DRAFT

HIGH LEVEL SUMMARY OF EMERGING VIRAL THREATS TO HUMAN HEALTH

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Overview

Viruses from 28 different families (10 DNA, 18 RNA) are known to infect mammals (Table 1).

Viruses from 27 of these families can infect humans.

Viruses from 22 of these families are capable of epidemic spread in human populations.

Viruses from 22 of these families have been associated with human deaths.

We stress that the wide taxonomic distribution of these traits makes it unwise to rule out a potential future public health threat from any broad category of mammal or bird viruses. Here, however, we limit discussion to three categories of viruses:

1) Clear and present danger
2) Concern
3) Gaps

We do not discuss viruses for which effective vaccines are already available (e.g. MMR, polio, rotavirus, rabies). However, we note the possibility of vaccine escape.

Nor do we discuss endemic viruses long identified as candidates for vaccine development (e.g. HIV, RSV).

Clear and present danger

This category covers taxa containing viruses that are well-recognised public health threats and where (better) vaccines are needed.

Filoviridae, including the ebolaviruses and Marburg virus. These cause haemorrhagic fevers and are transmitted by contact. Most, but not all, are associated with severe disease in humans.

Coronaviridae, including the severe respiratory infections SARS CoV and MERS CoV. We note that although there are not currently any vaccines available against human coronaviruses there are vaccines for animal coronaviruses (canine CoV and porcine epidemic diarrhoea virus).

Orthomyxoviridae, the human influenza viruses, plus the avian influenzas. Vaccine reformulation is a long-standing issue. Antivirals have the advantage of being effective against a broader spectrum of influenza viruses than strain-specific vaccines.

Concern

This category covers taxa containing viruses that can cause severe disease and/or are transmissible (to some degree) between humans, but there is currently no vaccine available for use in humans.

Arenaviridae, includes at least 8 species of haemorrhagic fever viruses associated with self-limiting outbreaks and some fatalities. They are transmitted by contact or inhalation. Vaccines are available for some (e.g. Junin virus) but not others (e.g. Lassa virus, Lujo virus). Multivalent vaccines are a possibility.

Bunyaviridae, a very diverse family including some species (all of which are vector-borne) for which no vaccine is available but have reportedly been associated with large outbreaks (e.g. Oropouche virus, Bwamba virus) and/or severe disease and death (e.g. SFTSV, CCHFV).

Paramyxoviridae, species Nipah virus, transmitted by contact and causing neurologic symptoms which can be fatal.

Flaviviridae, genus flavivirus, includes epidemic (e.g. dengue virus) and outbreak (e.g. St Louis encephalitis virus) vector-borne species that can cause fatalities. Vaccines are at varying stages of development in both humans and animals (though yellow fever vaccine has been available since the 1930s).

Poxviridae, species monkeypox, self-limiting outbreaks including a pet-borne outbreak in the US. Transmitted by contact and can be fatal. No vaccine but cross-protection from smallpox vaccine.

Togaviridae, genus alphavirus, includes a number of vector-borne viruses associated with large outbreaks or epidemics (e.g. Chikungunya virus, Venezuelan equine encephalitis virus), though infections are typically associated with flu-like symptoms. There are a number of alphavirus vaccines at various stages of development for humans, and several available for animals.

Gaps

New human viruses continue to be identified at a rate of 2 to 3 species per year, so the assessment of viral threats to public health needs continual reappraisal.

There are a number of virus families for which we found no reports of any human vaccine up to or beyond the clinical trial stage.

Viruses in 4 to 6 families (*Coronaviridae* [see above], *Astroviridae*, *Parvoviridae*, *Polyomaviridae* and possibly *Bornaviridae* and *Picobirnaviridae*) are associated with human disease.

Viruses in 2 other families (*Asfarviridae* and *Circoviridae*) can infect humans but have not so far been associated with disease in humans, but some of these viruses do cause severe disease in animals.

Although there have not yet been any reports of *Arteriviridae* in humans, these viruses can cause severe disease in non-human primates.

Although human vaccines are lacking there are animal vaccines available for viruses in many of these families (*Coronaviridae* [see above], *Parvoviridae*, *Polyomaviridae*, *Bornaviridae*, *Asfarviridae* [clinical trials], *Circoviridae* and *Arteriviridae*).

Knowledge base

Whole (or near whole) genome sequences are available for the all the viruses thought to be able to spread between humans, although in many cases (e.g. several arenaviruses, Andes virus [a hantavirus], several togaviruses and some pox viruses) there are only 1-2 (near) complete sequences from human infections and for others (e.g. Nelson Bay orthoreovirus, Titi monkey adenovirus) sequences have been obtained only from non-human hosts.

Data sources

Taxonomy. ICTV 9th report (2012), supplemented by recent reports in peer-reviewed journals.

Virus traits. Research group database developed through systematic literature searches and maintained since 2001 (see Woolhouse, M.E.J., Adair, K. and Brierley, L. (2013) RNA viruses: a case study of the biology of emerging infectious diseases. *Microbiology Spectrum* **1**: OH-0001-2012).

Vaccine availability. Obtained from systematic literature searches for every human virus taxon. Note that this does not cover information of vaccines not yet published in the scientific literature.

Virus sequences. Obtained from GenBank (as of March 24th 2015).

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Table 1. List of virus families containing species that infect mammals, infect humans specifically, are capable of epidemic spread in human populations, and have been reported to cause fatalities in human patients.

Virus family	Virus type	Species infecting humans	Species epidemic in humans	Species can be fatal in humans
Adenoviridae	dsDNA	yes	yes	yes
Asfarviridae	dsDNA	yes	no	no
Herpesviridae	dsDNA	yes	yes	yes
Papillomaviridae	dsDNA	yes	yes	yes
Polyomaviridae	dsDNA	yes	yes	possibly
Poxviridae	dsDNA	yes	yes	yes
Anelloviridae	ssDNA	yes	yes	no
Circoviridae	ssDNA	yes	yes	no
Parvoviridae	ssDNA	yes	yes	possibly
Hepadnaviridae	RT dsDNA	yes	yes	yes
Arenaviridae	-ve ssRNA	yes	no	yes
Bunyaviridae	-ve ssRNA	yes	no	yes
Orthomyxoviridae	-ve ssRNA	yes	yes	yes
Bornaviridae	-ve ssRNA	yes	no	no
Filoviridae	-ve ssRNA	yes	yes	yes
Paramyxoviridae	-ve ssRNA	yes	yes	yes
Rhabdoviridae	-ve ssRNA	yes	no	yes
Arteriviridae	+ve ssRNA	no		
Astroviridae	+ve ssRNA	yes	yes	possibly
Caliciviridae	+ve ssRNA	yes	yes	possibly
Coronaviridae	+ve ssRNA	yes	yes	yes
Flaviviridae	+ve ssRNA	yes	yes	yes
Hepeviridae	+ve ssRNA	yes	yes	yes
Picornaviridae	+ve ssRNA	yes	yes	yes
Togaviridae	+ve ssRNA	yes	yes	yes
Picobirnaviridae	+ve ssRNA	yes	yes	no
Reoviridae	+ve ssRNA	yes	yes	yes
Retroviridae	RT ssRNA	yes	yes	yes

Note 1: Hepatitis D virus is not classified.
Note 2: Birnaviridae occur in birds but have not been reported from any mammal species.
Note 3: Nodaviridae have been reported from pigs but the evidence is not compelling.