World Health Organization

R&DBlueprint
Powering research
to prevent epidemics

PATHOGENS PRIORITIZATION

A SCIENTIFIC FRAMEWORK FOR EPIDEMIC AND PANDEMIC RESEARCH PREPAREDNESS

HEALTH EMERGENCIES programme

JUNE 2024

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EXECUTIVE SUMMARY

The WHO R&D Blueprint for Epidemics has a primary goal to accelerate the development of medical countermeasures (MCMs). Since 2015, its primary goal is to make these countermeasures available for diseases with epidemic and pandemic potential, thereby contributing to the prevention of Public Health Emergencies of International Concern (PHEICs) and saving lives during outbreaks. The WHO R&D Blueprint for Epidemics functions as a global platform for research and development collaboration, stressing the significance of international cooperation in expediting the research and development of medical countermeasures (MCMs) to respond to epidemics and pandemics. At the core of its efforts lies the concept of 'pathogen prioritization'. This document outlines the findings of a global pathogen prioritization process involving over 200 scientists from more than 50 countries who evaluated the evidence related to 28 Viral Families and one core group of Bacteria, encompassing 1,652 pathogens. This process emphasized the imperative nature of collaborative efforts to attain global resilience against epidemics and pandemics.

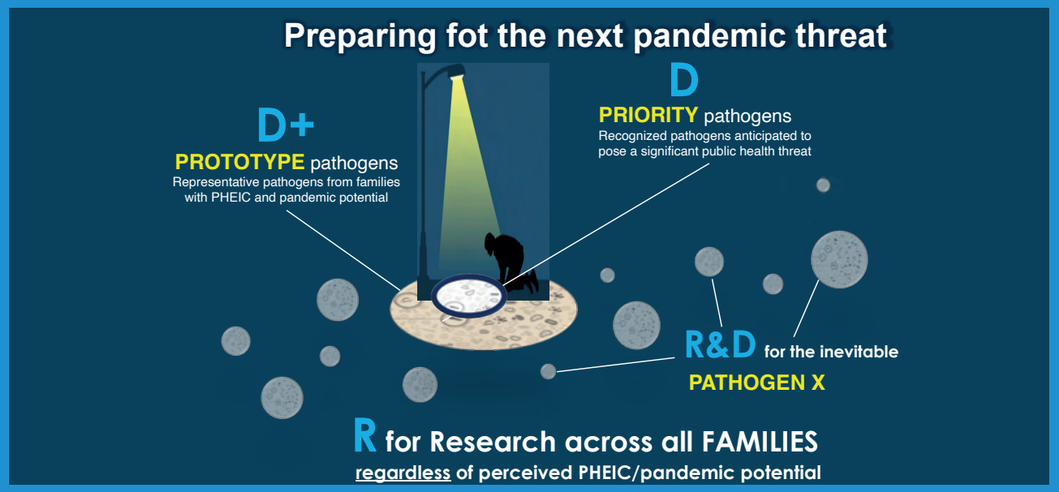
The approach used advocates for a scientific framework to enhance preparedness for forthcoming outbreaks, Public Health Emergencies of International Concern (PHEICs), and pandemics by focusing on research of Viral and Bacterial Families, rather than isolated pathogens deemed to present global risks.

It also emphasizes the critical necessity for investments in research, development, and innovation on an international scale, underscoring the need to uphold fundamental principles. Within this context of numerous collaborative initiatives striving to support MCM R&D during epidemics and pandemics, regarding a collaborative effort to ensure access to MCMs during pandemics, some have emphasized the importance of speed and sometimes cost in responding to future pandemics. It is equally important in considering the entire value chain to take a broader view that recognizes the primary importance of quality, equity in access, and trust in the product's safety and efficacy. Preparations and implementation of pandemic response thus should be country-centered, transparent, and collaborative.

By prioritizing research on entire pathogen Families as opposed to a handful of individual pathogens, this strategy bolsters the capability to respond efficiently to unforeseen variants, emerging pathogens, zoonotic transmissions, and unknown threats such as 'Pathogen X.' It also emphasizes the need for prompt identification and characterization of emerging threats, the streamlining of global R&D efforts, via collaborative and efficient research roadmaps and the integration of research into outbreak and pandemic response. The widespread geographic distribution of the viral and bacterial families and pathogens identified in this report, with several known to circulate across diverse nations and regions globally, underscores the pivotal role of global initiatives in linking national and regional research actions. Significantly, the strategy advocates for decentralized collaborative approaches and supporting research efforts in areas critical for pandemic research preparedness. This comprehensive approach aims to foster international collaboration by establishing a global framework for researchers, developers, policymakers, funders, manufacturers, and institutions, fostering a collaborative space to advance research across all Viral and Bacterial Families, as well as R&D for Priority and Prototype pathogens.

BOX 1 The streetlight effect

The metaphor of looking for lost keys under a streetlamp – often referred to as the 'streetlight effect' – is a powerful illustration of the ongoing challenges and biases in identifying the pathogen that will cause the next pandemic. This metaphor highlights how researchers and public health officials might focus their efforts on illuminated areas where it is easiest to search, rather than where the actual answers might lie. This proposed Family approach to identifying the next pandemic pathogen emphasizes the importance of broadening our perspective strategically.



Imagine scientists and public health officials as individuals searching for the "lost keys" (the next pandemic pathogen). The area illuminated by the "streetlight" represents the Priority Pathogens, well-studied pathogens with readily accessible data that indicate their risk of causing a PHEIC or a pandemic. We can expand the lighted area a bit by researching the Prototype Pathogens and using them as pathfinders within Families to expand our knowledge and understanding. Neglecting the “Dark Areas” is not advisable given the uncertainty about which pathogen will indeed cause the next PHEIC or pandemic. The “Dark Areas” in this metaphor include many regions, particularly in resource-scarce settings with high biodiversity, which are still under-monitored and under-studied. These areas might harbour novel pathogens, but the lack of infrastructure and resources makes it difficult to conduct comprehensive research. The focus on known pathogens can lead to a neglect of emerging or re-emerging pathogens that have not yet caused significant outbreaks but have the potential to do so.

Therefore, the proposed approach of supporting research in all families, regardless of their pandemic potential, helps mitigate the risk of missing potential pandemic pathogens that might be lurking in the "dark areas" beyond the immediate reach of current surveillance systems and research efforts.

The Prioritization meeting held on 9-10 May 2024 engaged all collaborators in the Pathogen Prioritization process to further develop a strategy that advocates for research spanning various pathogen families based on our existing understanding of their pandemic potential. This strategy also emphasizes research and development efforts aimed at readiness for both anticipated and unanticipated threats by focusing on entire families, Prototype Pathogens, and Priority Pathogens.

The continuous revision of this strategy will facilitate the ongoing assessment of risks associated with emerging infectious diseases and advancements in scientific research.

The global health landscape is subject to constant evolution, with the potential emergence of new pathogens and evolution in the threat levels posed by existing ones. These developments play a crucial role in shaping strategies to tackle emerging challenges. The strategy adopted demonstrates a proactive stance towards addressing emerging infectious diseases, as well as improving global research and development preparedness and response capabilities.

Table 1 compares the results of previous R&D Blueprint for Epidemics Priority Pathogen lists in 2017 and 2018 with the results from 2024. Following the finalization of the list of Families, Priority pathogens, and Prototype Pathogens, the combinations were arranged by family and alphabetical order.

Importantly, the outputs in 2024 incorporate for the first time the concept of the Family approach and the addition of the Prototype Pathogen. Some of the "new" Priority Pathogens incorporated in the 2024 outputs were noted in 2017 and or 2018 as pathogens of concern or as outside the remit of the WHO R&D Blueprint for Epidemics[1,2].

Lastly, besides the pathogens listed in 2018, the WHO R&D Blueprint for Epidemics has supported R&D efforts for Plague, SARS CoV2 and Monkeypox following the declaration of outbreaks, PHEICs, or pandemics and considering the lack of suitable MCMs.

Nota Bene
As scientific understanding deepens, viruses are renamed, or currently classified as members of one family may be moved or adopted into another family, or be put into a completely new family of their own. In this document, an effort was made to refer to the most recent recommendations of the International Committee on Taxonomy of Viruses (ICTV)[3]. However, to facilitate the readers' review, we have created a "translation table" (Table 14) that provides the MSL39 Viral Species name and reference to the previous, perhaps more familiar, names of the various viruses.

[1] **https://www.who.int/publications/m/item/an-r-d-blueprint-for-action-to-prevent-epidemics---update-2017**

[2] **https://www.who.int/activities/prioritizing-diseases-for-research-and-development-in-emergency-contexts**

[3] **https://ictv.global/**

Table 1. Families and Pathogens that were prioritized in the 2024 update, as compared with the 2017 and 2018 prioritization processes[4].

	2017	2018	2024		
Family	**Priority Pathogens**	**Priority Pathogens**	**PHEIC risk**	**Priority Pathogens**	**Prototype Pathogens**
Adenoviridae			Low-Medium		Recombinant Mastadenovirus
Adenoviridae			Low-Medium		Mastadenovirus blackbeardi serotype 14
Anelloviridae			Low		
Arenaviridae	Arenaviral hemorrhagic fevers including Lassa Fever	Lassa Fever virus	High	Mammarenavirus lassaense	Mammarenavirus lassaense
Arenaviridae			High		Mammarenavirus juninense
Arenaviridae			High		Mammarenavirus lujoense
Astroviridae			Low		Mamastrovirus virginiaense
Bacteria			High	*Vibrio cholerae serogroup 0139*	
Bacteria			High	*Yersinia Pestis*	
Bacteria			High	*Shigella dysenteriae serotype 1*	
Bacteria			High	*Salmonella enterica non typhoidal serovars*	
Bacteria			High	*Klebsiella pneumoniae*	
Bornaviridae			Low		Orthobornavirus bornaense
Coronaviridae	Middle East Respiratory Syndrome Coronavirus	Middle East Respiratory Syndrome Coronavirus	High	*Subgenus* Merbecovirus	*Subgenus* Merbecovirus
Coronaviridae	Other highly pathogenic coronaviral diseases such as Severe Acute Respiratory Syndrome	Severe Acute Respiratory Syndrome	High	*Subgenus* Sarbecovirus	*Subgenus* Sarbecovirus
Filoviridae	Filoviral diseases Ebola	Ebola virus disease	High	Orthoebolavirus zairense	Orthoebolavirus zairense
Filoviridae	Filoviral diseases Marburg	Marburg virus disease	High	Orthomarburgvirus marburgense	
Filoviridae			High	Orthoebolavirus sudanense	
Flaviviridae	Zika virus	Zika virus	High	Orthoflavivirus zikaense	Orthoflavivirus zikaense
Flaviviridae			High	Orthoflavivirus denguei	Orthoflavivirus denguei
Flaviviridae			High	Orthoflavivirus flavi	
Flaviviridae			High		Orthoflavivirus encephalitidis
Flaviviridae			High		Orthoflavivirus nilense
Hantaviridae			High	Orthohantavirus sinnombreense	Orthohantavirus sinnombreense
Hantaviridae			High	Orthohantavirus hantanense	
Hepadnaviridae			Low		Orthohepadnavirus hominoidei genotype C
Hepeviridae			Low		Paslahepevirus balayani genotype 3
Herpesviridae			Low		
Nairoviridae	Crimean Congo Haemorrhagic Fever	Crimean Congo Haemorrhagic Fever	High	Orthonairovirus haemorrhagiae	Orthonairovirus haemorrhagiae
Orthomyxoviridae			High	Alphainfluenzavirus Influenzae H1	Alphainfluenzavirus Influenzae H1
Orthomyxoviridae			High	Alphainfluenzavirus Influenzae H2	
Orthomyxoviridae			High	Alphainfluenzavirus Influenzae H3	
Orthomyxoviridae			High	Alphainfluenzavirus Influenzae H5	Alphainfluenzavirus Influenzae H5
Orthomyxoviridae			High	Alphainfluenzavirus Influenzae H6	
Orthomyxoviridae			High	Alphainfluenzavirus Influenzae H7	
Orthomyxoviridae			High	Alphainfluenzavirus Influenzae H10	
Papillomaviridae			Low		
Paramyxoviridae	Nipah and related henipaviral diseases	Nipah and henipaviral diseases	High	Henipavirus nipahense	Henipavirus nipahense
Parvoviridae			Low		Protoparvovirus carnivoran
Peribunyaviridae			Low		Orthobunyavirus oropoucheense
Phenuiviridae	Severe Fever with Thrombocytopenia Syndrome		High	Bandavirus dabieense	Bandavirus dabieense
Phenuiviridae	Rift Valley Fever	Rift Valley Fever	High		Phlebovirus riftense
Picobirnaviridae			Low		Orthopicobirnavirus hominis
Picornaviridae			Medium	Enterovirus coxsackiepol	
Picornaviridae			Medium		Enterovirus alphacoxsackie 71
Picornaviridae			Medium		Enterovirus deconjucti 68
Pneumoviridae			Low-Medium		Metapneumovirus hominis
Polyomaviridae			Low		
Poxviridae			High	Orthopoxvirus variola	
Poxviridae			High		Orthopoxvirus vaccinia
Poxviridae			High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypox
Retroviridae			Medium	Lentivirus humimdef1	Lentivirus humimdef1
Rhabdoviridae			Low		Genus Vesiculovirus
Sedoreoviridae			Low		Genus Rotavirus
Spinareoviridae			Low		Orthoreovirus mammalis
Togaviridae			High	Alphavirus chikungunya	Alphavirus chikungunya
Togaviridae			High	Alphavirus venezuelan	Alphavirus venezuelan
Pathogen X	Pathogen X	Pathogen X		Pathogen X	

[4] https://www.who.int/activities/prioritizing-diseases-for-research-and-development-in-emergency-contexts

Identifying priorities using the Pathogen Family approach

Independent Family Expert Groups (FEGs) examined the evidence and reviewed individual Families and pathogens, and the scientific knowledge gaps that need to be addressed

Starting in late 2022, over 200 scientists from 54 countries evaluated the evidence related to 28 Viral Families and one core group of Bacteria, encompassing 1,652 pathogens (Annex 1). The overall aim of FEGs was to assemble and debate the current knowledge that would provide the foundation for the Families and Pathogens selection and prioritization.

Family Expert Groups (FEGs) methodology.

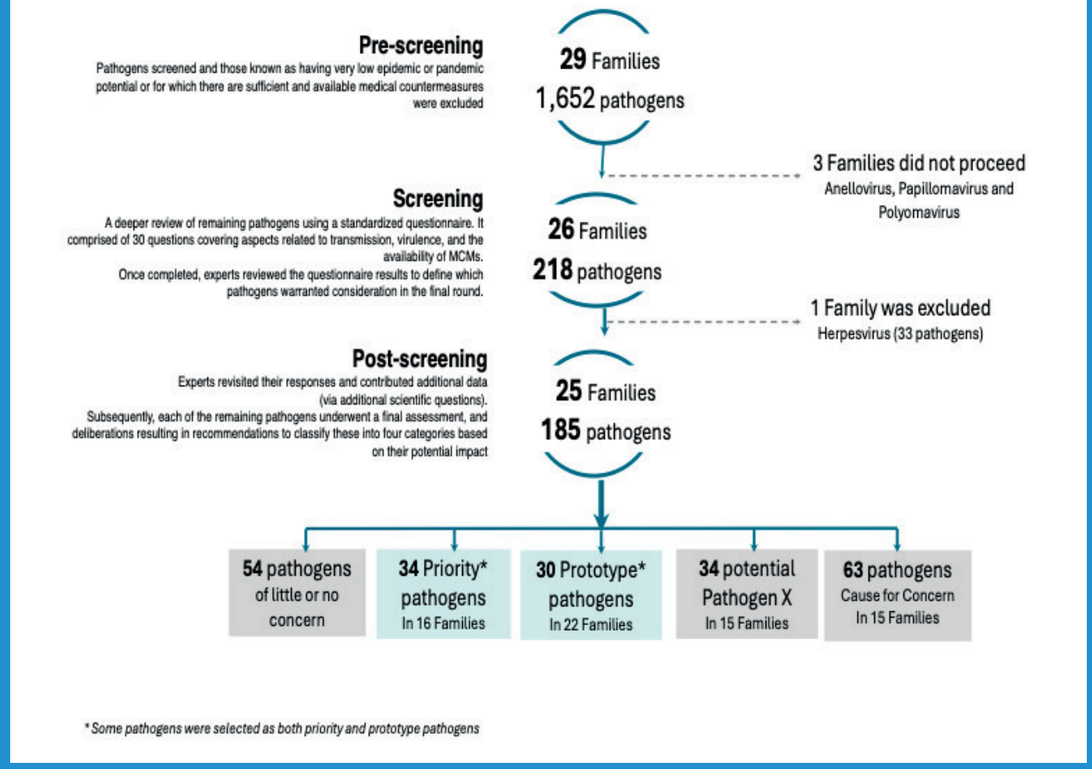
Thousands of known viruses and bacteria can infect humans, but only a relatively small number have caused pandemics or large-scale epidemics in history. Much of the information required for decision-making on many pathogens is either unavailable, not documented in the literature, or not conducive to systematic review. The specific number of pathogens to consider can change over time as our comprehension of infectious diseases expands and as new pathogens emerge or known ones evolve.

Family Expert Groups (FEGs) were established for 28 viral families and one for bacteria. The expectation was that there would be enough common ground within each FEG to allow consensus to emerge and to provide a basis for defining the risks associated with the various pathogens in each family and for selecting priority pathogens, prototype pathogens, and potential Pathogen X.

The aim was to foster a consensus development process that was transparent and well-documented. The recognized Delphi method was used, starting with participants giving independent answers to a series of questions, and then receiving anonymized feedback in the form of frequency distributions of pre-coded answers and free-text comments from the rest of the group. Our process followed this by at least one meeting (often two or more) to discuss and conclude on consensus recommendations. This process has the advantage of providing within each FEG: a) some limits on the influence of groupthink and context for dominating views; b) an indication of how many experts felt the available knowledge made them able to answer each question; and c) an indication of the extent of consensus.

Potential chairpersons for each group were contacted by the WHO Secretariat, from a pool of global experts for each family. Each chairperson was invited to contribute to identifying the expertise needed for each FEG. Potential experts that matched those knowledge needs were approached by the WHO Secretariat, based primarily on their scientific expertise, but also aiming to achieve overall balance in terms of gender and representativeness of all world regions. To facilitate the latter, the meetings of the FEGs were all conducted online. Experts signed Declarations of Conflict of Interest and Confidentiality Disclosure Agreements as per WHO guidelines.

Figure 1. Overview of the prioritization process within each of the FEGs



A review of the International Committee on Taxonomy of Viruses list[5] (2022) helped create an initial comprehensive list of viral families containing pathogens that can infect humans and have the potential to cause outbreaks.

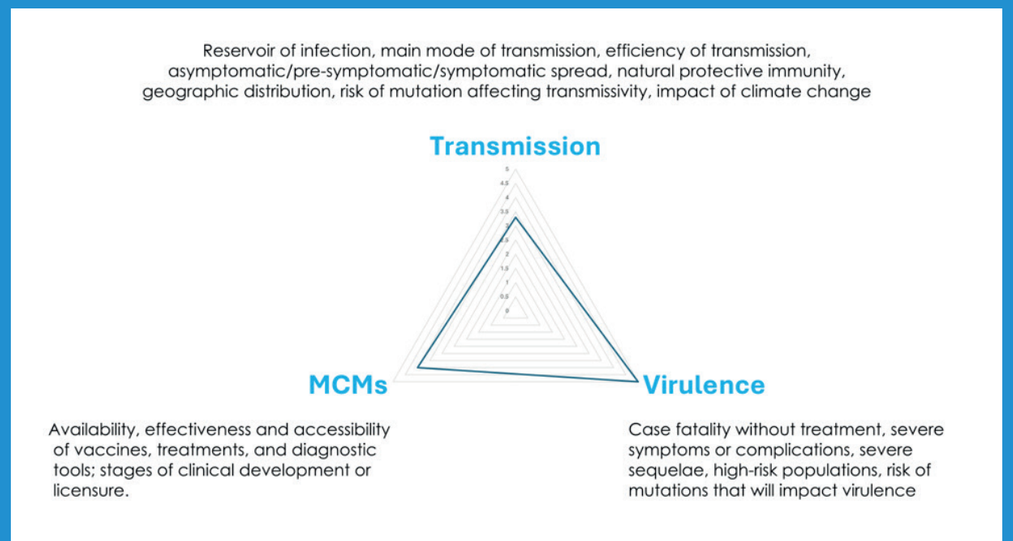
At their first meeting experts within each FEG, experts reviewed the initial list of pathogens in their family and eliminated those considered (based on current knowledge) to have very low or no epidemic or pandemic potential. They noted the reasons for their elimination. The bacterial FEG also compiled a list of bacterial pathogens considered to have PHEIC or pandemic potential (Figure 1).

After this step, each member of every FEG independently completed an online questionnaire for each pathogen on the agreed list. The questionnaire was tested with the assistance of a dozen global experts, and the final version incorporated the feedback received.

The first section of the questionnaire included technical questions that assessed current knowledge (Figure 2).

[5] International Committee on Taxonomy of Viruses: ICTV https://ictv.global/

Figure 2. Evidence elements considered to assess a pathogen's potential to cause a PHEIC or pandemic



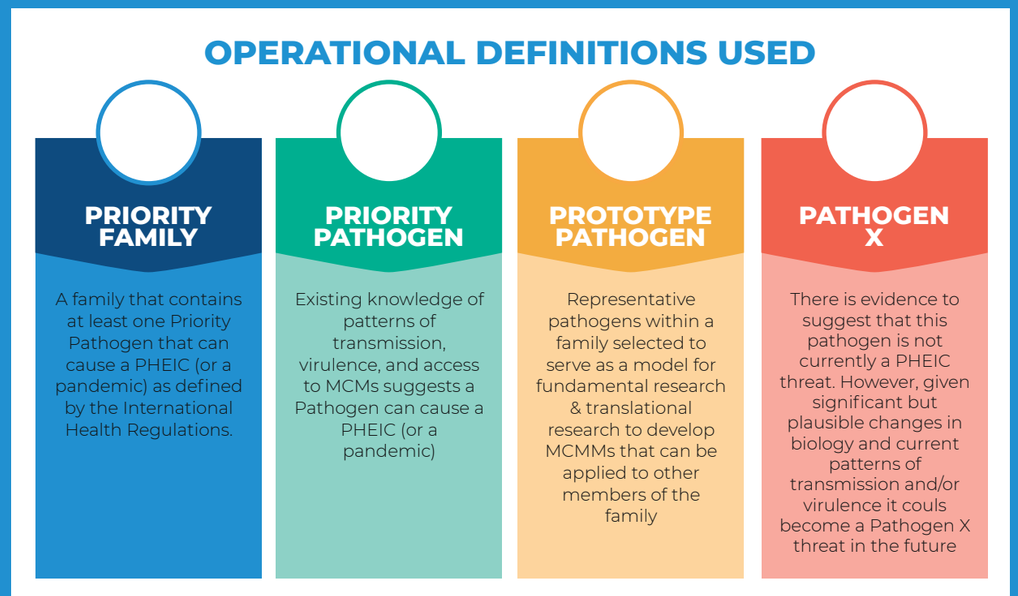
The second section necessitated expert adjudication, soliciting comprehensive evaluations to determine whether each pathogen warranted inclusion in either of two categories: (i) if there existed substantial evidence indicating its high transmissibility and virulence, capable of triggering a PHEIC or a pandemic if left unchecked, and (ii) if available evidence was inadequate to support classification under (i), but sufficient to raise concerns and potentially qualify as Pathogen X (refer to operational definition provided below).

