks Accessed 13 May 2025

[104] INNT (2024). A bivalent vaccine to reduce the risk of Nipah virus outbreaks https://www.fli.de/en/institute/institut-fuer-neue-und-neuartige-tierseuchenerreger-innt/projekte/research-projects-single-view/a-bivalent-vaccine-to-reduce-the-risk-of-nipah-virus-outbreaks/ Accessed 13 May 2025

[105] Afzal S et al (2023) Hantavirus: an overview and advancements in therapeutic approaches for infection. Front Microbiol;14:1233433. doi: 10.3389/fmicb.2023.1233433

Prior to 2016, one Hanta vaccine candidate had entered clinical development, developed by the US Army. Since 2016, a second candidate has completed a Phase I study (Table 13).

Table 13 Hantavirus vaccine candidates in clinical trials globally

Vaccine platform category	Developer	Clinical trial phase
DNA	US Army US NIH/NIAID	Phase II Phase I

Source: WHO International Clinical Trials Registry Platform, literature review.

UKVN-funded projects and contributions

The UKVN funded one project targeting Hantavirus vaccines, the development of a viral vector-based candidate by UKHSA, providing a total of £2.5m (3.4% of UKVN vaccine R&D funding).

The project progressed the vaccine candidate from discovery to completion of the pre-clinical development phase. Although the candidate showed positive data and a GMP-standard vaccine batch was produced, the planned Phase I trial (971618) did not move forward as UKHSA was redirecting its efforts toward the COVID-19 pandemic.[106] Further development of this candidate is funded through UKVN 2.0.

While findings are promising, the portfolio is limited to a single funded vaccine candidate, leaving future benefits highly vulnerable to the inherent risks of research.

3.2.2.4 Bacterial pathogens: Yersinia pestis (plague), Coxiella burnetii (Q fever)

Plague

Plague, caused by the bacterium *Yersinia pestis*, is a zoonotic disease with three clinical forms: bubonic, septicaemic and pneumonic.[107,108] Occurring naturally in wild rodent populations, the bacterium is transmitted to humans through the bite of infected fleas or contact with infected animal tissues. In addition, pneumonic plague can spread person-to-person through respiratory droplets. The disease has a high fatality rate if not treated promptly.

Plague affects over 25 countries globally and approximately 2000 cases are reported to the WHO each year.[109] In the past, plague vaccines showed some protection, but their use was limited by safety concerns and limited efficacy against pneumonic plague.[110]

Two plague vaccines are available in Russia and/or China: A live-attenuated vaccine, effective against all three forms plague, has been in use since 1936, but is not approved in

[106] Aram M et al (2025) A Multi-Valent Hantavirus Vaccine Based on Recombinant Modified Vaccinia Ankara Reduces Viral Load in a Mouse Infection Model. Vaccines 13(3):270. doi: 10.3390/vaccines13030270.

[107] WHO (2021) Plague. https://www.who.int/news-room/fact-sheets/detail/plague Accessed 13 May 2025

[108] CDC (2025) Plague. https://www.cdc.gov/plague/maps-statistics/index.html Accessed 13 May 2025

[109] Sun W (2016) Plague Vaccines: Status and Future. Adv Exp Med Biol. 918:313-360. doi: 10.1007/978-94-024-0890-4_12

[110] Williamson ED, Kilgore PB, et al (2024) Progress on the research and development of plague vaccines with a call to action. NPJ Vaccines 7;9(1):162. doi: 10.1038/s41541-024-00958-1

other countries due to safety concerns. In 2024, Russia approved a second vaccine.[111] Five further vaccine candidates have entered clinical trials (four prior to 2016) (Table 14).

Table 14 Plague vaccine candidates in clinical trials globally

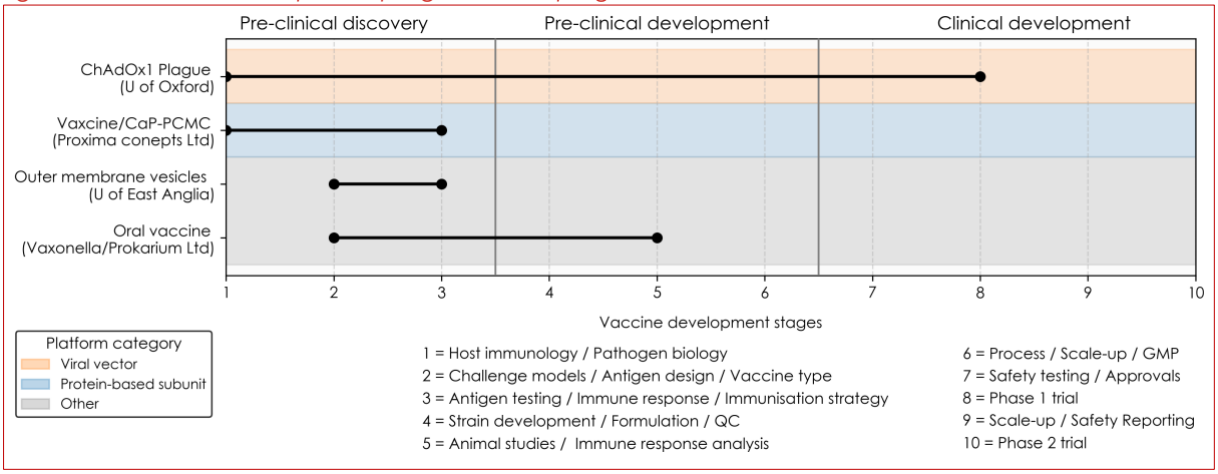
Vaccine platform category	Developer	Clinical trial phase
Viral vector	**University of Oxford (UK)**	Phase I
Inactivated/Live-attenuated	Stavropol Anti-Plague Scientific Research Inst (RU)	Approved/Phase IV (Russia, China)
Protein-based subunit	State Research Center Applied Microbiol. & Biotech (RU) Dynavax / US Army (US) Jiangsu Province CDC (CN) Saint Louis University/NIAID (US)	Approved (Russia) Phase II Phase II Phase I
(no information)	Lanzhou Institute of Biological Products (CN)	Phase I

Source: WHO International Clinical Trials Registry Platform, literature review. In bold: UKVN-supported candidate.

UKVN-funded projects and contributions

The UKVN 1.0 funded four plague vaccine R&D projects, providing a total of £5.7 million (8.0% of the UKVN vaccines R&D portfolio) (Figure 19). One project targeted two pathogens, *Y. pestis* and MERS-CoV. While each of the projects focussed on a different vaccine platform category, three of the four projects investigated options for oral vaccine administration. All candidates started in discovery stages, led by groups from academia (2) and by SMEs (2).

Figure 19 Vaccine development progression for plague



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project.
Source: Survey, final project reports, interviews and desk research.

One project progressed the viral vector-based ChAdOx1 PlaVac candidate from discovery to Phase I clinical trials. The team secured follow-on funding through UKVN 2.0 but redirected efforts toward an RNA-based platform, citing limited acceptability of adenoviral vectors in high-income countries due to rare side effects that have discouraged industry investment.

[111] Trial not registered on WHO ICTRP registry platform. Anisimov AP et al (2025) Live Plague Vaccine Development: Past, Present, and Future. Vaccines 13: 66. https://doi.org/10.3390/vaccines1301006

Concurrently, the team is in discussions with a manufacturer to stockpile ChAdOx1 PlaVac for emergency use, given that in outbreak scenarios, the threat posed by plague outweighs concerns over vector-related risks (see Box 8 and case study 'Development of a new vaccine against Plague').

In summary, the UKVN1.0 supported plague vaccine candidates based on diverse platforms, with an emphasis on oral formulations (i.e. well suited to use in LMICs). The ChAdOx1 PlaVac candidate showed promising results in Phase I clinical trials and the developers are currently discussing stockpiling doses with a manufacturer. Going forward, this has the potential to yield direct benefit to LMICs, as it would make the candidate immediately available for trialling when an outbreak occurs. It is unclear to what extent the other UKVN-funded plague vaccine candidates are still in active development.

Box 8 Development of a new vaccine against plague

Plague remains a persistent threat to global health, requiring rapid and effective countermeasures to contain outbreaks and save lives. From 2016 to 2024, three consecutive UKVN 1.0/InnovateUK awards totalling £3.9 million advanced the development of a viral vector-based plague vaccine, ChAdOx1 Plague. Led by Prof Andrew Pollard, University of Oxford, the team inserted two antigens from the plague-causing bacterium Yersinia pestis into the ChAdOx1 viral vector and showed that it provided complete protection against the pathogen in a mouse model. Subsequent clinical trials in the UK and Uganda demonstrated that the vaccine candidate was safe and triggered immune responses in both populations. The team also successfully developed plague-specific laboratory assays and established international collaborations. The ChAdOx1 Plague candidate is now ready to be trialled in future outbreaks and the team are discussing the manufacture of a stockpile with industry.

The team has since shifted focus to an RNA-based platform, supported by a £2m Innovate UK SBRI award (2023–2025). RNA vaccines offer similar rapid deployment advantages with fewer safety concerns compared to adenoviral vectors, which improves their acceptability in high-income markets and for global use outside of major outbreaks. The RNA vaccine R&D draws heavily on development of the ChAdOx-based candidate, including antigen design, assay development, collaboration network and trial experiences in Uganda.

A key enabler of the project was the successful collaboration between University of Oxford scientists, UK and US high-containment labs and Ugandan trial partners, combining vaccine know-how, ready animal models and local community support. On the other hand, project progress was slowed by several challenges, including a lack of validated immunological assays, correlates of protection and convalescent samples.

Q Fever

Q fever is a zoonotic disease caused by the bacterium Coxiella burnetiid.[112] Human infection typically occurs via inhalation of aerosols or dust contaminated with birthing fluids, placenta, faeces, or milk from infected sheep, goats or cattle. Acute disease is often self-limiting and rarely fatal (mortality among all acute cases is < 1–2%). A small proportion of patients, however, develop chronic infection, often manifesting as endocarditis or vascular complications, which despite treatment carries a case-fatality rate of ~20-25%. Q fever is globally distributed but detection and reporting are patchy. In 2019, 1,069 cases were reported in EU/EEA member

[112] CDC (2024) Q Fever. https://www.cdc.gov/q-fever/about/ Accessed 13 May 2025

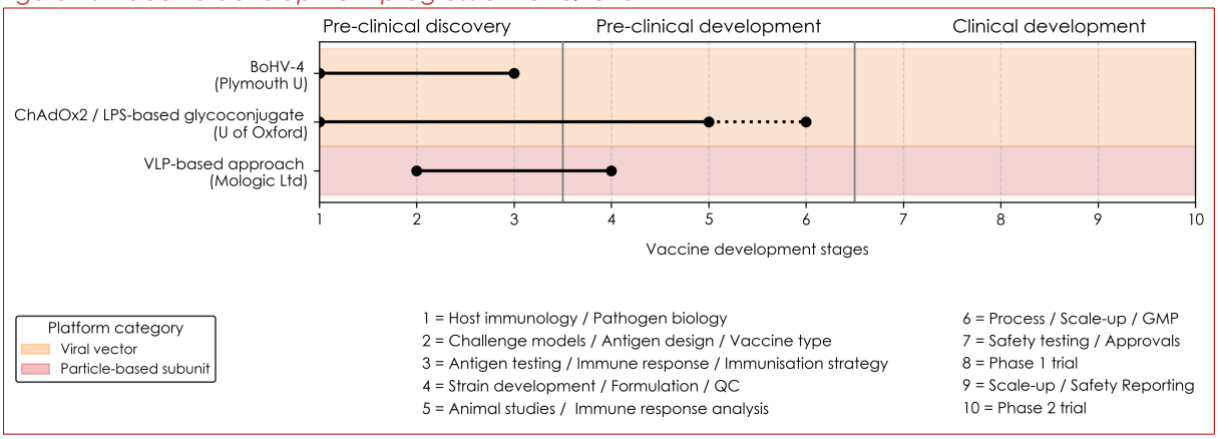
states, many among persons with occupational exposure, including farm workers, abattoir workers and veterinarians.[113]

Two Q fever vaccines are currently available: Q-VAX®, for human use, is approved in Australia but requires pre-screening to avoid severe reactions in those previously exposed to C. burnetii; and Coxevac®, a vaccine for veterinary use. A Phase II trial of an inactivated virus-based vaccine began in 2006 by the US Army, but no further updates have been identified.

UKVN-funded projects and contributions

The UKVN 1.0 funded three vaccine R&D projects targeting Q fever, with one project focussing on a vaccine candidate for veterinary use and one project developing a multivalent vaccine against Q fever and RVF (Figure 20). The portfolio was supported with £4.2 million in funding (5.8% of the UKVN vaccine R&D investment). All three projects started with candidates in the discovery phase.

Figure 20 Vaccine development progression for Q fever



Black lines indicate the development stage at the start and at the end of the UKVN1.0-funded project. Dotted lines show development after the end of the UKVN 1.0 award (funding secured, ongoing). Source: Survey, final project reports and desk research.

Two candidates moved from discovery into pre-clinical development. Insights gained led to a second vaccine approach, a lipopolysaccharide (LPS)-based glycoconjugate, to be included alongside the ChAdOx2 candidate.[114] Projects also provided data on immunological responses which can support further research, e.g. the immune response to *C. burnetii* LPS and protection in challenged mice.[115]

Development of at least one candidate, the ChAdOx2/LPS-based approach, is continuing with UKVN 2.0 funding, focussing on the LPS component.

[113] ECDC (2019). Q Fever Annual Epidemiological Report for 2019 https://www.ecdc.europa.eu/sites/default/files/documents/AER-Q-fever-2019.pdf Accessed 13 May 2025

[114] Dold C et al (2023) Immunisation with purified Coxiella burnetii phase I lipopolysaccharide confers partial protection in mice independently of co-administered adenovirus vectored vaccines. Vaccine 41(19): 3047-3057. https://doi.org/10.1016/j.vaccine.2023.04.012

[115] Ibid.

