A Scientific Framework for Epidemic and Pandemic Research preparedness

WHO Headquarters in Geneva
August 2024

FACULTAD DE MEDICINA UASLP

LABORATORIO DE GENOMICA VIRAL Y HUMANA
FACULTAD DE MEDICINA
UASLP

MSc. J Manuel Mendoza-Mendez
Dr. CA García-Sepúlveda

Laboratorio de Genómica Viral y Humana
Facultad de Medicina
Universidad Autónoma de San Luis Potosí

WHO R&D Blueprint for Epidemics

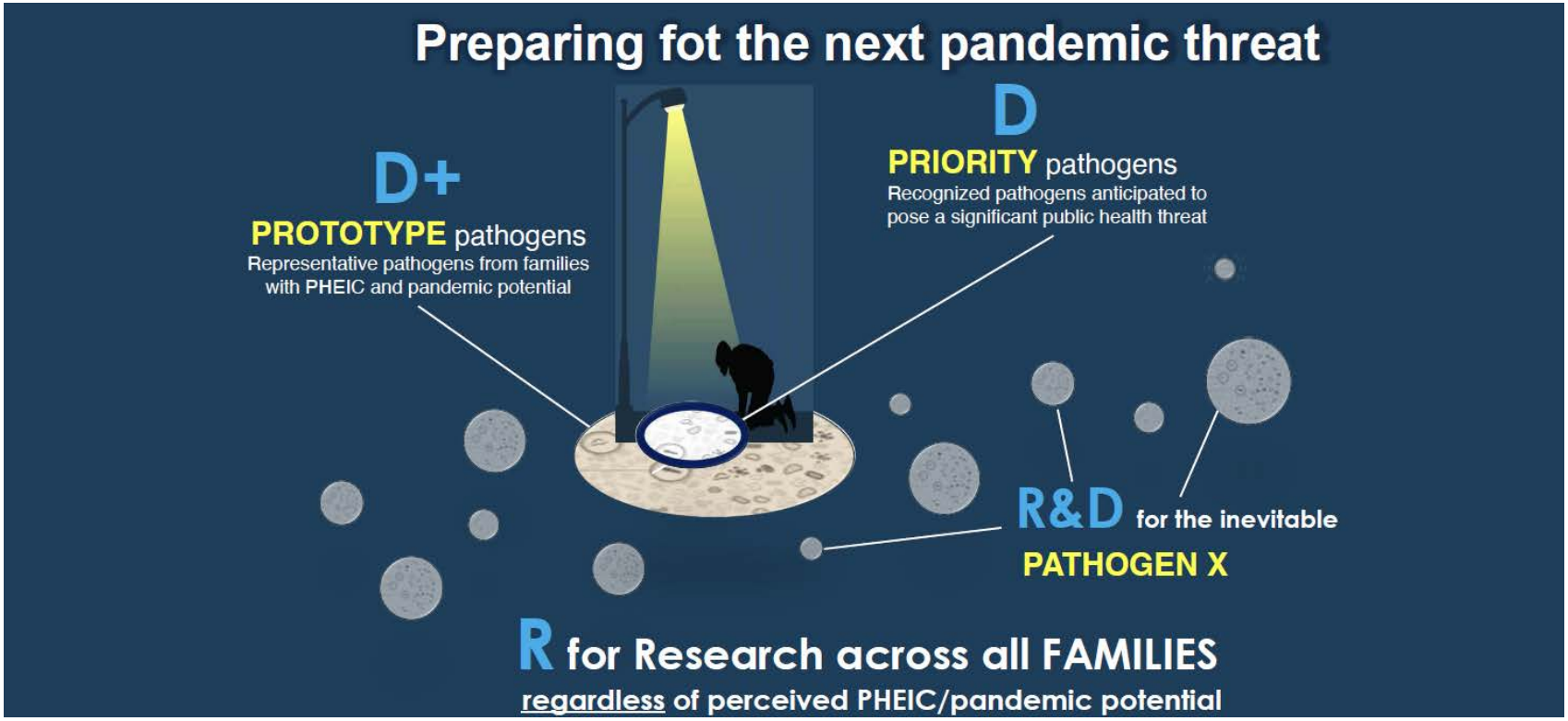
The WHO R&D Blueprint for Epidemics aims to speed up the creation of medical countermeasures (MCMs).

Since its inception in 2015, the initiative has focused on making these countermeasures accessible for diseases with the potential to cause epidemics or pandemics, thereby aiding in the prevention of Public Health Emergencies of International Concern (PHEICs) and protecting lives during outbreaks.

This document presents the results of a global process for prioritizing pathogens, which involved over 200 scientists from more than 50 countries.

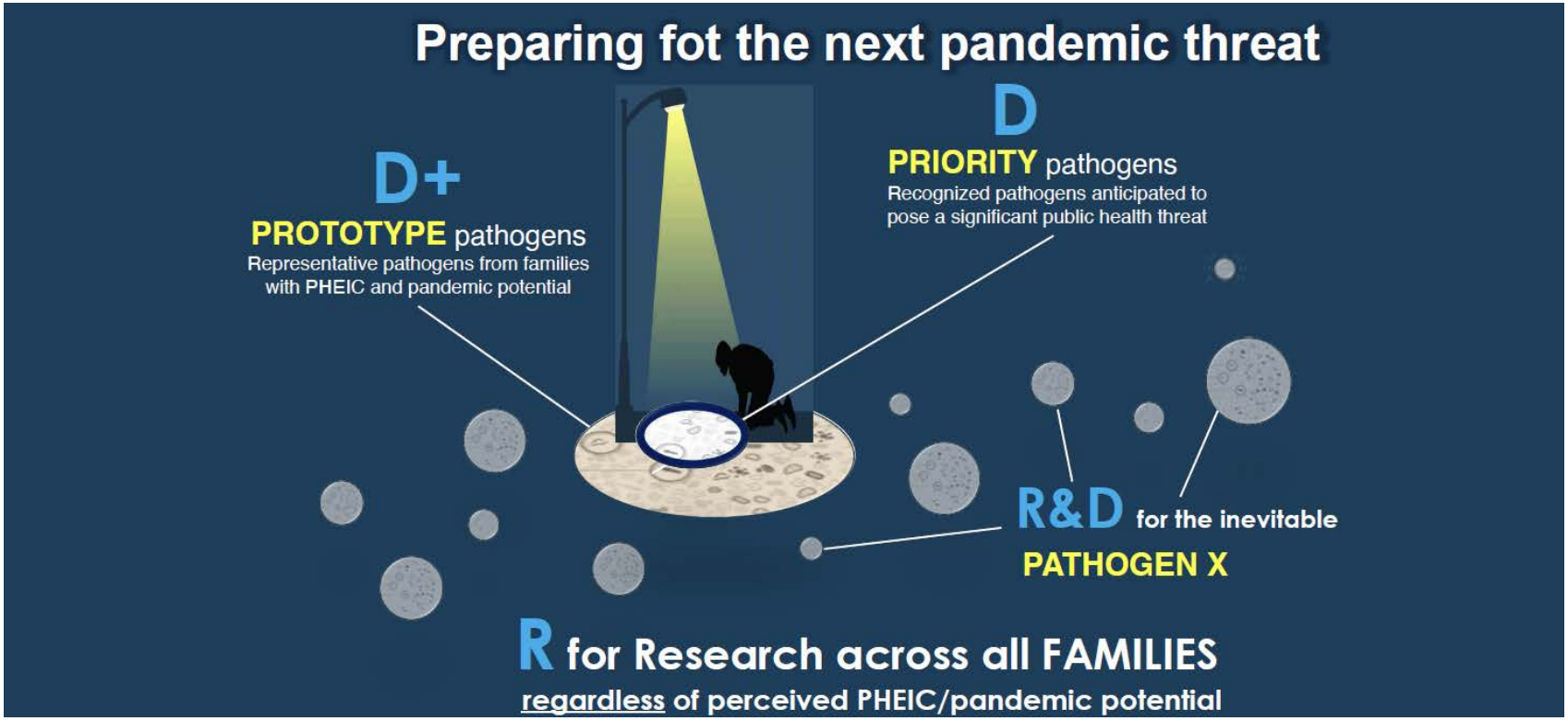
These experts assessed evidence related to 28 Viral Families and one primary group of Bacteria, totaling 1,652 pathogens.