In each Functional Expert Group (FEG), participants received individual anonymized feedback on their group outcomes. Subsequently, a deliberation session was held, allowing members the option to amend their initial responses. Upon the conclusion of this revision phase, the WHO Secretariat reviewed each survey for comprehensiveness and to document any open-ended remarks. The surveys were then finalized to prevent any further modifications. In certain groups, there was an additional opportunity for deliberation on the potential exclusion of certain pathogens that were determined to pose no significant threats upon further evaluation. Following this, participants in each FEG completed a post-screening survey for each remaining pathogen, which encompassed supplementary inquiries and an expanded evaluation segment.

Each participant was requested to furnish a risk assessment for each pathogen, taking into account the probability of triggering a PHEIC or a pandemic, by evaluating its transmission capabilities, virulence, and the accessibility of MCMs. A rating ranging from 1 to 5 (indicating very low to very high risk) or "insufficient data" to render a judgment was employed.

Subsequently, members of the FEG were inquired about their inclination to endorse each pathogen for any of the listed below (see Figure 3), utilizing the provided definitions aimed at enhancing uniformity within and across FEGs.

Figure 3. Operational definitions used[6]



In addition, some pathogens were designated as Cause for Concern. These pathogens are characterized by limited existing knowledge of transmission, virulence, and MCMs, which prevents them from being categorized elsewhere. However, current understanding gives cause for concern, nonetheless.

During the FEGs' final meetings, reports prepared by the WHO Secretariat on the responses to the questionnaires and used to debate the risk assessments, and the listings by individual group members were discussed. Each FEG provided recommendations regarding which pathogens should be categorized.

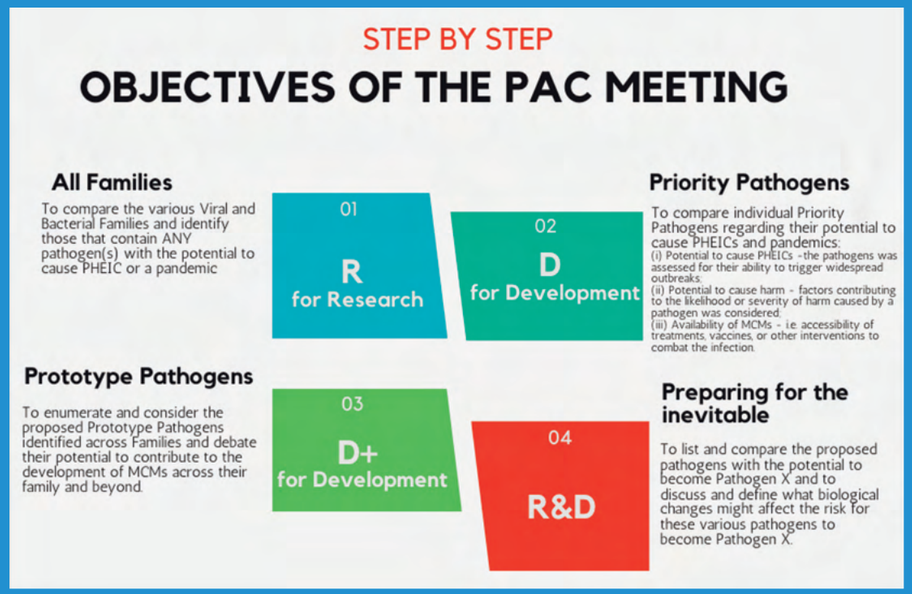
These recommendations laid the groundwork for the final discussions of the overarching Prioritization Advisory Committee (PAC) when all FEGs were joined by additional experts to conclude the results of the prioritization process.

[6] PHEIC as defined in the International Health Regulations. https://www.who.int/news-room/questions-and-answers/item/emergencies-international-health-regulations-and-emergency-committees#

The Prioritization Advisory Committee (PAC) took a broad view across all Families and pathogens and outlined priority research to accelerate the development and evaluation challenges of medical countermeasures

The meeting of the PAC in 2024 served as the culmination of the process initiated in late 2022. It provided an opportunity to share the outcomes across various viral and bacterial families and finalize the prioritization process (Figure 4).

Figure 4. Objectives of the PAC deliberations



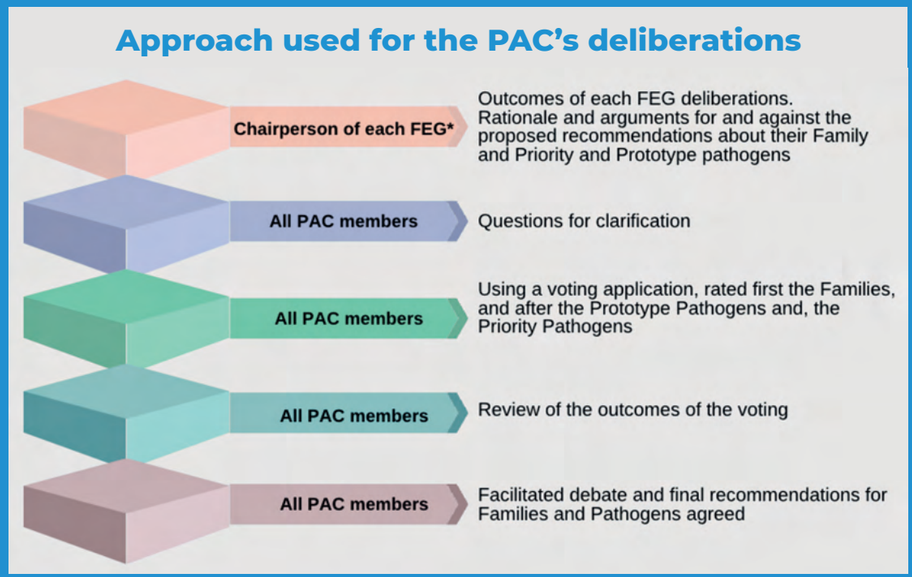
On day 1, the meeting welcomed a diverse group of participants, including the Chairpersons of each of the FEG (or their delegates) and additional experts in research and development and public health. Observers included representatives from R&D funders, experts, and emergency response focal points from WHO's regional and global levels.

Deliberations were structured using strategic presentations from invited experts. The rationale behind adopting a family approach and the importance of fundamental research across all families set the stage. Guest speakers showcased notable advancements, tools, and innovative approaches in basic research during keynote presentations, covering early R&D and R&D, to clinical research.

Day 1 also included the review of the outcomes of initial prioritization across the 29 families and the 185 pathogens from the post-screening round (Figure 1). The ISARIC (International Severe Acute Respiratory and Emerging Infection Consortium) team independently analyzed the responses from each FEG member across the different families and presented a summary of preliminary results (https://blueprint-who-isaric-x36.replit.app/ using the following password: Wh0_Blu3Pr1nT!).

The ISARIC analysis of the FEG members' responses to questionnaires and outcomes also uncovered a small list of pathogens with similar scores from the experts' answers in the categories of Family risk and Priority Pathogens but which were not included in the FEGs recommendations. Those pathogens were considered again on Day 2.

Figure 5. The approach used for the deliberations of the PAC



It was planned that the final recommendations would be informed by the recommendations of each individual FEG but adjusted once a final review of all families by the PAC members takes place.

On Day 2, deliberations delved deeper into the review process. The Prioritization Advisory Committee discussions were led by the FEGs Chairpersons (Figure 5).

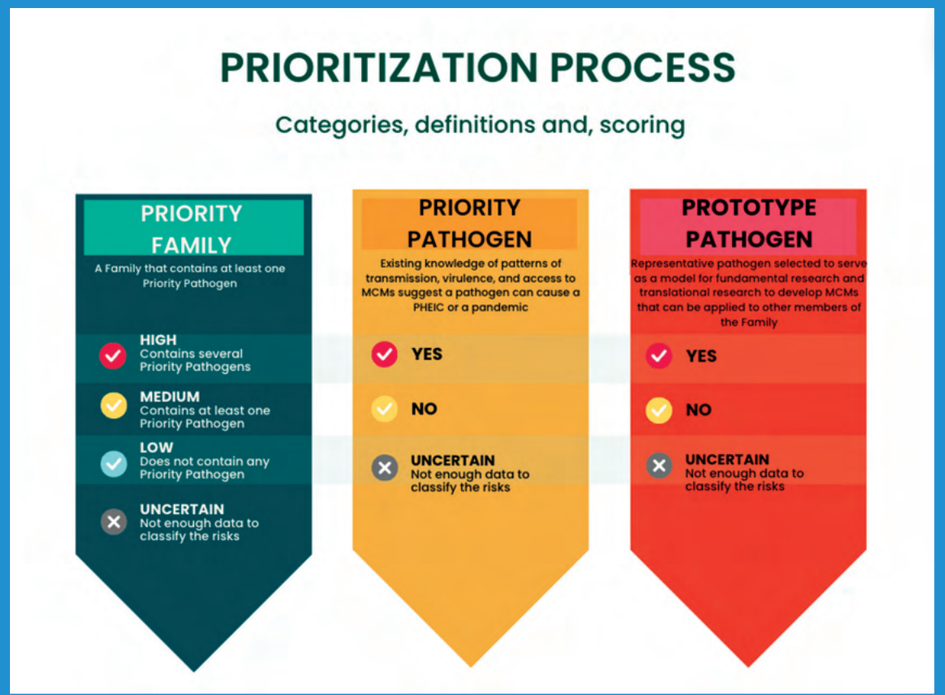
Despite facing challenges such as evidence gaps in surveillance, serology, transmission, virulence, and zoonotic infections, the consistency of the results across the various FEGs underscored the validity of the methodology. Addressing these knowledge gaps is crucial for advancing the development of MCMs and delineating actions required for each family regarding basic research, surveillance, diagnostics, vaccine development, and antivirals.

PAC members welcomed the regional analyses and emphasized the varying relevance of identifying important families and Priority Pathogens across different Regions. Contextualizing research efforts in each Region promotes equity and fosters multidisciplinary collaborations, particularly in "at-risk" countries. This collaborative approach is the swift integration of research into future epidemic responses, supported by global networks of designated researchers.

PAC members were asked to consider strategic research priorities that have broad applicability across diverse regions, as well as to outline those that are critical for specific regions. Furthermore, experts utilized the identified knowledge gaps to create a comprehensive list of research priorities aimed at addressing broader public health concerns and advancing the development of MCMs.

Figure 6 illustrates the criteria used to guide the deliberations of the PAC members while preparing the final list of Families, and Priority and Prototype pathogens. The deliberations also considered what biological changes can trigger a pathogen to become Pathogen X.

Figure 6. Prioritization categories, definitions, and levels



R for RESEARCH for all Families

The priority of families was evaluated with consideration given to the pathogens they encompass. Figure presented below depicts the viral and bacterial families that were analyzed, along with the results of deliberations by the PAC members. Overall, the PAC members reviewed and discussed evidence from eight DNA virus families, nineteen RNA virus families, and five bacterial families.

Families were classified based on their capacity to harbour priority pathogens capable of causing a PHEIC or a pandemic. Of significance, four families were previously categorized as low risk by their respective FEG (Anelloviridae, Papillomaviridae, Polyomaviridae, and Herpesviridae), and they were reaffirmed as low risk during the PAC deliberations.

Figure 7. Families considered by the PAC and overview of the outcomes of the risk of PHEIC assessment

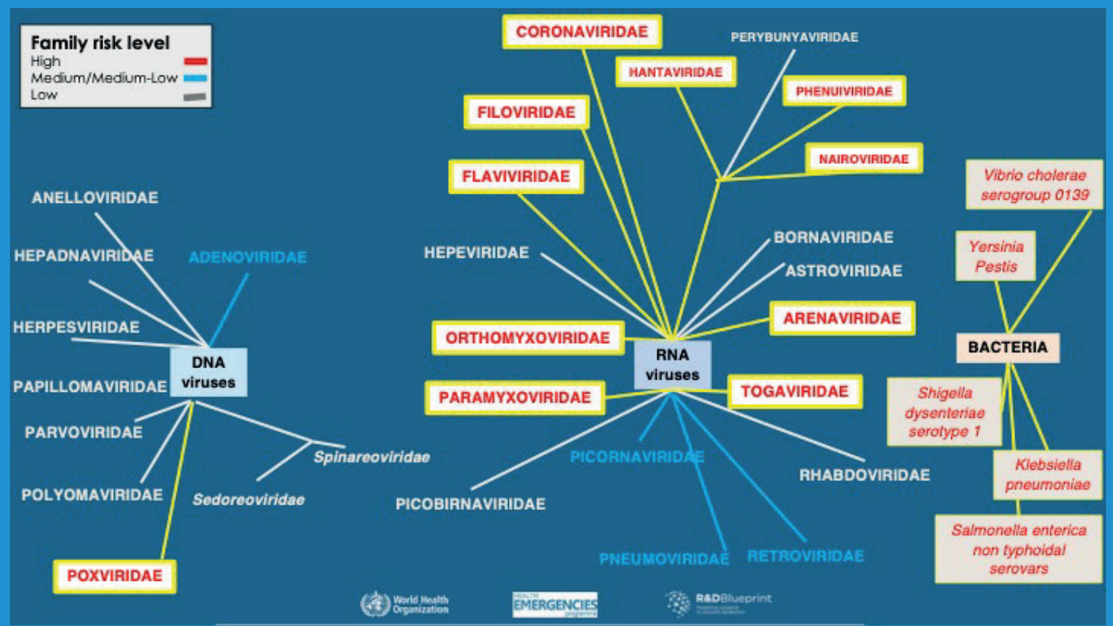


Table 2 presents a summary of the conclusions concerning the PHEIC risks associated with pathogens in specific families. It also outlines the concerns raised by members of the PAC during discussions on the risks posed by pathogens in different families.

It is crucial to emphasize the need for regular examination of evidence to evaluate whether families previously deemed of minimal or no risk (due to the absence of known human-infecting pathogens) could serve as a potential reservoir for pathogen X (as discussed in the PAC meeting, including arteriviridae, Deltaarterivirus hemfev, etc.).

Table 2. Outcomes of the PAC considerations on the risks of various Families

Family	PHEIC risk	PHEIC or pandemic risk notes on pathogens in each Family
Adenoviridae	Low to Medium	Respiratory transmission for some viruses suggests greater than low risk, but no priority pathogen was selected. Adenovirus can cause outbreaks in military recruits, and other settings. Capability for recombination can increase tropism/host range.
Anelloviridae	Low	No known human or mammalian disease. Considered to be low pathogenic or pandemic potential.
Arenaviridae	High	Some viruses have documented high pathogenicity and transmissibility via rodent vectors, some human-human transmission.
Astroviridae	Low	All viruses have low risk of transmission and relatively low virulence (though some possible risk to immunocompromised).
Bacteria	High	Highly pathogenic bacteria with high level enteric or respiratory spread have caused and will cause severe outbreaks.
Bornaviridae	Low	High genetic stability, fatal encephalitis, no evidence of human-to-human transmission.
Coronaviridae	High	Includes viruses with known risk to cause of pandemics, with multiple pandemic threats in family.
Filoviridae	High	Includes viruses which are highly pathogenic, history of devastating regional outbreaks.
Flaviviridae	High	Include multiple insect-vectored pathogenic and virulent viruses.
Hantaviridae	High	Includes multiple viruses with high virulence.
Hepadnaviridae	Low	Existing vaccine protects against current Orthohepadnavirus hominoidei strains.
Hepeviridae	Low	Virulence and pathogenicity for included viruses generally considered low but some viruses have large numbers of animal reservoirs.
Herpesviridae	Low	Herpesviridae has a low PHEIC or pandemic potential, though they cause very important diseases, latent infections and long-term consequences.
Nairoviridae	High	Several viruses with high virulence & broad geographic distribution.
Orthomyxoviridae	High	New alphainfluenza influenzae strains can evolve quickly and pose high PHEIC and pandemic risk.
Papillomaviridae	Low	Includes viruses with low PHEIC and pandemic risk (transmission by direct contact). Risks tend to be species-specific and MCMs are available.
Paramyxoviridae	High	Includes an important priority pathogen.
Parvoviridae	Low	Includes pathogenic members, some with evidence of species jumps, but low risk for human pandemics and PHEICs.
Peribunyaviridae	Low	Include viruses with lower virulence than other families in the class Bunyaviricetes.
Phenuiviridae	High	Includes multiple pathogens with high virulence.
Picobirnaviridae	Low	Pathogenicity in mammals including humans is unclear.
Picornaviridae	Medium	Includes an important priority pathogen (though vaccine-controllable).
Pneumoviridae	Low to Medium	Respiratory transmission of some viruses suggests higher than low priority, existing orthopnemovirus hominis vaccine.
Polyomaviridae	Low	No pandemic or PHEIC risk identified.
Poxviridae	High	Orthopoxvirus monkeypox caused previous PHEIC.
Retroviridae	Medium	Lentivirus humimdef1 caused global pandemic. Delayed but devastating symptoms, ability to jump species contribute to threat. Antivirals are effective. There is no vaccine.
Rhabdoviridae	Low	Includes viruses with high pathogenicity but relatively low transmissibility.
Sedoreoviridae	Low	High global immunity to genus rotavirus makes it an unlikely PHEIC or pandemic pathogen.
Spinareoviridae	Low	Spinareoviruses have a broad host range, infecting animals, fungi and plants, but have low pandemic potential.
Togaviridae	High	Includes several viruses that cause severe disease and with PHEIC and pandemic concern. Overall seropositivity rates not known.

The deliberations also identified key research actions that should be supported across all Families considered[7].

Figure 8. Overview of priority research actions

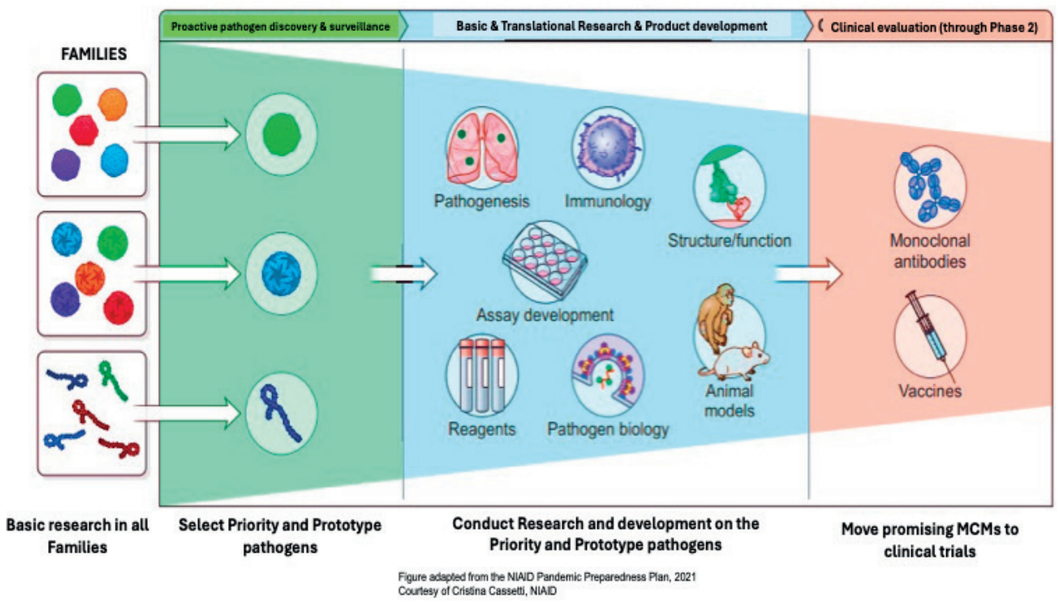


Figure adapted from the NIAID Pandemic Preparedness Plan, 2021
Courtesy of Cristina Cassetti, NIAID

Proactive Pathogen Discovery & Surveillance

Efforts should be directed toward improving the detection, monitoring, and response to infectious disease outbreaks through the utilization of various data streams and advanced technologies.

It is essential to promptly detect and characterize new pathogens that have the potential to cause pandemics. Adopting a One Health approach, which acknowledges the interconnection of human, animal, and environmental health in surveillance and response endeavors, holds significant importance. The significance and utility of monitoring migrating birds and wastewater were acknowledged. Particularly, monitoring activities at interfaces between humans and animals (e.g., slaughterhouses, etc.) entail enhancing genomic sequencing capacities, creating comprehensive diagnostic tools, and strengthening worldwide surveillance systems for emerging infectious diseases.

Efforts aimed at broadening viral surveillance and pathogen discovery networks are multifaceted, encompassing the incorporation of advanced genomic technologies, digital disease detection tools, and sophisticated risk modeling approaches. This encompasses the surveillance of zoonotic diseases and antimicrobial resistance.

[7] **A scientific framework for epidemic and pandemic research preparedness. https://cdn.who.int/media/docs/default-source/consultation-rdb/who-report-scientific-approach-pandemic-preparedness.pdf?sfvrsn=1f209cb3_4**

Targeted basic research

It is essential to investigate the basic biology, transmission, and pathogenesis of high-risk viral families, prioritizing priority and prototype pathogens. Additional important requirements involve the creation of suitable animal models, validated assays, reference materials, and adjuvants to expedite the development and assessment of countermeasures. The comprehension of viral structures, infection mechanisms, immune responses, and host interactions is crucial in informing the development of medical interventions.

Translational research and product development

It is essential to narrow the gap between fundamental scientific discoveries and their practical applications in the field of public health. Efforts should include a focus on developing broad-spectrum antiviral drugs that can be readily deployed during an outbreak. Additionally, the creation of vaccines using a prototype pathogen approach entails developing MCMs for representative viruses within a viral family. Such research could facilitate the development of MCMs with a broader spectrum, capable of addressing multiple pathogens or evolving pathogens.