In summary, the UKVN supported a small portfolio of three vaccine R&D projects targeting Q fever, with one candidate taken forward through a UKVN 2.0 award. While data for this candidate are promising, the high risk inherent in R&D make future benefits uncertain.

3.2.3 Progressing technologies to accelerate vaccine response to an unknown pathogen

In addition to the 12 priority pathogens, UKVN 1.0 also included provision for 'Disease X', a term coined by the WHO Blueprint team representing 'a pathogen currently unknown to cause human disease' that could however lead to an international epidemic.[116] Disease X research is defined as 'cross-cutting R&D preparedness that is also relevant for an unknown disease'.

Effective preparedness for Disease X relies on a coordinated R&D ecosystem that can respond rapidly to emerging threats. This includes:

- Rapidly adaptable vaccine platforms
- Scalable manufacturing processes
- Surveillance systems and real-time data sharing
- Essential R&D tools and assays
- Clinical trial infrastructure and capacity
- Regulatory capacity
- Pre-established R&D collaboration networks.

Rapidly adaptable vaccine platforms

Traditional platform types, such as inactivated/live-attenuated vaccines and some more modern platforms, e.g. protein-based subunit vaccines, require bespoke process optimisation for each new vaccine candidate. More recently, vaccines are being developed on configurable "plug-and-play" platforms which offer the ability to rapidly swap in new antigen sequences without changes to the validated "backbone", manufacturing process and formulation.[117,118] This reduces discovery-to-approval timelines, as safety and efficacy are already established for the platform and allows manufacturing to be scaled or repurposed between pathogens. An example is the ChAdOx platform, with ChAdOx-based candidates entering clinical development for nine of the 12 UKVN priority pathogens since 2018.

Plug-and-play platforms are crucial to achieving the UKVN's aim of supporting "new technologies that can accelerate vaccine response to an unknown pathogen". At the same time, platform technologies must consider manufacturing and distribution needs in LMICs to enable rapid deployment and equitable access. Advantages and disadvantages of platform categories, alongside their definitions as used in this report, are set out in Table 15.

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[116] Chapman *et al* (2022) Landscape of Emerging Infectious Disease Research and Development. G-FINDER website. Available at: https://policy-cures-website-assets.s3.ap-southeast-2.amazonaws.com/wp-content/uploads/2022/06/16191104/2022-G-FINDER-EID-Report.pdf Accessed 6 June 2024

[117] Yang, K (2025) Accelerating Vaccine Development: Plug-and-Play Platforms for Emerging Infectious Diseases. Virus Research 199601. https://doi.org/10.1016/j.virusres.2025.199601

[118] Jeon J, Kim E (2025) Exploring Future Pandemic Preparedness Through the Development of Preventive Vaccine Platforms and the Key Roles of International Organizations in a Global Health Crisis. Vaccines 13(1):56. https://doi.org/10.3390/vaccines13010056

Table 15 Vaccine platform categories

Platform category	Definition	Advantages	Disadvantages
Viral vector	Uses modified viruses (e.g. ChAd, MVA) to deliver genetic material encoding antigens	Strong immune response, can mimic natural infection; single-dose potential	Pre-existing immunity to vector may reduce efficacy, complex manufacturing
Inactivated / live-attenuated	Whole pathogens that are either killed (inactivated) or weakened (attenuated)	Established safety profiles, strong immune responses (especially live-attenuated)	Not 'plug-and-play'. Risk of reversion to virulent form (attenuated); multiple doses needed (inactivated), stringent biosafety for production
Protein-based subunit	Purified recombinant proteins / toxoids from the pathogen	Well-defined composition, safe and stable, well-established expression systems	Not 'plug-and-play' as each antigen needs optimisation. Often needs adjuvants, weaker immune response
Particle-based subunit	Self-assembling nanoparticles or virus-like particles to display antigens	High immunogenicity, mimic virus structure	Manufacturing complex, limited platforms approved to date
Synthetic peptide subunit	Chemically synthesised short peptides representing parts of antigens	Highly specific, simple to produce, stable at room temperature	Low immunogenicity, requires adjuvants and precise epitope identification
DNA	Plasmid DNA encoding antigen is delivered into host cells	Rapid design, inexpensive to produce, stable at room temperature	Low immunogenicity in humans, delivery challenges
RNA (mRNA/saRNA)	Encodes antigen using messenger RNA, typically delivered via lipid nanoparticles	Rapid design, scalable production, no risk of genome integration	Requires ultra-cold storage, short shelf life, side-effect (reactogenicity) concerns

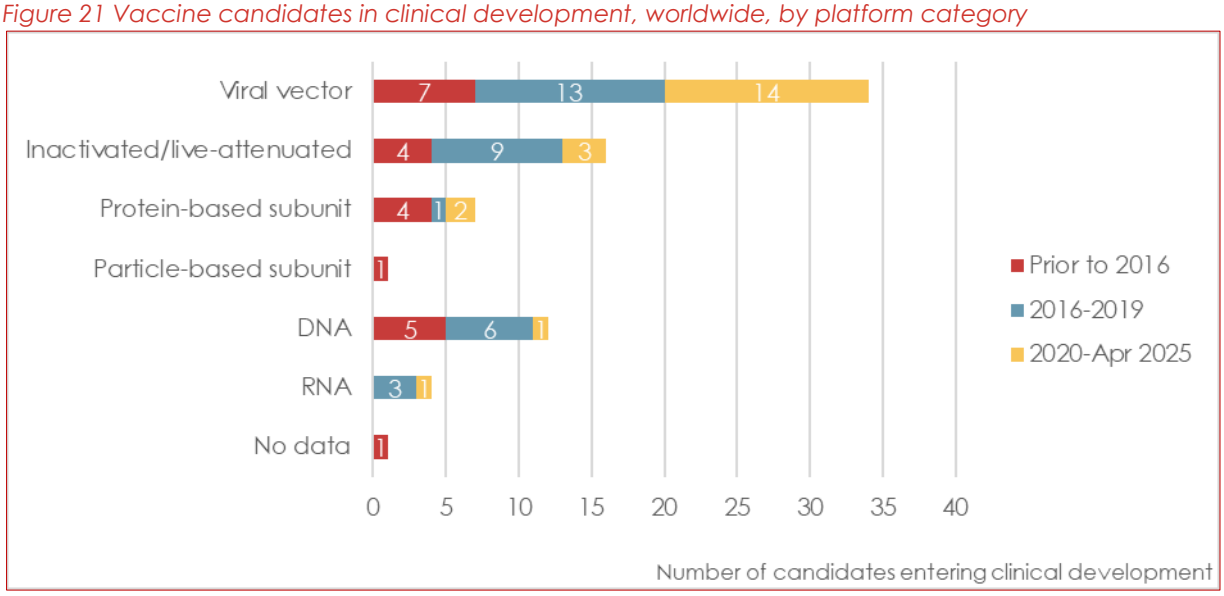
Source: Evaluation team

A shift in platforms over recent years is evident in an analysis of vaccine R&D candidates that have entered clinical development targeting UKVN priority pathogens (Figure 21).

Nearly half of the 75 candidates (34; 45%) were based on viral vectors, with the first starting Phase I trials in 2014 (7 candidates in 2014/15). Since 2020, viral vector platforms dominate, underpinning 67% (14 of 21) of candidates entering clinical development, with at least one candidate for ten of the 12 UKVN priority pathogens (except Hanta and Q fever).

Many candidates entering clinical trials after 2016 were based on inactivated/live-attenuated pathogens (23%, 12 of 53) and DNA (13%, 7). However, use of these platforms declined from 2020 (3; 14% and 1; 5%, respectively).

Figure 21 Vaccine candidates in clinical development, worldwide, by platform category



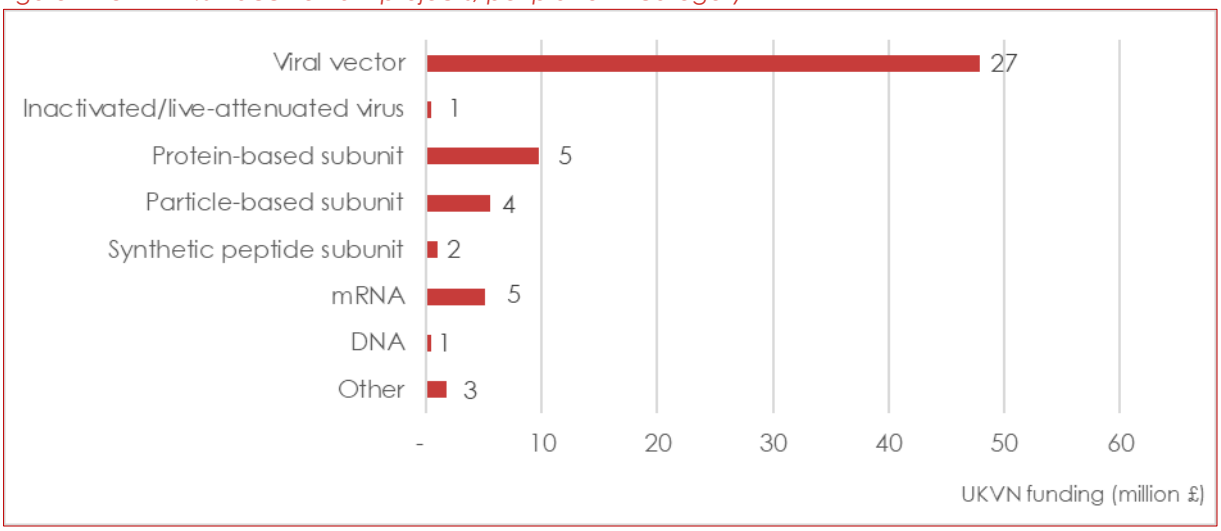
Source: WHO ICTRP, literature review

The UKVN 1.0 contributed to platform development, both through R&D projects aimed at vaccine candidates - which also advance the underlying platforms - and through initiatives dedicated specifically to the development of individual platforms.

Of the 48 vaccine R&D projects, more than half of candidates under development were based on viral vector platforms (27, 56%), supported by nearly £50 million (66% of the vaccine R&D portfolio). This was followed by five projects each focussed on protein-based subunit, particle-based subunit and RNA (mRNA/saRNA) candidates (Figure 22).

The strong support for viral vector platforms and their increase in maturity over the past years, is illustrated by the fact that all 12 UKVN 1.0-supported vaccine candidates that entered clinical trials are based on viral vectors. Eight candidates were based on ChAdOx1 or 2, two candidates on MV (measles-virus) and two on MVA (Modified Vaccinia Ankara) vectors.

Figure 22 UKVN 1.0 vaccine R&D projects, per platform category



Bar labels: Number of projects. Source: UKVN 1.0 portfolio analysis

It should be noted that the vaccine platform trends may reflect the expertise of developers eligible for UKVN 1.0 funding and the maturity of their plug-and-play technologies, which are then applied across pathogens. As a result, trends may differ from global patterns. For example, 56% of UKVN 1.0-funded candidates were based on viral vectors, compared to 11% of company-sponsored candidates under development globally in 2023.[119] By contrast, company pipelines placed greater emphasis on protein- and particle-based subunit vaccines (35% vs. 18% for UKVN 1.0) and RNA platforms (21% vs. 10%).

Progress in platform development and the UKVN 1.0's sustained support for vaccine platform technologies, is also illustrated by 'clusters' of vaccine R&D awards, such as:

- A total of 18 UKVN 1.0 awards to teams at the University of Oxford and the University of Surrey supported the development of vaccine candidates for ten priority pathogens: eight based on the ChAdOx1 platform and two on ChAdOx2.
- Two UKVN 1.0 awards to Activirosomes Ltd supported pre-clinical activities for multivalent candidates based on their "Active Virosome" platform for CHIKV, ZIKV, EBOV and preclinical characterisation and optimisation of a candidate for CHIKV.
- Two UKVN 1.0 awards to iosBio Ltd supported the development of an oral formulation of their viral vector-based ZIKV vaccine candidate, advancing it to Phase I trial-readiness.[120,121] In response to the COVID-19 outbreak, the company joined a US consortium developing a COVID-19 vaccine and contributed its oral vaccine delivery technology, OraPro.[122] Since then, iosBio has licensed the technology to US-company ImmunityBio for oral delivery of its COVID-19 vaccine candidate.[123] To further broaden its pipeline of candidates based on the OraPro technology, iosBio secured funding from UKVN 1.0 for the development of a Nipah virus vaccine (2022-23) and from UKVN 2.0 for Enterovirus 68 vaccine (2023-25).
- An X-ray irradiation approach to producing inactivated virus vaccines for RVFV was funded by an UKVN 1.0 award to UKHSA. The approach is developed further through a UKVN 2.0 award, this time for a vaccine candidate targeting ZIKV.

In addition to progressing platform R&D as part of vaccine R&D projects, the UKVN 1.0 portfolio included 11 projects that specifically focussed on early-stage development and optimisation of novel vaccine platforms and delivery technologies, with a total of £5.5 million in funding (for project details, see Appendix G).

One of these projects illustrates how R&D platform development can lead to multiple vaccine candidates (EVAC, University of Cambridge). Funded from 2016 to 2017, the project contributed to the development of the DIOS platform, which uses computational methods to design synthetic gene inserts for viral vector-based vaccines. This led to DIOS-HFVac3, a trivalent candidate against SUDV, MARV and LASV (see case study Box 15). In 2017, DIOSynVax Ltd was spun out from the university to develop the platform further. Subsequent UKVN 1.0 and UKVN 2.0 funding supported HFVac3 and HFVac4 (latter combines HFVac3 with a CCHF

[119] Thomas d & Wessel C, Biotechnology Innovation Organization (BIO) (Dec 2023) State of Innovation in Vaccines and Prophylactic Antibodies for Infectious Diseases, BIO Industry Analysis

[120] Bacon A et al (2023) Generation of a thermostable, oral Zika vaccine that protects against virus challenge in non-human primates. Vaccine 41(15):2524-2533. doi: 10.1016/j.vaccine.2023.02.055

[121] IosBio (2025) Our Pipeline: Advancing Oral Vaccines for Major Diseases https://iosbio.com/pipeline/ Accessed 01 June 2025

[122] Gabitzsch E et al (2021) Dual-Antigen COVID-19 Vaccine Subcutaneous Prime Delivery With Oral Boosts Protects NHP Against SARS-CoV-2 Challenge. Front Immunol 16;12:729837. doi: 10.3389/fimmu.2021.729837

[123] Iosbio (2021) iosBio signs exclusive worldwide licensing agrément. https://iosbio.com/bio-signs-exclusive-worldwide-licensing-agreement/ Accessed 01 June 2025

vaccine), while DIOSynVax also secured Innovate UK funding to develop vaccines against corona and influenza viruses.