WHO R&D Blueprint for Epidemics



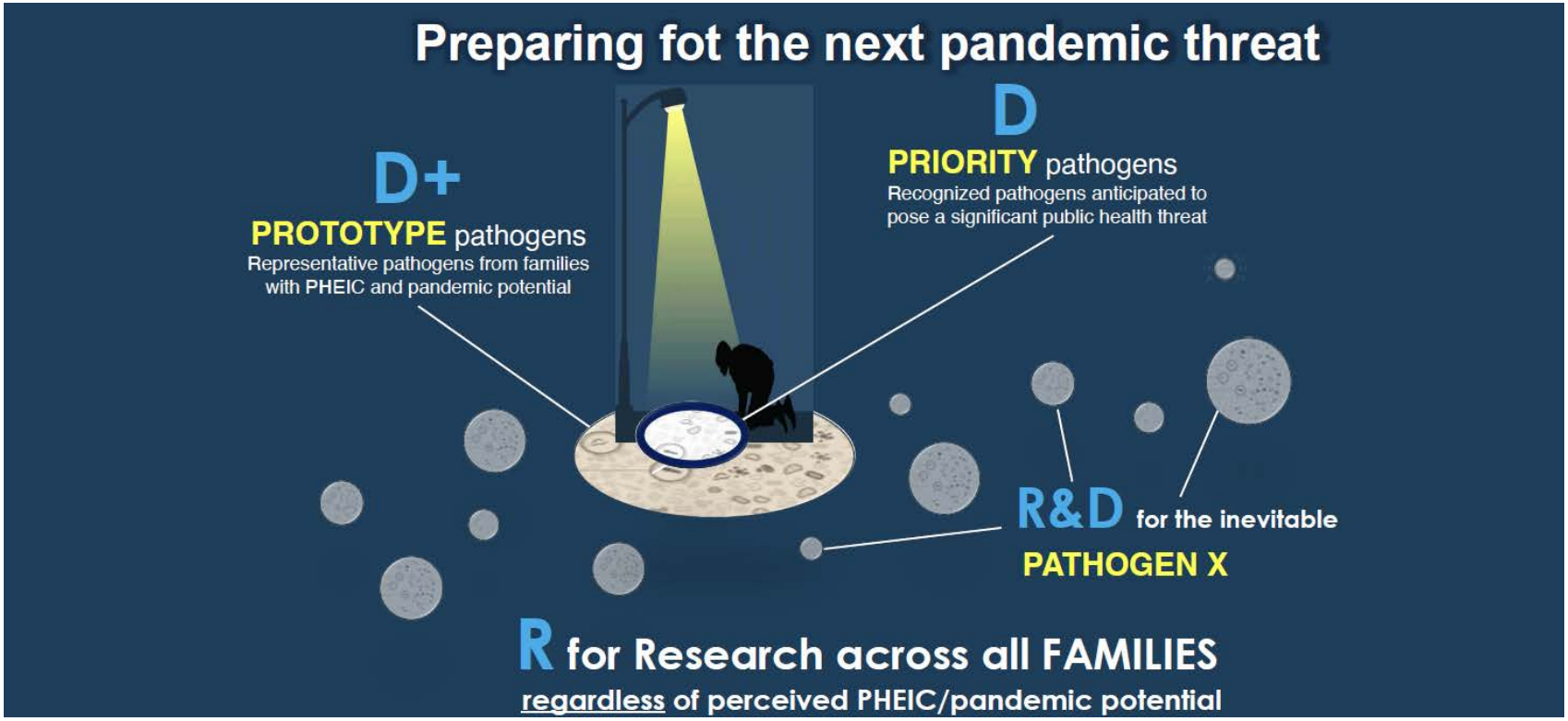
Scientists and public health officials searching for "lost keys," (next pathogen).

WHO R&D Blueprint for Epidemics



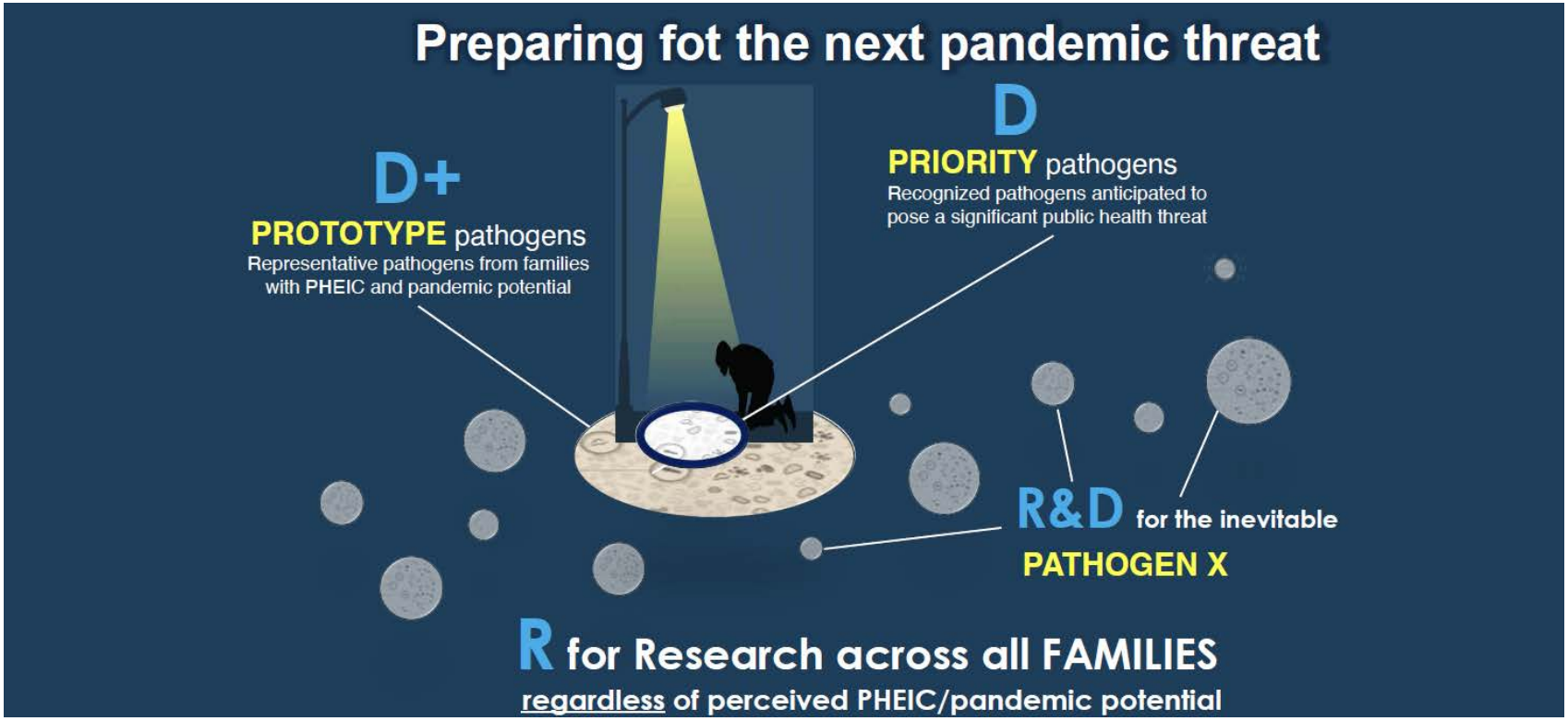
This study of priority pathogens and their risk of causing a pandemic (streetlight).