Furthermore, there is a necessity for further research on host-directed antivirals that target human proteins vital for the viral life cycle, which can potentially provide broad-spectrum activity against multiple viruses; evaluate diverse vaccine platforms to ensure rapid adaptability to new pathogens; rapid development and deployment of monoclonal antibodies for immediate response to emerging pathogens; and point-of-care diagnostics.

Establishing robust clinical trial capabilities and deployment strategies

The prompt initiation of clinical trials is essential for the prompt evaluation and distribution of new medical countermeasures during an outbreak. This involves simplifying trial design and establishing public confidence in the evidence generated. Efforts to streamline trial design, such as the creation of CORE clinical trial designs capable of swift adaptation to evaluate novel treatments and vaccines in the event of an outbreak, are crucial. Simplified regulatory processes could facilitate the rapid authorization of new vaccines, treatments, and diagnostic tools in times of pandemics. This involves the advance approval of CORE protocols and the promotion of cooperation between international ethics committees and regulatory bodies.

Collaborative research

In employing a multifaceted research strategy is crucial to ensure equitable global access and sustain adequate manufacturing capacity. It is essential to emphasize the significance of global networks and capacity enhancement through collaborative efforts. Collaborative research that encompasses pathogen discovery, basic and translational research, product development, clinical assessment, and worldwide coordination is imperative to bolster preparedness for Pathogen X and potential future pandemics. Additionally, the establishment of networks of networks and the sharing of data play pivotal roles in this context.

D for DEVELOPMENT of MCMs against known threats

The risk of Priority Pathogens causing a PHEIC was determined by considering available information on transmission patterns, virulence, and availability of countermeasures, indicating the potential threat.

In the initial prioritization process, no priority pathogens were identified for four viral families, all of which belong to DNA viruses: Anelloviridae, Herpesviridae, Polyomaviridae, and Papillomaviridae.

Priority pathogens with a high potential to cause a PHEIC necessitate immediate research and development interventions (refer to Table 3). The majority of the newly identified Priority Pathogens align with those identified in previous pathogen prioritization reports issued by the WHO R&D Blueprint for Epidemics.

Table 4 presents a summary of the conclusions concerning the PHEIC risks associated with the chosen Priority Pathogens and the concerns raised by PAC members during discussions on the risks posed by pathogens within different Families. Annexes 2 and 3 offer a comprehensive outline of the principal epidemiological features of the selected Priority Pathogens and the potential vaccines and therapies currently in progress.

Among the selected Priority Pathogens some exhibit a global distribution, being present in all six WHO Regions, while others are concentrated in specific regions, often associated with the presence of an animal reservoir, transmitting vector, or substandard living conditions.

Pathogens with worldwide distribution encompass viruses (such as Subgenus Sarbecovirus, Alphainfluenzavirus influenzae, Lentivirus humimdef1, and Orthoflavivirus denguei) and bacteria (such as *Salmonella enterica invasive non-typhoidal serovars* and *Klebsiella pneumoniae*).

Moreover, several prototype pathogens belonging to lower-risk viral families are present in all six regions, such as Metapneumovirus hominis and Rotavirus. Further information can be found in the section titled Global and Regional Perspective.

Table 3. Selected Priority pathogens by family and known geographic distribution

Family	Priority Pathogen	AFR	AMR	EMR	EUR	SEAR	WPR
Adenoviridae	No Priority pathogen proposed						
Anelloviridae	No Priority pathogen proposed						
Arenaviridae	Mammarenavirus lassaense	X					
Astroviridae	No Priority pathogen proposed						
Bacteria	Vibrio cholera (O139)	X		X		X	X
Bacteria	Yersinia pestis	X	X				
Bacteria	Shigella dysenteriae serotype 1	X		X		X	
Bacteria	Salmonella enterica non typhoidal serovars	X	X	X	X	X	X
Bacteria	Klebsiella pneumoniae	X	X	X	X	X	X
Bornaviridae	No Priority pathogen proposed						
Coronaviridae	Subgenus Merbecovirus			X			
Coronaviridae	Subgenus Sarbecovirus	X	X	X	X	X	X
Filoviridae	Orthoebolavirus zairense	X					
Filoviridae	Orthoebolavirus sudanens	X		X			
Filoviridae	Orthomarburgvirus marburgense	X					
Flaviviridae	Orthoflavivirus flavi	X	X				
Flaviviridae	Orthoflavivirus denguei	X	X	X	X	X	X
Flaviviridae	Orthoflavivirus zikaense	X	X			X	X
Hantaviridae	Orthohantavirus hantanense				X		X
Hantaviridae	Orthohantavirus sinnombreense		X				
Hepadnaviridae	No Priority pathogen proposed						
Hepeviridae	No Priority pathogen proposed						
Herpesviridae	No Priority pathogen proposed						
Nairoviridae	Orthonairovirus haemorrhagiae	X		X	X		X
Orthomyxoviridae	Alphainfluenzavirus influenzae H1, H2, H3, H5, H6, H7, H10	X	X	X	X	X	X
Papillomaviridae	No Priority pathogen proposed						
Paramyxoviridae	Henipavirus nipahense					X	X
Parvoviridae	No Priority pathogen proposed						
Peribunyaviridae	No Priority pathogen proposed						
Phenuiviridae	Bandavirus dabieense					X	X
Picobirnaviridae	No Priority pathogen proposed						
Picornaviridae	Enterovirus coxsackiepol	X		X		X	
Pneumoviridae	No Priority pathogen proposed						
Polyomaviridae	No Priority pathogen proposed						
Poxviridae	Orthopoxvirus variola						
Poxviridae	Orthopoxvirus monkeypox	X	X	X	X	X	X
Retroviridae	Lentivirus humimdef1	X	X	X	X	X	X
Rhabdoviridae	No Priority pathogen proposed						
Sedoreoviridae	No Priority pathogen proposed						
Spinareoviridae	No Priority pathogen proposed						
Togaviridae	Alphavirus chikungunya	X	X			X	X
Togaviridae	Alphavirus venezuelan		X				

Table 4. Selected Priority Pathogens by Family and PAC notes during deliberations

Family	PHEIC risk	Priority Pathogen(s)	Priority Pathogen notes
Adenoviridae	Low to Medium	No Priority pathogen proposed	
Anelloviridae	Low	No Priority pathogen proposed	
Arenaviridae	High	Mammarenavirus lassaense	Currently causes annual outbreaks in West Africa, highest disease burden with broad range of natural reservoir.
Astroviridae	Low	No Priority pathogen proposed	
Bacteria	High	*Vibrio cholera* (O139)	Enteric, concern for new O serogroup (Pandemic risk).
Bacteria	High	*Yersinia pestis*	Respiratory (Pandemic risk).
Bacteria	High	*Shigella disenteriae serotype 1*	Enteric, Shiga toxin, concern for other serotypes (Pandemic risk).
Bacteria	High	*Salmonella enterica* invasive non typhoidal	Enteric (PHEIC risk).
Bacteria	High	*Klebsiella pneumoniae*	MDR is an emerging issue globally, can cause PHEIC.
Bornaviridae	Low	No Priority pathogen proposed	
Coronaviridae	High	Subgenus Sarbecovirus	Beta Subgenus sarbecoviruses considered greatest risk within family.
Coronaviridae	High	Subgenus Merbecovirus	A subgenus of viruses in the genus Betacoronavirus, including the human pathogen Middle East respiratory syndrome–related coronavirus (MERS-CoV).
Filoviridae	High	Orthoebolavirus zairense	No cross-protection among these viruses.
Filoviridae	High	Orthoebolavirus sudanense	Licensed vaccines available for Orthoebolavirus zairense.
Filoviridae	High	Orthomarburgvirus marburgense	A highly virulent disease that causes haemorrhagic fever, with a fatality ratio of up to 88%.
Flaviviridae	High	Orthoflavivirus flavi	Yellow Fever Vaccine available but shortages frequent.
Flaviviridae	High	Orthoflavivirus denguei	Dengue: severe disease due to antibody-dependant enhancement ADE.
Flaviviridae	High	Orthoflavivirus zikaense	Previous PHEIC with congenital disease.
Hantaviridae	High	Orthohantavirus hantanense	Spread from rodents to humans, old and new world Hantavirus has become endemic in many continents, with sporadic cases of person-to-person transmission.
Hantaviridae	High	Orthohantavirus sinnombreense	It is unclear how climate change and demographic shifts, such as the continued migration of people from rural to urban settings, will impact both rodent populations and the potential for transmission to people.
Hepadnaviridae	Low	No Priority pathogen proposed	
Hepeviridae	Low	No Priority pathogen proposed	
Herpesviridae	Low	No Priority pathogen proposed	
Nairoviridae	High	Orthonairovirus haemorrhagiae	Most widespread haemorrhagic fever virus in the world.
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H1N1)	Ability to reassort places all new types as high risk.
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H2Nx)	All proposed priority pathogens also have high virulence.
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H3N2)	All proposed priority pathogens also have high virulence.
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H5Nx)	All proposed priority pathogens also have high virulence.
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H6Nx)	All proposed priority pathogens also have high virulence.
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H7Nx)	All proposed priority pathogens also have high virulence.
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H10Nx)	All proposed priority pathogens also have high virulence.
Paramyxoviridae	High	Henipavirus nipahense	Mid-high transmissivity in animals, high virulence, no MCMs.
Parvoviridae		No Priority Pathogen proposed	
Peribunyaviridae	Low	No Priority pathogen proposed	
Phenuiviridae	High	Bandavirus dabieense	High lethality and known person to person spread.
Picobirnaviridae	Low	No Priority pathogen proposed	
Picornaviridae	Medium	Enterovirus coxsackiepol	Despite vaccines, polio presents continuing PHEIC threat.
Pneumoviridae	Low to Medium	No Priority pathogen proposed	
Polyomaviridae	Low	No Priority pathogen proposed	
Poxviridae	High	Orthopoxvirus variola	As immunity wanes, orthopoxvirus variola has potential to cause pandemic if released.
Poxviridae	High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypox has caused PHEIC.
Retroviridae	Medium	Lentivirus humimdef1	No vaccine available yet.
Rhabdoviridae		No Priority Pathogen proposed	
Sedoreoviridae	Low	No Priority pathogen proposed	
Spinareoviridae	Low	No Priority pathogen proposed	
Togaviridae	High	Alphavirus chikungunya	Aerosol transmission and encephalitis.
Togaviridae	High	Alphavirus venezuelan	Enteric, concern for new O serogroup (Pandemic risk).

D+ for DEVELOPMENT of MCMs for Prototype Pathogens

If a Family was considered to contain pathogens with attributes that suggest the likelihood (even remote) of causing a PHEIC, Prototype Pathogens were identified.
Prototype pathogens were not recommended for bacteria, because of the uniqueness of each priority pathogen (Table 5).

Selecting Prototype Pathogens is challenging due to the breadth and diversity of some viral Families (Table 6). Prototype Pathogens were selected primarily for their potential ability to serve as a guide for generating generalizable evidence and filling knowledge gaps that will facilitate the development of MCMs for other pathogens in the same family or functional group (which may include existing vaccines or countermeasures).

Considerations for Prototype Pathogen selection varied across the FEGs and included their importance as human pathogens, current knowledge of replication and pathogenesis, the existence of animal reservoirs causing cross-species infections, the shared structural and functional properties, the existing research knowledge, for example, the availability of animal models that recapitulate human disease, and the status of countermeasure development.

Where the weight of these considerations was similar among potential Prototype Pathogens, the PAC also considered additional factors: burden and type of disease, existing collaborations, and reagents are likely to speed up work on one pathogen or another.

Additional considerations included the geographic distribution of the pathogen and its perceived local and regional relevance (e.g., old world vs new world), differences in pathogenesis (e.g., insect vectors, intermediate hosts), and biocontainment levels (e.g., Orthopoxvirus vaccinia selected along with Orthopoxvirus monkeypox).

Therefore, multiple prototype pathogens were recommended for some virus families. The main reason for selecting multiple pathogens was the diversity of viruses within the group, such that the study of a single pathogen might not be sufficient to facilitate the development of countermeasures that could be useful for the entire group. For example, in the flavivirus family, additional prototype pathogens were recommended due to differences in vector and viral transmission mechanisms. Such additional representative family members were sometimes instead classified as “viruses of concern”, as in the parvovirus family.

Table 5. Selected Prototype Pathogens by family and known geographic distribution

Family	Perceived Risk	Prototype Pathogen	AFR	AMR	EMR	EUR	SEAR	WPR
Adenoviridae	Low-Medium	Mastadenovirus blackbeardi serotype 14		X				X
Adenoviridae	Low-Medium	Recombinant mastadenovirus	X	X	X	X	X	X
Anelloviridae	Low	No Prototype pathogen proposed						
Arenaviridae	High	Mammarenavirus juninense		X				
Arenaviridae	High	Mammarenavirus lassaense	X					
Arenaviridae	High	Mammarenavirus lujoense	X					
Astroviridae	Low	Mamastrovirus virginiaense	X	X	X	X	X	X
Bacteria	High	No Prototype pathogen proposed						
Bornaviridae	Low	Orthobornavirus bornaense				X		
Coronaviridae	High	Subgenus Merbecovirus			X			
Coronaviridae	High	Subgenus Sarbecovirus	X	X	X	X	X	X
Filoviridae	High	Orthoebolavirus zairense	X					
Flaviviridae	High	Orthoflavivirus denguei	X	X	X	X	X	X
Flaviviridae	High	Orthoflavivirus encephalitidis				X		X
Flaviviridae	High	Orthoflavivirus nilense	X	X	X	X	X	X
Flaviviridae	High	Orthoflavivirus zikaense	X	X			X	X
Hantaviridae	High	Orthohantavirus sinnombreense		X				
Hepadnaviridae	Low	Orthohepadnavirus hominoidei genotype C					X	
Hepeviridae	Low	Paslahepevirus balayani genotype HEV-3	X	X	X	X	X	X
Herpesviridae	Low	No Prototype pathogen proposed						
Nairoviridae	High	Orthonairovirus haemorrhagiae	X		X	X		X
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H1N1)	X	X	X	X	X	X
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H5Nx)	X	X	X	X	X	X
Papillomaviridae	Low	No Prototype pathogen proposed						
Paramyxoviridae	High	Henipavirus nipahense					X	X
Parvoviridae	Low	Protoparvovirus carnivoran	X	X	X	X	X	X
Peribunyaviridae	Low	Orthobunyavirus oropoucheense		X				
Phenuiviridae	High	Bandavirus dabieense					X	X
Phenuiviridae	High	Phlebovirus riftense	X					
Picobirnaviridae	Low	Orthopicobirnavirus hominis	X	X	X	X	X	X
Picornaviridae	Medium	Enterovirus alphacoxsackie 71	X	X	X	X	X	X
Picornaviridae	Medium	Enterovirus deconjucti 68	X	X	X	X	X	X
Pneumoviridae	Low-Medium	Metapneumovirus hominis	X	X	X	X	X	X
Polyomaviridae	Low	No Prototype pathogen proposed						
Poxviridae	High	Orthopoxvirus monkeypox	X	X	X	X	X	X
Poxviridae	High	Orthopoxvirus vaccinia		X	X		X	
Retroviridae	Medium	Lentivirus humimdef1	X	X	X	X	X	X
Rhabdoviridae	Low	Genus Vesiculovirus	X	X	X	X	X	X
Sedoreoviridae	Low	Genus Rotavirus	X	X	X	X	X	X
Spinareoviridae	Low	Orthoreovirus mammalis	X	X	X	X	X	X
Togaviridae	High	Alphavirus chikungunya	X	X			X	X
Togaviridae	High	Alphavirus venezuelan		X				

Table 6. Selected Prototype Pathogens by family and PAC notes during deliberations

Concentrating research efforts on Prototype Pathogens within each virus family is expected to increase synergies and opportunities for collaboration, more efficiently leading to knowledge that can be applied to other pathogens within the same family. Ideally, the development of a vaccine or countermeasure for the recommended prototype pathogens will yield sufficient knowledge to facilitate the development of parallel countermeasures against related viruses.

For antivirals, inhibitors of viral enzymes that are similar within the family may be effective against multiple family members. For vaccines, this knowledge may facilitate understanding of viral antigens likely to induce protective immunity or likely correlates of protection.

Family	Prototype Pathogens	Prototype pathogen notes
Adenoviridae	Recombinant adenovirus	Recombinant adeno needs more definition. No MCMs available. Recombination should also be studied.
Adenoviridae	Mastadenovirus blackbeardi serotype 14	No MCMs available. Recombination should also be studied.
Anelloviridae	No Prototype Pathogens proposed	
Arenaviridae	Mammarenavirus juninense	Old world, several MCMs under development.
Arenaviridae	Mammarenavirus lassaense	New world, treatments available.
Arenaviridae	Mammarenavirus lujoense	80% mortality, in single known outbreak.
Astroviridae	Mamastrovirus virginiaense	Human origin, association with encephalitis, able to propagate in cell culture.
Bacteria	No Prototype Pathogens proposed	Prototypes aren't as meaningful for bacteria.
Bornaviridae	Orthobornavirus bornaense	Spill-over from animal reservoir; fatal encephalitis in humans.
Coronaviridae	Subgenus Merbecovirus	Surveillance should consider animal reservoirs.
Coronaviridae	Subgenus Sarbecovirus	Surveillance should consider animal reservoirs.
Filoviridae	Orthoebolavirus zairense	Concern re different strains and variants of Ebola as a potential threat. Ebola can yield information relevant to MCMs for other viruses.
Flaviviridae	Orthoflavivirus denguei	Flavivirus prototypes chosen to represent different vectors and intermediate hosts - transmitted by Aedes aegypti
Flaviviridae	Orthoflavivirus zikaense	Flavivirus prototypes chosen to represent different vectors and intermediate hosts - transmitted by Aedes mosquitoes
Flaviviridae	Orthoflavivirus nilense	Flavivirus prototypes chosen to represent different vectors and intermediate hosts -
Flaviviridae	Orthoflavivirus encephalitidis	Flavivirus prototypes chosen to represent different vectors and intermediate hosts - tick-
Hantaviridae	Orthohantavirus sinnombreense	Higher lethality with less evidence of person-person spread.
Hepadnaviridae	Orthohepadnavirus hominoidei genotype C	Genotype C has higher mortality, higher mutation rate with reported false negative HBsAg test result and reported lower treatment response.
Hepeviridae	Paslahepevirus balayani genotype HEV-3	Human infections with a large number of animal reservoirs, wide geographic distribution. Foodborne transmission (FAO/WHO considered Paslahepevirus balayani one of the top 3 foodborne viral pathogens). Can cause chronic hepatitis, neurological complications.
Herpesviridae	No Prototype Pathogens proposed	
Nairoviridae	Orthonairovirus haemorrhagiae	Outbreaks occur infrequently, typically infect only very few individuals, and most cases are asymptomatic or mild (e.g. headache, myalgia, joint pain, fever and nausea with vomiting). However, the disease may present with a sudden onset and rapid deterioration to severe haemorrhage, organ shutdown and death (lethality 5–80%.
Orthomyxoviridae	Alphainfluenzavirus influenzae (H1N1),	Human alphainfluenzavirus influenzae.
	Alphainfluenzavirus influenzae (H5Nx),	Avian alphainfluenzavirus influenzae.
Papillomaviridae	No Prototype Pathogens proposed	
Paramyxoviridae	Henipavirus nipahense	Pathogenic in humans without effective MCMs.
Parvoviridae	Protoparvovirus carnivoran	Demonstrated ability to jump species and cause severe animal disease. Animal vaccine exists.
Peribunyaviridae	Orthobunyavirus oropoucheense	Normally not fatal.
Phenuiviridae	Bandavirus dabieense	Causes Severe Fever with Thrombocytopenia Syndrome.
Phenuiviridae	Phlebovirus riftense	Rodent screening plus seroepidemiology in people at risk.
Picobirnaviridae	Human picobirnavirus	No known human disease, likely enteric transmission.
Picornaviridae	Enterovirus deconjucti 68	Causes outbreaks.
Picornaviridae	Enterovirus alphacoxsackie 71	Respiratory transmission and causes paralysis (vaccine available in Asia).
Pneumoviridae	Metapneumovirus hominis	Currently causes important outbreaks in children and adults. RSV evolved from avian metapneumovirus. Key need: antivirals.
Polyomaviridae	No Prototype Pathogens proposed	
Poxviridae	Orthopoxvirus monkeypox	Orthopox monkeypox needed to study pathogenesis. Impossible to work with variola except in special settings.
Poxviridae	Orthopoxvirus vaccinia	Vaccinia provides BSL2 alternative that is cross-protective and likely susceptible to same antivirals.
Retroviridae	Lentivirus humimdef1	Most important human retroviral pathogen, with widespread research programs. Research has already shown benefits for understanding of other viruses.
Rhabdoviridae	Genus Vesiculovirus	Important as vaccine vector and as potential prototype for future vaccines.
Sedoreoviridae	Genus Rotavirus	Genus rotavirus vaccines less effective in LMICs.
Spinareoviridae	Orthoreovirus mammalis	Have long been considered non-pathogenic, although mild respiratory and enteric diseases have occasionally been reported in young animals and children. Recent data have shown that MRVs can cause severe disease.
Togaviridae	Alphavirus chikungunya	Vaccine prototype.
Togaviridae	Alphavirus venezuelan	Vaccine prototype.

R&D - PREPARING FOR THE INEVITABLE

Pathogen X is a term used to denote an unidentified or unspecified pathogen. Unknown pathogens with the potential to induce a PHEIC or pandemics in the future.

It is challenging to predict the specific pathogen that may lead to the next PHEIC or pandemic. While numerous viruses and bacteria capable of infecting humans exist, only a limited subset has historically been responsible for pandemics or widespread epidemics.

Hence, researchers utilize the term to refer to potential infectious pathogens without singling out a specific one. This term symbolizes a theoretical pathogen that could result in significant outbreaks, PHEICs, or pandemics. Pathogen X is envisioned as an unidentified future hazard that could originate from recognized viruses within each viral family or potentially from viruses that are currently unidentified.

The concept of Pathogen X underscores the importance of readiness for an unidentified disease-causing pathogen with the potential to cause a pandemic. Regardless of the preparations undertaken, it is improbable to have a readily available effective vaccine or treatment for a particular pandemic pathogen strain at the onset of the next pandemic.

Hence, the challenge in pandemic preparedness lies in acquiring the essential knowledge to promptly disseminate globally high-quality, cost-effective, and reliable countermeasures.

Utilizing the aforementioned definition, potential Pathogens X was selected for each pathogen family (excluding bacteria) as outlined in Table 7. This selection of potential Pathogen X from each family serves as a resource tool for strategizing necessary research and efforts needed to enhance the understanding developed within the family, thereby effectively addressing spectrum diversity potential threats. arise.

