

Eco-Epidemiology of Monkeypox zoonotic transmission in Central African Republic

Master 2 internship project 2023 – 6 months

Background

Monkeypox virus made the headlines in April 2022 due to the spread of a pandemic clade following the patterns of a sexually transmitted infection. However, since the 1970s, this virus causes small outbreaks in forest communities in Western and Central Africa, with an index case generally linked to zoonotic (animal-to-human) transmission by followed limited inter-human transmission. Epidemiological studies have pointed at several at-risk exposures, such as forestry activities and contact with wildlife, as well as bushmeat trade and preparation. The virus is expected to have a wild mammal reservoir, and rodents such as forest squirrels or rats are suspected, but the exact specie(s) remain unknown.

Before the pandemic spread, monkeypox was already raising interest due to increasing numbers of reported cases in Democratic Republic of Congo and Central African Republic (CAR) for the last decade. This increase could be linked to increasing contacts between humans and natural environment occurring with deforestation, but also result from a decrease in the proportion of the population vaccinated against smallpox, which provides a cross-immunity (small pox vaccination ended in the 1980s after successful eradication). The lack of routine surveillance impaired basic epidemiological analyses: for example, a systematic review of the literature identified only 181 well-documented outbreaks for 1970-2021 in Africa. Since 2001, Institut Pasteur of Bangui has developed a surveillance system to collect epidemiological alerts, confirm and investigate outbreaks in CAR (1). Since 2019, the Afripox multidisciplinary One Health research project investigates outbreaks, works to improve diagnostic tools, and studies the relationship between affected communities and wildlife and the potential mammal reservoir species. Afripox team includes Institut Pasteur Bangui (epidemiology, surveillance, virology), Institut Pasteur Paris (epidemiology, virology, anthropology), National Museum of Natural History (zoology, molecular biology) and UMR SESSTIM (eco-epidemiology).

When so little is known about monkeypox spillovers, it is crucial to understand which environments are at risk to improve surveillance and prevention, and target further studies on viral circulation and spill-overs.

Objectives

The aim of this project is to analyse environmental factors associated with monkeypox virus zoonotic events in CAR from 2001 to 2022.

Specific objectives are to evaluate the link between occurrence of MPX outbreaks and specific geographical/ecological landscapes, deforestation during the previous years, specific meteorological conditions.

Challenges

- address major gaps in understanding the link between environment and monkeypox zoonotic outbreaks;
- adapt to monkeypox advanced analysis methods for infectious diseases characterized by data scarcity;
- work at the interface between ecology and epidemiology in a One Health approach.

Strengths

- analyse a unique dataset of documented, localized, recent monkeypox outbreaks (see data);
- manipulate open access environmental data and analysis methods reusable in geoeidemiology;
- be involved in the final stages (results, restitution) of a 3-year multidisciplinary project.

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Data

- Outbreaks recorded in CAR from 2010 to 2022 (n=49), including location and month-year of index case;
- Population data combining the map of human settlements in CAR, available census data, and estimated population from remote sensing methods (Worldpop raster);
- Environmental data: meteorology (daily rainfall, 8-day temperature, daily fires, yearly landuse-landcover and deforestation, floristic composition...), obtained from remote-sensing open access sources;
- Ecological niche maps for potential reservoir hosts developed by Afripox partners;
- The candidate will participate to the elaboration of the environmental descriptive variables dataset: extract necessary additional variables, define relevant indicators (distances, fragmentation indices...) and landscape or climate profiles (PCA and hierarchical clustering);

Methods

The analysis plan draws from investigations of diseases with limited numbers of reported events and require specific analysis strategies, such as Ebola (2-3), or melioidosis (4). We will use geoepidemiological methods, involving the identification of localities reporting outbreaks or not, and develop an exploratory approach to evaluate the statistical association between outbreak occurrence and combined environment profiles or specific environmental variables, including a time-dependent aspect. If necessary, we will develop an ecological niche model approach in collaboration.

- Analysis of spatial clustering and spatial autocorrelation of outbreak sites;
- Statistical analysis using advanced spatial or spatio-temporal regression models (uni- and multivariate multilevel logistic regression);
- Produce maps documenting the presence or absence of documented risk factors;
- Collaborate, exchange informations and discuss results with other teams of Afripox. Short missions to Paris (Institut Pasteur, Museum) +/- Montpellier (IRD) are likely.

Requested Competences/qualities

Master 2 student: Epidemiology or public health with strong quantitative methods background:

- basic skills in **Geographical Information Systems** (GIS) software (ArcGIS or QGIS);
- working **knowledge of R** and **willingness to learn advanced methods** (spatial data management, statistics including spatial analyses, ecological niche models, multilevel models);
- interested in **biology and environment**, including complex Host(s)-Pathogen-Environment interactions;
- able to work autonomously and ready to collaborate with other Afripox teams.

Practical details

Who are we? GeoEpi group at SESSTIM, UMR affiliated to Aix Marseille University, IRD, INSERM

2 Professors, 2 full time researchers, 1 hospital researcher, 1 study engineer, 6 PhD students. We work in geoepidemiology, mainly of malaria in various regions of the world but also other infectious diseases.

Where will the internship take place ? Faculté des Sciences Médicales et Paramédicales de la Timone, 25 Bd Jean Moulin, 13005 Marseille, France

When & how long ? 6 months, between 15 January to 15 September 2023

Contact: Jordi Landier, IRD researcher : jordi.landier@ird.fr

References

1. Besombes et al, National surveillance for monkeypox disease in Central African Republic, 2001-2021, Emerg. Inf. Dis. (accepted)
2. Olivero et al, Recent loss of closed forests is associated with Ebola virus disease outbreaks. Scientific reports 2017
3. Lee-Cruz et al, Mapping of Ebola virus spillover: Suitability and seasonal variability at the landscape scale. PLoS NTD 2022
4. Bulterys et al, Climatic drivers of melioidosis in Laos and Cambodia: a 16-year case series analysis. Lancet Plan Health 2018

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