WHO R&D Blueprint for Epidemics



Research of Prototype Pathogens can expand additional areas of risk of future outbreaks.

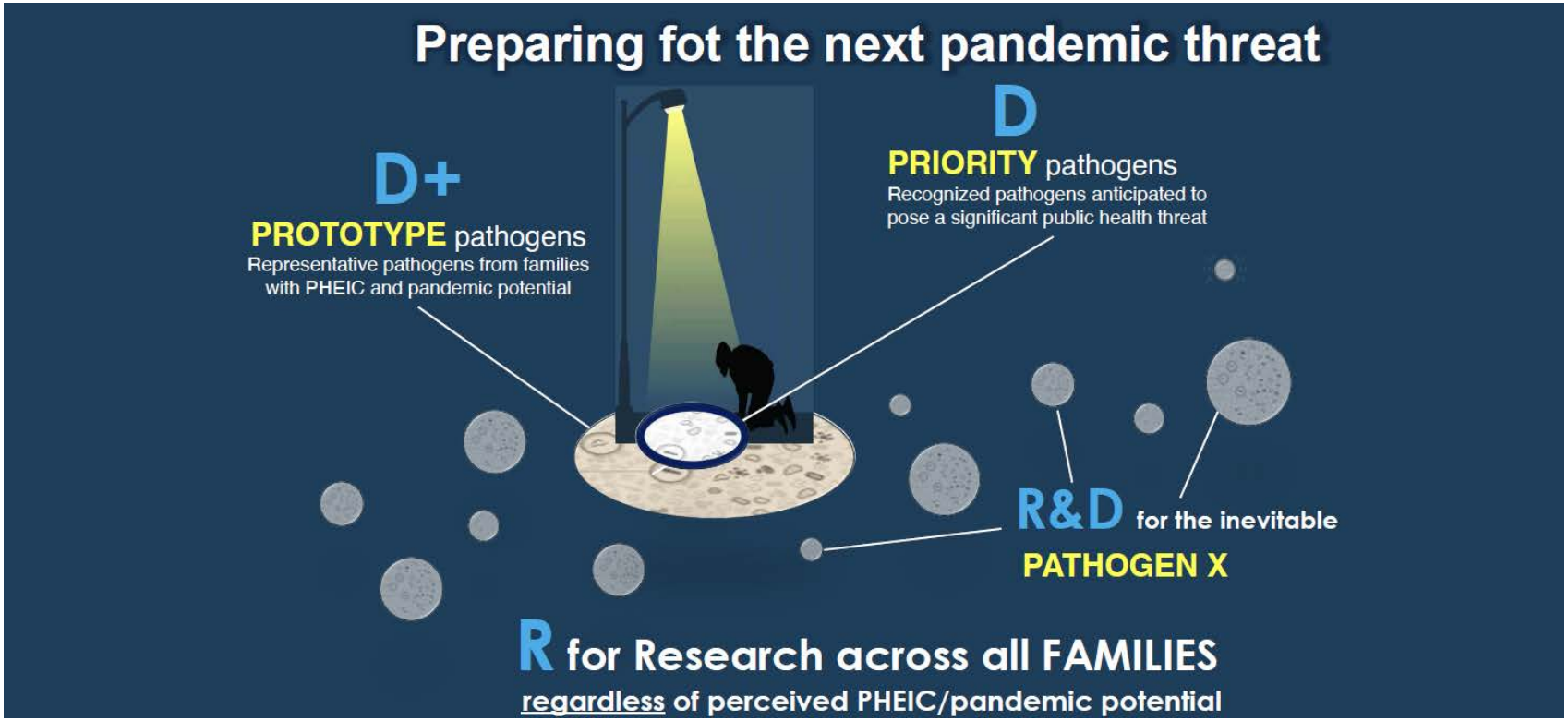
WHO R&D Blueprint for Epidemics



"Dark Areas" represent under-monitored and under-studied geographical areas:

- Resource-limited settings
- High biodiversity.
- Novel pathogens
- Insufficient research infrastructure.

WHO R&D Blueprint for Epidemics



Focusing on known pathogens leads to overlooking emerging or re-emerging pathogens that have potential to cause significant outbreaks in the future.

Pandemic nearsightedness

Broadening pathogen surveillance

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.'

The Prioritization meeting was held on 9-10 May 2024.

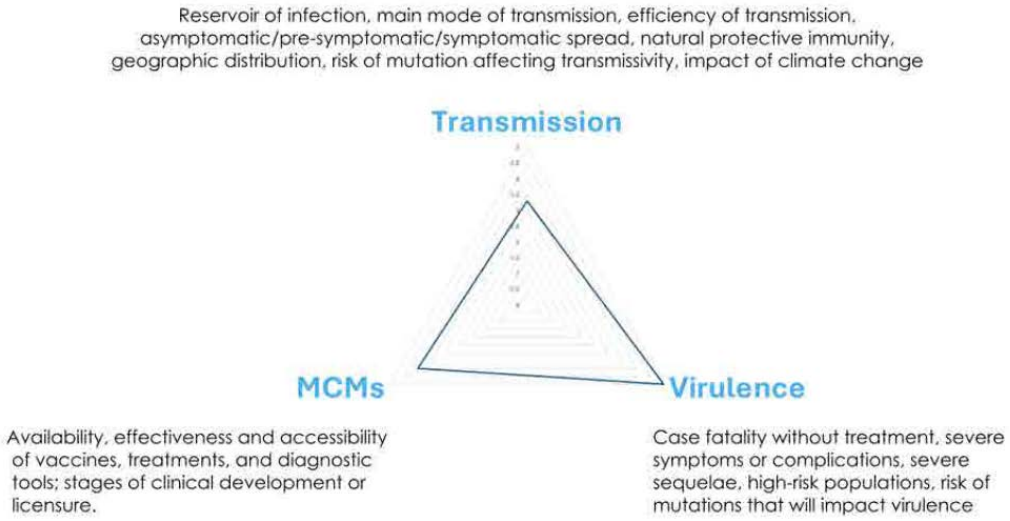
Important: The results of the 2024 meeting emphasize the need to broaden pathogen surveillance to not focus on a single species or causative agent.

Public Health Emergency of International Concern

In late 2022, over 200 scientists from 54 countries conducted a thorough assessment of 1,652 pathogens, including 28 viral families and a core group of bacteria.

Many viruses and bacteria can infect humans, but only a small number have historically led to pandemics or large-scale epidemics.