Pre-pandemic readiness should prioritize the advancement of discovery, basic, and translational research. It is essential to underscore the importance of employing generalizable strategies. This will ensure that in the event of identifying Pathogen X, expedited product development and clinical trials can be promptly initiated.

Furthermore, the experts discussed the potential alterations in the pathogen's biology, climate, and that could enable any pathogen to evolve into the next Pathogen X. Of particular significance was the discussion on strategies for monitoring these changes.

Table 7. Some of the proposed Pathogen X and other Pathogens of Concern per Family

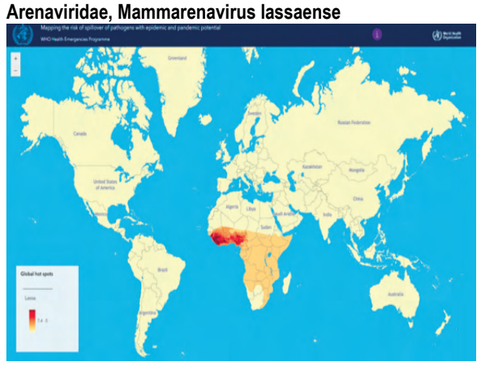
Viral Family	Pathogen X	Other Pathogens of Concern
Adenoviridae	Mastadenovirus blackbeardi 21	10 Mastadenovirus species
Adenoviridae	Mastadenovirus blackbeardi 55	
Adenoviridae	Mastadenovirus blackbeardi 7	
Adenoviridae	Mastadenovirus exoticum	
Arenaviridae	Mammarenavirus chapareense	Mammarenavirus cardamones
Arenaviridae	Mammarenavirus choriomeningitis	Mammarenavirus guanaritoense
Arenaviridae	Mammarenavirus lujoense	
Arenaviridae	Mammarenavirus machupoense	
Astroviridae		Mamastrovirus mustelae
Astroviridae		Mamastrovirus ovis
Astroviridae		Mamastrovirus porcine
Astroviridae		Mamastrovirus virginiaense
Bornaviridae		Orthobornavirus bornaense
Bornaviridae		Orthobornavirus sciuri
Coronaviridae	Alphacoronavirus suis (CCoV-HuPn-2018)	Betacoronavirus gravedinis (PHEV)
Coronaviridae	Alphacoronavirus porci	Recombinant alphacoronavirus
Coronaviridae		Group 2d betacoronaviruses
Coronaviridae		Alphacoronavirus amsterdamense
Coronaviridae		Subgenus Embecovirus
Coronaviridae		Deltacoronavirus (PDCoV)
Filoviridae	Orthoebolavirus bombaliense	Thamnovirus thamnaconi
Filoviridae	Orthoebolavirus X	Cuevavirus lloviuense
Filoviridae	Orthoebolavirus restonense	Dianlovirus menglaense
Filoviridae		Striavirus antennarii
Flaviviridae	Orthoflavivirus japonicum	Orthoflavivirus ilheusense
Flaviviridae	Orthoflavivirus encephalitidis	Orthoflavivirus usutuense
Flaviviridae	Orthoflavivirus nilense	Orthoflavivirus wesselsbronense
Flaviviridae		Jingmenvirus
Flaviviridae		Orthoflavivirus rocio
Flaviviridae		Orthoflavivirus spondweni
Hepadnaviridae	Orthohepadnavirus felisdomestici	Orthohepadnavirus pomi
Hepadnaviridae	Recombinant Orthohepadnavirus	
Hepeviridae		Paslahepevirus balayani (genotype 1)
Hepeviridae		Paslahepevirus balayani (genotype 2)
Hepeviridae		Paslahepevirus balayani (genotype 3)
Hepeviridae		Paslahepevirus balayani (genotype 4)
Orthomyxoviridae	Alphainfluenzavirus influenzae (H9N2)	
Orthomyxoviridae	Betainfluenzavirus influenzae	
Paramyxoviridae	Henipavirus hendraense	Orthorubulavirus mapueraense
Paramyxoviridae		Pararubulavirus menangleense
Paramyxoviridae		Pararubulavirus sosugaense
Paramyxoviridae		*Parahenipavirus* genus
Parvoviridae	Protoparvovirus carnivoran	Amdoparvovirus carnivoran
Parvoviridae		Erythroparvovirus primate
Phenuiviridae	Phlebovirus riftense	Phlebovirus napoliense, Phlebovirus siciliaense, Phlebovirus toscanaense
Picobirnaviridae		Orthopicobirnavirus hominis
Picornaviridae	Enterovirus deconjucti 68	Enterovirus-X
Picornaviridae	Enterovirus alphacoxsackie 71	
Pneumoviridae		Metapneumovirus avis
Pneumoviridae		Metapneumovirus hominis
Pneumoviridae		Novel emerging pneumovirus
Poxviridae	Orthopoxvirus cowpox	Orthopoxvirus alaskapox
Poxviridae		Orthopoxvirus vaccinia
Reovirales		Orthoreovirus mammalis
Retroviridae	Gammaretrovirus gibleu-like viruses in koalas, bats and rodents	Lentivirus humimdef2
Retroviridae	Lentivirus simimdef	Deltaretrovirus priTlym3
Rhabdoviridae		Genus Ledantevirus
Rhabdoviridae		Genus Tibrovirus
Rhabdoviridae		Genus Vesiculovirus
Togaviridae	Alphavirus eastern	Alphavirus onyong
Togaviridae	Alphavirus madariaga	
Togaviridae	Alphavirus mayaro	
Togaviridae	Alphavirus rossriver	

A GLOBAL AND A REGIONAL PERSPECTIVE

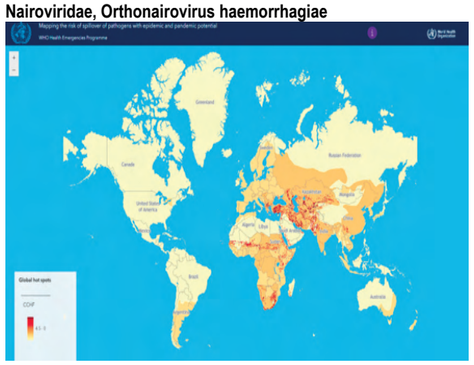
Priorities may differ if a regional perspective is adopted, as many pathogens are limited to, or more of a problem in, particular geographic regions. To stimulate research in each region it is particularly important to have a locally relevant prototype pathogen. For many families, a single prototype pathogen was considered sufficient to cover the entire family. However, for other families, it was considered necessary to select multiple prototype pathogens, if, for example, potential prototype pathogens were confined to certain regions or were transmitted by different vectors.

Figure 9. Geographic distribution of selected Priority Pathogens

Arenaviridae, Mammarenavirus lassaense

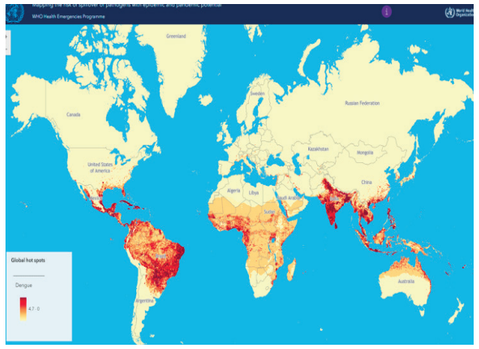


Nairoviridae, Orthonairovirus haemorrhagiae



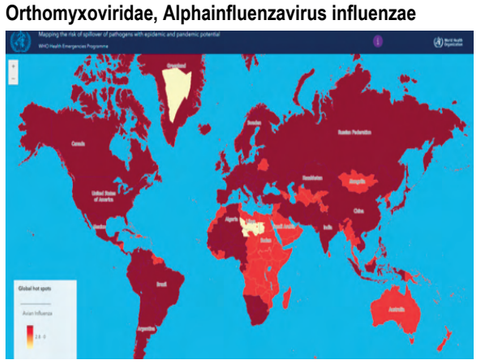
Filoviridae, Orthomarburgvirus marburgense

Flaviviridae, Orthoflavivirus denguei



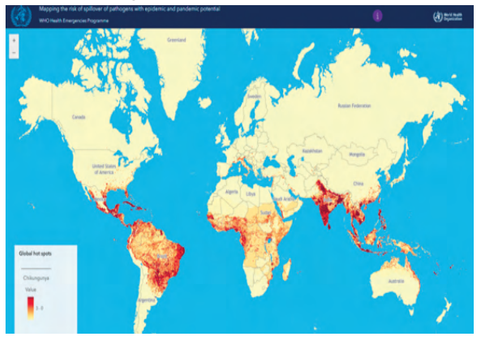
Flaviviridae, Orthoflavivirus zikaense

Orthomyxoviridae, Alphainfluenzavirus influenzae



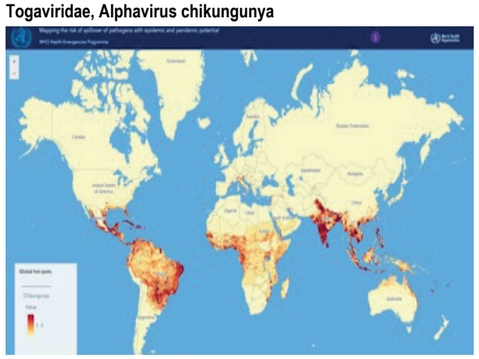
Paramyxoviridae, Henipavirus nipahense

Poxviridae, Orthopoxvirus Variola

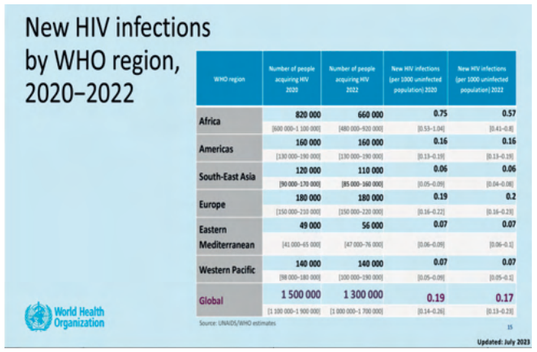


Poxviridae, Orthopoxvirus monkeypox

Togaviridae, Alphavirus chikungunya



Retroviridae, Lentivirus humimdef1



WHO region	Number of people acquiring HIV 2020	Number of people acquiring HIV 2022	New HIV infections (per 1000 uninfected population) 2020	New HIV infections (per 1000 uninfected population) 2022
Africa	820 000 [600 000–1 100 000]	660 000 [480 000–920 000]	0.75 [0.53–1.04]	0.57 [0.41–0.8]
Americas	160 000 [130 000–190 000]	160 000 [130 000–190 000]	0.16 [0.13–0.19]	0.16 [0.13–0.19]
South-East Asia	120 000 [90 000–170 000]	110 000 [85 000–160 000]	0.06 [0.05–0.09]	0.06 [0.04–0.08]
Europe	180 000 [150 000–210 000]	180 000 [150 000–220 000]	0.19 [0.16–0.22]	0.2 [0.16–0.23]
Eastern Mediterranean	49 000 [41 000–65 000]	56 000 [47 000–76 000]	0.07 [0.06–0.09]	0.07 [0.06–0.1]
Western Pacific	140 000 [98 000–180 000]	140 000 [100 000–190 000]	0.07 [0.05–0.09]	0.07 [0.05–0.1]
Global	1 500 000 [1 100 000–1 900 000]	1 300 000 [1 000 000–1 700 000]	0.19 [0.14–0.24]	0.17 [0.13–0.23]

Source: UNAIDS/WHO estimates

African Region

Particular priorities in the African Region include the Filoviruses (Orthoebolavirus zairense, sudanense, and marburgense), Orthopoxvirus monkeypox, and Mammarenavirus lassaense. Others include all three priority Orthoflaviviruses (denguei, encephalitidis, and zikaense), and Alphavirus chikungunya.
Of the global pathogens, Lentivirus humimdef1, has particular significance. All five bacterial priority pathogens are also significant in this Region (Vibrio cholera O139, Yersinia pestis, Shigella dysenteriae serotype 1, Salmonella enterica (invasive non-typhoidal), Klebsiella pneumoniae). The following Prototype Pathogens are specific to the African Region: Mammarenavirus lujoense and the Phlebovirus riftense.

Table 8. Selected Priority Pathogens with circulation in the WHO African Region

Family	PHEIC risk	Priority Pathogens	Prototype Pathogens
Arenaviridae	High	Mammarenavirus lassaense	Mammarenavirus lassaense
Arenaviridae	High		Mammarenavirus lujoense
Bacteria	High	*Klebsiella pneumoniae*	
Bacteria	High	*Salmonella enterica non typhoidal serovars*	
Bacteria	High	*Shigella dysenteriae serotype 1*	
Bacteria	High	*Vibrio cholerae serogroup 0139*	
Bacteria	High	*Yersinia Pestis*	
Coronaviridae	High	*Subgenus* Sarbecovirus	*Subgenus* Sarbecovirus
Filoviridae	High	Orthoebolavirus sudanense	
Filoviridae	High	Orthoebolavirus zairense	Orthoebolavirus zairense
Filoviridae	High	Orthomarburgvirus marburgense	
Flaviviridae	High	Orthoflavivirus denguei	Orthoflavivirus denguei
Flaviviridae	High	Orthoflavivirus flavi	
Flaviviridae	High	Orthoflavivirus zikaense	Orthoflavivirus zikaense
Flaviviridae	High		Orthoflavivirus nilense
Hantaviridae	High		
Nairoviridae	High	Orthonairovirus haemorrhagiae	Orthonairovirus haemorrhagiae
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H1	Alphainfluenzavirus Influenzae H1
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H2	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H3	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H5	Alphainfluenzavirus Influenzae H5
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H6	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H7	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H10	
Paramyxoviridae	High		
Phenuiviridae	High		Phlebovirus riftense
Poxviridae	High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypox
Togaviridae	High	Alphavirus chikungunya	Alphavirus chikungunya
Picornaviridae	Medium	Enterovirus coxsackiepol	
Picornaviridae	Medium		Enterovirus alphacoxsackie 71
Picornaviridae	Medium		Enterovirus deconjucti 68
Retroviridae	Medium	Lentivirus humimdef1	Lentivirus humimdef1
Adenoviridae	Low-Medium		Recombinant mastadenovirus
Pneumoviridae	Low-Medium		Metapneumovirus hominis
Anelloviridae	Low		
Astroviridae	Low		Mamastrovirus virginiaense
Bornaviridae	Low		
Hepadnaviridae	Low		
Hepeviridae	Low		Paslahepevirus balayani genotype 3
Herpesviridae	Low		
Papillomaviridae	Low		
Parvoviridae	Low		Protoparvovirus carnivoran
Peribunyaviridae	Low		
Picobirnaviridae	Low		Orthopicobirnavirus hominis
Polyomaviridae	Low		
Rhabdoviridae	Low		Genus Vesiculovirus
Sedoreoviridae	Low		Genus Rotavirus
Spinareoviridae	Low		Orthoreovirus mammalis

Region of the Americas

The priority pathogens specific to the Region of the Americas are Orthohantavirus sinnombrense, and Alphavirus venezuelan. All three priority Orthoflaviviruses (denguei, encephalitidis, and zikaense) are endemic in the Region. The prototype viruses specific to the Region of the Americas are: Mammarenavirus juninense and Orthobunyavirus oropoucheense.

Table 9. Selected Priority Pathogens with circulation in the WHO Americas Region

Family	PHEIC risk	Priority Pathogens	Prototype Pathogens
Arenaviridae	High		Mammarenavirus juninense
Bacteria	High	*Klebsiella pneumoniae*	
Bacteria	High	*Salmonella enterica non typhoidal serovars*	
Bacteria	High	*Yersinia Pestis*	
Coronaviridae	High	*Subgenus* Sarbecovirus	*Subgenus* Sarbecovirus
Filoviridae	High		
Flaviviridae	High	Orthoflavivirus denguei	Orthoflavivirus denguei
Flaviviridae	High	Orthoflavivirus flavi	
Flaviviridae	High	Orthoflavivirus zikaense	Orthoflavivirus zikaense
Flaviviridae	High		Orthoflavivirus encephalitidis
Flaviviridae	High		Orthoflavivirus nilense
Hantaviridae	High	Orthohantavirus sinnombreense	Orthohantavirus sinnombreense
Nairoviridae	High		
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H1	Alphainfluenzavirus Influenzae H1
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H2	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H3	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H5	Alphainfluenzavirus Influenzae H5
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H6	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H7	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H10	
Paramyxoviridae	High		
Phenuiviridae	High		
Poxviridae	High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypox
Poxviridae	High		Orthopoxvirus vaccinia
Togaviridae	High	Alphavirus chikungunya	Alphavirus chikungunya
Togaviridae	High	Alphavirus venezuelan	Alphavirus venezuelan
Picornaviridae	Medium		Enterovirus alphacoxsackie 71
Picornaviridae	Medium		Enterovirus deconjucti 68
Retroviridae	Medium	Lentivirus humimdef1	Lentivirus humimdef1
Adenoviridae	Low-Medium		Mastadenovirus blackbeardi serotype 14
Adenoviridae	Low-Medium		Recombinant mastadenovirus
Pneumoviridae	Low-Medium		Metapneumovirus hominis
Anelloviridae	Low		
Astroviridae	Low		Mamastrovirus virginiaense
Bornaviridae	Low		
Hepadnaviridae	Low		
Hepeviridae	Low		Paslahepevirus balayani genotype 3
Herpesviridae	Low		
Papillomaviridae	Low		
Parvoviridae	Low		Protoparvovirus carnivoran
Peribunyaviridae	Low		Orthobunyavirus oropoucheense
Picobirnaviridae	Low		Orthopicobirnavirus hominis
Polyomaviridae	Low		
Rhabdoviridae	Low		Genus Vesiculovirus
Sedoreoviridae	Low		Genus Rotavirus
Spinareoviridae	Low		Orthoreovirus mammalis

Eastern Mediterranean Region

Subgenus merbecoviruses and enterovirus coxsackiepol are particular priorities in the Eastern Mediterranean Region. Bacterial pathogens are also significant including Vibrio cholera O139 and Shigella dysenteriae serotype 1.

Table 10. Selected Priority Pathogens with circulation in the WHO Eastern Mediterranean Region

Family	PHEIC risk	Priority Pathogens	Prototype Pathogens
Arenaviridae	High		
Bacteria	High	*Klebsiella pneumoniae*	
Bacteria	High	*Salmonella enterica non typhoidal serovars*	
Bacteria	High	*Shigella dysenteriae serotype 1*	
Bacteria	High	*Vibrio cholerae serogroup 0139*	
Coronaviridae	High	*Subgenus* Merbecovirus	*Subgenus* Merbecovirus
Coronaviridae	High	*Subgenus* Sarbecovirus	*Subgenus* Sarbecovirus
Filoviridae	High	Orthoebolavirus sudanense	
Flaviviridae	High	Orthoflavivirus denguei	Orthoflavivirus denguei
Flaviviridae	High		Orthoflavivirus nilense
Hantaviridae	High		
Nairoviridae	High	Orthonairovirus haemorrhagiae	Orthonairovirus haemorrhagiae
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H1	Alphainfluenzavirus Influenzae H1
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H2	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H3	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H5	Alphainfluenzavirus Influenzae H5
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H6	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H7	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H10	
Paramyxoviridae	High		
Phenuiviridae	High		
Poxviridae	High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypox
Poxviridae	High		Orthopoxvirus vaccinia
Togaviridae	High		
Picornaviridae	Medium	Enterovirus coxsackiepol	
Picornaviridae	Medium		Enterovirus alphacoxsackie 71
Picornaviridae	Medium		Enterovirus deconjucti 68
Retroviridae	Medium	Lentivirus humimdef1	Lentivirus humimdef1
Adenoviridae	Low-Medium		Recombinant mastadenovirus
Pneumoviridae	Low-Medium		Metapneumovirus hominis
Anelloviridae	Low		
Astroviridae	Low		Mamastrovirus virginiaense
Bornaviridae	Low		
Hepadnaviridae	Low		
Hepeviridae	Low		Paslahepevirus balayani genotype 3
Herpesviridae	Low		
Papillomaviridae	Low		
Parvoviridae	Low		Protoparvovirus carnivoran
Peribunyaviridae	Low		
Picobirnaviridae	Low		Orthopicobirnavirus hominis
Polyomaviridae	Low		
Rhabdoviridae	Low		Genus Vesiculovirus
Sedoreoviridae	Low		Genus Rotavirus
Spinareoviridae	Low		Orthoreovirus mammalis

European Region

In addition to the priority pathogens with global distribution, Orthonairovirus haemorrhagiae occurs in the European Region. The prototypes Orthoflavivirus encephalitidis and Orthobornavirus bornaense are mostly found in the European Region.

Table 11. Selected Priority Pathogens with circulation in the WHO European Region

Family	PHEIC risk	Priority Pathogens	Prototype Pathogens
Arenaviridae	High		
Bacteria	High	*Klebsiella pneumoniae*	
Bacteria	High	*Salmonella enterica non typhoidal serovars*	
Coronaviridae	High	*Subgenus* Sarbecovirus	*Subgenus* Sarbecovirus
Filoviridae	High		
Flaviviridae	High	Orthoflavivirus denguei	Orthoflavivirus denguei
Flaviviridae	High		Orthoflavivirus encephalitidis
Flaviviridae	High		Orthoflavivirus nilense
Hantaviridae	High	Orthohantavirus hantanense	
Nairoviridae	High	Orthonairovirus haemorrhagiae	Orthonairovirus haemorrhagiae
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H1	Alphainfluenzavirus Influenzae H1
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H2	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H3	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H5	Alphainfluenzavirus Influenzae H5
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H6	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H7	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H10	
Paramyxoviridae	High		
Phenuiviridae	High		
Poxviridae	High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypox
Togaviridae	High		
Picornaviridae	Medium		Enterovirus alphacoxsackie 71
Picornaviridae	Medium		Enterovirus deconjucti 68
Retroviridae	Medium	Lentivirus humimdef1	Lentivirus humimdef1
Adenoviridae	Low-Medium		Recombinant mastadenovirus
Pneumoviridae	Low-Medium		Metapneumovirus hominis
Anelloviridae	Low		
Astroviridae	Low		Mamastrovirus virginiaense
Bornaviridae	Low		Orthobornavirus bornaense
Hepadnaviridae	Low		
Hepeviridae	Low		Paslahepevirus balayani genotype 3
Herpesviridae	Low		
Papillomaviridae	Low		
Parvoviridae	Low		Protoparvovirus carnivoran
Peribunyaviridae	Low		
Picobirnaviridae	Low		Orthopicobirnavirus hominis
Polyomaviridae	Low		
Rhabdoviridae	Low		Genus Vesiculovirus
Sedoreoviridae	Low		Genus Rotavirus
Spinareoviridae	Low		Orthoreovirus mammalis

South-East Asia Region

Bacterial pathogens are priorities in the South-East Asia Region including *Vibrio cholera* O139 and *Shigella dysenteriae serotype 1*. The priority pathogens Henipavirus nipahense and Bandavirus dabieense are endemic in the South-East Asia Region, as are the mosquito-borne Orthoflavivirus denguei and zikaense, and Alphavirus chikungunya. The prototype pathogen Orthohepadnavirus hominoidei genotype C is most common in the South-East Asia Region.