Scalable manufacturing processes

Development of manufacturing processes plays a key role in vaccine R&D by ensuring that candidates can be produced quickly and at scale, meeting quality, consistency and regulatory requirements for clinical development and in response to outbreaks. LMICs face additional challenges in vaccine manufacturing, including high production costs, limited infrastructure, dependence on high-income countries for supply and difficulties in scaling up production rapidly during health crises. Enabling and strengthening local vaccine manufacturing capabilities is critical to ensuring equitable access, reducing dependency on imports and enhancing global health security.

To address these challenges, the UKVN 1.0 funded two EPSRC Vaccine Manufacturing Research hubs with a total of £24.6 million[124,125] and three projects that specifically focussed on manufacturing processes and infrastructure with a total of £1.5 million (for project details, see Appendix G).

The EPSRC Vaccine Manufacturing Research hubs aimed to conduct research to develop vaccine manufacturing technologies benefitting LMICs, with a focus on ease, speed and manufacturing cost. The hubs were also intended to provide leadership by collaborating with partners worldwide. In the following the two funded hubs are reviewed.

- The Future Vaccine Manufacturing Research Hub (FVMR) (£12.5m, Dec 2017-Aug 2023)[126]

The Future Vaccine Manufacturing Research Hub (FVMR) was led by Professor Robin Shattock and colleagues at Imperial College London. The hub delivered a portfolio of research advancing adaptable, low-cost vaccine technologies while strengthening manufacturing and research capacity in Africa and Asia.

The hub focussed on two platform technologies: self-amplifying RNA (saRNA) and outer membrane vesicles (OMVs). The work on the saRNA platform included process innovations to maximise yield, development of a GMP-compatible workflow[127] and a thermostable formulation suitable for LMIC deployment, leading to a collaboration with GlaxoSmithKline Biologicals SA (GSK)[128,129]. A prototype saRNA vaccine for RVFV produced robust immune responses in mice but provided only limited protection in sheep. The hub also supported Africa's first clinical trial of an saRNA vaccine against COVID-19, in partnership with the MRC/UVRI & LSHTM Uganda Research Unit.

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[124] DoH/EPSRC Future Vaccine Manufacturing Research Hub, Call for proposals (Jan 2017); Amendment to Memorandum of Understanding between DoH and EPSRC, 5 March 2018

[125] DHSC (2023) UK Vaccine Network (UKVN) - Engineering and Physical Sciences Research Council (EPSRC) - Future Vaccine Manufacturing Research Hub Competition 1 (2017-2021) https://devtracker.fcdo.gov.uk/programme/GB-GOV-10-UKVN-FVMRH-EPSRC/summary. Accessed 24 Feb 2025

[126] Project Reference EP/R013764/1; https://gtr.ukri.org/projects?ref=EP%2FR013764%2F1

[127] Samnuan K et al (2022) Design-of-experiments in vitro transcription yield optimization of self-amplifying RNA. F1000Research 11:333

[128] End of project report

[129] Imperial (2024). GSK and Imperial to eliminate costly cold-chain storage of RNA vaccines https://www.imperial.ac.uk/news/254134/gsk-imperial-eliminate-costly-cold-chain-storage/ Accessed 01 June 2025

To strengthen manufacturing and research capacity in LMICs, the FVMR hub collaborated with partners in LMICs and transferred two established protein expression platforms for vaccine manufacturing to Vietnam and Bangladesh (see Box 9).

Box 9 FVMR Hub: Successful vaccine platform transfer sparks wider collaboration with Vietnam

The Future Vaccine Manufacturing Research (FVMR) Hub supported the transfer of a vaccine production platform, the MultiBac baculovirus expression vector system (BEVS), from Professor Imre Berger's laboratory at the University of Bristol to Vabiotech, one of Vietnam's leading vaccine manufacturers.

The project was originally designed to enable the production of influenza and rabies vaccines in Vietnam using BEVS, but its scope shifted when COVID-19 emerged. Through the collaboration, Vabiotech successfully established baculovirus-based vaccine production under Good Manufacturing Practice (GMP) conditions. Collaborating with FVMR Hub experts, the company successfully developed a COVID-19 vaccine, scaled up manufacturing and showed effectiveness in animal studies. Vabiotech is now in a position to quickly initiate and scale up vaccine production using the baculovirus system as and when needed.

Work on influenza and rabies vaccines continues post-COVID and as part of the FVMR Hub 2.0, including research on a second type of vaccines, protein nanoparticles. Going forward, the Bristol group and Vabiotech are also planning to collaborate outside the FVMR Hub on innovative animal vaccines.

In addition to the long-term partnership between UK groups and Vietnamese researchers, the FVMR Hub collaboration nucleated a wider partnership between Bristol and Vietnam: In 2022, the University of Bristol and two Vietnamese universities signed a Memorandum of Understanding (MoU), creating a student visit programme and research collaborations.

- Vax-Hub (£10m, Mar 2018-Aug 2023)[130,131]

The Vax-Hub was co-led by Professor Martina Micheletti at University College London (UCL) and Professor Sarah Gilbert at the University of Oxford. Vax-Hub's aim was to "establish the UK as the global centre for integrated discovery through to bioprocess manufacture of next generation vaccines".[132] Vax-Hub advanced manufacturing processes for three vaccine platforms: the viral vector-based ChAdOx, Virus-Like Particle (VLP) and glycoconjugate vaccines (see Box 10). In addition, Vax-Hub worked with an LMIC partner in Indonesia to transfer and optimise vaccine manufacturing using a yeast expression system.

The hub's work on the ChAdOx vaccine platform contributed directly to the production of over three billion doses of the Oxford-AstraZeneca COVID-19 vaccine (see section 3.5 on Cost-Benefit Analysis) and has underpinned the development of vaccines against other diseases. An example is the ChAdOx platform, with ChAdOx-based candidates entering clinical development for nine of the twelve UKVN priority pathogens since 2018.

[130] Project Reference EP/R013756/1; https://gtr.ukri.org/projects?ref=EP%2FR013756%2F1

[131] Including grant extensions for Mar 2022 to Aug 2023: Project Reference EP/X038564/1 https://gtr.ukri.org/projects?ref=EP%2FX038564%2F1 and EP/X03867X/1 https://gtr.ukri.org/projects?ref=EP%2FX03867X%2F1

[132] UKRI Gateway to Research (2025). The Future Vaccine Manufacturing Research Hub (Vax-Hub) https://gtr.ukri.org/projects?ref=EP%2FR013756%2F1 Accessed 01 June 2025

Box 10 Advancing affordable glycoconjugate vaccine production through Vax-Hub

Vax-Hub played a key role in advancing the work of Professor Brendan Wren at the London School of Hygiene & Tropical Medicine (LSHTM) in developing a platform for vaccine manufacturing against a range of bacterial diseases. Wren had pioneered a method for producing glycoconjugate vaccines in *Escherichia coli*, with substantially reduced manufacturing costs compared to traditional chemical approaches. Collaborating with Professor Martina Micheletti at University College London (UCL), an expert in bioprocess engineering, the team took this work further towards scale-up, developed an automated screening platform for vaccine candidates, generated high-yield *E. coli* strains and achieved larger-scale production.

Vax-Hub expanded Wren's research from lab-based discovery to include applied research - vaccine manufacturing - and connected him with manufacturing experts. The experience and network he gained through Vax-Hub have helped him secure multiple follow-on grants, from funders including Wellcome, the BBSRC and the EPSRC, to develop vaccines against a range of bacterial diseases. Vax-Hub's outputs now underpin the further development of a scalable, low- and middle-income country (LMIC)-adapted vaccine production platform in the follow-on hubs, VaxHub Sustainable and VaxHub Global. Crucially, retaining control of the platform outside industry ensures that glycoconjugate vaccine production will remain accessible to LMICs.

Both hubs are continuing R&D activities, supported by follow-on funding from the UKVN 2.0 and the EPSRC:

- In 2023, the FVMR Hub was awarded £10.5m from the UKVN 2.0 and EPSRC, over 4.5 years to continue work on the vaccine platforms, with existing and new partners in LMICs, e.g. Vabiotech in Vietnam and Incepta Pharma in Bangladesh.[133]
- Vax-Hub received £10m in follow-on funding over a 4.5-year period from the UKVN 2.0 and the EPSRC.[134] The new hub, VaxHub Global, continues its focus on the development of low-cost, effective and globally deployable vaccines to LMICs. In addition, a second hub, VaxHub Sustainable, received £12m over seven years from the EPSRC to establish the UK as a global leader in next-generation vaccine discovery and manufacturing.[135]

UKVN 1.0 projects focussed on manufacturing

Of the three UKVN 1.0 projects focussed on manufacturing processes, at least two have secured follow-on funding.

One of the awards funded the development of a compact, user-friendly mRNA vaccine manufacturing platform tailored to use in LMICs (see case study Box 11). The platform received over £2.3m from Innovate UK and US$5m from CEPI to support further development and implementation as part of CEPI's 100 Days Mission.

Another award supported development of saRNA manufacturing processes at Imperial College London (10026859), which are also a priority of the FVMR hub. This work underpinned

[133] Imperial (2023). £17m awarded to develop globally important vaccine hubs https://www.imperial.ac.uk/news/249293/17m-awarded-develop-globally-important-vaccine/ Accessed 01 June 2025.

[134] VaxHub Global (2025). https://vaxhubglobal.com/ Accessed 01 June 2025.

[135] VaxHub Global (2025). Addressing Pandemic Preparedness and Sustainability Challenges https://vaxhubsustainable.com/ Accessed 01 June 2025.

the development of EML-VAC, an saRNA vaccine candidate, funded by two further UKVN awards. UKVN 2.0 is currently funding the team at Imperial to take EML-VAC into clinical development, relying on the manufacturing processes developed with UKVN 1.0 funding.

Box 11 Rapid, accessible, globally distributed RNA vaccine manufacture on demand

Access to vaccine manufacturing remains limited in many LMICs, where infrastructure and cold chain capabilities are often insufficient. To address this, a UKVN-funded project led by the UK based BiologIC Technologies Limited aimed to develop a compact, modular mRNA manufacturing platform that supports decentralised vaccine production in low-resource settings.

With £475,000 funding from the UKVN, BiologIC developed and validated a prototype of an automated system that can produce RNA vaccines without using living cells. Working with the Centre for Process Innovation, the team benchmarked the system against current industry standards and initiated development of a quality management system to support future clinical and regulatory use. The project also supported regulatory landscape mapping and IP strategy development.

Designed for use in challenging environments, the system requires minimal infrastructure, uses less energy and reduces reliance on cold chain logistics or highly specialised personnel, making it well-suited for LMICs aiming to build local vaccine production capacity.

These achievements enabled BiologIC to secure £2.62 million in follow-on funding from Innovate UK and CEPI. Additionally, CEPI are providing $4.7m of funding for a consortium including BiologIC to implement the system as part of CEPI's 100 days mission. As the technology has matured, BiologIC has entered into new partnerships with commercial partners to apply the platform in related therapeutic areas, including cell and gene therapies and space biomanufacturing.

3.3 Enabling vaccine development and deployment during outbreaks

The UKVN 1.0 played a critical role in strengthening the UK's and partner countries' capacity to deploy vaccines during disease outbreaks. The UKVN 1.0 delivered practical tools, assessed vaccine candidates and produced high-impact research to support outbreak response in LMICs. These investments directly supported outbreak responses during the 2018-20 Ebola epidemic in the Democratic Republic of the Congo, contributing evidence that underpinned WHO vaccine policy as well as digital and communication tools to support decision making for public health measures. This section covers UKVN funded projects focused on ensuring that protocols and processes for using or trialling vaccines are outbreak ready. It includes projects that:

- Generated strategic epidemiological and immunological data to inform vaccination policy, such as insights into vaccine efficacy, trial readiness and long-term immunity
- Underpinned tools, assays and datasets
- Investigated long-term immunity to support effective deployment of vaccines
- Strengthened outbreak preparedness through clinical trials in LMICs

Together, these projects strengthened outbreak response through research, enhancing institutional capacity and promoting research equity. Survey data identified 165 LMIC-based and 141 HIC-based team members across these projects, alongside evidence of formal and informal training of over 1,000 individuals – including researchers and public health practitioners. While these figures likely underestimate total reach due to data gaps, they provide evidence of capacity building both in the UK and internationally.

3.3.1 *Epidemiology for vaccinology: generating strategic data and tools*

Five projects funded under NIHR epidemiology for vaccinology competition advanced outbreak preparedness between 2018 and 2023. These projects combined expertise in epidemiology, statistics, anthropology, molecular biology and public health to develop advanced modelling and forecasting tools, generate critical evidence for vaccine policy and support health systems.

A notable example is the University of Oxford's project on estimating vaccine efficacy against onward transmission.[136] By integrating pathogen genetic sequencing and contact tracing data, the team reconstructed transmission chains, enabling more accurate assessments of vaccine impact on disease spread. They also developed a trial design tool that accounts for real-world challenges, such as when trial participants don't follow their assigned treatment. This helps to ensure that trials are better planned and more reliable, even in complex outbreak conditions.[137]

The 'VEEPED' project led by the London School of Hygiene and Tropical Medicine (LSHTM) focused on development of data-driven epidemiological modelling. A case study was developed on VEEPED and a summary is presented in Box 12 below.

Box 12 The VEEPED project

Many emerging diseases still lack licensed vaccines and the unpredictable nature of outbreaks poses substantial challenges for designing and implementing vaccine trials. The 'Vaccine Efficacy Evaluation for Priority Emerging Diseases' (VEEPED) project addressed this issue by developing mathematical models to support vaccine trial design and inform outbreak response strategies for seven of the UKVN's priority pathogens.

