WHO Monkeypox Research: What are the knowledge gaps and priority research questions?

Monkeypox and wildlife (animals)

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Overall objectives:

Overall Objective:
Prevent transmission between animals and humans including future spillover and potential creation of novel animal reservoirs, applying a One Health approach for risk reduction strategies at the human-animal-environment interface

- Identify animal source(s) and reservoir(s), as well as the mode of transmission between animals and humans
- Identify risk factors of spillover - behavioral, ecological, socio-economic
- Identify risk reduction strategies at the human-animal-environment interface
State of the art

• Definitive animal reservoir unknown

Mariën, Laudisoit, Patrono, et al. *in press*
State of the art

- Definitive animal reservoir unknown
- Evidence of infection/susceptibility:
  - *Crocidura littoralis*, Butiaba naked-tailed shrew
State of the art

• Definitive animal reservoir unknown

• Evidence of infection/susceptibility:
  • *Crocidura littoralis*, Butiaba naked-tailed shrew
  • *Funisciurus anerythrus*, Thomas's rope squirrel

West and Central Africa

Wet lowland and swamp forest
State of the art

- Definitive animal reservoir unknown
- Evidence of infection/susceptibility:
  - *Crocidura littoralis*, Butiaba naked-tailed shrew
  - *Funisciurus anerythrus*, Thomas's rope squirrel
  - *Funisciurus bayonii*, Lunda rope squirrel

Moist Grasslands - Savanna
State of the art

• Definitive animal reservoir unknown

• Evidence of infection/susceptibility:
  • *Crocidura littoralis*, Butiaba naked-tailed shrew
  • *Funisciurus anerythrus*, Thomas's rope squirrel
  • *Funisciurus bayonii*, Lunda rope squirrel
  • *Stochomys longicaudatus*, target rat

Humid rainforest and swamps
State of the art

- Definitive animal reservoir unknown.

- Evidence of infection/susceptibility:
  - *Crocidura littoralis*, Butiaba naked-tailed shrew
  - *Funisciurus anerythrus*, Thomas's rope squirrel
  - *Funisciurus bayonii*, Lunda rope squirrel
  - *Stochomys longicaudatus*, target rat
  - *Cricetomys sp*, Giant pouched rats

Forests and thickets - colonies
State of the art

• Definitive animal reservoir unknown

• Evidence of infection/susceptibility:
  • *Crocidura littoralis*, **Butiaba naked-tailed shrew**
  • *Funisciurus anerythrus*, **Thomas's rope squirrel**
  • *Funisciurus bayonii*, **Lunda rope squirrel**
  • *Stochomys longicaudatus*, **target rat**
  • *Cricetomys sp*, **Giant pouched rats**
  • Human and non-human primates
State of the art

- Definitive animal reservoir unknown

- Evidence of infection/susceptibility:
  - *Crocidura littoralis*, Butiaba naked-tailed shrew
  - *Funisciurus anerythus*, Thomas's rope squirrel
  - *Funisciurus bayonii*, Lunda rope squirrel
  - *Stochomys longicaudatus*, target rat
  - *Cricetomys sp*, Giant pouched rats
  - Human and non-human primates
  - Prairie dogs, hamsters - pet trade related
## Research priorities

<table>
<thead>
<tr>
<th>1. Investigation of animal sources and routes of transmission</th>
<th><strong>Why?</strong></th>
<th><strong>What type of research/studies are needed?</strong></th>
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</thead>
</table>
| | To identify animal sources | - Identify/characterise MPXV’s in captive and free-ranging wildlife and, livestock and pets animals.  
- Trace-back investigations of wildlife around index cases  
- Wildlife surveillance in endemic areas |
| | To increase knowledge about transmission pathways between animals and humans | - Monitoring and characterization of the infection with MPXV in susceptible species;  
- Effectiveness and impact of protective and sanitary measures for high risk / high value animals  
- Human to animal transmission routes |
| | To increase knowledge of the role of animals and animal products for human and animal infections to inform risk reduction strategies | - Monitoring of susceptible species;  
- Surveillance of animals and animal products in trade |
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| 2. Understanding viral circulation in animal populations | To prevent spillover (risk reduction) | • Monitoring of the emergence in susceptible species;  
• Characterization of the susceptibility, infectivity, pathogenicity and transmissibility in animal species and populations.  
• Characterization of different strains in circulation |
| 3. Socio-economic and behavioural risk factors for spill-over | To identify the risks linked to trade and consumption of potentially infected animal species and the communities or occupational groups more at risk across different interfaces. | • Better understanding of the dynamics around wildlife capture, transport, and trading, and current prevention strategies  
• Analysis of behavioural and organisational risks along the wild animal value chain  
• Identify strategies to manage infection risks related to handling of wild animals |
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<td>4. Risk reduction strategies at the human-animal-environment interface</td>
<td>To increase knowledge about reducing risk along transmission pathways between animals and humans</td>
<td>• Risk communication strategies avoiding stigmatisation and other unintended consequences;</td>
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<td>• Social and behavioural change (SBC) practices to improve hygiene practices along the food chain;</td>
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<td>• SBC practices to implement realistic and feasible strategies to encourage a high level of compliance with hygienic and other universally adopted standards in markets;</td>
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# Ongoing research priorities

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<td>1. Drivers of emergence and hotspots</td>
<td>Identification of areas, timing, and activities that increase risk of infection.</td>
<td>Spatial analyses and modeling of ecological factors and human activities associated with infections.</td>
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<td>2. Investigation of circulation of viruses in animal populations in emerging infectious diseases hotspots; development of field diagnostic tools</td>
<td>Determination of viruses circulating in wildlife, farmed and domestic animals and potentially dangerous for humans</td>
<td>Continued sampling of species of interest for identification of OPXV’s, could be extended to other virus families</td>
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One Health
In practice

After the outbreak ended and the investigation was complete, agencies compared this response to previous outbreak responses. The use of a One Health approach in this case was estimated to provide a two-thirds reduction in the total cost of the investigation and a response time that was a full 10 days faster. This was achieved through sending a single investigation team with representatives from multiple ministry sectors and requiring only a single government travel authorization.
Land Degradation, Climate, Mediators, and Health Outcomes

CHANGES IN LAND USE AND COVER
- Deforestation, dams and irrigation, agricultural extension and intensification, livestock management, urbanization, road construction

DETERIORATION OF ECOSYSTEM SERVICES
- Provision of nutrition, safe water, clean air, protection against natural hazards, regulation of infectious diseases, and maintenance of stable climate

CLIMATE CHANGE
- Warming temperatures, more extreme storms, hydrologic extremes, sea-level rise

NEGATIVE HEALTH OUTCOMES

Insulating layers
Working Group:

Emmanuel Nakoune (IP, Central African Republic), EBOSURSY collaborator

William Karesh (EcoHealth Alliance, UK), President WOAH wildlife Working Group

Helen Roberts (Defra, UK), OIE CC Risk Analysis and Modelling

Donata Hoffmann (FLI, Germany), OIE CC Zoonoses in Europe

Keith Hamilton (WOAH, Paris), Head Preparedness and Resilience Dept

Casey Barton Behravesh (CDC, USA), OIE CC Emerging and Re-Emerging Zoonotic Diseases

Emmanuel Couacy-Hymann (Cote D’Ivoire), president of WOAH Biological Standards Commission