Table 12. Selected Priority Pathogens with circulation in the WHO South East Asia Region

Family	PHEIC risk	Priority Pathogens	Prototype Pathogens
Arenaviridae	High		
Bacteria	High	*Klebsiella pneumoniae*	
Bacteria	High	*Salmonella enterica non typhoidal serovars*	
Bacteria	High	*Shigella dysenteriae serotype 1*	
Bacteria	High	*Vibrio cholerae serogroup 0139*	
Coronaviridae	High	*Subgenus* Sarbecovirus	*Subgenus* Sarbecovirus
Filoviridae	High		
Flaviviridae	High	Orthoflavivirus denguei	Orthoflavivirus denguei
Flaviviridae	High	Orthoflavivirus zikaense	Orthoflavivirus zikaense
Flaviviridae	High		Orthoflavivirus nilense
Hantaviridae	High		
Nairoviridae	High		
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H1	Alphainfluenzavirus Influenzae H1
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H2	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H3	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H5	Alphainfluenzavirus Influenzae H5
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H6	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H7	
Orthomyxoviridae	High	Alphainfluenzavirus Influenzae H10	
Paramyxoviridae	High	Henipavirus nipahense	Henipavirus nipahense
Phenuiviridae	High	Bandavirus dabieense	Bandavirus dabieense
Poxviridae	High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypox
Poxviridae	High		Orthopoxvirus vaccinia
Togaviridae	High	Alphavirus chikungunya	Alphavirus chikungunya
Picornaviridae	Medium	Enterovirus coxsackiepol	
Picornaviridae	Medium		Enterovirus alphacoxsackie 71
Picornaviridae	Medium		Enterovirus deconjucti 68
Retroviridae	Medium	Lentivirus humimdef1	Lentivirus humimdef1
Adenoviridae	Low-Medium		Recombinant mastadenovirus
Pneumoviridae	Low-Medium		Metapneumovirus hominis
Anelloviridae	Low		
Astroviridae	Low		Mamastrovirus virginiaense
Bornaviridae	Low		
Hepadnaviridae	Low		Orthohepadnavirus hominoidei genotype C
Hepeviridae	Low		Paslahepevirus balayani genotype 3
Herpesviridae	Low		
Papillomaviridae	Low		
Parvoviridae	Low		Protoparvovirus carnivoran
Peribunyaviridae	Low		
Picobirnaviridae	Low		Orthopicobirnavirus hominis
Polyomaviridae	Low		
Rhabdoviridae	Low		Genus Vesiculovirus
Sedoreoviridae	Low		Genus Rotavirus
Spinareoviridae	Low		Orthoreovirus mammalis

Western Pacific Region

Influenza and Subgenus sarbecoviruses are a high priority in the Western Pacific region. The priority pathogens henipavirus nipahense, Orthohantavirus hantanense and Bandavirus dabieense are endemic in the Western Pacific Region, as are the mosquito-borne Orthoflavivirus denguei and Alphavirus chikungunya.

Table 13. Selected Priority Pathogens with circulation in the WHO Western Pacific Region

Family	Family Risk	Priority Pathogens	Prototype Pathogens
Arenaviridae	High		
Bacteria	High	*Vibrio cholera* (O139) *Salmonella enterica non typhoidal serovars* *Klebsiella pneumoniae*	
Bunyavirales Nairoviridae	High	Orthonairovirus haemorrhagiae	Orthonairovirus haemorrhagiae
Bunyavirales Bunyavirales Hantaviridae	High	Orthohantavirus hantanense	
Bunyavirales Phenuiviridae	High	Bandavirus dabieense	Bandavirus dabieense
Coronaviridae	High	Subgenus Sarbecoviruses	Subgenus Sarbecoviruses
Filoviridae	High		
Flaviviridae	High	Orthoflavivirus denguei Orthoflavivirus zikaense	Orthoflavivirus denguei Orthoflavivirus zikaense Orthoflavivirus nilense encephalitidis
Orthomyxoviridae	High	Alphainfluenzavirus influenzae (H1N1), Alphainfluenzavirus influenzae (H2Nx), Alphainfluenzavirus influenzae (H3N2), Alphainfluenzavirus influenzae (H5Nx), Alphainfluenzavirus influenzae (H6Nx), Alphainfluenzavirus influenzae (H7Nx), Alphainfluenzavirus influenzae (H10Nx)	Alphainfluenzavirus influenzae (H1N1), Alphainfluenzavirus influenzae (H5Nx),
Paramyxoviridae	High	Henipavirus nipahense Orthopoxvirus vaccinia	Henipavirus nipahense Orthopoxvirus vaccinia
Poxviridae	High	Orthopoxvirus monkeypox	Orthopoxvirus monkeypoxOrthopoxvirus vaccinia
Togaviridae	High	Alphavirus chikungunya	Alphavirus chikungunya
Picornaviridae	Medium	Human polioviruses	Enterovirus D68, (EV-D68) Enterovirus A71 (EV-A71)
Retroviridae	Medium	Human immunodeficiency virus 1 (HIV-1)	Human immunodeficiency virus 1 (HIV-1)
Adenoviridae	Low-Medium		Human mastadenovirus B
Pneumoviridae	Low-Medium		Metapneumovirus hominis
Astroviridae	Low		Mamastrovirus 9 (GII.B-human)
Bornaviridae	Low		
Bunyavirales Peribunyavirus	Low		
Hepdnaviridae	Low		
Hepeviridae	Low		Paslahepevirus balayani, genotype 3
Parvoviridae	Low		Carnivore protoparvoviruses (CPV)
Picobirnaviridae	Low		Human picobirnavirus
Reoviriales *Spinareoviridae* *Sedoreoviridae*	Low		Orthoreovirus mammalis Genus Rotavirus
Rhabdoviridae	Low		Genus Vesiculovirus

KEY GLOBAL COLLABORATIVE RESEARCH ACROSS FAMILIES AND PATHOGENS

The WHO's scientific framework for pandemic preparedness emphasizes a comprehensive approach to research and development[8]. By focusing on entire pathogen families and Priority and Prototype pathogens, the strategy aims to create generalizable knowledge and tools that can be rapidly adapted to emerging threats. This framework underscores the importance of global collaboration, sustained support, and equitable access. Implementing these key research actions will significantly enhance the world's ability to detect, prevent, and respond to potential pandemic threats. Coordinating and accelerating global research must promote universal values. Regarding a collaborative effort to ensure access to MCMs during pandemics, some have emphasized the importance of speed and sometimes cost in responding to future pandemics. It is equally important to take a broader view that recognizes the primary importance of quality, equity in access, and trust in the products' safety and efficacy. As a community, we need to explore the different scientific challenges openly and broadly.

Collaboration, collaboration, collaboration…

Collaborative Open Research Consortium (CORC) for each Priority Pathogen Family

A key action for improving global research collaboration and, advance research preparedness and response to epidemics and pandemics include establishing a CORC for each Family. Each CORC is supported by one or more WHO Collaborative Centers, using an agreed approach and common goals.

Decentralized Approach: the CORCs, distributed globally, will be implemented using a decentralized structure that promotes equitable participation from researchers in high-, middle-, and low-income countries, particularly those from locations where pathogens are known to circulate.

The aims of the CORCs

This Consortia approach aims to leverage scientific advancements and global collaboration to ensure rapid, equitable, and effective research and development. The CORC initiative aims to establish a network of international research consortia focused on priority Families, Priority pathogens and Prototype pathogens. This concept builds on the WHO's scientific framework for pandemic research preparedness and leverages global scientific expertise to enhance our collective ability to detect, prevent, and respond to emerging pathogen threats[9].

A concerted parallel effort to advance research in all priority Families

CORCs aim to promote collaborative approaches to: (i) assess and characterize the diversity of pathogens in each Family, their evolution and potential for zoonotic spill-over events; (ii) promote targeted basic research, and (iii) support the R&D of MCMs. Each CORC will operate in parallel with the others to accelerate the

[8] **https://www.who.int/news-room/events/detail/2024/01/09/default-calendar/a-scientific-framework-for-epidemic-and-pandemic-research-preparedness**

[9] **https://journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1010805**

development of MCMs, while establishing sustainable processes aiming to improve research preparedness and response.

A navigator's approach to guide research efforts

The navigator's approach In the context of R&D for pandemic preparedness this approach entails knowing the destination (equitable access to effective MCMs for epidemic and pandemic response) and the best route to get there (collaborative Research and R&D approaches).

The focus of this objective is on developing comprehensive Roadmaps and TPPs while building the necessary infrastructure for sustained global cooperation in research and development.

Global R&D and Innovation Roadmaps for each Family. These Roadmaps identify the knowledge gaps and research priorities in all areas of pandemic preparedness research, including enabling research. These Roadmaps function as strategic blueprints, regularly updated, guiding crucial research initiatives focused on each identified priority Viral or Bacterial Family. They draw on expertise from scientists and experts across the world. These roadmaps are debated openly and benefit from inputs from various stakeholders.

WHO priority Family-specific Target Product Profile (TPPs) for MCMs. For all Priority Pathogens Families, these TPPs will help to guide research directed toward the development of one or more prototype vaccines, therapeutics and diagnostics. These TPPs will emphasize research needs that may be generalizable both within and outside of a given Family. These Family-specific TPPs are to be distinguished from TPPs that are developed for specific products intended to address individual pathogens. The Family TPPs provide the vital public health specifications and attributes necessary in formulating vaccines, treatments, or diagnostic tests with a generalizability approach in mind.

Preparing for the inevitable.

By prioritizing research on entire Families as opposed to a handful of individual Priority Pathogens, this strategy bolsters the capability to respond efficiently to unforeseen variants, emerging pathogens, zoonotic transmissions, and unknown threats such as 'Pathogen X.'

It also emphasizes the need for prompt identification and characterization of emerging threats, the streamlining of global R&D efforts, via collaborative and efficient research Roadmaps and the integration of research into outbreak and pandemic response.

Depending on what Pathogen X turns out to be, there may be gaps in the pre-pandemic research, and activities outlined in this document aim to promptly fill these knowledge gaps.

The lessons drawn from the COVID-19 pandemic underscore the importance of continued investment in basic, clinical, and implementation research, technology development, and engineering innovation. A brief summary is presented below.

Pathogen Discovery and Surveillance

Basic research into infectious disease is the foundation of design for applied research. Even when MCMs exist, the relevance of these MCMs needs to be assured in the event of natural evolution in the face of selective pressure. Whilst laboratory isolates are invaluable to MCMs development, being able to reach into at-risk populations to obtain meaningful surveillance information is essential for an applied research programme.

International networking will be essential to ensure at-risk populations have assurance that developing MCMs remain relevant to the contemporary risk. This objective will require in-country collaboration to monitor both in humans and potential zoonotic or other reservoirs of infectious agents. Coordinated and collaborative viral monitoring in hotspot regions is a priority. Initiatives aiming to enhance genomic sequencing, bioinformatics, and data sharing to rapidly identify and characterize in real-time novel pathogen threats globally.

Targeted basic research

The genetic and molecular composition of an infectious disease agent provides invaluable data to inform and design MCMs. Without basic research, MCMs design is at risk of becoming outdated and at worse, redundant in the face of natural evolution. Sharing the outcome and potential rewards of such basic research will be essential in ensuring that meaningful collaborations are formed and endure even in the event of an epidemic or a new pandemic. Sharing resources will also be essential to the downstream applied research.

Critical needs include improved understanding of pathogen microbiology (i.e., virology and bacteriology), pathogenesis (e.g., virulence, pathogen-host interactions) and immunology (including protective immune responses against different types of pathogens). Improved high-throughput tools to apply cutting-edge science to pandemic research will increase its impact. Understanding the roles of different arms of the immune system in protection, and how to induce immune responses with particular specificities and memory phenotypes, has the potential to lead to more effective pandemic vaccines. Rapid detection and isolation of human monoclonal antibodies is at the nexus of reagents needed for developing vaccines and diagnostics and the development of potential therapeutic MCMs.

Translational Research and Product Development

Equitable access to knowledge of discoveries, research methods and manufacturing methods is important to address local problems before they become global.

For example, developing of reagents and tools and MCMs development (vaccines, therapeutics, and diagnostics) using cutting-edge technologies like AI, structural biology, and high-throughput screening. Further research is expected to improve predictions of how genetic sequences lead to pathogenicity and antigenicity (termed “functional viromics”). These methods combined with high throughput synthetic biology will enable rapid execution of design-build-validate cycles to aid in designing antigens that will induce the desired immune responses.

Equitable access to knowledge of discoveries, research methods and manufacturing is critical to address local problems before they become global. Animal models enable the study of viral pathogenesis and vaccines in live organisms containing the full range of cell and organ types, including the diverse elements of the immune system.

Target Product Profiles and Vaccine Development

To maximize pandemic preparedness, it will be important to emphasize

generalizability and high-priority pathogen Families and prototypes in infrastructure development. An example of considerations to bear in mind is presented here.
For all priority Families, a WHO pathogen family-specific target product profile (TPP) will help to guide research directed toward the development of one or more prototype vaccines, therapeutics and diagnostics. These TPPs will emphasize research needs that may be generalizable both within and outside of a pathogen Family. These Family-based TPPs are to be distinguished from TPPs that are developed for products intended to address individual pathogens. The Family TPPs provide the vital specifications and attributes necessary in formulating vaccines, treatments, or diagnostic tests with a generalizability approach in mind.

Monitor the pipeline of candidate MCMs and prioritize for evaluation during outbreaks

▸ A critical activity in delivering effective medical countermeasures is the dissemination of the best available knowledge and evidence on the clinical development pipeline of candidate vaccines and treatments.
▸ This is achieved by meticulously tracking the progress of promising candidate products throughout the clinical research pipeline.

Product development and production

Further work on vaccine platforms, and in particular, identification of vaccine platforms that induce the types of immune responses likely to be important for members of an individual pathogen Family, could help to maximize protective responses. To maximize pandemic preparedness, to the extent possible, it will be important to emphasize generalizability and high-priority pathogen Families and prototypes in infrastructure development.

Finding mechanisms to make small-market MCms economically feasible and sustainable would be a more productive way to have vaccines readily available for future potential pandemic threats. GMP material is needed to perform clinical studies during epidemics, and it is considered important to fund and study candidate MCMs for Families with pandemic potential, even if short-term public health needs are less clear.

The ultimate goal (and pre-pandemic stopping point) of vaccine development for each pathogen Family will need to be individually considered. For example, if regulators indicated that phase 1 or phase 2 data for a prototype vaccine could support going directly into phase 3 with a pandemic vaccine, this could be an argument for obtaining phase 1 or phase 2 data before the next pandemic. Decisions about performing phase 3 studies would likely depend on independent reviews, regulatory science, and various regulatory pathways.

Independent expert evaluation of various candidate MCMs will contribute to achieving this. Unless there is substantial progress on broadly protective vaccines (though it's unlikely that an effective vaccine will be on the shelf when a pandemic occurs), stockpiling of candidate vaccines is unlikely to be highly successful or cost-effective.

Similar efforts and deliberations are important and will be promoted for Therapeutics and Diagnostics.

Through collaboration with at-risk countries, there is a need to help build the infrastructure to enable production and development of MCMs in at-risk locations, as appropriate.

Clinical Trial Infrastructure and Research Deployment Capacity

Outbreaks often occur in areas where these do not exist, thus efforts aiming to facilitate the development of research capability are needed. Those efforts must include technology sharing and transfer and, access to funding sources to bring those resources to at-risk locations[10].
Building infrastructure for simple clinical trials integrated into outbreak response and ensuring efficient research deployment of MCMs[11].

WHO independent Expert Groups provide advice on which candidate MCMs should be given priority for evaluation in the context of an outbreak.

Harmonization of research protocols and tools are being made to standardize viral assays, animal models, reagents, and CORE protocols for clinical evaluation across Families[12] to streamline research during epidemics and pandemics. This proactive approach facilitates the agreement on clinical trial designs and the selection of investigational products and candidates to prioritize in clinical trials during an outbreak.

In the context of epidemics and pandemics, the WHO R&D Blueprint for Epidemics and other stakeholders collaboratively co-Sponsors clinical trials integrated into the outbreak response for MCMs with Ministries of Health.

Valid and rigorous observational effectiveness studies are needed, especially during an epidemic or outbreak, to advance evidence-based programmatic and policy decisions[13].

10 chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.who.int/docs/default-source/blue-print/working-group-for-vaccine-evaluation-(4th-consultation)/ap1-guidelines-online-consultation.pdf

11 chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.who.int/docs/default-source/blue-print/working-group-for-vaccine-evaluation-(4th-consultation)/ap1-guidelines-online-consultation.pdf

Accelerating evaluation and deployment of MCMs in the context of epidemics and pandemics

In the context of outbreaks, the aim is to provide a blueprint that contributes to the rapid start of simple trials integrated into initial outbreak response (randomized trials or randomization during deployment). It also incorporates elements to facilitate the rapid deployment of candidate MCMs (as expanded access/compassionate use) if evidence is available/ is emerging that they are efficacious and safe.

The availability of candidate MCMs is one of the essential steps to evaluate candidate MCMs and generate data required for regulatory review, eventual licensure, and policy recommendation, considering the limited time-span to evaluate field efficacy during outbreaks caused by infrequent and unpredictable diseases outbreaks.

In addition, greater global coordination and a new mechanism for the supply, financing, and maintenance of candidate vaccines in preparation for future outbreaks of priority pathogens is needed.

Through these efforts candidate MCMs will be promptly evaluated according to innovative simple protocols, which meet the highest scientific and ethical standards, and which generate results to inform regulatory assessment and policy decisions, while ensuring that national and individual interests are respected. Such simple protocols can be integrated in the outbreak response. In addition, the collaborative approach pursued puts the Ministries of Health at the core of all research efforts during outbreaks.

12 https://www.science.org/doi/10.1126/scitranslmed.aat0360

13 https://www.who.int/news-room/events/detail/2023/09/14/default-calendar/improving-vaccine-effectiveness-studies--a-vital-step-before-the-next-pandemic

Table 14. "Translation table" MSL39 Viral Species name and previous, perhaps more familiar, names of the various viruses.

Family	Previous Name	MSL39 Viral Species Name
Adenoviridae	Adenovirus B	Mastadenovirus blackbeardi
Adenoviridae	Human mastadenovirus E	Mastadenovirus exoticum
Arenaviridae	Cardamones variant Wenzhou virus (CVWV)	Mammarenavirus cardamones
Arenaviridae	Chapare virus	Mammarenavirus chapareense
Arenaviridae	Junin virus	Mammarenavirus juninense
Arenaviridae	Lassa Fever virus	Mammarenavirus lassaense
Arenaviridae	Lujo virus	Mammarenavirus lujoense
Arenaviridae	Lymphocytic choriomeningitis virus	Mammarenavirus choriomeningitis
Arenaviridae	Machupo virus	Mammarenavirus machupoense
Arenaviridae	Venezuelan Hemorrhagic Fever virus	Mammarenavirus guanaritoense
Arteriviridae	Simian hemorrhagic fever virus	Deltaarterivirus hemfev
Astroviridae	Mamastrovirus 10 - mink	Mamastrovirus mustelae
Astroviridae	Mamastrovirus 13 - ovine	Mamastrovirus ovis
Astroviridae	Mamastrovirus 9	Mamastrovirus virginiaense
Bornaviridae	Mammalian Bornavirus 1 (BoDV-1)	Orthobornavirus bornaense
Bornaviridae	Variegated squirrel bornavirus 1 (VSBV-1)	Orthobornavirus sciuri
Coronaviridae	Alpha recombinant CoV	Recombinant alphacoronavirus
Coronaviridae	Canine coronavirus-human pneumonia-2018 (CCoV-HuPn-2018)	Alphacoronavirus suis (CCoV-HuPn-2018)
Coronaviridae	Human coronavirus NL63 (Bat)	Alphacoronavirus amsterdamense
Coronaviridae	Middle East Respiratory Syndrome Coronavirus	*Subgenus* Merbecovirus
Coronaviridae	Porcine deltacoronavirus PDCoV	Deltacoronavirus (PDCoV)
Coronaviridae	Porcine hemagglutinating encephalomyelitis virus	Betacoronavirus gravedinis (PHEV)
Coronaviridae	Severe Acute Respiratory Syndrome coronavirus	*Subgenus* Sarbecovirus
Coronaviridae	Swine acute diarrhea syndrome coronavirus (SADS-CoV)	Alphacoronavirus porci
Filoviridae	Bombali viruss	Orthoebolavirus bombaliense
Filoviridae	Ebola virus	Orthoebolavirus zairense
Filoviridae	Huángjiāo virus	Thamnovirus thamnaconi
Filoviridae	Lloviu virus	Cuevavirus lloviuense
Filoviridae	Marburg virus	Orthomarburgvirus marburgense
Filoviridae	Mengla virus	Dianlovirus menglaense
Filoviridae	Reston virus	Orthoebolavirus restonense
Filoviridae	Sudan ebolavirus	Orthoebolavirus sudanense
Filoviridae	Xilang virus	Striavirus antennarii
Flaviviridae	Dengue virus	Orthoflavivirus denguei
Flaviviridae	Ilheus virus	Orthoflavivirus ilheusense
Flaviviridae	Japanese encephalitis virus	Orthoflavivirus japonicum
Flaviviridae	Jingmen tick virus	Jingmenvirus
Flaviviridae	Rocio virus	Orthoflavivirus rocio
Flaviviridae	Spondweni virus	Orthoflavivirus spondweni
Flaviviridae	Tick-borne encephalitis virus	Orthoflavivirus encephalitidis
Flaviviridae	Usutu virus	Orthoflavivirus usutuense
Flaviviridae	Wesselsbron virus	Orthoflavivirus wesselsbronense
Flaviviridae	West Nile virus	Orthoflavivirus nilense
Flaviviridae	Yellow fever virus	Orthoflavivirus flavi
Flaviviridae	Zika virus	Orthoflavivirus zikaense
Hantaviridae	Hantaan orthohantavirus	Orthohantavirus hantanense
Hantaviridae	Hantaan virus	Orthohantavirus hantanense
Hantaviridae	Sinnombre virus	Orthohantavirus sinnombreense
Hepadnaviridae	Domestic Cat Orthohepadnavirus	Orthohepadnavirus felisdomestici
Hepadnaviridae	Hepatitis B virus genotype C	Orthohepadnavirus hominoidei genotype C
Hepadnaviridae	Pomona bat Orthohepadnavirus	Orthohepadnavirus pomi
Hepeviridae	Hepatitis E virus	Paslahepevirus balayani
Nairoviridae	Crimean-Congo hemorrhagic fever virus (CCHF)	Orthonairovirus haemorrhagiae
Orthomyxoviridae	Influenza A	Alphainfluenzavirus influenzae
Orthomyxoviridae	Influenza B	Betainfluenzavirus influenzae
Paramyxoviridae	Hendra virus	Henipavirus hendraense
Paramyxoviridae	Mapuera virus	Orthorubulavirus mapueraense
Paramyxoviridae	Menangle virus	Pararubulavirus menangleense
Paramyxoviridae	Nipah virus	Henipavirus nipahense
Paramyxoviridae	Sosuga virus	Pararubulavirus sosugaense
Parvoviridae	Carnivore amdoparvoviruses (AMDV)	Amdoparvovirus carnivoran
Parvoviridae	Carnivore protoparvoviruses	Protoparvovirus carnivoran
Parvoviridae	Primate erythroparvoviruses (SPV)	Erythroparvovirus primate
Peribunyaviridae	Oropouche virus	Orthobunyavirus oropoucheense
Phenuiviridae	Phlebovirus Sandfly fever virus	Phlebovirus napoliense, Phlebovirus siciliaense, Phlebovirus toscanaense
Phenuiviridae	Rift Valley Fever virus	Phlebovirus riftense
Phenuiviridae	SFTS virus	Bandavirus dabieense
Picobirnaviridae	Human picobirnavirus	Orthopicobirnavirus hominis
Picornaviridae	Enterovirus A71 (EV-A71)	Enterovirus alphacoxsackie 71
Picornaviridae	*Enterovirus D68* (EV-D68)	Enterovirus deconjucti 68
Picornaviridae	Polio virus	Enterovirus coxsackiepol
Pneumoviridae	Avian metapneumovirus	Metapneumovirus avis
Pneumoviridae	Human metapneumovirus	Metapneumovirus hominis
Poxviridae	Alaskapox virus	Orthopoxvirus alaskapox
Poxviridae	Cowpox virus	Orthopoxvirus cowpox
Poxviridae	Monkeypox virus	Orthopoxvirus monkeypox
Poxviridae	Vaccinia virus	Orthopoxvirus vaccinia
Poxviridae	Variola virus	Orthopoxvirus variola
Reovirales	Mammalian orthoreovirus	Orthoreovirus mammalis
Retroviridae	GALV virus	Gammaretrovirus gibleu
Retroviridae	Human immunodeficiency virus 1 (HIV-1)	Lentivirus humimdef1
Retroviridae	Human immunodeficiency virus 2 (HIV-2)	Lentivirus humimdef2
Retroviridae	Human T-lymphotropic virus 3 (HTLV-3)	Deltaretrovirus priTlym3
Retroviridae	Simian immunodeficiency virus	Lentivirus simimdef
Rhabdoviridae	Genus Ledantevirus	Genus Ledantevirus
Rhabdoviridae	Genus Tibrovirus	Genus Tibrovirus
Rhabdoviridae	Genus Vesiculovirus	Genus Vesiculovirus
Togaviridae	Chikungunya virus	Alphavirus chikungunya
Togaviridae	Eastern equine encephalitis virus	Alphavirus eastern
Togaviridae	Madariaga virus	Alphavirus madariaga
Togaviridae	Mayaro virus	Alphavirus mayaro
Togaviridae	Onyong-nyong virus	Alphavirus onyong
Togaviridae	Ross River virus	Alphavirus rossriver
Togaviridae	Venezuelan equine encephalitis virus	Alphavirus venezuelan