A £1.5m UKVN grant enabled researchers from the London School of Hygiene and Tropical Medicine and project partners - Imperial College London, University of Warwick and University of Oxford -, to produce data-driven models to simulate disease transmission and evaluate vaccination strategies. These models supported assessment of the rVSV-ZEBOV vaccine, contributing to its eventual licensing as the first approved Ebola vaccine, and informed World Health Organisation policy recommendations for its deployment.

The project highlighted the importance of tailoring vaccination strategies based on disease characteristics and transmission pathways. It showed that One Health approaches – considering both human and animal health – can be particularly effective. For example, in the case of Rift Valley Fever, vaccinating livestock was found to reduce transmission more effectively than vaccinating people. For low-prevalence diseases such as MERS-CoV and Marburg virus, the research showed that targeting healthcare workers and other high-risk groups is more efficient than mass vaccination.

VEEPED generated over 30 peer reviewed publications and contributed valuable insights to international efforts during the COVID-19 pandemic.

Projects funded under the NIHR competition also developed practical tools for policymakers and public health practitioners. The 'MEVACP' project, led by the University of Oxford, created digital tools to support meningitis vaccination strategies in Africa. [138] Outputs included:

[136] NIHR Project PR-OD-1017-20006: Leveraging Pathogen Sequence Data and Adaptive Designs to Improve Vaccine Trials in Emerging Epidemics in LMIC (2018-2023)

[137] Survey responses received as part of the evaluation

[138] MECAVP refers to NIHR project PR-OD-1017-20007: Molecular Epidemiology for Vaccination Policy (2018-2022)

- A bilingual, low-bandwidth interactive dashboard for visualising vaccine coverage for one-year-olds (2014–2019) across 54 African countries
- An interactive map to assist practitioners in locating healthcare centres and WHO contacts for logistical coordination

In parallel, the MEVACP team developed diagnostic tools by identifying key genetic markers of four bacterial meningitis pathogens. This enabled the creation and field testing of lab assays suitable for low-resource settings, enhancing diagnostic speed and accuracy.

The 'EDK' project, led by LSHTM, created electronic tools to support vaccine trial delivery during outbreaks. A case study was conducted on EDK and a summary is presented in Box 13 below.

Box 13 The EDK project

During disease outbreaks, unlicensed vaccines may be deployed to mitigate the spread of infections. A major challenge in these situations is obtaining timely, reliable data on vaccine safety and efficacy. A £539,000 UKVN grant enabled researchers from the London School of Hygiene and Tropical Medicine to address this challenge by developing a rapidly deployable electronic data collection platform to support outbreak response.

The project 'Electronic Data Capture to support rapid epidemiological research and response during epidemics' (EDK) built on an existing open-source system to create new software and methods for real-time data collection. These tools played an important role in the 2018-20 Ebola virus disease outbreak in the Democratic Republic of the Congo:

- The platform supported the collection of safety and efficacy data from over 260,000 recipients of the unlicensed vaccine (VSV-ZEBOV-GP)
- The team introduced biometric cards for offline data capture, which is critical for tracking vaccination in remote areas. This innovation eliminated the need to manually process more than 15 million paper records of vaccination data

By delivering an electronic data collection system for use in health emergencies, the EDK project strengthened research capabilities and contributed to more effective public health responses during an outbreak.

Projects under the NIHR competition also addressed vaccine acceptance through social science research and tailored communication materials for policymakers, health professionals and communities. The MEVACP project produced animated videos and child-friendly materials to support meningitis vaccine education intended for dissemination through schools and community health programmes. The 'AViD' project examined the sociocultural drivers of vaccine acceptance, generating insights relevant to both policy and public engagement. Its findings supported public health responses during the COVID-19 pandemic in Sierra Leone. A case study was conducted on AVID and a summary is presented in Box 14 below.

Box 14 The AViD project

Vaccine hesitancy presents a critical challenge to the effective deployment of vaccines during disease outbreaks. Despite global recognition of its importance, vaccine hesitancy remains insufficiently understood in LMICs and is frequently attributed to ignorance, overlooking valid concerns and local contexts.

A £747,000 grant from the UKVN enabled researchers from the London School of Hygiene and Tropical Medicine and project partners to implement the 'AViD' project: an Anthropological exploration of facilitators and barriers to vaccine deployment and administration during diseases outbreaks. AViD investigated the social and cultural dimensions of vaccine hesitancy in six LMICs, employing a multi-case study approach co-designed with local researchers to ensure community engagement.

The AViD project generated evidence on how local beliefs, past experiences with health systems and wider political or religious factors shape vaccine acceptance. Its findings were applied in real time during the COVID-19 pandemic in Sierra Leone to inform vaccination strategies. Outputs include peer-reviewed publications and training materials, which have informed policy discussions and contributed to capacity building in LMICs.

All NIHR-funded projects incorporated capacity strengthening and engagement with diverse stakeholders, including students, clinicians, laboratory technicians and frontline public health workers. Examples include:[139]

- A 2022 workshop in Côte d'Ivoire on molecular epidemiology and diagnostic assays, attended by 25 participants, was hosted by the MEVACP project team
- The tools and methos developed in the EDK project were integrated into MSc curricula and used to train over 1,000 individuals across 400 projects
- Training sessions delivered by the AViD project team on community listening and addressing vaccine misinformation reached approximately 100 community health workers in Sierra Leone, Tanzania and Uganda

Findings from NIHR CCF-funded projects were widely disseminated through international conferences, public engagement activities and policy dialogues.[140] Findings from the VEEPED project generated critical evidence underpinning WHO recommendations on Ebola vaccine policy, as well as the efficacy assessment of unlicensed vaccines (i.e., rVSV-ZEBOV vaccine, as noted above). Project teams demonstrated agility during the COVID-19 pandemic by rapidly adapting their projects and applying the knowledge developed through these projects to support global responses.

3.3.2 Underpinning tools, assays and datasets

The UKVN 1.0, via BBSRC and Innovate UK, awarded 13 grants for projects aimed to generate the underpinning tools, assays and datasets required for vaccine R&D. These projects received a total of £10.4 million in funding and covered:

- One Health for vaccinology projects, funded via BBSRC, to advance understanding of pathogen biology and immune response
- Standardised diagnostic tests, serological standards, assays and animal models to support vaccine development, funded by Innovate UK

[139] Survey responses received as part of the evaluation and case study interviews

[140] Survey responses received as part of the evaluation and case study interviews

A total of 5 projects funded via BBSRC (£5.4 million) focused on enabling vaccine development against UKVN priority pathogens and on characterising host immune responses to these pathogens. For example, data on viral diversity was gathered as part of the 'One Health and accelerating Vaccines for Ebola and Lassa (OVEL)' project, led by University of Cambridge. This project informed the design and development of the HFVac3 vaccine candidate and improved understanding of LASV epidemiology (see case study Box 15).

Box 15 One Health and accelerating Vaccines for Ebola and Lassa (OVEL)

Lassa fever and Ebola virus disease are haemorrhagic fevers caused by rapidly mutating RNA viruses. Developing vaccines that remain effective over time is challenging, as new variants emerge in animal reservoirs and when they infect humans. The £1.5 m BBSRC-funded "One Health and accelerating Vaccines for Ebola and Lassa (OVEL) project (2018-2023), led by Prof Jonathan Heeney, University of Cambridge, set out to address the issue of strain diversity, viral mutation and the potential for virus reactivation in individuals after recovery from infection, crucial information to underpin development of broadly protective vaccines.

Sampling of rodents showed that LASV prevalence and the range of carrier species both expand during human outbreaks, pointing to shifts in rodent populations as drivers of spill-over to humans. The findings highlighted the value of ongoing animal monitoring to predict and control LASV outbreaks. In parallel, OVEL's immunological studies showed that Lassa fever survivors produce virus-neutralising antibodies that recognise genetically diverse LASV strains - pointing to the possibility of a broadly protective 'universal' vaccine. To support project OVEL, the team developed Sentinel, a survey app for gathering data from Lassa fever survivors and their contacts. This later evolved into a predictive platform for disease outbreaks, using machine learning and climate, human and animal case data.

Based on the OVEL datasets, as well as data collected on the Ebola Sudan and Marburg viruses, the team then used a computational tool to select conserved viral segments and inserted these into the viral Modified Vaccinia Ankara (MVA) vector. The resulting trivalent vaccine candidate, HFVac3, was fully protective in animal challenge studies. To further develop HFVac3, the university spun out a company, DIOSynVax. The next phase is to advance HFVac3 to Phase I clinical trials. The company has secured UKVN2.0 funding to develop the vaccine's GMP manufacturing processes and plans to apply for further funding to conduct clinical trials and to optimise the vaccine platform for broader use against other high-priority pathogens.

Project OVEL also helped strengthen Nigeria's epidemic preparedness by training local laboratories in advanced immunology and engaging communities on rodent control and stigma, thereby expanding in-country capacity for vaccine research and outbreak response. The team is now preparing for clinical testing in LMICs and, via a partnership with the African subsidiary of a CDMO, is building local GMP manufacturing capacity to contribute to the goal of producing vaccines "in Africa, for Africa."

The project 'Bunyavirus Immunity Consortium', led by University of Oxford and also funded via BBSRC, focused on generating the immunological data for CCHFV vaccine development (see Box 16).

Box 16 Bunyavirus Immunity Consortium

Crimean-Congo haemorrhagic fever virus (CCHFV) is a tick-borne virus with no licensed vaccine or treatment, placing an estimated three billion people, particularly in LMICs, at risk. The UKVN/BBSRC-funded the £1.1 million project "Delineating the immune response against CCHFV and other Nairoviruses to aid effective vaccine design" (2018-2022), led by Professor

Teresa Lambe at the University of Oxford, to generate the immunological data and research tools needed for vaccine development.

The team developed a set of assays capable of detecting and differentiating antibody responses to CCHFV and related nairoviruses like NSDV, which enable a more detailed understanding of the immune response. These tools, along with data on immune targets and antibody cross-reactivity, are important to understand which immune responses are protective and how to reliably measure them - a prerequisite for designing, evaluating and advancing effective vaccines. The results were disseminated in four peer-reviewed publications. The project also fostered international collaborations with institutions such as ILRI in Kenya and The Pirbright Institute, strengthening global capacity to address CCHFV and related diseases.

Building on the project outputs, the Oxford team constructed and tested a viral vector vaccine, ChAdOx2 CCHF. This vaccine candidate provided full protection in mice and is now in Phase I human trials, showing strong early immune responses. In addition, the CCHF assays underpinned fieldwork in Uganda, funded by Wellcome and the MRC, which revealed high rates of CCHFV exposure in both humans and livestock and identified key behavioural risk factors, e.g. regular contact with livestock and handling or even eating engorged ticks. This information can now support future trial design and inform public health interventions.

Going forward, the team will continue to develop the ChAdOx2 CCHF vaccine candidate through clinical trials and participate in a collaboration funded by the UK-US Ecology and Evolution of Infectious Diseases programme to investigate whether people in areas with low CCHF cases are protected by cross-reactive immune responses to other viruses.

Other projects funded via BBSRC focused on early development of vaccine for veterinary use. The project 'Accelerated development of a safe and easily manufactured Q fever vaccine', led by the Moredun Institute, progressed development of a new protein subunit Q fever vaccine, conducting preclinical testing on mice and sheep. The project showed that the veterinary vaccine Coxevac®, approved for use in cattle and goats, also provides protection for sheep. This finding is important for controlling Q Fever as sheep are a major source of human Q fever outbreaks.

At least 3 projects were funded via Innovate UK with the aim of progressing standardised diagnostic tests for priority diseases. For example, a project led by BG Research Ltd (Differential diagnostics of haemorrhagic fevers in resource poor environments) developed approaches for detection of viral infections from a whole blood sample, designing a larger reaction vessel which could enable low-cost, scalable diagnostic tests suitable for use in LMICs.

Another project, led by Excivion Ltd, focused on developing a low-cost diagnostic test for ZIKV that could be used at the point of care without the need for electricity or laboratory infrastructure. This approach offers advantages in LMIC contexts, enabling real-time outbreak detection, more strategic vaccine deployment and improved management of risks such as Antibody-Dependent Enhancement (ADE). In 2020, Excivion collaborated with the Future Vaccine Manufacturing Research Hub (FVMRH) at Imperial College London and other partnering organisations, to develop a novel Zika vaccine.[141]

[141] CPI (2020). CPI partners with Excivion to optimise and scale up production of safe and effective Zika vaccine https://www.uk-cpi.com/news/cpi-partners-with-excivion-to-optimise-and-scale-up-production-of-safe-and-effective-zika-vaccine Accessed 01 Jun 2025

Five grants awarded via Innovate UK focused on accelerating the development of serological standards, assays and animal models to support vaccine development. For example, two grants awarded in 2017 and 2018 provided funding to the UK's National Institute for Biological Standards and Control (NIBSC, now part of MHRA) to accelerate the development of serological standards for priority pathogens and assess their protective value using animal challenge models (see Box 17). Further to this work, MHRA and UKHSA received funding to develop a Nipah model of disease, immune assays for CCHF to aid Phase I clinical trials and to accelerate international serological standard for plague. These projects provided critical data for epidemic preparedness, for example, the Nipah disease hamster model established by UKHSA is now available to support the wider R&D community in preclinical testing.

Box 17 Supporting vaccine R&D through serological standards and animal models

Vaccine development for emerging diseases is costly and complex, requiring high-containment facilities and specialised testing. Serological standards - reference materials for measuring immune responses – can reduce costs and complexity by enabling earlier evaluation of vaccine candidates. In 2016, no World Health Organization (WHO) international serological standards existed for any of the UKVN's 12 recognised priority pathogens.

A £2.5 million UKVN grant enabled researchers at the UK's National Institute for Biological Standards and Control – and partners at Public Health England and at the Defence Science and Technology Laboratory -, to accelerate the development of these standards and assess their protective value using animal challenge models.