The assessment evaluated evidence to determine each pathogen's potential to cause a Public Health Emergency of International Concern (PHEIC) or pandemic.



Identifying priorities

OPERATIONAL DEFINITIONS USED

PRIORITY FAMILY

A family that contains at least one Priority Pathogen that can cause a PHEIC (or a pandemic) as defined by the International Health Regulations.

PRIORITY PATHOGEN

Existing knowledge of patterns of transmission, virulence, and access to MCMs suggests a Pathogen can cause a PHEIC (or a pandemic)

PROTOTYPE PATHOGEN

Representative pathogens within a family selected to serve as a model for fundamental research & translational research to develop MCMMs that can be applied to other members of the family

PATHOGEN X

There is evidence to suggest that this pathogen is not currently a PHEIC threat. However, given significant but plausible changes in biology and current patterns of transmission and/or virulence it couls become a Pathogen X threat in the future

Identifying priorities

STEP BY STEP

OBJECTIVES OF THE PAC MEETING

All Families

To compare the various Viral and Bacterial Families and identify those that contain ANY pathogen(s) with the potential to cause PHEIC or a pandemic

01

R

for Research

02

D

for Development

Priority Pathogens

To compare individual Priority Pathogens regarding their potential to cause PHEICs and pandemics:
(i) Potential to cause PHEICs - the pathogens was assessed for their ability to trigger widespread outbreaks.
(ii) Potential to cause harm - factors contributing to the likelihood or severity of harm caused by a pathogen was considered.
(iii) Availability of MCMs - i.e. accessibility of treatments, vaccines, or other interventions to combat the infection.

Prototype Pathogens

To enumerate and consider the proposed Prototype Pathogens identified across Families and debate their potential to contribute to the development of MCMs across their family and beyond.