ANNEX 1. Scientists who evaluated the evidence related to 28 Viral Families and one core group of Bacteria, encompassing 1,652 pathogens

Adenoviridae
1. Mária Benkő, HUN-REN Veterinary Medical Research Institute, Hungary
2. Renald Gilbert, National Research Council, Canada
3. Gregory C. Gray, University of Texas Medical Branch, United States of America
4. Joanne Langley, Dalhousie University and IWK Health Centre, Canada
5. Thomas Lion, St.Anna Children´s Cancer Research Institute, Austria
6. Donald Seto, George Mason University, United States of America
7. Jim Wellehan, University of Florida College of Veterinary Medicine, United States of America

Anelloviridae
1. Mariet Feltkamp, Leiden University Medical Center, Netherlands
2. Jelle Matthijnssens, KU Leuven University, Rega Institute, Belgium
3. Joaquim Segalés, Institute of Agrifood Research and Technology, Spain
4. Lia van der Hoek, Amsterdam University Medical Centers, Netherlands

Arenaviridae
1. Remi Charrel, Aix Marseille Université, Hôpitaux Universitaires de Marseille, France
2. Juan Carlos de la Torre, The Scripps Research Institute, United States of America
3. Delia A. Enria, Instituto Nacional de Enfermedades Virales Humanas, Argentina
4. Stephan Günther, Bernhard-Nocht-Institute for Tropical Medicine, Germany
5. Sylvanus Okogbenin, Irrua Specialist Teaching Hospital and Ambrose Alli University, Nigeria
6. Jiro Yasuda, National Research Center for the Control and Prevention of Infectious Diseases, Nagasaki University, Japan

Astroviridae
1. Carlos Federico Arias, Instituto de Biotecnología, Universidad Nacional Autónoma de México, Mexico
2. Ákos Boros, University of Pécs, Medical School, Hungary
3. Paola de Benedictis, Istituto Zooprofilattico Sperimentale delle Venezie, Italy
4. Vijaykrishna Dhanasekaran, LKS Faculty of Medicine, University of Hong Kong, China
5. Susana Guix, University of Barcelona, Spain
6. Christine M Jonassen, Norwegian Institute of Public Health, Norway
7. Rosa Maria Pinto, University of Barcelona, Spain
8. Stacey Schultz-Cherry, St. Jude Children's Research Hospital, United States of America
9. David Wang, Washington University School of Medicine in St. Louis, United States of America
10. Huachen Maria Zhu, Li Ka Shing Faculty of Medicine, University of Hong Kong, China

Bacteria
1. Nicholas Feasay, Liverpool School of Tropical Medicine, United Kingdom
2. Benjamin Howden, Doherty Institute, University of Melbourne, Australia
3. Ann E Jerse, Uniformed Services University of the Health Sciences, United States of America
4. Gagandeep Kang, Vellore Christian Medical College Foundation, India
5. Sam Kariuki, Drugs for Neglected Diseases initiative (DNDi) Eastern Africa, Kenya
6. Myron M. Levine, University of Maryland School of Medicine, United States of America
7. Khitam Muhsen, School of Public Health, Tel Aviv University, Israel
8. Javier Pizarro-Cerda, Institut Pasteur, France
9. Firdausi Qadri, International Centre for Diarrheal Disease Research, Bangladesh
10. Christoph Tang, Sir William Dunn School of Pathology, University of Oxford, United Kingdom

Bornaviridae
1. Markus Bauswein, Institut für Klinische Mikrobiologie und Hygiene, Universitätsklinikum Regensburg
2. Germany
3. Martin Beer, Friedrich-Loeffler-Institut, Germany
4. Liv Bode, Virology and Infectious Diseases. Independent Senior Research Scientist, Germany
5. Daniel Dunia, University Toulouse, Purpan Hospital, France
6. Mady Hornig, Columbia University Mailman School of Public Health, United States of America
7. Susan Payne, retired, Texas A&M University, United States of America
8. Dennis Rubbenstroth, Federal Research Institute for Animal Health, Friedrich-Loeffler-Institut, Germany
9. Martin Schwemmle, Institute of Virology, Medical Center - University Freiburg, Germany
10. Barbara Schmidt, University Hospital Regensburg, Germany
11. Dennis Tappe, Bernhard Nocht Institute for Tropical Medicine, Germany
12. Keizo Tomonaga, Institute for Life and Medical Sciences (LiMe), Kyoto University, Japan
13. Peng Xie, The First Affiliated Hospital of Chongqing Medical University, China

Bunyavirales
1. Felicity Burt, University of the Free State, Faculty of Health Sciences, South Africa
2. Miles Carroll, University of Oxford, Pandemic Sciences Institute, United Kingdom
3. Nazif Elaldi, Sivas Cumhuriyet University, Turkey
4. Önder Ergönül, Koç University Iş Bank Center for Infectious Diseases, Turkey
5. Roger Hewson, London School of Hygiene & Tropical Medicine, United Kingdom
6. Bushra Jamil, The Aga Khan University, Pakistan
7. Ali Mirazimi, Karolinska Institute Research area, Sweden
8. Mostafa Salehi-Vaziri, Pasteur Institute of Iran, Iran
9. Pragya D Yadav, Indian Council of Medical Research-National Institute of Virology, India

Coronaviridae
1. Gabriel Leung, LKS Faculty of Medicine, School of Public Health, The University of Hong Kong, China
2. Kyeong-Ok Chang, College of Veterinary Medicine, Kansas State University, United States of America
3. Malik Peiris, LKS Faculty of Medicine, School of Public Health, The University of Hong Kong, China
4. Stanley Perlman, University of Iowa, United States of America
5. Kanta Subbarao, University of Melbourne, Doherty Institute, Australia
6. Zhengli Shi, Wuhan Institute of Virology, Chinese Academy of Sciences, China
7. Tim Sheahan, University of North Carolina, School of Medicine, United States of America
8. Linfa Wang, Duke-NUS Medical School, Singapore

Filoviridae
1. Stephan Becker, Institut für Virologie, Phillipps Universität Marburg, Germany
2. William Fischer, University of North Carolina School of Medicine, United States of America
3. Placide Mbala, Institut National de Recherche Biomédicale, Democratic Republic of Congo
4. Sabue Mulangu, Ridgeback Bio, Congo Republic
5. Nancy Sullivan, National Emerging Infectious Diseases Laboratories, Boston University, United States of America

Flaviviridae
1. Alan Barrett, University of Texas Medical Branch, United States of America
2. Sonja Best, National Institute of Allergy and Infectious Diseases, United States of America
3. Patricia Brasil, Instituto Nacional de Infectologia Evandro Chagas – FIOCRUZ, Brazil
4. Philippe Desprès, Université de La Réunion, La Réunion
5. Mike Diamond, Washington University School of Medicine, United States of America
6. Andrea Gamarnik, Fundación Instituto Leloir, Argentina
7. Eva Harris, University of California, United States of America
8. Laura Kramer, School of Public Health, State University of New York, United States of America
9. Ira Longini, University of Florida, United States of America
10. Neelika Malavige, University of Sri Jayewardenepura, Sri Lanka
11. Lee-Ching Ng, National Environmental Agency, Singapore

Hepadnaviridae
1. Marceline Djuidje Ngounoue Epse Ndzie, University of Yaoundé, Cameroon
2. Anand Gaurav, School of Health Sciences & Technology, India
3. Neeraj Masand, LLRM Medical College (Government), India
4. Salu Olumuyiwa Babalola, College of Medicine of the University of Lagos, Nigeria
5. Vaishali Patil, Charak School of Pharmacy, Chaudhary Charan Singh University, India
6. Saroj Verma, K.R. Mangalam University, India
7. Bryan Tegomoh, University of California, United States of America

Hepeviridae
1. Qiuwei Abdullah Pan, University Medical Center, Rotterdam, Netherlands
2. Kavita Lole, Indian Council of Medical Research-National Institute of Virology, India
3. Xiang-Jin Meng, Virginia Polytechnic Institute and State University, United States of America
4. Helene Norder, Gothenburg University, Sahlgrenska University Hospital, Sweden
5. Nicole Pavio, French Agency for Food, Environmental and Occupational Health and Safety, France
6. Michael A Purdy, Centers for Disease Control and Prevention, United States of America
7. Eike Steinmann, Faculty of Medicine, Ruhr University, Germany
8. Ting Wu, National Institute of Diagnostics and Vaccine Development in Infectious Diseases, Xiamen University, China

Herpesviridae
1. Lynn W. Enquist, Dept. Molecular Biology, Princeton University, United States of America
2. Herman Favoreel, Ghent University, Belgium
3. Klaus Frueh, Vaccine and Gene Therapy Institute of Oregon Health & Science University, United States of America
4. Felicia Goodrum, BIO5 Institute, University of Arizona, United States of America
5. Eain A. Murphy, SUNY - Upstate Medical University, United States of America
6. Klaus Osterrieder, Freie Universität Berlin, Germany
7. Daniel Streblow, Oregon Health & Science University, United States of America

Orthomyxoviridae
1. Christopher Chiu, Imperial College London, Hammersmith Campus, United Kingdom
2. Hideki Hasegawa, National Institute of Infectious Diseases, Influenza Virus Research Center, Japan
3. Nailya G. Klivleyeva, Research and Production Center for Microbiology and Virology, Kazakhstan
4. Florian Krammer, Icahn School of Medicine at Mount Sinai, United States of America
5. Tommy Lam, University of Hong Kong, China
6. Quynh Mai Le thi, National Institute of Hygiene and Epidemiology, Viet Nam
7. Kanta Subbarao, University of Melbourne, The Peter Doherty Institute for Infection and Immunity, Australia
8. Richard J. Webby, St Jude Children's Research Hospital, United States of America

Papillomaviridae
1. Paul KS Chan, The Chinese University of Hong Kong, China
2. Zigui Chen, The Chinese University of Hong Kong, China
3. Koenraad Van Doorslaer, University of Arizona College of Medicine, United States of America
4. Lisa Mirabello, National Cancer Institute, NIH, United States of America
5. Fanghui Zhao, Chinese Academy of Medical Sciences, China

Paramyxoviridae
1. Danielle Anderson, University of Melbourne, Australia
2. Dalan Bailey, The Pirbright Institute, United Kingdom
3. Anne Balkema-Bushann, Friedrich-Loeffler-Institut, Germany
4. Sandra Diederich, Friedrich-Loeffler-Institut, Germany
5. Gabor Kemenesi, University of Pécs, National Laboratory of Virology, Hungary
6. Benhur Lee, Icahn School of Medicine at Mount Sinai, United States of America
7. Piet Maes, Zoonotic infectious diseases unit, Rega Institute, Belgium
8. Mustafizur Rahman, International Center for Diarrhoeal Disease Research, Bangladesh

Parvoviridae
1. Eric Delwart, retired, UCSF, Vitalant Research Institute, United States of America
2. Anna-Maria Eis-Hübinger, Institut für Virologie, Universitätsklinikum Bonn, Germany
3. Giorgio Gallinella, University of Bologna, Department of Pharmacy and Biotechnology, Italy
4. Modra Murovska, Riga Stradins University, Latvia
5. Colin Parrish, College of Veterinary Medicine, Cornell University, United States of America
6. Judit Pénzes, Rutgers University, United States of America
7. Maria Söderlund-Venermo, Department of Virology, University of Helsinki, Finland

Picobirnaviridae
1. Souvik Gosh, Ross University School of Veterinary Medicine, India
2. Pattara Khamrin, Faculty of Medicine, Chiang Mai University, Thailand
3. Yashpal Singh Malik, Guru Angad Dev Veterinary and Animal Sciences University, India
4. Niwat Maneekarn, Faculty of Medicine, Chiang Mai University, Thailand
5. Gisela Masachessi, Faculty of Medical Sciences National University of Córdoba, Argentina

Picornaviridae
1. Kimberley Benschop, National Institute for Public Health and the Environment, Netherlands
2. Edson Elias da Silva, Oswaldo Cruz Institute (Fiocruz) Rio de Janeiro, Brazil
3. Thea Kølsen Fischer, Nordsjaellands Hospital, Copenhagen University Hospital, Denmark
4. Min-Shi Lee, National Health Research Institutes, Taiwan
5. Heli Harvala Simmonds, NHS Blood and Transplant and UCL, United Kingdom
6. Steve Oberste, Centers for Disease Control, United States of America
7. Miao Xu, National Institutes for Food and Drug Control, China
8. Hongjie Yu, Fudan University at School of Public Health from China CDC, China

Pneumoviridae
1. Larry J. Anderson, Emory University School of Medicine, United States of America
2. Louis J. Bont, University Medical Centre Utrecht, Netherlands
3. Ruth Karron, Johns Hopkins Bloomberg School of Public Health, United States of America
4. Jerome H. Kim, International Vaccine Institute, Republic of Korea
5. Claudio Lanata, Instituto de Investigación Nutricional, Peru

6. Octavio Ramilo, St. Jude Children's Research Hospital, United States of America
7. John Williams, UPMC Children's Hospital of Pittsburgh, United States of America
8. Heather Zar, University of Cape Town, South Africa
9. Mohammed Ziaur Rahman, International Center for Diarrhoeal Disease Research, Bangladesh

Polyomaviridae
1. Chris Buck, US National Cancer Institute, United States of America
2. Sébastien Calvignac-Spencer, Helmholtz Institute for One Health, University of Greifswald, Germany
3. Michael Carr, National Virus Reference Laboratory, University College Dublin, Ireland
4. Yuan Chang, University of Pittsburgh, Cancer Virology Program, Hillman Cancer Research Institute, United States of America
5. Sayeh Ezzikouri, Institut Pasteur, Morocco
6. Mariet Feltkamp, Leiden University Medical Center, Netherlands
7. Michael Imperiale, University of Michigan, United States of America

Poxviridae
1. Rafael Blasco, Centro Nacional INIA, Consejo superior de investigaciones cientificas, Spain
2. Inger Damon, retired, Centers for Disease Control and Prevention (CDC), United States of America
3. Clarissa Damaso, Universidade Federal do Rio de Janeiro, Brazil
4. Gunasegaran Karupiah, University of Tasmania, Australia
5. Andreas Nitsche, Robert Koch Institut, Germany
6. Stefan Rothenburg, University of California, Davis, School of Medicine, United States of America

Rhabdoviridae
1. Martin Faye, Institut Pasteur Dakar, Senegal
2. Anthony Fooks, Animal & Plant Health Agency, United Kingdom
3. Marie-Paule Kieny, Drugs for Neglected Diseases and Medicines Patent Pool Foundation, Switzerland
4. Matthias Schnell, Thomas Jefferson University, United States of America
5. Nikos Vasilakis, University of Texas Medical Branch, United States of America
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2. Jelle Matthijnssens, Rega Institute at the University of KU Leuven, Belgium
3. Polly Roy, London School of Hygiene & Tropical Medicine, United Kingdom

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2. Alex Greenwood, Leibniz Institute for Zoo and Wildlife Research and Freie Universität Berlin, Germany
3. Theodora Hatziioannou, Rockefeller University, United States of America
4. Aris Katzourakis, University of Oxford, United Kingdom

5. Pontiano Kaleebu, Uganda Virus Research Institute and London School of Hygiene and Tropical Medecinet, Uganda
6. Eric M. Poeschla, University of Colorado School of Medicine, United States of America
7. Gilda Tachedjian, Burnet Institute for Medical Research and Public Health, Australia

Togaviridae
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2. Naomi Forrester-Soto, The Pirbright Institute, United Kingdom
3. Kylene Kehn-Hall, Virginia-Maryland College of Veterinary Medicine, United States of America
4. Sandra López Vergès, Gorgas Memorial Research Institute for Health Studies, Panama
5. Tem Morrison, University of Colorado School of Medicine, United States of America

ANNEX 2. Prioritization Advisory Committee (PAC)

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ANNEX 3. Summary of Epidemiological Information on Proposed Priority Pathogens

Family	Pathogen	Vector/ Reservoir	Mode of Transmission	Extent of person-to-person transmission	Spread	Areas with Documented Transmission
Arenaviridae	Mammarenavirus lassaense	Mastomys rodents	Contact with infected rodents, person-to-person transmission	Sufficient to cause outbreaks	Africa	West African countries, including Nigeria, Liberia, Sierra Leone
Bacteria	Vibrio Cholerae (sero 01)	Aquatic environment, human hosts	Fecal-oral transmission, contaminated water sources	Some	South Asia	Primarily in Developing countries, potential for global spread
Bacteria	Klebsiella Pneumonia	Humans, environmental reservoirs	Nosocomial transmission, person-to-person spread	Some	Global	Reported worldwide
Bacteria	Yersinia Pestis (Plague)	Rodents, fleas	Flea-borne transmission, person-to-person spread of pneumonic plague	Some	Asia, Africa, Americas	Endemic in parts of Asia, Africa, and the Americas, potential for global spread
Bacteria	Shigella Dysenteria 1	Humans	Fecal-oral transmission, contaminated food/water	Sufficient to cause outbreaks		Primarily in Developing countries, potential for global spread
Bacteria	Salmonella Enterica (invasive non-typhoidal)	Humans, animals, environmental reservoirs	Foodborne transmission, person-to-person spread	Sufficient to cause outbreaks	Global	Reported worldwide distribution
Hantaviridae	Orthohantavirus hantanense	Field mice	Inhalation of virus from rodent excreta	Little or none	Asia	Primarily confined to endemic regions in Asia
Hantaviridae	Orthohantavirus sinnombreense	Deer mice	Inhalation of virus from rodent excreta	Little or none	North America	Primarily confined to North America
Nairoviridae	Orthonairovirus haemorrhagiae	Ticks, livestock	Tick-borne transmission, contact with infected animals	Some	Asia, Africa, Europe	Primarily confined to endemic regions in Africa, Asia, Europe
Phenuiviridae	Bandavirus dabieense	Ticks, small mammals	Tick-borne transmission	Little or none	Asia	Outbreaks in parts of Asia
Coronaviridae	Sub genus Merbecoviruses	Bats, humans	Bat-borne transmission, potential for person-to-person spread	Sufficient to cause outbreaks	Asia, Middle-East	Outbreaks in parts of Asia and the Middle East
Coronaviridae	Sub genus Sarbecoviruses	Bats, humans	Bat-borne transmission, person-to-person spread	Sufficient to cause outbreaks	Global	Global, already caused a PHEIC
Filoviridae	Orthoebolavirus sudanense	Unknown, potential animal reservoir	Contact with infected bodily fluids	Sufficient to cause outbreaks	Central and East Africa	Primarily in Central and East Africa
Filoviridae	Orthomarburgvirus marburgense	Fruit bats, potential animal reservoir	Contact with infected bodily fluids	Sufficient to cause outbreaks	Central and East Africa	Primarily in Central and East Africa
Filoviridae	Orthoebolavirus zairense	Fruit bats, potential animal reservoir	Contact with infected bodily fluids	Sufficient to cause outbreaks	Central and East Africa	Primarily in Central and West Africa
Flaviviridae	Orthoflavivirus flavi	Mosquitoes, non-human primates	Mosquito-borne transmission	Little or none	Africa, South America	In parts of Africa and South America
Flaviviridae	Orthoflavivirus denguei	Aedes mosquitoes	Mosquito-borne transmission	Little or none		Widespread in tropical and subtropical regions
Flaviviridae	Orthoflavivirus zikaense	Aedes mosquitoes	Mosquito-borne transmission, potential for vertical and sexual transmission	Some	Americas, Africa, Asia, Pacific	Outbreaks in the Americas, Africa, Asia, and the Pacific
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	Avian reservoirs, humans	Respiratory transmission, potential for zoonotic transmission	Little or none	Asia, Africa, Europe	Outbreaks in parts of Asia, Africa, and Europe
Orthomyxoviridae	Alphainfluenzavirus influenzae H2	Avian reservoirs, humans	Respiratory transmission, potential for zoonotic transmission	Sufficient to cause outbreaks	Asia, Europe	Outbreaks in parts of Asia and Europe
Orthomyxoviridae	Alphainfluenzavirus influenzae H1,H3	Avian reservoirs, humans	Respiratory transmission, potential for zoonotic transmission	Sufficient to cause outbreaks	Global	Worldwide distribution
Paramyxoviridae	Henipavirus nipahense	Bats, humans	Bat-borne transmission, potential for person-to-person spread	Little or none	Asia	Outbreaks in parts of Asia
Picornaviridae	Enterovirus coxsackiepol	Humans	Fecal-oral transmission, contaminated water sources	Sufficient to cause outbreaks	Asia	Primarily confined to Afghanistan and Pakistan
Poxviridae	Orthopoxvirus Variola	Humans	Respiratory transmission, direct contact	Sufficient to cause outbreaks	Eradicated	Historically widespread, now confined to laboratories
Poxviridae	Orthopoxvirus Monkeypox	Rodents, humans	Animal-to-human transmission, person-to-person spread	Sufficient to cause outbreaks	Global	Endemic in Central and West Africa, already caused a PHEIC with global spread
Retroviridae	Lentivirus humimdef1	Humans	Bloodborne transmission, sexual transmission	Endemic in humans	Global	Worldwide distribution
Togaviridae	Alphavirus chikungunya	Aedes mosquitoes	Mosquito-borne transmission	Little or none	Asia, Africa, Americas	Outbreaks in parts of Africa, Asia, and the Americas
Togaviridae	Alphavirus Venezuelan	Mosquitoes, rodents	Mosquito-borne transmission	Little or none	Central and South America	Outbreaks in parts of Central and South America