The 'Serological Vaccine Standards' project supported the establishment of WHO international standards for eight emerging diseases. Standards for Ebola, Rift Valley fever and Zika were directly attributed to the project, while contributions were made to those for MERS, Lassa, Marburg, Nipah and Q fever.

These standards now underpin global vaccine development efforts by ensuring consistent, comparable immune response data across studies and settings, including in LMICs. The project also demonstrated, through animal models, that standards for MERS and chikungunya confer protective immunity, providing correlate of protection for vaccine development. This work supports faster, more reliable vaccine development and facilitates international collaboration and regulatory approval.

3.3.3 Understanding long-term immunity to support effective deployment of vaccines

Understanding the persistence of vaccine-induced immunity is critical for designing effective vaccination strategies and enable rapid deployment of vaccines during outbreaks. Evidence on how long protection lasts and how it can be enhanced with booster doses helps to inform decisions on vaccine schedules, deployment and strategies for protecting high-risk populations. A case study was conducted on the project 'Assessment of persistence of immunity in multiple viral-vector Ebola vaccines and response to a booster dose of Ad26.ZEBOV'. A summary is presented in Box 18.

Box 18 Assessment of persistence of immunity in multiple viral-vector Ebola vaccines and response to a booster dose of Ad26.ZEBOV

The project "Evaluating the Long-Term Immunogenicity of Ebola Virus Vaccines Ad26-ZEBOV and MVA-BN-Filo" was funded by the UKVN 1.0 through a £1.2m Innovate UK award (2017-2022). The project partners - the University of Oxford, Imperial College London and The Institute for Research, Epidemiological surveillance and Training (IRESSEF) in Dakar, Senegal - had previously conducted six clinical trials investigating various combinations of four different viral vector-based vaccines during the 2014/15 Ebola virus outbreak.

As part of the UKVN-funded project, the team re-contacted participants of the earlier trials for follow-up, to determine the long-term immune response to different Ebola vaccine schedules and to investigate the effect of a delayed booster vaccination (Ad26.ZEBOV, provided by industry partner Janssen) on the immune response.

Results showed that all Ebola virus vaccine schedules studied generated persistent antibody and T cell responses three years after initial vaccination. A late Ad26.ZEBOV booster dose reactivated strong immune responses, confirming the potential for rapid re-immunisation in outbreak scenarios. These results provide evidence for proactive immunisation of high-risk populations, with the potential to inform policy in countries affected by the Ebola virus.

The project was supported by the long-term involvement of collaborators, starting with the 2014/15 trials and by centralised lab analysis, enabling high data comparability. However, challenges included navigating data protection and coordinating follow-up across studies, negotiating industry agreements and technical issues with sample preparation in Senegal. In addition, the COVID-19 pandemic caused a substantial delay, e.g. in sample shipments. While findings have been presented at international conferences, shifting research priorities and staff turn-over, affected by COVID-19, have so far hindered publication of the project results.

3.3.4 Strengthening outbreak preparedness in LMICs

The UKVN 1.0 funded at least eight vaccine candidates whose projects led to Phase 1, 1b or 2 clinical trials (or veterinary field trials) in LMICs. Conducting such trials in LMICs contributes to outbreak preparedness, institutional capacity, workforce development and research equity. These efforts can benefit regulatory authorities, research institutions and health workers. The eight trials are outlined below:

- Kenya:
  - Phase II trial of ChAdOx1 RVF (University of Oxford)[142]
  - Field trial of ChAdOx1 RVF (livestock vaccine, Pirbright Institute)[143]
  - Phase 1b/II trial of COVID-19 candidate (University of Oxford)[144]
- Mexico:
  - Phase I trial of ChAdOx1 CHIK (University of Oxford)[145,146]

[142] ClinicalTrials.Gov (2025). Safety and Immunogenicity of a Candidate Rift Valley Fever Vaccine (RVF003) (RVF003) https://clinicaltrials.gov/study/NCT06799234 Accessed 01 June 2025

[143] Final project report and case studies

[144] Final project report

[145] ClinicalTrials.Gov (2019). Safety and Immunogenicity of a Candidate CHIKV Vaccine (CHIK001) https://clinicaltrials.gov/study/NCT03590392 Accessed 01 June 2025

[146] ClinicalTrials.Gov (2022). Research Study to Assess New Chikungunya and Zika Vaccines in Healthy Adults in Mexico. https://clinicaltrials.gov/study/NCT04440774 Accessed 01 June 2025

  - Phase I trial of ChAdOx1-ZIKV (University of Oxford)[147]
- Tanzania: Phase Ib trial of ChAdOx1 biEBOV (University of Oxford)[148]
- Uganda: Phase I trial of ChAdOx1 Plague (University of Oxford)[149]
- Bangladesh: Field trial of NiV PrV (Nipah virus vaccine for pigs, Pirbright Institute)[150]

Clinical trials can enhance outbreak preparedness by building local capacity to detect, characterise and respond rapidly to emerging pathogens. They strengthen national public health authorities and research institutions' ability to generate critical vaccine data during outbreaks, thus supporting local resilience to health emergencies.[151] For example, the EDK project (see Box 13) supported delivery of workshops and training activities targeted at national and international public health agencies, helping to strengthen outbreak analytics and preparedness.

Trials also strengthen institutional capacity by supporting regulatory agencies and ethics committees to develop or refine systems for trial oversight, protocol review and research governance.[152] Researchers from project 'Advanced development of a safe and effective Rift Valley Fever vaccine for livestock' (see Box 5) collaborated with national regulators in Kenya to navigate the approval of a viral-vector vaccine classified as a genetically modified organism, creating an important precedent for future trials.

Trials can also support health workers by training clinicians, laboratory staff and trial managers in international research standards and biosafety practices. In Kenya, training in veterinary Good Clinical Practice enabled local teams to conduct field trials and catalysed investments in both personnel and infrastructure, enhancing the institute's ability to conduct further livestock vaccine studies in the future (see Box 5).

Finally, conducting clinical trials in LMICs promotes research equity and scientific ownership by enabling local researchers and institutions to take leadership roles in R&D, ensuring that study designs and implementation reflect local contexts.

It should be remarked that outbreak preparedness is also largely enhanced by the availability of local and regional manufacturing. The FVMR hub collaborated with partners in LMICs and transferred two established protein expression platforms for vaccine manufacturing to Vietnam and Bangladesh and efforts are underway to develop production of influenza and rabies vaccines locally (see Box 9).

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[147] ibid

[148] ClinicalTrials.Gov (2023). A Study in Tanzania of a New Vaccine Against Two Types of Ebola. https://clinicaltrials.gov/study/NCT05301504 Accessed 01 June 2025

[149] ISRCTN (2024). Investigating a vaccine against plague in Uganda (PlaVac Uganda). https://www.isrctn.com/ISRCTN79243381 Accessed 01 June 2025

[150] Final Project report

[151] Bhadelia N., et al. Building Biomedical Research Capacity in Low- and Middle-Income Countries: Why It Matters and Some of the Barriers to Success. 2024 Aug 31. In: Sorenson RA., et al., editors. Principles and Practice of Emergency Research Response Cham (CH): Springer; 2024. Chapter 8.

[152] Bhadelia N., et al. Building Biomedical Research Capacity in Low- and Middle-Income Countries: Why It Matters and Some of the Barriers to Success. 2024 Aug 31. In: Sorenson RA., et al., editors. Principles and Practice of Emergency Research Response Cham (CH): Springer; 2024. Chapter 8.

3.4 Strengthening R&D communities' capacity for public health emergency response

The UKVN 1.0 generated a rich body of new knowledge and enhanced the UK's and LMIC's capacity to respond to public health emergencies through new and existing collaborations and early-stage innovation activity.

UKVN-funded projects generated high volume of accessible, peer-reviewed research, with 96% available through open access. Research was highly collaborative, involving over 400 institutions and substantial engagement from LMIC researchers. Citation analysis shows strong academic performance, with most publications exceeding global benchmarks.

The activities conducted in the implementation of UKVN-funded projects broadened the skills and collaborations underpinning capacity for rapid responses to public health emergencies. Over 85% of survey respondents reported gaining skills in fields ranging from molecular diagnostics to scale -up manufacturing. Over 200 individuals based in LMICs supported UKVN projects through new or existing partnerships with UK organisations. By nurturing these partnerships and supporting projects involving hands-on training in vaccine R&D, the UKVN created a more connected and skilled R&D community in the UK and in partner LMICs. Evidence from case studies, survey and follow-on funding suggest some of these established partnerships are continuing beyond UKVN 1.0.

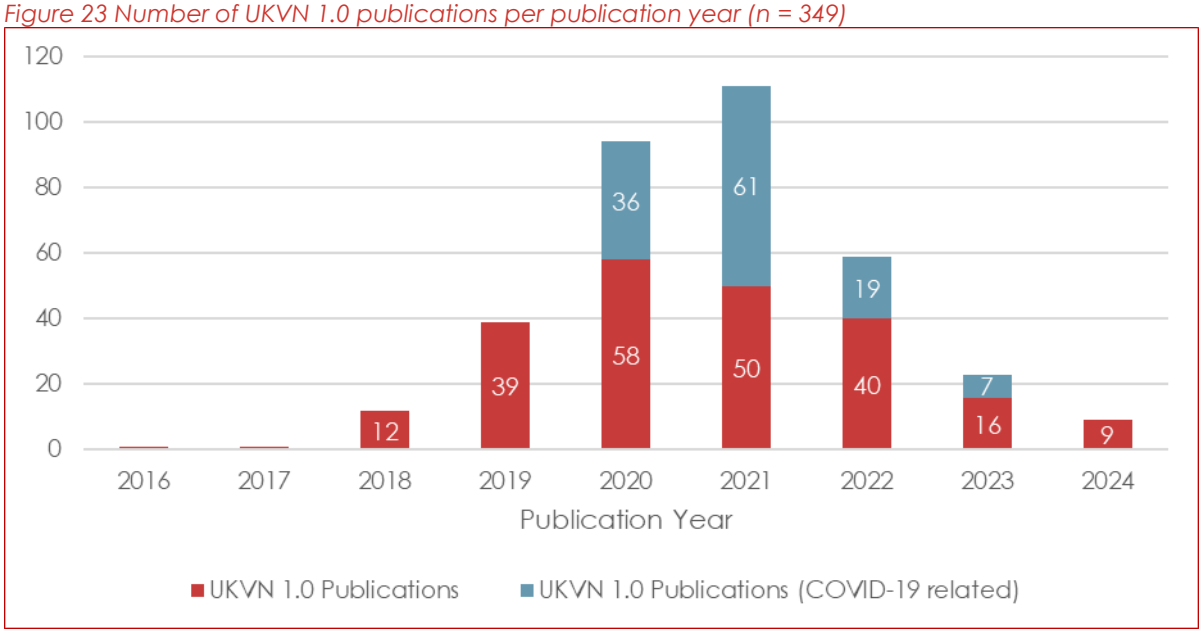
The UKVN 1.0 generated early-stage innovation outputs, including patents, spin-out companies and licensing agreements, reflecting progress towards vaccine commercialisation. These outputs enhance the UK's capacity to translate research into products with relevance to public health responses.

3.4.1 UKVN research publications and knowledge dissemination

Projects funded by the UKVN 1.0 produced a substantial volume of scientific publications, including 382 peer-reviewed journal articles and 39 conference papers, in addition to other research materials such as databases and software. Due to data limitations, these figures likely represent a conservative estimate. Further detail on research and dissemination outputs is provided in Appendix C.

An analysis using the OpenAlex database offers a detailed view of the publications attributed to UKVN funding, with Figure 23 showing the number of publications per year. Few publications emerged in the early years of the UKVN 1.0, likely due to the initial focus on short-term Innovate UK projects, which were not primarily designed to generate publications. Of the 349 publications identified in OpenAlex, 123 (35%) addressed COVID-19 research. Although these publications were partly enabled by UKVN funding (e.g., through support for researchers' time), their outcomes are not solely attributed to the UKVN 1.0, as they were also supported by other funders. Nonetheless, this reflects UKVN-funded researchers pivot to pandemic response and contribution to COVID-19 research, beyond UKVN's core remit of the 12 priority pathogens.

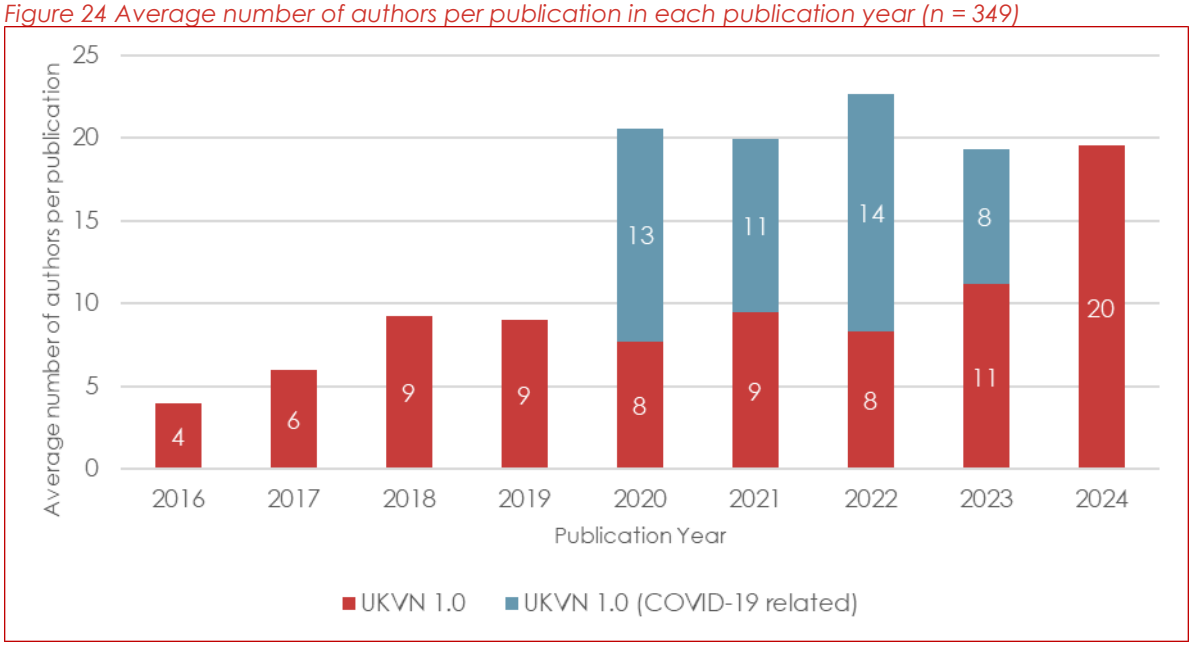
Figure 23 Number of UKVN 1.0 publications per publication year (n = 349)



Source: Evaluation team

To assess research collaboration, authorship patterns were analysed across 349 peer-reviewed publications. A total of 408 distinct organisations were identified among co-authors, indicating a broad collaborative base. As a proxy for collaboration, the average number of authors per publication per year was calculated (Figure 24). This average increased from 2018 onwards, suggesting a trend towards more collaborative research. The origin of this trend is unclear; it is possible that hat the project foci during this period were inherently more collaborative. Across 2016–2024, publications had an overall mean of nine authors.