03

D+

for Development

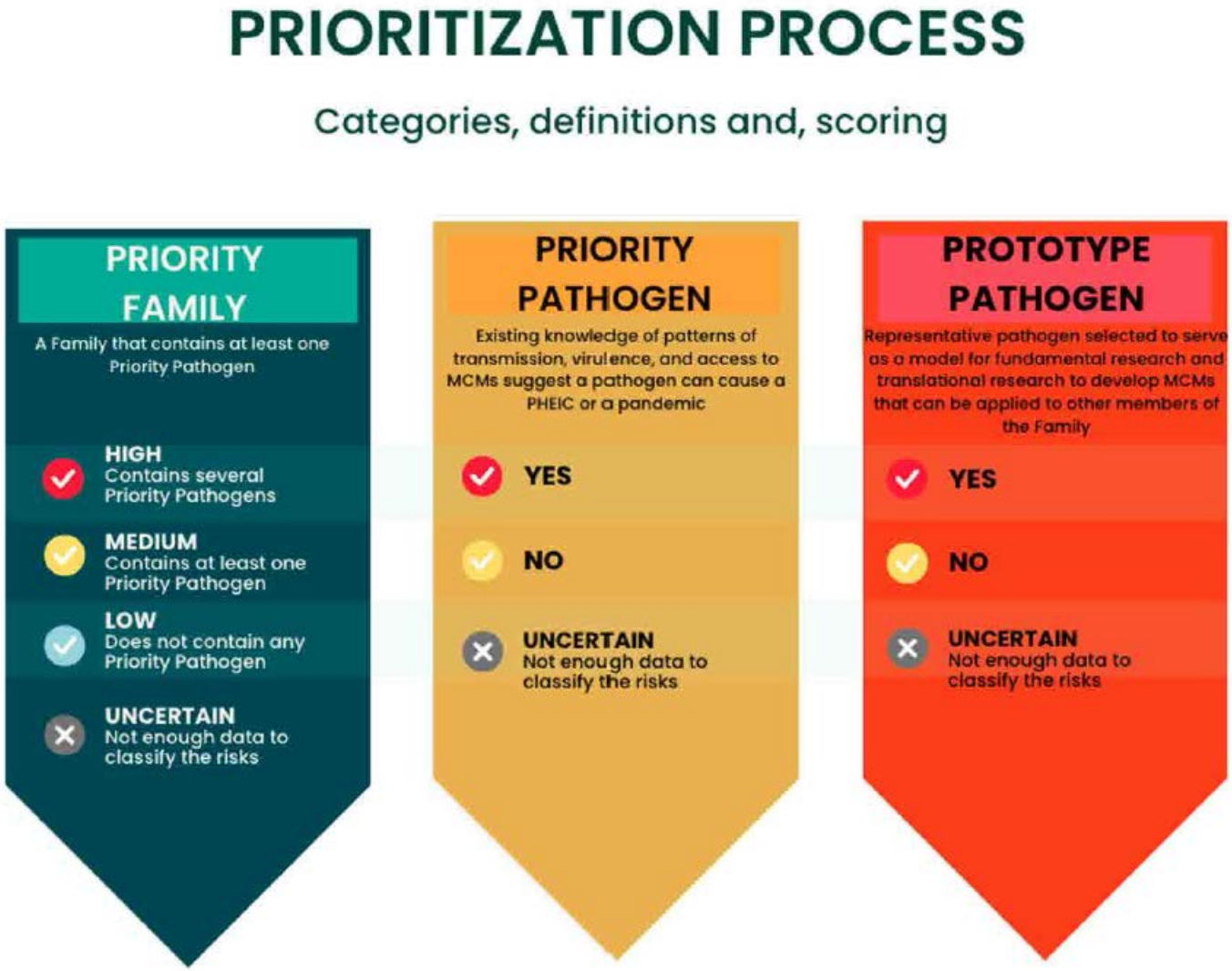
04

R&D

Preparing for the inevitable

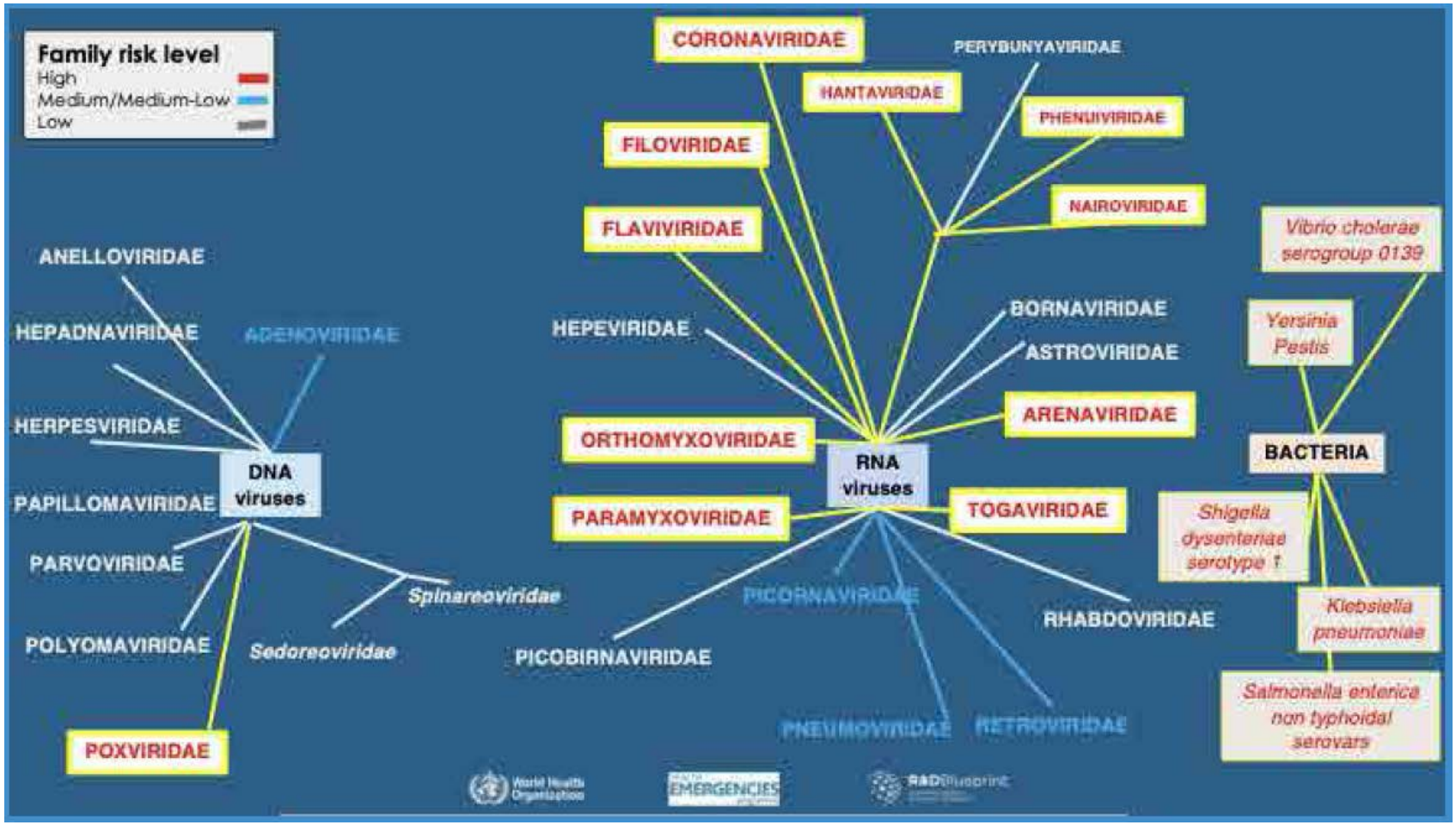
To list and compare the proposed pathogens with the potential to become Pathogen X and to discuss and define what biological changes might affect the risk for these various pathogens to become Pathogen X.

Identifying priorities



Identifying priorities

Families considered and overview of the outcomes of the risk of the Public Health Emergency of International Concern assessment.



Identifying priorities

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.

Identifying priorities

Outcomes of the PAC considerations on the risks of various Families

Family	PHEIC risk	PHEIC or pandemic risk notes on pathogens in each Family
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.
Pneumoviridae	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).

Identifying priorities

Outcomes of the PAC considerations on the risks of various Families

Family	PHEIC risk	PHEIC or pandemic risk notes on pathogens in each Family
Pneumoviridae	Low to Medium	Respiratory transmission of some viruses suggests higher than low priority, existing orthopneumovirus 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.

Identifying priorities

- The risk of Priority Pathogens causing a PHEIC was assessed by examining transmission patterns, virulence, and available countermeasures.

- No priority pathogens were identified for four DNA viral families: Anelloviridae, Herpesviridae, Polyomaviridae, and Papillomaviridae.

- Priority Pathogens with high PHEIC potential require immediate research and development efforts.

- Most newly identified Priority Pathogens are consistent with previous WHO R&D Blueprint reports.

- A summary of PHEIC risks and concerns raised by PAC members is provided in Table 4, while Annexes 2 and 3 detail the epidemiological features and ongoing vaccine and therapy developments for the selected pathogens.

- Some Priority Pathogens have a global distribution across all six WHO Regions, while others are region-specific, often linked to animal reservoirs, vectors, or poor living conditions.

Evolution of EID related public health priorities

	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

Evolution of EID related public health priorities

	2017	2018	2024		
Family	**Priority Pathogens**	**Priority Pathogens**	**PHEIC risk**	**Priority Pathogens**	**Prototype Pathogens**
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

Evolution of EID related public health priorities

	2017	2018	2024		
Family	**Priority Pathogens**	**Priority Pathogens**	**PHEIC risk**	**Priority Pathogens**	**Prototype Pathogens**
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

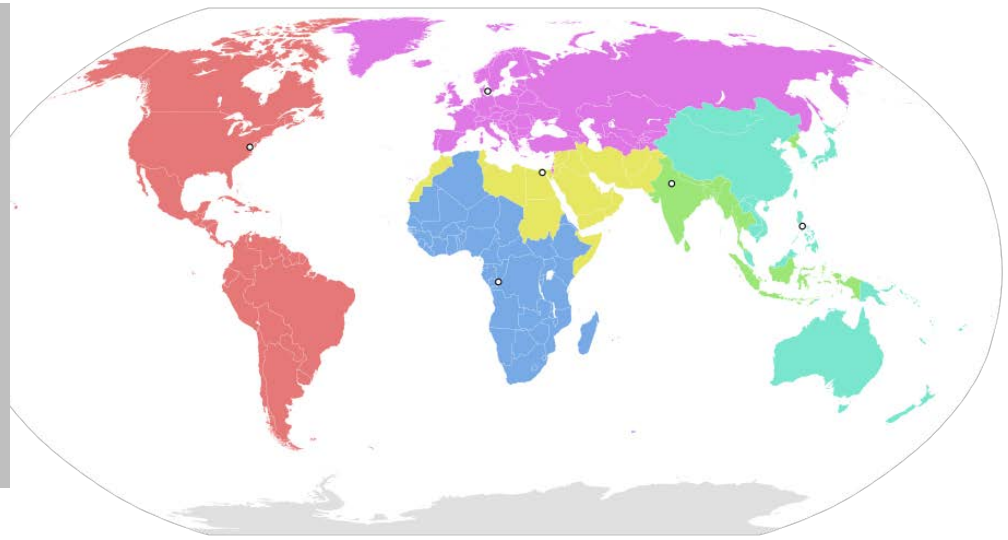
Evolution of EID related public health priorities

	2017	2018	2024		
Family	**Priority Pathogens**	**Priority Pathogens**	**PHEIC risk**	**Priority Pathogens**	**Prototype Pathogens**
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	

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.

1. African Region (AR)
2. Region of Americas (AMR)
3. Eastern Mediterranean Region (EMR)
4. European Region (ER)
5. South-East Asia Region (SEAR)
6. Western Pacific Region (WPR)



Yes, prevention and knowledge are important.

More important to know what pathogens put each region at risk.

Selected priority pathogens by family and 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

Selected priority pathogens by family and distribution

Family	Priority Pathogen	AFR	AMR	EMR	EUR	SEAR	WPR
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				

Deliberation notes on selected priority pathogens

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.

Deliberation notes on selected priority pathogens

Family	PHEIC risk	Priority Pathogen(s)	Priority Pathogen notes
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	

Deliberation notes on selected priority pathogens

Family	PHEIC risk	Priority Pathogen(s)	Priority Pathogen notes
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).

Selected prototype pathogens by family and region

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						

Selected prototype pathogens by family and region

Family	Perceived Risk	Prototype Pathogen	AFR	AMR	EMR	EUR	SEAR	WPR
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				

A global and a regional perspective

The priority pathogens specific to the Region of the Americas are **Orthohantavirus sinnombrense**, and Alphavirus venezuelan.

And finally, *Orthomyxoviridae*.