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ANNEX 4. Current landscape of candidate Vaccines and Therapeutics for proposed Priority Pathogens

Candidate vaccines

Family	Pathogen	Vaccine name	Platform	Phase of development	Developer	Source
Arenaviridae	Mammarenavirus lassaense	INO-4500	DNA	Phase 1	Inovio Pharmaceuticals	https://ctv.veeva.com/study/dose-ranging-study-safety-tolerability-and-immunogenicity-of-ino-4500-in-healthy-volunteers-in-gha
Arenaviridae	Mammarenavirus lassaense	MV-LASV	Live-attenuated Measles Virus vector	Phase 1	Institut Pasteur, Themis Bioscience	https://clinicaltrials.gov/study/NCT04055454
Arenaviridae	Mammarenavirus lassaense	rVSV-LASV	Vesicular Stomatitis Virus (VSV) vector	Phase 2	IAVI	https://clinicaltrials.gov/study/NCT04794218; https://clinicaltrials.gov/study/NCT05868733?cond=rVSV%E2%88%86G-LASV-GPC&rank=2
Arenaviridae	Mammarenavirus lassaense	ML29	Reassortant virus	Preclinical		https://www.sciencedirect.com/science/article/abs/pii/S0264410X08010062?via%3Dihub
Bacteria	Klebsiella Pneumonia	Ribosomal fraction	Ribosomal	Clinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Klev4V	Bioconjugate	Phase 1/2	LimmaTech Biologics AG	https://clinicaltrials.gov/study/NCT04959344?cond=Klebsiella%20Pneumonia&term=vaccine&rank=1
Bacteria	Klebsiella Pneumonia	Capsular poliysaccharides	Subunit	Phase 1/2		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Outer Membrane Proteins (OMP)-based vaccine	Protein	Preclinical	Various	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6656602/
Bacteria	Klebsiella Pneumonia	Fimbriae Subunits	Protein	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Toxins	Protein	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Lipopolysaccharides	Subunit	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Outer membrane vesicles (OMBVs)	Subunit	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Inactivated K. pneumoniae vaccine	Whole Cell Vaccines/Cell Lysates	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Mixed bacterial vaccines (MBV) with heat-killed pathogens	Whole Cell Vaccines/Cell Lysates	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Klebsiella Pneumonia	Respivax	Whole Cell Vaccines/Cell Lysates	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8412853/
Bacteria	Salmonella Enterica (invasive non-typhoidal)	iNTS-typhoid conjugate	Conjugate	Phase 1		https://academic.oup.com/ofid/article/10/Supplement_1/S58/7188900
Bacteria	Salmonella Enterica (invasive non-typhoidal)	GMMA-based bivalent (S. Typhimurium/S. Enteritidis)	Outer membrane vesicles	Phase 1	GSK Vaccines Ins. For Global Health (GVGH)	https://academic.oup.com/ofid/article/10/Supplement_1/S58/7188900
Bacteria	Salmonella Enterica (invasive non-typhoidal)	Trivalent (S. Typhi/S. Typhimurium/S. Enteritidis)	Conjugate	Phase 2	University of Maryland/Bharat Biotech	https://academic.oup.com/ofid/article/10/Supplement_1/S58/7188900
Bacteria	Salmonella Enterica (invasive non-typhoidal)	O:4 and O:9 conjugate (S. Typhimurium/S. Enteritidis) - MAPS	Conjugate	Preclinical	Boston's Children's Hospital	https://academic.oup.com/ofid/article/10/Supplement_1/S58/7188900
Bacteria	Salmonella Enterica (invasive non-typhoidal)	Trivalent (S. Typhi/S. Typhimurium/S. Enteritidis)		Preclinical	SK Bioscience/IVI	https://academic.oup.com/ofid/article/10/Supplement_1/S58/7188900
Bacteria	Shigella Dysenteria 1	Shigella ETEC live attenuated vaccine consisting of six Shigella strains	Live attenuated	Preclinical		https://pubmed.ncbi.nlm.nih.gov/31194282/
Bacteria	Vibrio Cholerae (sero 0139)	Shanchol	Killed whole-cell bivalent (O1 and O139)	Licensed	Shantha Biotechnics/Sanofi Pasteur	https://www.who.int/teams/immunization-vaccines-and-biologicals/diseases/cholera
Bacteria	Vibrio Cholerae (sero 0139)	Euvichol	Killed whole-cell bivalent (O1 and O139)	Licensed	EuBiologics	https://www.who.int/teams/immunization-vaccines-and-biologicals/diseases/cholera
Bacteria	Vibrio Cholerae (sero 0139)	Euvichol-Plus	Killed whole-cell bivalent (O1 and O139)	Licensed	EuBiologics	https://www.who.int/teams/immunization-vaccines-and-biologicals/diseases/cholera
Bacteria	Yersinia Pestis	rF1 and rV Antigens	Recombinant	Phase 1	PharmAthene UK Limited	NCT00246467
Bacteria	Yersinia Pestis	Flagellin/F1/V	Recombinant	Phase 1	NIAID	NCT01381744
Bacteria	Yersinia Pestis	ChAdOx1 PlaVac	Viral Vector	Phase 1	University of Oxford	https://www.ox.ac.uk/news/2021-07-26-phase-i-trial-begins-new-vaccine-against-plague
Bacteria	Yersinia Pestis	rF1V Vaccine with CpG 1018	Recombinant	Phase 2	DynPort Vaccine Company LLC, A GDIT Company	NCT05506969
Bacteria	Yersinia Pestis	plague vaccine(F1+rV)	Live Attenuated	Phase 2b	Jiangsu Province Centers for Disease Control and Prevention	NCT05330624
Bacteria	Yersinia Pestis	rF1V vaccine	Recombinant	Phase 2b	DynPort Vaccine Company LLC, A GDIT Company	NCT01122784
Bacteria	Yersinia Pestis	EV 76 NIIEG	Live Whole Cell	Phase 4	Scientific Research Institute of Epidemiology and Hygiene (Russian abbreviation—NIIEG, Kirov)	
Bacteria	Yersinia Pestis	Y. pestis CO92 ΔLMA*	Live attenuated	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Y. pestis CO92 ΔLMP	Live attenuated	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Y. pestis EV76-B-SHUΔpla1	Live attenuated	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Y. pestis CO92 ΔpgmΔpPst	Live attenuated	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Calcium Phosphate based Protein-coated Microcrystals F1V	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Single dose F1-V polyanhydride nanoparticle coupled with cyclic dinucleotides	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	rv10	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Peptidoglycan-Free OMV (Bacterial Ghosts)-phage lytic system	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Manganese silicate nanoparticle rF1-V10	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	polymeric F1 + LcrV (ILB1)-R	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Y. Pseudotuberculosis-based LcrV MPLA OMV	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	LicKM-LcrV-F1	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Microvessicle (Bacteroides spp.) F1-V	Subunit	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	DNA F1-V vaccines	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Ad5-F1+ Ad5-LcrV	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Ad5-YFV	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	T4-Phage	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/

Family	Pathogen	Vaccine name	Platform	Phase of development	Developer	Source
Bacteria	Yersinia Pestis	S. Typhimurium expressing plague antigens	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	S. Typhi expressing plague antigens	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Lactiplantibacillus plantarum expressing lcrV	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	F1 mRNA-LNP	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Y. pseudotuberculosis producing F1	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	Self-amplifying RNA (F1+LcrV)	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Bacteria	Yersinia Pestis	F. tularensis ΔcapB + F1-LcrV/PA	Vector-Based	Preclinical		https://pubmed.ncbi.nlm.nih.gov/34142207/
Nairoviridae	Orthonairovirus haemorrhagiae	Russian/Bulgarian Vaccine	Inactivated	Licensed in Bulgaria		https://pubmed.ncbi.nlm.nih.gov/21142621/
Nairoviridae	Orthonairovirus haemorrhagiae	KIRIM-KONGO-VAX	MVA based vaccine	Phase 1	The Scientific and Technological Research Council of Turkey	https://clinicaltrials.gov/study/NCT03020771?cond=cchf&rank=2
Nairoviridae	Orthonairovirus haemorrhagiae	DNA Vaccine	DNA	Preclinical	Linköping University	https://pubmed.ncbi.nlm.nih.gov/28250124/
Nairoviridae	Orthonairovirus haemorrhagiae	mRNA-LNP vaccine	mRNA	Preclinical	Public Health Agency of Sweden	https://pubmed.ncbi.nlm.nih.gov/34817199/
Nairoviridae	Orthonairovirus haemorrhagiae	Replicon particle vaccine	Replicon particle vaccine	Preclinical		https://pubmed.ncbi.nlm.nih.gov/30947619/
Nairoviridae	Orthonairovirus haemorrhagiae	GEM-PA vaccine	Subunit Protein	Preclinical		https://pubmed.ncbi.nlm.nih.gov/36016285/
Nairoviridae	Orthonairovirus haemorrhagiae	ChAdOx2 CCHF	Viral Vector	Preclinical	University of Oxford	https://www.thelancet.com/journals/ebiom/article/PIIS2352-3964%2823%2900088-9/fulltext
Nairoviridae	Orthonairovirus haemorrhagiae	MVA CCHF	Viral Vector	Preclinical	UKHSA	https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0091516
Nairoviridae	Orthonairovirus haemorrhagiae	rVSV	Viral Vector	Preclinical	University of Texas Medical Branch	https://pubmed.ncbi.nlm.nih.gov/31123310/
Phenuiviridae	Bandavirus dabieense	DNA Vaccine	DNA	Preclinical		https://www.nature.com/articles/s41467-019-11815-4
Phenuiviridae	Bandavirus dabieense	rHB2912aaNSs and rHB29NSsP102A	Live attenuated	Preclinical		www.mdpi.com/1999-4915/13/4/627; https://www.mdpi.com/1999-4915/16/1/128
Phenuiviridae	Bandavirus dabieense	rVSV-SFTSV	Recombinant Viral Vector	Preclinical		www.mdpi.com/1999-4915/13/4/627; https://www.mdpi.com/1999-4915/16/1/128
Phenuiviridae	Bandavirus dabieense	LC16m8 - MVA	Recombinant Viral Vector	Preclinical		www.mdpi.com/1999-4915/13/4/627; https://www.mdpi.com/1999-4915/16/1/128
Coronaviridae	Merbecoviruses	MERS DNA	DNA	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8603276/
Coronaviridae	Merbecoviruses	AcHERV-MERS-S1 pcDNA3.1-S1 pS1	DNA	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8603276/
Coronaviridae	Merbecoviruses	pSDER-pSDTM	DNA-protein	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8603276/
Coronaviridae	Merbecoviruses	RBD-LSRBD-NP(cdGMP)	Nanoparticle	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8603276/
Coronaviridae	Merbecoviruses	SRBD-HBD2	Protein	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8603276/
Coronaviridae	Merbecoviruses	Trivalent RBD Nanoparticle Vaccine	Recombinant protein	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10245799/
Coronaviridae	Merbecoviruses	RV/MERSMERSBLPRVDP MERS/S1	Viral or bacterial vector	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8603276/
Coronaviridae	Merbecoviruses	rAd/spikePIV5/MERS-S ChAdOx1-MERS	Viral Vector	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8603276/
Coronaviridae	Sarbecoviruses	VBI-2901	eVLP (enveloped virus-like particle)	Preclinical	VBI Vaccines	vbivaccines.com/press-releases/vbi-vaccines-pan-coronavirus-vaccine-candidate-vbi-2901-induced-broad-and-durable-protective-titers-against-variants-of-concern/

Family	Pathogen	Vaccine name	Platform	Phase of development	Developer	Source
Coronaviridae	Sarbecoviruses	Mucosal vaccine	Live attenuated	Preclinical		https://www.nature.com/articles/s41467-023-42349-5
Coronaviridae	Sarbecoviruses	Universal Sarbecovirus Vaccine	n/a	Preclinical	Shionogi & KOTAI Biotechnologies	https://www.shionogi.com/global/en/news/2023/6/230619_1.html
Coronaviridae	Sarbecoviruses	Mosaic-8	Nanoparticle	Preclinical	CalTech	https://www.science.org/doi/10.1126/science.abq0839
Coronaviridae	Sarbecoviruses	IgG Fc-conjugated RBD of the original SARS-CoV-2 strain (WA1) plus a novel STING agonist-based adjuvant CF501 (CF501/RBD-Fc)		Preclinical	Fudan University, China	https://pubmed.ncbi.nlm.nih.gov/36897979/
Filoviridae	Orthoebolavirus zairense	Ad26.ZEBOV/MVA-BN-Filo	Adenovirus vector/Modified vaccinia Ankara (MVA)	Licensed	Janssen/Bavarian Nordic	https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	Ervebo (rVSVΔG-ZEBOV-GP)	Recombinant vesicular stomatitis virus (rVSV)	Licensed	Merck	https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	Ad5-EBOV	Viral Vector	Licensed I China	BIT CanSino	https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	GamEvac-Combi and GamEvacLyo Heterologous prime-boost w/ rVSV and Ad5 expressing EBOV GP (Makona)	Viral Vector	Licensed in Russia/Phase 3 in Guinea		https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	DNA Vaccine	DNA	Phase 1		https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	DNA plasmid vaccine	DNA	Phase 1		https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	Monovalent nanoparticle	Nanoparticle	Phase 1		https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	Vesiculovax	Viral Vector	Phase 1	Auro Vaccines	https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthoebolavirus zairense	INO-4201	DNA	Phase 1b	Inovio Pharmaceuticals	https://academic.oup.com/jid/article/220/3/400/5395966
Filoviridae	Orthoebolavirus zairense	cAd3-EBOZ/ChAd3-EBO-Z	Chimpanzee adenovirus vector	Phase 2/3	GlaxoSmithKline	https://journals.plos.org/plospathogens/article?id=10.1371%2Fjournal.ppat.1010078
Filoviridae	Orthomarburgvirus marburgense	VRC-MARDNA025-00-VP	DNA Plasmid	Phase 1	NIAID Vaccine Research Center	https://clinicaltrials.gov/study/NCT00997607?cond=marburg&rank=9
Filoviridae	Orthomarburgvirus marburgense	Ad26-MARV	Viral Vector	Phase 1	Janssen Pharmaceuticals	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9534391/
Filoviridae	Orthomarburgvirus marburgense	cAd3-Marburg Vaccine	Viral Vector	Phase 1	NIAID	https://clinicaltrials.gov/study/NCT03475056?cond=marburg&rank=2
Filoviridae	Orthomarburgvirus marburgense	rVSVΔG-MARV-GP	Viral Vector	Phase 1	Public Health Vaccines	https://clinicaltrials.gov/study/NCT06265012?cond=marburg&rank=3
Filoviridae	Orthomarburgvirus marburgense	cAd3-Marburg vaccine	Viral Vector	Phase 2	Sabin Vaccine Institute	https://clinicaltrials.gov/study/NCT05817422?cond=marburg&rank=1
Filoviridae	Orthomarburgvirus marburgense	Several		Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9560149/
Filoviridae	Orthoebolavirus sudanense	HPIV3-SUDV GP	Parainfluenza virus vector	Phase 1	NIAID	NCT03462004
Filoviridae	Orthoebolavirus sudanense	rVSVΔG-SEBOV-GP	Viral Vector	Phase 1	IAVI	https://clinicaltrials.gov/study/NCT05724472?cond=sudan&term=vaccine&rank=3
Filoviridae	Orthoebolavirus sudanense	cAd3-EBO S	Viral Vector	Phase 1	NIAID	https://clinicaltrials.gov/study/NCT04041570?cond=sudan&term=vaccine&rank=4
Filoviridae	Orthoebolavirus sudanense	ChAdOx1 biEBOV	Viral Vector	Phase 1b	University of Oxford	https://clinicaltrials.gov/study/NCT05301504?cond=sudan&term=vaccine&rank=6
Filoviridae	Orthoebolavirus sudanense	cAd3-Sudan Ebolavirus	Chimpanzee adenovirus vector	Phase 2	Sabin Vaccine Institute	https://clinicaltrials.gov/study/NCT06036602?cond=sudan&term=vaccine&rank=2
Filoviridae	Orthoebolavirus sudanense	MVA-SUDV	Modified Vaccinia Ankara (MVA) vector	Preclinical		https://www.nature.com/articles/s41541-022-00512-x

Family	Pathogen	Vaccine name	Platform	Phase of development	Developer	Source
Filoviridae	Orthoebolavirus sudanense	VSV-SUDV	Vesicular Stomatitis Virus (VSV) vector	Preclinical	NIAID	https://www.niaid.nih.gov/news-events/experimental-nih-sudan-virus-vaccine-protects-macaques
Flaviviridae	Orthoflavivirus denguei	Dengvaxia	Chimeric virus YFV/DEN1-4	Licensed	Sanofi Pasteur	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	TV003/TV005	Live atteunuated and chimeric virus	Phase 3	NIAID and Butantan	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	TAK-003	Chimeric viruses	Phase 2	Takeda	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	TDEN	Live attenuated	Phase 1/2	WRAIR and GSK	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	DPIV	Inactivated Virus	Phase 1	WRAIR, GSK, FIOcruz	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	TVDV	DNA vaccine	Preclinical/Phase 1	US AMRDC, WRAIR, NMRC and Vical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	V180	Recombinant protein	Phase 1	Merck	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	DSV4	Virus-like particles	Preclinical	International Centre for Genetic Engineering and Biotechnology	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus denguei	E80-mRNA	mRNA	Preclinical	CAS laboratory of Molecular Virology and Immunology, Institute Pasteur of Shanghai	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10228381/
Flaviviridae	Orthoflavivirus zikaense	ZPIV	Inactivated	Phase 1	NIAID/WRAIR/BIDMC	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	PIZV/TAK-426	Inactivated	Phase 1	Takeda	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	VLA1601	Inactivated	Phase 1	Valneva Austria GmbH	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	BBV121	Inactivated	Phase 1	Bharat Biotech International	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	VRC5288	DNA vaccine	Phase 1	NIAID, VRC	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	VRC5283	DNA vaccine	Phase 2	NIAID, VRC	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	GLS-5700	DNA vaccine	Phase 1	GeneOne Life Science/Inovio	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	rZIKV/D430–713	Live attenuated	Phase 1	NIAID	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	mRNA 1325	mRNA	Phase 2	Moderna Therapeutics	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	mRNA 1893	mRNA	Phase 2		https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	MV-ZIKA-RSP	Viral Vector	Phase 1	Themis Bioscience GmbH	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	MV-ZIKA	Viral Vector	Phase 1	Themis Bioscience GmbH	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	ChAdOx1 ZIKA	Viral Vector	Phase 1	University of Oxford	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus zikaense	Ad26.ZIKV.001	Viral Vector	Phase 1	Janssen Vaccines and Prevention BV	https://academic.oup.com/femspd/article/doi/10.1093/femspd/ftad036/7513202
Flaviviridae	Orthoflavivirus flavi	YF17D	Live attenuated	Licensed		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	XRX-001	Inactivated	Phase 1		https://www.mdpi.com/1424-8247/14/9/891