Figure 24 Average number of authors per publication in each publication year (n = 349)



Source: OpenAlex

Involvement of LMIC researchers in UKVN supported research

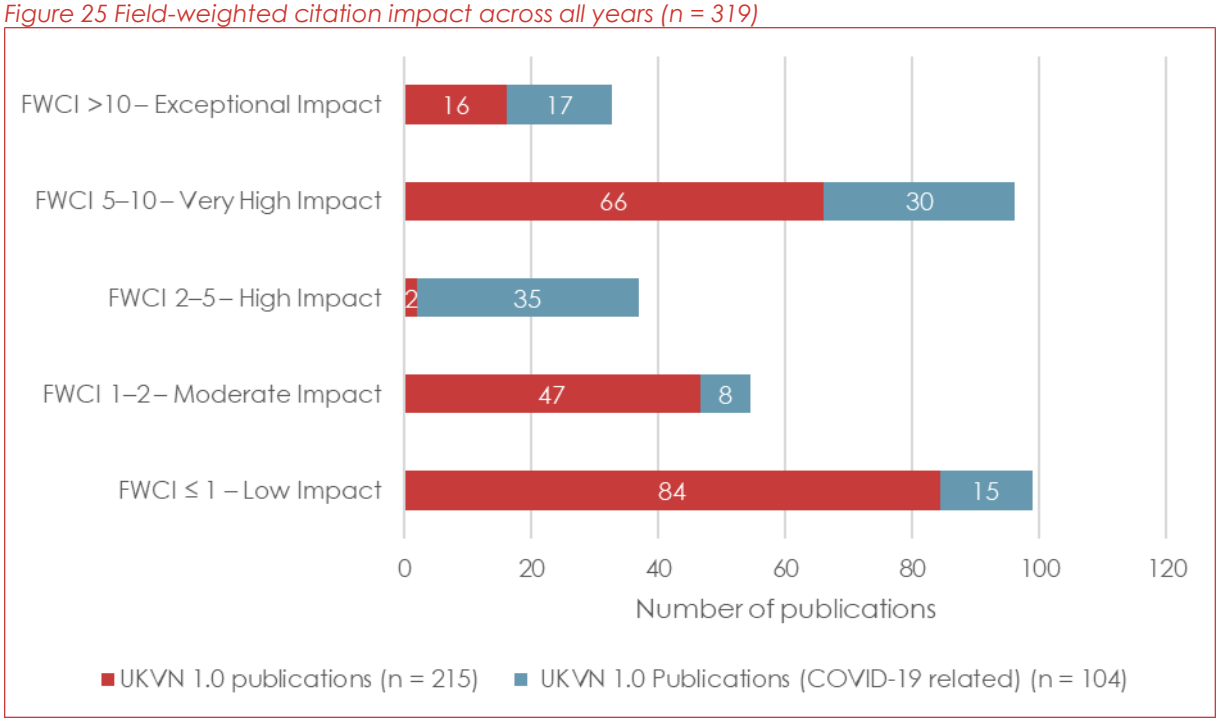
Of the 349 publications, 76 (22%) included at least one author affiliated with an LMIC institution. Most publications focused on UKVN priority pathogens (n = 58), while 18 focused on COVID-19 related research. Across these publications, 243 researchers from 37 LMICs were involved, with authors from the African Region contributing the highest number: 129 authors from 15 countries. Notably, all six WHO regions were presented, highlighting the global scope of collaborations.[153] This level of LMIC engagement suggests that UKVN funded projects have contributed to strengthening research capacity in regions affected by priority pathogens. Importantly, 96% of all publications are available via some form of open access, helping to ensure wide dissemination and accessibility of research findings.

Supporting high-quality, impactful research

To assess the academic impact of UKVN-funded research, citation metrics were analysed. For publications covering the 12 priority pathogens (i.e., excluding COVID-19), more than 6,000 citations were recorded to date. To support comparison across publication years, annualised citation rates were calculated, excluding 2023 and 2024 to account for citation lag. This analysis revealed an average of six citations per publication per year, indicating a moderate level of academic influence and uptake by the research community.

To explore this further, Field-Weighted Citation Impact (FWCI) was used, which compares citation performance of UKVN publications against the global average within each research field. As illustrated in Figure 25, over 60% of UKVN publications exceeded global average citations, with this figure rising to 86% for COVID-19-research. These findings provide evidence that UKVN-supported research performs strongly in terms of academic impact.

Figure 25 Field-weighted citation impact across all years (n = 319)



Source: OpenAlex. 30 publications with FWCI field missing were removed. FWCI ≤ 1 – Low Impact: cited as expected or less than the global average. FWCI 1–2 – Moderate Impact: cited up to 2 times more than the global average. FWCI 2–5 – High Impact: cited 2–5 times more than the global average. FWCI 5–10 –

[153] WHO regions refer to the six regions in which WHO Member States are grouped: Africa, Americas, South-East Asia, Europe, Eastern Mediterranean and Western Pacific. See Countries and areas by WHO region - 12bfe12.pdf

Very High Impact: cited 5–10 times more than the global average. FWCI >10 – Exceptional Impact = cited over 10 times more than the global average.

Knowledge generated from these publications was disseminated through over 120 presentations, 79 online articles, 64 workshops and various other activities. Several workshops conducted by UKVN project teams focused on sharing knowledge with LMIC organisations. For example, researchers from the UKVN-funded EPSRC manufacturing hubs conducted workshops in India, Vietnam and online:

- Workshop on 'Optimization of vaccines manufacturing, containers and testing for global supply', conducted in India in 2018[154]
- Workshop on 'Quality by design and supply chain management training for vaccine manufacturers', conducted in Vietnam in 2017
- Joint Webinar with IAVI on RNA vaccine technologies and applies, conducted online in 2021

Data collected from UKVN-funded EPSRC hubs suggest knowledge dissemination activities and training sessions reached over 700 individuals in the funding period (2018-2023). The total number of beneficiaries across the entire UKVN Project 1.0 is likely to be substantially higher.

3.4.2 Capacity building

The UKVN 1.0 has strengthened R&D communities' readiness to respond to future public health emergencies, in both the UK and partnering LMICs. Evidence from surveys, interviews and case studies shows that UKVN projects generated capabilities for vaccine development for the UKVN 12 priority pathogens as well as wider vaccine innovation:

- Development of new expertise in clinical trials across UK institutions and LMIC partners
- Creation of new methods, tools and software to support emergency preparedness and response
- Formal and informal training to UK and LMIC project team members in various vaccine R&D activities, such as molecular diagnostics, immunology and bioinformatics.

Scale and composition of UKVN project teams. Survey data suggest a minimum of 764 team members were involved in the delivery of the UKVN-funded projects that responded to the survey (n = 39). These included research students, post-doctoral fellows, technicians and permanent university and company staff, of which 202 are based in LMICs. Although these figures are likely conservative estimates due to partial survey responses, they illustrate the breath and international characteristics of UKVN project teams (for more details, see Appendix D).

Collaboration and knowledge exchange. Two-thirds of projects that responded to the survey (26 out of 39) indicated that they formed new collaborations as result of the UKVN funding. These partnerships enabled the use of biocontainment facilities, joint training sessions and exchange of best practices. Project leads interviewed emphasised that collaborations support staff retention and accelerated technology development. For example, in interviews, project leads mentioned researchers gained experience developing and implementing clinical trials for testing vaccines.

[154] DCVMN (2018). Optimization of vaccines' manufacturing, containers and testing for global supply DCVMN Regional Training Workshop Hyderabad, 07 to10 May 2018 https://dcvmn.org/wp-content/uploads/2018/05/workshop_final_agenda_hyderabad.pdf Accessed 01 Jun 2025

Skills development. Of 56 individual survey respondents, more than 85% reported improved skills, citing training in biochemistry, bioinformatics, genomics, immunology and molecular diagnostics, alongside practical instruction in vaccine platforms, biosafety, scale-up manufacturing, regulatory affairs and field-trial logistics. One project alone reported training up to 35 post-doctoral researchers, exemplifying UKVN investments supported skills development.

External stakeholders interviewed (experts not directly involved in the UKVN Project 1.0) observed that LMIC partners gained valuable experience in early-stage vaccine design and clinical studies. The previously discussed publication analysis reinforces this view, as a substantial share of UKVN publications includes LMIC-affiliated co-authors. Interviewees anticipated that these collaborations could deliver long-term benefits for LMICs, including vaccine R&D expertise, strengthened infrastructure and increased confidence in developing vaccines.

In summary, the evidence shows that UKVN funding has fostered the skills and collaborations needed to expand vaccine R&D capacity in both the UK and LMIC partners.

3.4.3 Innovation outputs

Innovation outputs, such as intellectual property and commercialisation activities, are key indicators of success of the UKVN 1.0 investment in vaccine R&D for the 12 priority pathogens. They reflect the extent of transformation of scientific knowledge into new technologies, such as vaccine platforms and manufacturing processes, that may ultimately be deployed as part of public health responses.

The UKVN 1.0 supported both academic and SME-led efforts to advance early-stage research towards translation into viable products. Approximately 66% of survey respondents (26 out of 39 projects) indicated that their work had not yet resulted in commercial outputs. This is an expected finding, as the UKVN 1.0 focused on early-stage R&D with the aim of advancing technologies towards commercialisation (e.g., Phase 2 vaccine candidates). Yet, emerging innovation outputs have already been identified and can serve as indicators of progress.

Patent applications. A total of 21 patents were submitted (not yet granted) by 13 UKVN projects. Pending patent applications demonstrate the generation of novel technical solutions that are sufficiently advanced to warrant legal protection.

Patents granted. A total of 15 granted patents were reported by 8 UKVN-funded projects. These patents span a range of technological areas, including bacterial vaccine platforms, biosafety devices for molecular pathogen detection, cell disruption methods and viral vector vaccines technologies.

Licensing agreements. Survey responses indicate two projects developed transferable know-how and three projects led to signing licensing agreements, facilitating the uptake of innovations by external partners. Details of these agreements were not disclosed.

Spin-out companies formed: Four new companies were established based on results generated by UKVN funded research, creating dedicated organisations to advance vaccine related technologies further:

- DIOSynVax Ltd (attributed to grant 971511 – Innovate UK, final report)
- ReNewVax Limited (attributed to grant 971554 - Innovate UK, final report)
- The Vaccine Group Limited (attributed to grant 972220 - Innovate UK, final report)
- ArkVax Limited (attributed to grant EP/R013756/1 – EPSRC, survey response)

These innovation outputs reflect tangible progress in advancing vaccine technologies and creating conditions for long-term impact. They signal that the UKVN 1.0 has laid important

groundwork for future 'valorisation' of research outputs and contributing to emergency response capacity.

3.5 Cost benefit analysis on the UKVN investment in the ChAdOx platform

According to interviews with wider stakeholders, the UKVN 1.0 investment played an important role in supporting the development of the ChAdOx vaccine platform, which underpinned the creation of the Oxford-AstraZeneca COVID-19 vaccine. The preparatory work on the ChAdOx platform provided the UK with a crucial advantage to accelerate vaccine development when the pandemic emerged. It was noted that the platform's versatility not only enabled a rapid response to COVID-19 but also underlined the long-term value of investing in scalable, adaptable vaccine technologies capable of addressing a wide range of emerging threats.

In this section we provide a summary of the cost-benefit analysis (CBA) conducted as part of the UKVN Project 1.0 evaluation. For more details, see Appendix E.

3.5.1 Approach for cost-benefit analysis for the ChAdOx platform

The aim of the CBA was to answer the following: what was the return on UKVN investment in the ChAdOx platform, considering its contribution to the development of the Oxford-AstraZeneca Covid-19 vaccine?