Family	PHEIC risk	Priority Pathogens	Prototype Pathogens
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

A global and a regional perspective

The priority pathogens specific to the Region of the Americas are **Orthohantavirus sinnombrense**, and Alphavirus venezuelan.

And finally, *Orthomyxoviridae*.

ANNEX 4. Candidate Vaccines

Arenaviridae, Mammarenavirus lassaense
DNA, live-attenuated, VSV-vector, and reassortant vaccines are in preclinical, Phase 1, and Phase 2 stages.

Klebsiella pneumoniae
Ribosomal, bioconjugate, capsular polysaccharide, OMP-based, fimbriae subunits, toxin, lipopolysaccharide, outer membrane vesicle, inactivated K. pneumoniae, mixed bacterial, and Respivax vaccines are in preclinical, Phase 1/2, and clinical stages.

Salmonella Enterica (invasive nontyphoidal)
Conjugate, GMMA-based bivalent, trivalent, and O:4 and O:9 conjugate vaccines are in preclinical, Phase 1, and Phase 2 stages.

Yersinia pestis
Vector-based vaccines, including those expressing plague antigens from S. Typhimurium, S. Typhi, Lactiplantibacillus plantarum, Y. pseudotuberculosis, and F. tularensis, as well as F1 mRNA-LNP and self-amplifying RNA (F1+LcrV) vaccines, are all in the preclinical stage.

Nairoviridae Orthonairovirus haemorrhagiae
Inactivated, MVA-based, DNA, mRNA-LNP, replicon particle, GEM-PA subunit, ChAdOx2 CCHF, MVA CCHF, and rVSV viral vector vaccines are in preclinical, Phase 1, and clinical stages.

Phenuiviridae Bandavirus dabieense
DNA, live attenuated, rVSV-SFTSV recombinant viral vector, and LC16m8-MVA recombinant viral vector vaccines are in the preclinical stage.

ANNEX 4. Candidate Vaccines

Coronaviridae Merbecoviruses MERS
DNA, DNA-protein, nanoparticle, protein, recombinant protein, viral or bacterial vector, and viral vector vaccines are in the preclinical stage. Coronaviridae Sarbecoviruses VBI-2901 eVLP (enveloped virus-like particle) is also in the preclinical stage.

Orthoebolavirus sudanense
Vesicular Stomatitis Virus (VSV) vector, preclinical stage.

Flaviviridae Orthoflavivirus dengue
Dengvaxia (chimeric virus, licensed), TV003/TV005 (live attenuated and chimeric virus, Phase 3), TAK-003 (chimeric viruses, Phase 2), TDEN (live attenuated, Phase 1/2), DPIV (inactivated virus, Phase 1), TVDV (DNA vaccine, Preclinical/Phase 1), V180 (recombinant protein, Phase 1), DSV4 (virus-like particles, Preclinical), and E80-mRNA (mRNA, Preclinical) vaccines are at various stages of development.

Flaviviridae Orthoflavivirus zikaense
ZPIV, PIZV/TAK-426, VLA1601, BBV121 (inactivated, Phase 1), VRC5288, GLS-5700 (DNA vaccine, Phase 1), VRC5283 (DNA vaccine, Phase 2), rZIKV/D430–713 (live attenuated, Phase 1), mRNA 1325, mRNA 1893 (mRNA, Phase 2), MV-ZIKA-RSP, MV-ZIKA (viral vector, Phase 1), ChAdOx1 ZIKA (viral vector, Phase 1), and Ad26.ZIKV.001 (viral vector, Phase 1) vaccines are at various stages of development.

Orthomyxoviridae Alphainfluenzavirus influenzae
H5,H6,H7,H10, H7N9 LAIV mRNA Preclinical

ANNEX 4. Candidate Vaccines

Paramyxoviridae Henipavirus nipahense

mRNA-1215 (subunit, Phase 1), HeV-sG-V (viral vector, Phase 1), rVSV Nipah Virus Vaccine (subunit, Phase 1), Nipah vaccine (subunit and viral vector, Preclinical), and VSV-NiVG (live attenuated virus, Preclinical) vaccines are at various stages of development.

Picornaviridae Enterovirus coxsackiepol

Novel Oral Polio Vaccine type 2 (inactivated virus, EUL), Inactivated Poliovirus Vaccine (IPV) (live attenuated virus, licensed), Oral Polio Vaccine (OPV) (inactivated Sabin strains, licensed), Sabin-IPV (inactivated virus, microneedle patch, Phase 3), Microneedle Array Patch IPV (virus-like particles, Preclinical), and VLP Polio Vaccine (protein subunit, Preclinical) are at various stages of development.

Poxviridae Orthopoxvirus Monkeypox

Ectodomains (protein subunit, Preclinical), 10 epitopes with 147 amino acid residues (protein subunit, Preclinical), multi-epitope vaccine with GPGPG linkers (protein subunit, Preclinical), MHC-I, MHC-II, and B-cell epitopes (virus-like particles, Preclinical), Novovirus shell and VLP platform (DNA vaccine, Preclinical), plasmid DNA encoding MPOX orthologs (DNA vaccine, Preclinical), plasmid cocktail mRNA vaccine (Preclinical), mRNA encoding three mABs (live attenuated, Preclinical), IMVAMUNE (live attenuated, Phase 3), MVA-BN (live attenuated, Phase 2), and Imvanex (adenovirus vector, Licensed) are at various stages of development.

Retroviridae Lentivirus humimdef1

Ad4-Env150KN/Ad4-Env145NFL + VRCHIVRGP096-00-VP (adenovirus vector, Phase 1), AdC6-HIVgp140 and AdC7-HIVgp140 (adenovirus vector, Phase 1), ChAdOx1.tHIVconsv1 prime followed by MVA.tHIVconsv3 and MVA.tHIVconsv4 boost (bivalent subunit vaccine, Phase 1), and AIDSVAX B/E+ IHV01 and A244/AHFG (CMV vector, Phase 1) vaccines are at various stages of development.

ANNEX 4. Candidate Therapeutics (only viral EIDs)

Mammarenavirus lassaense

Ribavirin (Off-Label Use/Phase 2/3), LHF-535 (Phase 1), Dexamethasone (Phase 2), Favipiravir (Phase 2/3), and ARN-75309 (Phase 1) are candidate therapeutics at various stages of development.

Orthonairovirus haemorrhagiae

Ribavirin (Off-Label Use/Phase 1), Favipiravir (Phase 1), antibody-based therapies (Preclinical), 2-Deoxy-2-fluorocytidine (Preclinical), Molnupiravir (Preclinical), and corticosteroids (Preclinical) are candidate therapeutics at various stages of development.

Bandavirus dabieense

Plasma Exchange (Ad Hoc use), Favipiravir (Clinical Use), and Ribavirin (Clinical Use) are candidate therapeutics at various stages of development. Methylprednisolone/IVI G/tocilizumab/heparin is in Phase 4; Fludarabine, nifedipine, and quinoline analogues are in preclinical stages.

Orthoflavivirus dengue

EYU688 (Phase 2), Montelukast (Phase 2/3), AV-1 (monoclonal antibody, Phase 1), Carica Papaya (Phase 3), JNJ-64281802 (Phase 2), Ivermectin (Phase 2/3), AT-752 (Phase 2), Doxycycline (Phase 2), Eltrombopag (Phase 2), UV-4B (Phase 1), Zanamivir (Phase 1), VIS513 (Phase 1), Ketotifen (Phase 4), Rupatadine (Preclinical), Metformin (Phase 1/2), Vitamin E (Preclinical), and Vitamin D (Preclinical) are candidate therapeutics at various stages of development.