Family	Pathogen	Vaccine name	Platform	Phase of development	Developer	Source
Flaviviridae	Orthoflavivirus flavi	VINFLAPI001/2010	Inactivated	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	Chumakov Institute inactivated YF vaccin	Inactivated	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	Recombinant vaccinia virus/17D YFV	Viral vector	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	MVA-YF and dVV-YF	Viral vector	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	MVA-BN-YF	Viral vector	Phase 1		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	pYF17D-16 iDNA	DNA	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	pBeloBAC-FLYF and pBeloBAC-YF/ΔC	DNA	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	pShuttle/YFV-17D	DNA	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	p/YFE and pL/YFE	DNA	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	CJaYZ	Virus-like particles	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	(YF) prME mRNA	RNA	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	Re-encoded wild-type YF viruses	Live attenuated	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	YFE and YFE-LicKM	Subunit vaccine	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	vYF-247	New manufacturing tools	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Flaviviridae	Orthoflavivirus flavi	YFCEF-01-07	New manufacturing tools	Preclinical		https://www.mdpi.com/1424-8247/14/9/891
Hantaviridae	Orthohantavirus sinnombreense	NONE	Multiple types	NONE	NONE	NONE
Orthomyxoviridae	Alphainfluenzavirus influenzae H1,H3	Licensed Seasonal flu vaccines	Computationally optimized HA antigens	Licensed		
Orthomyxoviridae	Alphainfluenzavirus influenzae H1,H3	Universal Influenza Vaccine Candidate	Inactivated	Phase 2	Sanofi Pasteur	NCT03300050
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	H5N1 influenza virus vaccine	Inactivated	Licensed		https://www.fda.gov/vaccines-blood-biologics/vaccines/influenza-virus-vaccine-h5n1-national-stockpile
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	AS03-adjuvanted pre-pandemic H5N1 influenza vaccine	Inactivated	Licensed		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10058720/
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	MF59-adjuvanted seasonal influenza vaccine (Fluad®)	Live attenuated	Licensed	Novartis Vaccines and Diagnostics Inc.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10058720/
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	H5N1 pandemic live-attenuated influenza virus vaccination	Live attenuated	Licensed		https://pubmed.ncbi.nlm.nih.gov/26082783/
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	Pandemic influenza vaccine H5N1 Astrazeneca	Live attenuated	Licensed		https://www.ema.europa.eu/en/medicines/human/EPAR/pandemic-influenza-vaccine-h5n1-astrazeneca-previously-pandemic-influenza-vaccine-h5n1-medimmune
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	H7 pandemic live-attenuated influenza vaccines (pLAIV)	n/a	Phase 1		https://pubmed.ncbi.nlm.nih.gov/25446831/
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	H10N8 vaccine		Phase 1		https://pubmed.ncbi.nlm.nih.gov/31079849/
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	VRC-FLUNPF0103-00-VP	Live attenuated	Phase 1		https://clinicaltrials.gov/study/NCT04579250?cond=h10&rank=1
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	H5 candidate vaccine strain A/17/turkey/Turkey/05/133		Phase 2		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10058720/
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	Panblok H7	Live attenuated	Phase 2	BARDA	https://clinicaltrials.gov/study/NCT03283319?cond=h7&rank=2

Family	Pathogen	Vaccine name	Platform	Phase of development	Developer	Source
Orthomyxoviridae	Alphainfluenzavirus influenzae H5,H6,H7,H10	H7N9 LAIV	mRNA	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10058720/
Paramyxoviridae	Henipavirus nipahense	mRNA-1215 vaccine	Subunit (Hendra virus glycoprotein)	Phase 1	NIAID	https://clinicaltrials.gov/study/NCT05398796
Paramyxoviridae	Henipavirus nipahense	HeV-sG-V	Viral Vector	Phase 1	AuroVaccines	https://classic.clinicaltrials.gov/ct2/show/NCT04199169
Paramyxoviridae	Henipavirus nipahense	rVSV Nipah Virus Vaccine	Subunit (soluble F and G proteins)	Phase 1		https://clinicaltrials.gov/study/NCT05178901
Paramyxoviridae	Henipavirus nipahense	Nipah vaccine	Subunit (stabilized prefusion F trimer, multimeric G)	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7870971/
Paramyxoviridae	Henipavirus nipahense	Nipah vaccine	Viral Vector	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7300195/
Paramyxoviridae	Henipavirus nipahense	VSV-NiVG	Live attenuated virus	Preclinical		https://www.thelancet.com/journals/ebiom/article/PIIS2352-3964%2822%2900587-4/fulltext
Picornaviridae	Enterovirus coxsackiepol	Novel Oral Polio Vaccine type 2 (nOPV2)	Inactivated virus	EUL		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10109087/
Picornaviridae	Enterovirus coxsackiepol	Inactivated Poliovirus Vaccine (IPV)	Live attenuated virus	Licensed	Multiple	
Picornaviridae	Enterovirus coxsackiepol	Oral Polio Vaccine (OPV)	Inactivated Sabin strains	Licensed	Multiple	
Picornaviridae	Enterovirus coxsackiepol	Sabin-IPV	Inactivated virus, microneedle patch	Phase 3	Sinovac Biotech	https://clinicaltrials.gov/study/NCT05850364?cond=polio%20vaccine&rank=16
Picornaviridae	Enterovirus coxsackiepol	Microneedle Array Patch IPV	Virus-like particles	Preclinical		https://www.nature.com/articles/s41541-022-00443-7
Picornaviridae	Enterovirus coxsackiepol	VLP Polio Vaccine	Protein subunit vaccine	Preclinical		https://www.mdpi.com/2076-0817/13/3/224
Poxviridae	Orthopoxvirus Monkeypox	Ectodomains A33/B5/A27 + Alhydrogel and CpG	Protein subunit vaccine	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	10 epitopes with 147 amino acid residues	Protein subunit vaccine	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	multi-epitope vaccine with GPGPG linkers	Protein subunit vaccine	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	MHC-I, MHC-II, and B-cell epitopes	Virus-like particles	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	Novovirus shell and VLP platform	DNA Vaccine	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	Plasmid DNA encoding MPOX orthologs	DNA Vaccine	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	Plasmid cocktail	mRNA vaccine	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	mRNA encoding three mABs	Live attenuated	Preclinical		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	IMVAMUNE	Live attenuated	Phase 3	Bavarian Nordic	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	MVA-BN	Live attenuated	Phase 2	Bavarian Nordic	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Poxviridae	Orthopoxvirus Monkeypox	Imvanex	Adenovirus vector	Licensed		https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10186953/
Retroviridae	Lentivirus humimdef1	Ad4-Env150KN/Ad4-Env145NFL + VRC-HIVRGP096-00-VP	Adenovirus vector	Phase 1	NIAID	https://clinicaltrials.gov/study/NCT03878121?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=45
Retroviridae	Lentivirus humimdef1	AdC6-HIVgp140 and AdC7-HIVgp140	Adenovirus vector	Phase 1	HIV Vaccine Trials Network	https://clinicaltrials.gov/study/NCT05182125?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=25
Retroviridae	Lentivirus humimdef1	ChAdOx1.tHIVconsv1 prime followed by MVA.tHIVconsv3 and MVA.tHIVconsv4 boost	Bivalent subunit vaccine	Phase 1	University of Oxford	https://clinicaltrials.gov/study/NCT04553016?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=18
Retroviridae	Lentivirus humimdef1	AIDSVAX B/E+ IHV01 and A244/AHFG (w/ALFQ)	CMV Vector	Phase 1	WRAIR	https://clinicaltrials.gov/study/NCT04586667?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=5

Family	Pathogen	Vaccine name	Platform	Phase of development	Developer	Source
Retroviridae	Lentivirus humimdef1	VIR 1388	DNA	Phase 1	Vir Biotechnology, Inc.	https://clinicaltrials.gov/study/NCT05854381?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=26
Retroviridae	Lentivirus humimdef1	Env-C Plasmid DNA and HIV Env gp145 C690 protein	Engineered immunogen	Phase 1	NIAID	https://clinicaltrials.gov/study/NCT04826094?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=15
Retroviridae	Lentivirus humimdef1	eOD-GT8 60mer	mRNA	Phase 1	IAVI	https://pubmed.ncbi.nlm.nih.gov/37224227/
Retroviridae	Lentivirus humimdef1	mRNA-1644/v2-Core	mRNA	Phase 1	IAVI, Moderna	NCT05001373
Retroviridae	Lentivirus humimdef1	BG505 MD39.3 mRNA, BG505 MD39.3 gp151 mRNA or BG505 MD39.3 gp151 CD4KO mRNA	Recombinant	Phase 1	NIAID	https://clinicaltrials.gov/study/NCT05217641?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=17
Retroviridae	Lentivirus humimdef1	SOSIP v8.2 763		Phase 1	Fundacion Clinic per a la Recerca Biomédica	https://clinicaltrials.gov/study/NCT05772286?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=35
Retroviridae	Lentivirus humimdef1	EHVA P01		Phase 1	ANRS, Emerging Infectious Diseases	https://clinicaltrials.gov/study/NCT04844775?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=43
Retroviridae	Lentivirus humimdef1	CH505TF gp120, adjuvanted with GLA-SE	Adenovirus vector	Phase 1	HIV Vaccine Trials Network	https://clinicaltrials.gov/study/NCT04607408?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=16
Retroviridae	Lentivirus humimdef1	Ad26.Mos4.HIV prime and a boost with Modified Vaccinia Ankara (MVA)-BN-HIV	Bivalent subunit vaccine	Phase 1/2a	Janssen Pharmaceuticals	https://clinicaltrials.gov/study/NCT04983030?cond=HIV&intr=vaccine&aggFilters=status:rec%20act%20not,studyType:int&rank=30
Retroviridae	Lentivirus humimdef1	AIDSVAX B/E	Prime-boost (viral vector + subunit)	Phase 3	VaxGen	NCT00006327, NCT00002441
Retroviridae	Lentivirus humimdef1	ALVAC-HIV + AIDSVAX B/E	Live attenuated	Phase 3	Sanofi Pasteur, VaxGen	NCT00223080
Togaviridae	Alphavirus chikungunya	Ixchiq	mRNA	Licensed	Valneva Austria GmbH	https://www.fda.gov/news-events/press-announcements/fda-approves-first-vaccine-prevent-disease-caused-chikungunya-virus
Togaviridae	Alphavirus chikungunya	mRNA-1388	mRNA	Phase 1	Moderna	https://pubmed.ncbi.nlm.nih.gov/37210308/
Togaviridae	Alphavirus chikungunya	mRNA-1944	Viral Vector	Phase 1	Moderna	https://pubmed.ncbi.nlm.nih.gov/34887572/
Togaviridae	Alphavirus chikungunya	ChAdOx1 Chik	Viral Vector	Phase 1	University of Oxford	https://classic.clinicaltrials.gov/ct2/show/NCT04440774
Togaviridae	Alphavirus chikungunya	MV-CHIK	Virus-like particle (VLP)	Phase 2	Themis Bioscience GmbH	https://pubmed.ncbi.nlm.nih.gov/30409443/
Togaviridae	Alphavirus chikungunya	PXVX0317 CHIKV-VLP	DNA	Phase 2	Bavarian Nordic	https://clinicaltrials.gov/study/NCT03483961
Togaviridae	Alphavirus venezuelan	VEE DNA Vaccine	VLP	Phase 1	US Dept of Defense	https://clinicaltrials.gov/study/NCT00582504?cond=Venezuelan%20Equine%20Encephalitis&rank=3
Togaviridae	Alphavirus venezuelan	VRC-WEVVLP073-00-VP	VLP	Phase 1	NIAID	https://clinicaltrials.gov/study/NCT03879603?cond=Venezuelan%20Equine%20Encephalitis&rank=6
Togaviridae	Alphavirus venezuelan	VEE VLP Vaccine	Modified Vaccinia Ankara (MVA)	Phase 1	SRI International	https://clinicaltrials.gov/study/NCT03776994?cond=Venezuelan%20Equine%20Encephalitis&rank=8
Togaviridae	Alphavirus venezuelan	MVA-BN WEV	Multiple	Phase 2	Bavarian Nordic	https://www.bavarian-nordic.com/investor/news/news.aspx?news=6667
Togaviridae	Alphavirus venezuelan	Multiple		Preclinical	Multiple	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7350001/

Candidate therapeutics

Family	Pathogen	Treatment	Phase of development	Resource
Arenaviridae	Mammarenavirus lassaense	Ribavirin	Off-Label Use/Phase 2/3	NCT06212336
Arenaviridae	Mammarenavirus lassaense	LHF-535	Phase 1	pubmed.ncbi.nlm.nih.gov/36314868/
Arenaviridae	Mammarenavirus lassaense	Dexamethasone	Phase 2	NCT06222723
Arenaviridae	Mammarenavirus lassaense	Favipiravir	Phase 2/3	NCT06212336; NCT06222723
Arenaviridae	Mammarenavirus lassaense	ARN-75309	Phase 1	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Bacteria	Klebsiella Pneumonia	Antibiotics (multiple)	Licensed	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960543/
Bacteria	Klebsiella Pneumonia	Phage Therapy	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960543/
Bacteria	Klebsiella Pneumonia	Traditional Chinese Medicine	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960543/
Bacteria	Klebsiella Pneumonia	Antimicrobial Nanoparticle Technology	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960543/
Bacteria	Klebsiella Pneumonia	Antisense Oligonucleotides & Gene Editing Technologies	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960543/
Bacteria	Klebsiella Pneumonia	Novel Antibiotics	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960543/
Bacteria	Klebsiella Pneumonia	Antimicrobial peptides	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960543/
Bacteria	Shigella Dysenteria 1	Antibiotics (multiple)	Licensed	
Bacteria	Vibrio Cholerae (sero 0139)	Antibiotics (Azirthromycin)	Licensed	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5972638/
Bacteria	Vibrio Cholerae (sero 0139)	Antibiotics (Erythromycin)	Licensed	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5972638/
Bacteria	Yersinia Pestis (Plague)	Antiobiotics	Licensed	https://www.who.int/health-topics/plague#tab=tab_3
Nairoviridae	Orthonairovirus haemorrhagiae	Ribavirin	Off-Label Use/Phase 1	https://kce.fgov.be/sites/default/files/2023-03/ADVICE_Ribavirin%20LF-CCHF_FINAL.pdf; clinicaltrials.gov/study/NCT05940545?cond=cchf&rank=1
Nairoviridae	Orthonairovirus haemorrhagiae	Favipiravir	Phase 1	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10013989/
Nairoviridae	Orthonairovirus haemorrhagiae	Antibody-based therapies	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10013989/
Nairoviridae	Orthonairovirus haemorrhagiae	2'-Deoxy-2'-fluorocytidine	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10013989/
Nairoviridae	Orthonairovirus haemorrhagiae	Molnupiravir	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10013989/
Nairoviridae	Orthonairovirus haemorrhagiae	Corticosteroids	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10013989/
Phenuiviridae	Bandavirus dabieense	Plasma Exchange	Ad Hoc use	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9510271/
Phenuiviridae	Bandavirus dabieense	Favipiravir	Clinical Use	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9510271/
Phenuiviridae	Bandavirus dabieense	Ribavirin	Clinical Use	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9510271/

Family	Pathogen	Treatment	Phase of development	Resource
Phenuiviridae	Bandavirus dabieense	methylprednisolone/IVIG/tocilizumab/heparin	Phase 4	https://clinicaltrials.gov/study/NCT05604859?cond=sfts%20virus&rank=1
Phenuiviridae	Bandavirus dabieense	Flurdarabine	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9510271/
Phenuiviridae	Bandavirus dabieense	nifedipine	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9510271/
Phenuiviridae	Bandavirus dabieense	Quinoline Analogues	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9510271/
Coronaviridae	Sarbecoviruses	mAbs binding hACE2	Preclinical	https://www.nature.com/articles/s41564-023-01389-9
Filoviridae	Orthoebolavirus zairense	Inmazeb (Atoltivimab, Maftivimab, and Odesivimab-ebgn)	Licensed	https://pubmed.ncbi.nlm.nih.gov/31774950/
Filoviridae	Orthoebolavirus zairense	mAb114 - ansuvimab (Ebanga)	Licensed	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus zairense	MBP134	Phase 1/2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6341996/
Filoviridae	Orthoebolavirus zairense	Galidesivir	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus zairense	GP inhibitors	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus zairense	Bispecific antibody targeting GP and NPV-1	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus zairense	Adaptor-associated kinase 1 (AAK1) inhibitors	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthomarburgvirus marburgense	Galidesivir	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9949811/
Filoviridae	Orthomarburgvirus marburgense	Favipiravir	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9949811/
Filoviridae	Orthomarburgvirus marburgense	mAbs	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9949811/
Filoviridae	Orthomarburgvirus marburgense	siRNA	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9949811/
Filoviridae	Orthomarburgvirus marburgense	antisense PMOs	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9949811/
Filoviridae	Orthoebolavirus sudanense	Inmazeb (Atoltivimab, Maftivimab, and Odesivimab-ebgn)	Licensed for Zaire	https://pubmed.ncbi.nlm.nih.gov/31774950/
Filoviridae	Orthoebolavirus sudanense	mAb114 - ansuvimab (Ebanga)	Licensed for Zaire	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus sudanense	MBP134	Phase 1/2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6341996/
Filoviridae	Orthoebolavirus sudanense	Galidesivir	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus sudanense	GP inhibitors	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus sudanense	Bispecific antibody targeting GP and NPV-1	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Filoviridae	Orthoebolavirus sudanense	Adaptor-associated kinase 1 (AAK1) inhibitors	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005

Family	Pathogen	Treatment	Phase of development	Resource
Filoviridae	Orthoebolavirus sudanense	Adaptor-associated kinase 1 (AAK1) inhibitors	Preclinical	journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1012038#sec005
Flaviviridae	Orthoflavivirus denguei	EYU688	Phase 2	https://clinicaltrials.gov/study/NCT06006559?cond=dengue&start=2020-01-01_&aggFilters=phase:0%201%203%202,status:com%20act,studyType:int&rank=2
Flaviviridae	Orthoflavivirus denguei	Montelukast	Phase 2/3	https://clinicaltrials.gov/study/NCT04673422?cond=dengue&start=2020-01-01_&aggFilters=phase:0%201%203%202,status:com%20act,studyType:int&rank=12
Flaviviridae	Orthoflavivirus denguei	AV-1 (monoclonal antibody)	Phase 1	https://clinicaltrials.gov/study/NCT04273217?cond=dengue&start=2020-01-01_&aggFilters=phase:0%201%203%202,status:com%20act,studyType:int&rank=17
Flaviviridae	Orthoflavivirus denguei	Carica Papaya	Phase 3	https://clinicaltrials.gov/study/NCT06121934?cond=dengue&start=2020-01-01_&aggFilters=phase:0%201%203%202,status:com%20act,studyType:int&rank=1
Flaviviridae	Orthoflavivirus denguei	JNJ-64281802	Phase 2	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Ivermectin	Phase 2/3	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	AT-752	Phase 2	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Doxycycline	Phase 2	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Eltrombopag	Phase 2	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	UV-4B	Phase 1	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Zanamivir	Phase 1	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	VIS513	Phase 1	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Ketotifen	Phase 4	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Rupatadine		https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Metformin	Phase 1/2	https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Vitamin E		https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus denguei	Vitamin D		https://pubmed.ncbi.nlm.nih.gov/37124673/
Flaviviridae	Orthoflavivirus zikaense	Polyanion suramin	Approved antiparasitic drug	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Brcomocriptine	Preclinical	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Novobiocin	Clinically used antibiotic	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Compounds 1 and 2	Preclinical	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Asunaprevir and simeprevir	FDA-approved	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Sofosbuvir	FDA-approved for HCV infection	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	4-HPR	Preclinical	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full

Family	Pathogen	Treatment	Phase of development	Resource
Flaviviridae	Orthoflavivirus zikaense	3-110-22	Preclinical	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	ZINC40621658	Preclinical	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Atovaquone	FDA-approved for malaria	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Phloretin	Preclinical	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	MTX	Clinical use for other treatment	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	JG40, JG132, and JG345	Preclinical	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	QC, MQ, and GSK369796	FDA approved for malaria	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	Memantine	Approved for other diseases	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	A-12	Phase 1 for cancer	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Flaviviridae	Orthoflavivirus zikaense	MMPD	FDA approved for HCV infection	https://www.frontiersin.org/articles/10.3389/fcimb.2022.946957/full
Orthomyxoviridae	Alphainfluenzavirus influenzae	GP681	Phase 3	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	ZX-7101A	Phase 3	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	CC-42344	Phase 1	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	HCN042	Phase 2	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Amantadine	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Baloxavir Marboxil	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Favipiravir	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Laninamivir	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Oseltamivir	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Peramivir	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf

Family	Pathogen	Treatment	Phase of development	Resource
Orthomyxoviridae	Alphainfluenzavirus influenzae	Rimantadine	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Zanamivir	Licensed	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Enisamium (VR17-04)	Licensed by other international authority	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Triazavirin	Licensed by other international authority	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Orthomyxoviridae	Alphainfluenzavirus influenzae	Umifenovir	Licensed by other international authority	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Paramyxoviridae	Henipavirus nipahense	Ribavirin (antiviral)	Clinical trials	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Remdesivir (antiviral)	Preclinical	https://www.science.org/doi/epdf/10.1126/scitranslmed.aau9242?src=getftr
Paramyxoviridae	Henipavirus nipahense	Favipiravir	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Chloroquine	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Heparin	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Rintatolimid	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Griffithsin	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	VIKI-dPEG4-Toco, VIKI-PEG4-chol	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Gliotoxin	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Bortezomib	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Balapiravir	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Lumicitabine	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	CH25H	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	KIN1408	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author

Family	Pathogen	Treatment	Phase of development	Resource
Paramyxoviridae	Henipavirus nipahense	Sulfonamide compounds	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Paramyxoviridae	Henipavirus nipahense	Monoclonal Antibodies	Preclinical	https://www.sciencedirect.com/science/article/pii/S147330992100400X?dgcid=author
Picornaviridae	Enterovirus coxsackiepol	V-7404	Phase 1	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Picornaviridae	Enterovirus coxsackiepol	Pocapavir	Phase 1	https://www.intrepidalliance.org/wp-content/uploads/2024/04/INTREPID-Alliance-Antiviral-Clinical-Development-Landscape-29APR2024.pdf
Poxviridae	Orthopoxvirus Monkeypox	Cidofovir	Off label use	https://www.mdpi.com/1999-4915/15/4/937
Poxviridae	Orthopoxvirus Monkeypox	Brincidofovir	Off label use/Phase 1	https://www.mdpi.com/1999-4915/15/4/937
Poxviridae	Orthopoxvirus Monkeypox	Tecovirimat	Off label use/Phase 3	https://www.mdpi.com/1999-4915/15/4/937
Poxviridae	Orthopoxvirus Monkeypox	VIGIV	Off label use	https://www.mdpi.com/1999-4915/15/4/937
Retroviridae	Lentivirus humimdef1	Nucleoside Reverse Transcriptase Inhibitors	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Non-Nucleoside Reverse Transcriptase Inhibitors	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Protease Inhibitors	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Fusion Inhibitors	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	CCR5 Antagonists	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Integrase Strand Transfer Inhibitor (INSTIs)	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Attachment Inhibitors	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Post-Attachment Inhibitors	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Capsid Inhibitors	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Pharmacokinetic Enhancers	Licensed	https://www.fda.gov/consumers/free-publications-women/hiv-and-aids-medicines-help-you
Retroviridae	Lentivirus humimdef1	Gene Therapy	Preclinical	https://medicine.wustl.edu/news/6-2-million-to-help-develop-gene-therapy-for-hiv/
Retroviridae	Lentivirus humimdef1	Immunotherapy	Preclinical	https://health.ucdavis.edu/news/headlines/clinical-trial-begins-using-car-t-cells-to-potentially-cure-hiv/2023/04
Togaviridae	Alphavirus chikungunya	Several antivirals	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8310245/
Togaviridae	Alphavirus venezuelan	Small molecule antiviral	Preclinical	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9958955/

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