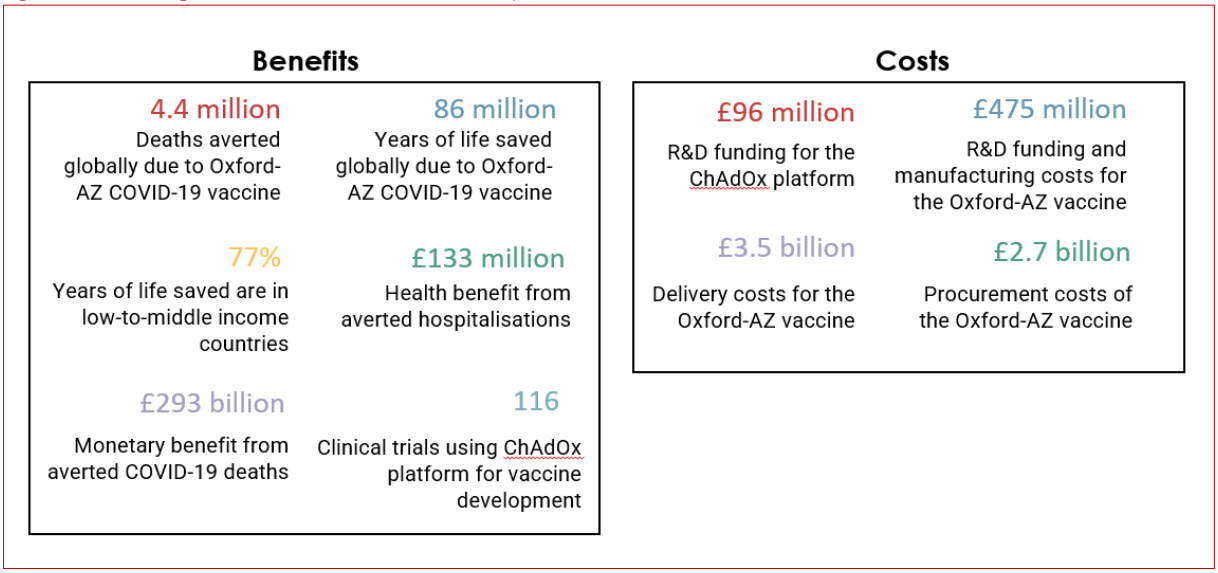
To answer this question, the CBA quantifies the global benefits of the first year of the Oxford-AstraZeneca COVID-19 vaccination programme in terms of the prevention of premature deaths from COVID-19 and reduction in quality of life from ward and Intensive Care Unit (ICU) hospitalisations.

The analysis estimates the value of UKVN 1.0's investment in the ChAdOx platform as a proportion of the total costs for developing and deploying the Oxford-AstraZeneca COVID-19 vaccine. This proportion is then applied this ratio to the vaccine's total estimated benefits to determine the share attributable to the UKVN 1.0. Finally, the analysis calculates a benefit-cost ratio by comparing this share of benefits with the cost of UKVN 1.0's investment in the ChAdOx platform. The analysis also includes qualitative discussion of the wider benefits from the platform to the development of other vaccine candidates beyond COVID-19.

3.5.2 Findings of the cost-benefit analysis for the ChAdOx platform

Figure 26 provides an overview of the CBA findings, specifically the benefits (averted mortality and hospitalisations) and costs (R&D, manufacturing, procurement and delivery).

Figure 26 Findings from the cost-benefit analysis: benefits and costs



Source: Evaluation team

Mortality impacts

We estimate that the Oxford-AstraZeneca vaccine prevented approximately 4.3 million premature COVID-19 deaths globally up to 8 December, 2021.[155] Of these, around 3.7 million occurred in low- and middle-income countries, representing 84% of the total deaths averted.

Based on estimates of life years lost per COVID-19 death, we estimate that the Oxford-AstraZeneca vaccine prevented the loss of approximately 86 million years of life within the first year of vaccination. Of these, around 78 million years were saved in low- and middle-income countries, representing 91% of the total years of life saved.

Using country-specific monetary estimates of cost-effectiveness thresholds, we estimate that t the Oxford-AstraZeneca's vaccine has generated £293 billion in value through the prevention of premature mortality.

3.5.2.1 Morbidity impacts

Globally, the Oxford-AstraZeneca vaccination programme directly averted over 2 million ward and 329,985 ICU hospitalisations up to 8th December 2021.

We estimate the monetary value of avoiding morbidity impacts from reduced quality of life following COVID-19 hospitalisation at £133 million. The majority of this benefit (£105 million) comes from preventing ward admissions.

3.5.2.2 Wider health benefits

Our analysis of ClinicalTrials.gov data indicates that over 116 trials have investigated ChAdOx-based vaccine candidates against a broad range of diseases. While COVID-19 represents the largest proportion of trials (n = 76), the ChAdOx platform has been utilised for the development of 11 of the 12 UKVN priority pathogens, other infectious diseases relevant to LMICs (e.g.,

[155] Another study by Airfinity, using a different methodology, estimated that the Oxford-AstraZeneca vaccine saved 6.3 million lives worldwide, around 2 million more than the estimate presented in this study. For more information, https://www.ox.ac.uk/news/2022-07-15-oxford-vaccine-saved-most-lives-its-first-year-rollout

tuberculosis, HIV/AIDS, malaria), as well as to immune-oncology vaccines (e.g. targeting prostate cancer).

3.5.2.3 Total costs

We estimate that the total cost associated with the development and delivery of the Oxford-AstraZeneca vaccine is £6.8 billion globally. Most of the total cost is associated with delivery costs (£3.5 billion) and procurement costs (£2.8 billion). An additional £475 million of public funding was invested to support clinical studies, scaled-up manufacturing and distribution costs.

3.5.2.4 Benefit-Cost ratio

Our findings indicate that the UKVN has contributed £36 million to the development of the ChAdOx platform and thus the Oxford-AstraZeneca vaccine, representing 0.5% of the total cost of the developing the vaccine and delivering the vaccination programme to affected populations. As such, we assume that the equivalent share of the observed health benefits from the Oxford-AstraZeneca vaccination are attributable to UKVN, resulting in a total benefit of £1.6 billion.

Our findings show that for every £1 invested by UKVN 1.0, approximately £43 in benefits was generated by preventing premature COVID-19 deaths and reducing quality of life losses from ward and ICU hospitalisations.

3.6 UKVN investments in the wider landscape

This section provides our answer to EQ4: has the UKVN allocated resources effectively to priority areas where there are gaps in the R&D landscape?

Our overall assessment is that the UKVN 1.0 effectively addressed critical gaps in the global and UK vaccine R&D landscape by strategically directing resources towards pathogens where progress had previously been limited or fragmented.

As discussed in section 3.2, prior to 2016, few vaccine candidates against UKVN priority pathogens had reached clinical development or obtained regulatory approval, with half of them targeting Ebola. No vaccine candidates reached these stages for Zika, Lassa, Rift Valley fever or Nipah. UKVN funding helped to shape this trajectory, advancing vaccine R&D against all 12 priority pathogens from pre-clinical stages towards clinical trials.

In interviews, experts (wider stakeholders) generally agreed that UKVN 1.0 focus on early-stage development was appropriate, given limited funding and the breadth of priority pathogens. According to them, this strategic approach helped to strengthen the wider R&D pipeline and to support a diverse portfolio of projects with the future potential to progress these to later stages. Project leads interviewed (beneficiaries of the UKVN funding) confirmed that the UKVN filled a critical funding gap, particularly where other funding sources (e.g. European Commission and MRC) were limited in scope, scale, or accessibility. According to project leads, the UKVN 1.0 ODA funding also enabled international collaboration, advancing health equity in LMICs and reinforcing the UK's position as a leader in global health research.

3.6.1 How have UKVN investments contributed to the wider landscape?

The UKVN 1.0 supported 13 (25%) of the 53 new vaccine candidates for priority pathogens that entered clinical development globally since 2016, second only to USA funders. At least five candidates supported by the UKVN have the potential to become 'Phase II ready' in the short term.

UKVN funding to research conducted in the UK was critical: almost all UK-developed candidates for priority pathogens in clinical trials received UKVN funding (10 candidates in

total). In contrast, prior to 2016, no UK-developed candidates had reached clinical development for these pathogens.

The UKVN 1.0 also contributed to a significant extent to the global R&D funding, including 40.5% for CCHF, 14.9% for Nipah and 11.9% for RVF. It funded a broad portfolio of vaccine candidates across multiple R&D stages:

- Diverse ZIKV vaccine candidates across platforms and development stages
- Non-Ebola filoviruses and multivalent candidates, which are now in clinical trials
- Three of the nine CHIKV and two of the four CCHFV vaccine candidates in clinical development worldwide

Platform technologies were also advanced, notably the ChAdOx viral vector platform. Development of the ChAdOx-based CHIK vaccine contributed to broader platform readiness, evidenced by the rapid pace of vaccine development in response to the COVID-19 pandemic. In turn, the pandemic catapulted progress on the ChAdOx platform. This enhanced capability now underpins the development of vaccines for other diseases based on the ChAdOx platform. Building a cluster of expertise around the University of Oxford teams that developed the ChAdOx vector offers clear benefits, including deep knowledge of the platform, experience in scaling of GMP manufacture using a local facility and networks needed to conduct clinical trials and field studies.

The ChAdOx platform was used for the development of the Oxford-AstraZeneca COVID-19 vaccine, originally supported through UKVN funded MERS-related research. The Phase I dosing studies for the ChAdOx1 MERS vaccine informed early dose selection for the ChAdOx1 nCoV-19 vaccine, streamlining the clinical development path. The Oxford-AstraZeneca COVID-19 vaccine is estimated to have saved over 4 million lives worldwide.

The UKVN 1.0 also invested in oral vaccine platforms, suitable for LMICs and innovative approaches to mosquito-borne diseases, broadening the technological base for future outbreaks. The UKVN 1.0 strengthened epidemic response capacity through epidemiological research and operational tools, particularly during the 2018–2020 Ebola outbreak. Several wider stakeholders interviewed noted the UKVN's contribution to the 100-Days Mission, an international initiative that aims to detect, identify and develop effective countermeasures for emerging infectious diseases within 100 days of their emergence.

These targeted investments not only enhanced the UK's contribution to global vaccine preparedness but strengthened its position as a leader in emerging infectious disease R&D. They underscore the UKVN's effective prioritisation of underfunded, high-risk disease areas with potential for both global impact and domestic preparedness.

3.7 UKVN delivery model

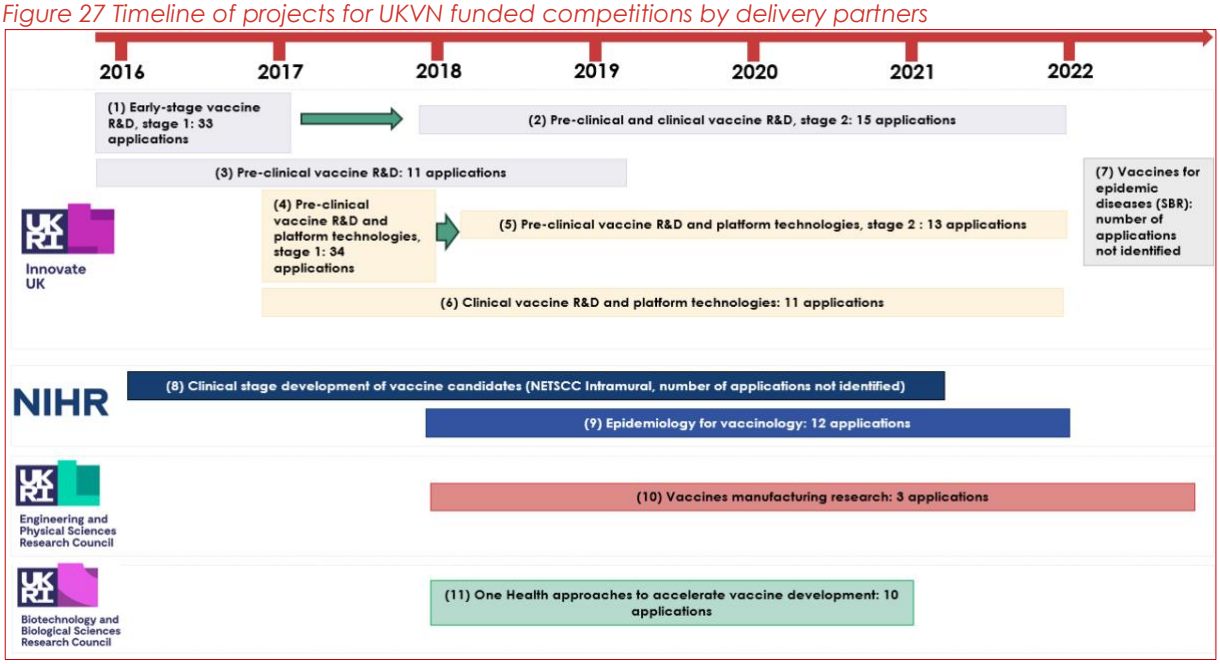
The UKVN 1.0 delivery model is based on research competitions jointly developed and managed by the DHSC and experienced UK research funders, referred to as 'delivery partners'. Delivery partners were selected for their capacity to manage funding calls and monitor research progress, allowing the UKVN 1.0 to leverage existing infrastructure and expertise. This strategic approach allowed the UKVN 1.0 to make use of existing national capabilities and ensure effective delivery through trusted mechanism.[156]

[156] Interviews conducted with DHSC and delivery partners for the UKVN evaluation

3.7.1 R&D community response to UKVN competitions

Between 2016 and 2023, the UKVN launched 11 competitive research calls. These varied in thematic scope and scale, with funding competitions managed by Innovate UK, NIHR, EPSRC and BBSRC. Figure 27 provides an overview of the timeline of each competition, showcasing the starting year of the competition, expected end of funded projects as well as the number of applications received.

Figure 27 Timeline of projects for UKVN funded competitions by delivery partners



Source: Evaluation team

Innovate UK's early-stage vaccine development competitions (2016–2018) focused on discovery and pre-clinical R&D, including two funding rounds and a bridging (Stage 2) call to support projects that are likely to reach Phase 1 trials. These three rounds, represented in Figure 27 as (1), (2) and (3), accounted for £19.4 million in UKVN funding and attracted 44 applications. Later calls (2017) introduced platform technologies and more focus on pre-clinical and clinical R&D, with similar structure (Stage 1 and Stage 2) and funding of £20.7 million (these are represented in the figure as (4), (5) and (6)). A separate competition under the Small Business Research Initiative (SBRI) in 2022 provided £9.3 million funding to bridge projects ahead of UKVN 1.0's next phase (UKVN 2.0).

In 2016, NIHR (NESTCC) awarded £12 million of UKVN funding to six projects focused on early clinical development, supporting vaccines candidates that were either approaching or already in Phase 1 trials (shown as (8) in the above figure).

In 2018, three competitions were launched to complement the portfolio of investments:

- NIHR (CCF) Epidemiology for vaccinology, to fund projects focused on epidemiological research to support outbreak preparedness and response (shown as (9) in the figure)
- EPSRC vaccine manufacturing hubs (shown as (10) in the figure)
- BBSRC one health competition (shown as (11) in the figure).

These competitions had smaller application pools (3 to 11 each).