ANNEX 4. Candidate Therapeutics (only viral EIDs)

Filoviridae Orthoebolavirus sudanense

Adaptor-associated kinase 1 (AAK1) inhibitors (Preclinical). Inmazeb (Atoltivimab, Maftivimab, and Odesivimab-ebgn) and mAb114 (ansuvimab/Ebanga), which are licensed for Zaire, while MBP134 is in Phase 1/2, and Galidesivir, GP inhibitors, bispecific antibodies targeting GP and NPV-1, and AAK1 inhibitors are in preclinical stages.

Filoviridae Orthoebolavirus zairense

Inmazeb (Atoltivimab, Maftivimab, and Odesivimab-ebgn) and mAb114 (ansuvimab/Ebanga) are licensed; MBP134 is in Phase 1/2; Galidesivir, GP inhibitors, bispecific antibody targeting GP and NPV-1, and AAK1 inhibitors are in preclinical stages.

Filoviridae Orthomarburgvirus marburgense

Galidesivir, Favipiravir, mAbs, siRNA, and antisense PMOs are in preclinical stages.

Orthoflavivirus zikaense

Polyanion suramin (Approved antiparasitic drug), Bromocriptine (Preclinical), Novobiocin (Clinically used antibiotic), Compounds 1 and 2 (Preclinical), Asunaprevir and Simeprevir (FDA-approved), Sofosbuvir (FDA-approved for HCV infection), and 4-HPR (Preclinical) are candidate therapeutics at various stages of development. 3-110-22, ZINC40621658, Phloretin, JG40, JG132, JG345, QC, MQ, and GSK369796 are in preclinical stages; Atovaquone and MMPD are FDA-approved for malaria and HCV infection, respectively; MTX and Memantine are clinically used for other treatments; A-12 is in Phase 1 for cancer.

ANNEX 4. Candidate Therapeutics (only viral EIDs)

Alphainfluenzavirus influenzae

Rimantadine, Zanamivir, Enisamium (VR17-04), Triazavirin, and Umifenovir are all licensed or licensed by other international authorities. GP681 and ZX-7101A are in Phase 3; HCN042 is in Phase 2; CC-42344 is in Phase 1. Amantadine, Baloxavir Marboxil, Favipiravir, Laninamivir, Oseltamivir, and Peramivir are licensed. GP681 and ZX-7101A in Phase 3, CC-42344 in Phase 1, and HCN042 in Phase 2, while Amantadine, Baloxavir Marboxil, Favipiravir, Laninamivir, Oseltamivir, and Peramivir are licensed.

Henipavirus nipahense

Ribavirin (Clinical trials), Remdesivir (Preclinical), Favipiravir (Preclinical), Chloroquine (Preclinical), Heparin (Preclinical), Rintatolimid (Preclinical), Griffithsin (Preclinical), VIKI-dPEG4-Toco and VIKI-PEG4-chol (Preclinical), Gliotoxin (Preclinical), Bortezomib (Preclinical), Balapiravir (Preclinical), Lumicitabine (Preclinical), CH25H (Preclinical), and KIN1408 (Preclinical) are candidate therapeutics at various stages of development.

Picornaviridae Enterovirus Coxsackiepol

V-7404 in Phase 1 and Pocapavir in development.

Poxviridae Orthopoxvirus Monkeypox

Cidofovir and Brincidofovir for off-label use and Phase 1, Tecovirimat for off-label use and Phase 3, and VIGIV for off-label use.

Retroviridae Lentivirus humimdef1

Nucleoside Reverse Transcriptase Inhibitors, Non-Nucleoside Reverse Transcriptase Inhibitors, Protease Inhibitors, Fusion Inhibitors, CCR5 Antagonists, Integrase Strand Transfer Inhibitors, Attachment Inhibitors, Post-Attachment Inhibitors, Capsid Inhibitors, and Pharmacokinetic Enhancers. Gene Therapy and Immunotherapy are in preclinical stages.

ANNEX 4. Candidate Therapeutics (only viral EIDs)

Alphainfluenzavirus influenzae
Rimantadine, Zanamivir, Enisamium (VR17-04), Triazavirin, and Umifenovir are all licensed or licensed by other international authorities. GP681 and ZX-7101A are in Phase 3; HCN042 is in Phase 2; CC-42344 is in Phase 1. Amantadine, Baloxavir Marboxil, Favipiravir, Laninamivir, Oseltamivir, and Peramivir are licensed. GP681 and ZX-7101A in Phase 3, CC-42344 in Phase 1, and HCN042 in Phase 2, while Amantadine, Baloxavir Marboxil, Favipiravir, Laninamivir, Oseltamivir, and Peramivir are licensed.

Henipavirus nipahense
Ribavirin (Clinical trials), Remdesivir (Preclinical), Favipiravir (Preclinical), Chloroquine (Preclinical), Heparin (Preclinical), Rintatolimid (Preclinical), Griffithsin (Preclinical), VIKI-dPEG4-Toco and VIKI-PEG4-chol (Preclinical), Gliotoxin (Preclinical), Bortezomib (Preclinical), Balapiravir (Preclinical), Lumicitabine (Preclinical), CH25H (Preclinical), and KIN1408 (Preclinical) are candidate therapeutics at various stages of development.

Picornaviridae Enterovirus Coxsackiepol
V-7404 in Phase 1 and Pocapavir in development.

Poxviridae Orthopoxvirus Monkeypox
Cidofovir and Brincidofovir for off-label use and Phase 1, Tecovirimat for off-label use and Phase 3, and VIGIV for off-label use.

Retroviridae Lentivirus humimdef1
Nucleoside Reverse Transcriptase Inhibitors, Non-Nucleoside Reverse Transcriptase Inhibitors, Protease Inhibitors, Fusion Inhibitors, CCR5 Antagonists, Integrase Strand Transfer Inhibitors, Attachment Inhibitors, Post-Attachment Inhibitors, Capsid Inhibitors, and Pharmacokinetic Enhancers. Gene Therapy and Immunotherapy are in preclinical stages.

Summary of epidemiological info for PHEIH

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

Summary of epidemiological info for PHEIH

Family	Pathogen	Vector/ Reservoir	Mode of Transmission	Extent of person-to-person transmission	Spread	Areas with Documented Transmission
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

Summary of epidemiological info for PHEIH

Family	Pathogen	Vector/ Reservoir	Mode of Transmission	Extent of person-to-person transmission	Spread	Areas with Documented Transmission
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

Selected priority pathogens WHO Americas Region

High-priority agents

Mammarenavirus juninense, Klebsiella pneumoniae, Salmonella enterica (non-typhoidal serovars), Yersinia Pestis, Sarbecovirus, Orthoflavivirus denguei, flavi, zikaense, encephalitidis and nilense, Orthohantavirus sinnombreense, Alphainfluenzavirus influenzae (H1, H2, H3, H5, H6, H7, H10), Orthopoxvirus monkeypox, Orthopoxvirus vaccinia, Alphavirus chikungunya, and Alphavirus venezuelan.

Medium-priority agents

Enterovirus alphacoxsackie 71, deconjucti 68, and Lentivirus humimdef1.

Low-medium priority agents

Mastadenovirus blackbeardi serotype 14, Recombinant mastadenovirus, and Metapneumovirus hominis

Low-priority agents

Mamastrovirus virginiaense, Paslahepevirus balayani genotype 3, Protoparvovirus carnivoran, Orthobunyavirus oropoucheense, Orthopicobirnavirus hominis, Vesiculovirus, Rotavirus, and Orthoreovirus mammalis.

Selected priority pathogens WHO African Region

High-priority agents

Mammarenavirus lassaense and lujoense, Klebsiella pneumoniae, Salmonella enterica (non-typhoidal serovars), Shigella dysenteriae serotype 1, Vibrio cholerae serogroup 0139, Yersinia Pestis, Sarbecovirus, Orthoebolavirus sudanense, zairense, and marburgense, Orthoflavivirus denguei, flavi, zikaense, and nilense, Orthonairovirus haemorrhagiae, Alphainfluenzavirus influenzae (H1, H2, H3, H5, H6, H7, H10), Phlebovirus riftense, Orthopoxvirus monkeypox, and Alphavirus chikungunya.

Medium-priority agents

Enterovirus coxsackiepol, alphacoxsackie 71, deconjucti 68, and Lentivirus humimdef1.

Low-medium priority agents

Recombinant mastadenovirus and Metapneumovirus hominis

Low-priority agents

Mamastrovirus virginiaense, Paslahepevirus balayani genotype 3, Protoparvovirus carnivoran, Orthopicobirnavirus hominis, Vesiculovirus, Rotavirus, and Orthoreovirus mammalis.

Selected priority pathogens WHO Mediterranean Region

High Risk Pathogens

Klebsiella pneumoniae, Salmonella enterica (non-typhoidal serovars), Shigella dysenteriae serotype 1, Vibrio cholerae serogroup O139, Merbecovirus, Sarbecovirus, Orthohantavirus haemorrhagaie, and Orthopoxvirus monkeypox. Several strains of Alphainfluenzavirus influenzae (H1 to H10) also included.

Medium Risk Pathogens

Enterovirus coxsackiepol and Lentivirus humimed1, both associated with diseases in the Picornaviridae and Retroviridae families, respectively.

Low-Medium Risk Pathogens

Recombinant mastadenovirus and Metapneumovirus hominis, with moderate risk.

Low Risk Pathogens

Anelloviridae, Astroviridae, Hepeviridae, Herpesviridae, Picobirnaviridae, and Rhabdoviridae. Notable pathogens include Paslahepevirus balayani genotype 3, Protoparvovirus carnivoran, and Genus Vesiculovirus.

Selected priority pathogens WHO European Region

High-priority agents

Klebsiella pneumoniae, Salmonella enterica (non-typhoidal serovars), Sarbecovirus, Orthoflavivirus denguei, encephalitidis, and nilense, Orthohantavirus hantanense, Orthonairovirus haemorrhagiae, Alphainfluenzavirus influenzae (H1, H2, H3, H5, H6, H7, H10), Orthopoxvirus monkeypox, Paramyxoviridae and Phenuiviridae families.

Medium-priority agents

Enterovirus alphacoxsackie 71, deconjucti 68, and Lentivirus humimdef1.

Low-medium priority agents

Recombinant mastadenovirus and Metapneumovirus hominis.

Low-priority agents

Mamastrovirus virginiaense, Orthobornavirus bornaense, Paslahepevirus balayani genotype 3, Protoparvovirus carnivoran, Orthopicobirnavirus hominis, Genus Vesiculovirus, Genus Rotavirus, and Orthoreovirus mammalis.

Selected priority pathogens WHO South East Asia Region

High-priority agents

Klebsiella pneumoniae, Salmonella enterica (non-typhoidal serovars), Shigella dysenteriae serotype 1, Vibrio cholerae serogroup 0139, Subgenus Sarbecovirus, Orthoflavivirus denguei, zikaense, and nilense, Alphainfluenzavirus influenzae (H1, H2, H3, H5, H6, H7, H10), Henipavirus nipahense, Bandavirus dabieense, Orthopoxvirus monkeypox, and vaccinia, and Alphavirus chikungunya.

Medium-priority agents

Enterovirus coxsackiepol, alphacoxsackie 71, deconjucti 68, and Lentivirus humimdef1.

Low-medium priority agents

Recombinant mastadenovirus and Metapneumovirus hominis.

Low-priority agents

Mamastrovirus virginiaense, Orthohepadnavirus hominoidei genotype C, Paslahepevirus balayani genotype 3, Protoparvovirus carnivoran, Orthopicobirnavirus hominis, Vesiculovirus, Rotavirus, and Orthoreovirus mammalis.

Selected priority pathogens WHO Western Pacific Region

High-priority agents

Vibrio cholera (O139), Salmonella enterica (non-typhoidal serovars), Klebsiella pneumoniae, Orthonairovirus haemorrhagiae, Orthohantavirus hantanense, Bandavirus dabieense, Sarbecoviruses, Orthoflavivirus denguei, zikaense, and nilense, Alphainfluenzavirus influenzae (H1N1, H2Nx, H3N2, H5Nx, H6Nx, H7Nx, H10Nx), Henipavirus nipahense, Orthopoxvirus monkeypox, and vaccinia, and Alphavirus chikungunya.

Medium-priority agents

Human polioviruses (Enterovirus D68, EV-D68; A71, EV-A71) and Human immunodeficiency virus 1 (HIV-1).

Low-medium priority agents

Human mastadenovirus B and Metapneumovirus hominis.

Low-priority agents

Mamastrovirus 9 (GII.B-human), Peribunyavirus, Paslahepevirus balayani (genotype 3), Carnivore protoparvoviruses (CPV), Human picobirnavirus, Orthoreovirus mammalis, Rotavirus, and Vesiculovirus.

Conclusions

- WHO's framework: holistic approach to research and development.
- Focus on entire pathogen families and key pathogens.
- Aims to create adaptable tools and knowledge.
- Stresses global collaboration and equitable access.
- Highlights speed, cost, quality, and trust in medical countermeasures.
- Encourages open exploration of scientific challenges.
- A key action for improving global research collaboration

RVPVE

Red de Vigilancia de Patógenos Virales Emergentes

Christian García-Sepúlveda — Laboratorio de Genómica Viral & Humana, Medicina UASLP
Juan Carlos Cuevas Tello — Grupo de Bioinformática, Ingeniería UASLP
Ignacio Amezcua Osorio — Comité Estatal para el Fomento y Protección Pecuaria de San Luis Potosí.
Guillermo Espinosa Reyes — Centro de Investigación Aplicada en Ambiente y Salud) (CIAAS), Medicina UASLP
Fernando Díaz-Barriga Martínez — Centro de Investigación Aplicada en Ambiente y Salud) (CIAAS), Medicina UASLP

Dulce Ma. Hernández Piña — Lab manager, LGVH UASLP
Sandra Guerra-Palomares — Virología molecular, LGVH UASLP
J. Manuel Mendoza Méndez — Coronavirus en murciélagos, LGVH UASLP
Nidya Jurado-Sánchez — Vigilancia de vectores y arbovirus, LGVH UASLP
Mariel Pacheco-Cortez — Tamizaje de hantavirus y arenavirus en roedores,LGVH UASLP
Samuel Mora Andrade — Patógenos Virales Emergentes en Murciélagos. Asesor externo
Salomón Altamirano Flores — Algoritmos de inteligencia artificial y datos genéticos, Ingeniería UASLP
Daniel Bandala Álvarez — Predicción epidemiológica algoritmos de inteligencia artificial, Ingeniería UASLP