Overall, these competitions enabled the funding of a diverse portfolio of vaccine candidates, platform technologies, manufacturing innovations and epidemiological studies. While the

number of applications received for each competition varied, most of them were of high quality project proposals.[157] Interviews indicated that delivery partners faced challenges in proposal assessment due to the small and specialised nature of the vaccine R&D community, complicating efforts to balance peer review with managing potential conflicts of interest.[158]

3.7.2 How effectiveness was the UKVN 1.0 delivery model?

Findings from interviews (with DSHC, delivery partners, project leads and wider stakeholders) and survey responses suggest that the delivery mode was broadly fit for purpose, particularly given the public health context at its inception (in 2016). The strengths of the delivery model include:

- Delivery partners contributed deep technical and thematic expertise
- Diverse funding mechanisms with staged approaches (e.g. Innovate UK stage 1 and 2)
- Effective coordination through communication between DHSC and delivery partners, supporting overall management of the UKVN 1.0.

However, limitations were also identified:

- Fragmented UKVN 1.0 branding: in interviewees, beneficiaries largely viewed funding as originating from delivery partners, not the UKVN.
- Administrative complexity: additional reporting requirements from DHSC combined with standard reporting from delivery partners may have added burden on beneficiaries. In addition, different monitoring frameworks across delivery partners have brought challenges for managing and assessing progress of the overall UKVN 1.0.
- There were mixed views on the international reach of UKVN's delivery model. Many stakeholders felt it was too UK-centric, raising concerns about its effectiveness in addressing LMIC-specific needs. While some appreciated the UK's ability to rapidly mobilise scientific expertise, others stressed the need for more inclusive models involving LMIC experts and communities in vaccine development.

The UKVN's monitoring and reporting framework evolved in parallel with the UKVN 1.0 delivery.[159] Each delivery partner was responsible for tracking project progress and submitting annual and financial reports to DHSC.

Overall, ODA compliance was not perceived as a major burden on researchers (according to interviews). Despite this, delivery partners interviewed highlighted that the overall administrative load for universities and researchers was relatively high due to different reporting requirements for the UKVN 1.0and standard reporting for delivery partners.[160]

UKVN1.0's access and IP framework prioritised equitable access to vaccines over commercialisation activities. DHSC rejected recommendations from interim UKVN 1.0 evaluation to enhance IP support to beneficiaries, emphasising that as an ODA-funded initiative, UKVN's priority was vaccine accessibility for LMICs rather than securing commercial

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[157] UKVN Annual Report 2018/19. Available at https://devflow.northeurope.cloudapp.azure.com/files/documents/UKVN-Vaccines-Project-Annual-Review-18-19_FOR-PUBLISHING-20210907010947.pdf

[158] Interviews conducted with DHSC and delivery partners for the UKVN evaluation

[159] Interviews conducted with DHSC and delivery partners for the UKVN evaluation

[160] Interviews conducted with DHSC and delivery partners for the UKVN evaluation

IP for UK entities.[161] While this approach may have deterred some private sector applicants, there is limited evidence of this. Application numbers remained modest, but the quality was consistently high, suggesting that key actors in the R&D ecosystem remained engaged.

In conclusion, the UKVN delivery model effectively enabled a strategically aligned vaccine R&D portfolio. It supported research from discovery through to readiness for clinical trial and coordinated effectively with global initiatives such as CEPI for downstream development and deployment.

4 Conclusions and Recommendations

The first phase of the UKVN Project 1.0 provided critical funding to strengthen global health security by accelerating the development of vaccines and related technologies to tackle epidemic threats. This independent evaluation assessed the extent to which the objectives and anticipated outcomes of the UKVN Project 1.0, as outlined in the theory of change, were achieved.

Advancing vaccine R&D for 12 priority pathogens.

UKVN Project 1.0 funding delivered significant progress across the vaccine R&D pipeline. Investment was strategically directed towards high-risk, early-stage research where UK organisations had strong scientific capabilities but commercial incentives or access to alternative funding were lacking. This broad, exploratory programme of investment supported the development of a diverse portfolio of vaccine candidates against the 12 priority pathogens. Although resources were spread relatively thinly across the priority pathogens, the MERS-CoV example demonstrated that even a single project can have a meaningful impact in outbreak response. Since 2016, the project has supported the development of 25% of the vaccine candidates targeting these pathogens that progressed to clinical trials. At least five of these vaccine candidates have the potential to become 'Phase II ready', of which two have secured CEPI funding for Phase II trials. Notably, the proportion of funded research at pre-clinical or clinical stages increased from 25% to 67% over the funding period.

Academic institutions and SMEs undertook a range of projects that, collectively, advanced vaccine research across the early development pathway, including discovery research, pre-clinical studies and early-phase clinical trials. To ensure relevance to global health needs, projects were required to align with target product profiles (TPPs) for use in LMICs.

Beyond core vaccine R&D, the portfolio supported complementary upstream and downstream research, including epidemiological studies, development of animal models, zoonotic disease surveillance and work developing serological standards. Platforms technologies and vaccine manufacturing innovations were also supported by UKVN funding.

Benefits for LMIC research communities and wider populations are emerging.

Whilst not mandated, collaboration with local organisations, capacity building and policy engagement in LMICs developed organically where relevant. These activities strengthened

[161] UKVN Management response and recommendations action plan (2020). Available at https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fdevflow.northeurope.cloudapp.azure.com%2Ffiles%2Fdocuments%2FUKVN-Interim-Evaluation-Management-Response-and-Reccomendations-NA-20210426080424.docx&wdOrigin=BROWSELINK Accessed 13 May 2025

local expertise and enhanced vaccine development capabilities in several LMICs. Notable examples included:

- Technology transfer activities for vaccine manufacturing in Vietnam and India
- The development of electronic data collection tools, outbreak models and social science research conducted to support response to the 2018-2020 Ebola outbreak in the Democratic Republic of the Congo
- Formal and informal training activities delivered across several projects, particularly those through the EPSRC manufacturing hubs
- Collaboration with the Nigeria Centre for Disease Control on Lassa Fever surveillance.

Several priority vaccine candidates advanced towards outbreak readiness and stockpiling, including the ChAdOx1 biEBOV and ChAdOx1 MARV vaccines, both recommended for deployment by WHO. In general, vaccine platforms can be developed using priority or exemplar pathogens as 'use cases', with the resulting learnings then applied more broadly across other pathogens. Research on the ChAdOx platform and a MERS vaccine candidate also enabled a rapid pivot during the COVID-19 pandemic, leading to the development of the Oxford-AstraZeneca vaccine, the first COVID-19 vaccine to receive global authorisation.

Whilst substantial additional investment was required to develop this vaccine (as detailed in the cost-benefit analysis section), UKVN funding validated the value of early public investment in disease-agnostic vaccine platforms. Ultimately, a relatively modest investment generated disproportionately high public health and economic returns during the pandemic, particularly for populations in LMICs.

For a funding programme such as the UKVN 1.0, building on existing strengths increases efficiency and reduces risk in achieving short-term outcomes, while maximising the chances of impact. The ChAdOx project portfolio illustrates this point: these projects had already developed the expertise, processes, networks, and advanced regulatory steps, all of which accelerate progress. In the longer run, maintaining a diverse technology portfolio creates opportunities for further innovation and new solutions. The COVID-19 pandemic response demonstrated the value of having multiple vaccine platforms, with some proving better suited to low-cost manufacturing and deployment in LMICs than others.

Support to science and capacity building.

UKVN Project 1.0 supported a range of projects that advanced the scientific and technological foundations of vaccine development and associated research. As evidenced by the research outputs, these projects delivered notable technological innovation and fostered interdisciplinary collaboration. Research activities were highly collaborative, involving over 400 institutions globally, including substantive engagement from researchers based in LMICs. Almost all resulting peer-reviewed scientific publications were made freely available via open access, with nearly one-quarter of these publications including at least one author affiliated with an LMIC institution.

Between 2016 and 2023, the UK vaccine R&D ecosystem matured considerably, with UKVN Project 1.0 contributing significantly to this growth. Strong research clusters emerged or consolidated their activities in vaccine R&D with UKVN 1.0 funding for institutions such as the University of Oxford, the UK Health Security Agency's Porton Down facility and the Pirbright Institute. Collaborative initiatives, including those facilitated through the EPSRC manufacturing hubs, brought together a range of partners to support technological innovation for scalable manufacturing and technology transfer. Capacity building also extended to universities and SMEs across the UK, enhancing national capabilities in vaccine development and production.

Importantly, projects outside the 'established research hubs', such as Liverpool and Nottingham, helped to build research base and expands capacity more widely.

An analysis of the UKVN-funded portfolio found that projects exhibited a reasonable degree of complementarity and synergy. Strategic mechanisms for cross-project knowledge exchange were limited, but researchers remained aware of progress across the portfolio due to the small size of the UK vaccine R&D community. As is typical of early-stage research, not all UKVN-funded projects progressed to clinical development, an expected outcome given the complexity and context-dependence of pathogen biology. Nonetheless, each project contributed to the scientific evidence base (including through negative results) and informed new hypotheses for future research.

The UKVN delivery model was fit for purpose.

The delivery model for UKVN Project 1.0 enabled DHSC to commission research through established funding organisations. Open funding calls broadened participation, attracting researchers from adjacent disciplines. Innovate UK's staged grant model effectively progressed projects from feasibility to larger-scale awards. Delivery partners were flexible in responding to unforeseen challenges, notably granting extensions to projects affected by COVID-19 delays. However, variability in reporting formats and timelines across delivery partners resulted in fragmented data on the outcomes of funding competitions and programme monitoring. This limited the ability to systematically assess performance across the portfolio.

Remaining Barriers to Vaccine R&D

Despite the progress made, several barriers remain that ongoing and future vaccine development funding programmes will need to consider:

1. Operational constraints such as persistent challenges with overseas shipment of biological samples, regulatory complexity, collaboration difficulties and gaps in technical capacity, continue to limit project potential.
2. Access to specialised infrastructure (e.g. high-containment units and challenge trial platforms) is prohibitively expensive and inaccessible. The sale and subsequent decommissioning of the UK's Vaccine Manufacturing and Innovation Centre have further undermined access to critical infrastructure.
3. Commercial pathways for SMEs developing vaccines for LMICs are unclear. Without patentable platform technologies or guaranteed purchase commitments, incentives for investment are weak. In most cases, platforms must be licensable or adaptable to other disease areas to attract commercial interest.
4. Responsibility for funding and maintaining vaccine stockpiles in LMICs is poorly defined, undermining epidemic preparedness.
5. Persistent financial instability in the international development sector limits both the continuity and scale of support for vaccine R&D programmes.

To maximise future impact of UKVN 2.0 and other vaccine R&D programmes, the following points may be considered by the DHSC:

Strengthen the strategic focus to support the vaccine R&D pipeline. Future investments should continue to refine the strategic focus to ensure that limited budgets are deployed effectively and maximise benefits for LMICs. Priorities should include:

1. Pathogens and pathogen families where alternative funding sources are limited, such as bacterial pathogens

2. Early discovery, pre-clinical development and Phase I clinical projects that are affordable and provide a strong foundation for later-stage clinical work

3. Areas with an ecosystem prepared for downstream investment, particularly where alignment exists with CEPI's eight priority pathogens and other global initiatives

4. Collaborative investment with other funders (to share risk and enhance feasibility) in a small number of projects where substantial funding could unlock high-impact scientific or translational breakthroughs

Enhance LMIC leadership and improve pathway to global access. As vaccine candidates progress to clinical phases (e.g. Phase Ib), greater testing and trial implementation in LMIC communities[162] and inclusive LMIC research leadership should be prioritised. Increased technology transfer from UKVN projects to LMICs would support regional manufacturing and strengthen future vaccine sovereignty (see the promotion of voluntary technology transfer in the new Pandemic treaty[163]). The UKVN should also consider requiring patents from UKVN-funded projects to include an equitable and affordable access plan and a commitment to socially responsible licensing.

Support knowledge exchange and capacity building. Collaboration and knowledge sharing across organisations are essential to accelerate vaccine R&D and ensure equitable outcomes. Future investments should explore how established research clusters can provide mentorship to less experienced organisations in the UK and LMICs, facilitating learning via collaboration and training. Future programmes would also benefit from annual cross-project engagement activities to disseminate lessons learned, technical updates and best practices. The UKVN could further mobilise UK regulatory and scientific expertise to provide technical assistance to programme beneficiaries to accelerate vaccine approval timelines.

Strengthen monitoring practices and enable flexible funding approaches. Future programmes should adopt harmonised, low-burden approaches to monitoring and data collection. Standardised templates, designed to minimise burden on beneficiaries, can ensure consistent capture of essential information across diverse projects and support learning during project and programme evaluations. New funding approaches, such as commissioned funding, may be appropriate in cases where the vaccine development pathway is clearly defined. These could include direct grant awards from DHSC to key organisations with established technical capacity and capability. Whilst this depends on sufficient administrative capacity at DHSC, it holds the potential streamline project implementation and reduce unnecessary delays.

UKVN should coordinate more closely with international partners and initiatives. While the UKVN plays a key role as a national forum and advisor on vaccine R&D investments, effective end-to-end planning for vaccine platforms and priority pathogen families requires coordinated collaboration with both domestic and international stakeholders. Strategic partners include UKHSA, which maintains its own priority pathogen list; CEPI; the European Commission's HERA and EDCTP; WHO Collaborative Research Consortia; and selected LMIC-based organisations and initiatives such as AVAREF[164] and Medaccess[165]. These partnerships may support alignment of priorities, facilitate access to complementary expertise and resources and enable joint initiatives to address gaps in critical research infrastructure.

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[162] See CERCLE, the LMIC network of clinical trials. https://cerclecoalition.org/

[163] https://www.who.int/news/item/20-05-2025-world-health-assembly-adopts-historic-pandemic-agreement-to-make-the-world-more-equitable-and-safer-from-future-pandemics

[164] https://www.afro.who.int/health-topics/immunization/avaref

[165] https://www.bii.co.uk/en/our-impact/direct-header/medaccess