

Nota

Bolivia and the risk of wildlife zoonotic diseases: a plea to young researchers

Bolivia y el riesgo de las enfermedades zoonóticas de la vida silvestre:
Un llamado a los jóvenes investigadores

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Emerging infectious diseases (EIDs) have been increasing in frequency and extension world-wide over the last decades. Zoonotic EIDs are largely originated in wildlife (Jones *et al.* 2008) and their outbreak risks are associated with a suite of social and environmental factors such as location within the tropical forest regions, high richness of mammalian species, and land use changes that render people closer to vector and host species (Allen *et al.* 2017). Bolivia presents all these characteristics and therefore is expected to be a hotspot of wildlife-borne zoonotic EIDs, with a high likelihood to face increased outbreaks of zoonotic diseases in the near future (Allen *et al.* 2017). As zoonotic EIDs convey a serious impact upon public health and economies, a question is whether Bolivia is up to the challenge EIDs represent. Here we briefly review the state-of-the-art regarding research and capability dealing with zoonoses associated to wild mammals in Bolivia in order to face the growing challenges posed by EIDs through a scientific literature perusal.

Hence, we assessed publication rate, host and pathogens studied, environment, as well as the involvement of Bolivian researchers in the studies of zoonosis in wild mammals. We searched in ISI-Web of Science, PubMed, Scopus and SciELO (accessed on August 2019) for publications over the last 60 years using the words and Boolean code: (Bolivia*) AND (wildlife OR fauna) AND (Acariosis OR Ancylostoma OR Angiostrongylus OR Anisakis OR bacter* OR Babesi* OR Bacillus OR Balantidium OR Barmah* OR Bartonell* OR Baylisascariasis OR Borreli* OR Brucell* OR Burkholderia* OR Campylobacter* OR "CCHF virus" OR Chikungunya OR Chlamyd* OR Clostridi* OR Cowpox OR Coxiell* OR "Creutzfeldt-Jakob disease" OR Cryptococco* OR Cryptosporidi* OR Cysticercos* OR Dengue OR Dermatophyto* OR disease*

OR Dirofilaria OR Ebola OR Echinococco* OR Ehrlich* OR encephalitis OR "Encephalomyelitis" OR Erysipel* OR Escherichia OR Fasciol* OR Flavivirus OR Francisell* OR fung* OR Giardia* OR Gnathostoma OR Hantavirus OR "Hemorrhagic Fever" OR Hendra OR Hepatitis OR Histoplasm* OR Hydatid* OR influenza OR "Lassa fever" OR Leishma* OR Leptospir* OR Listeri* OR "Lymphocytic Choriomeningitis" OR Machupo OR malaria OR "Marburg virus" OR "Middle East respiratory síndrome" OR Mycobacteri* OR Mycobacterium OR necator OR "Newcastle Disease" OR Nipah OR "Orf virus" OR Orthopoxvirus OR Paragonimus OR parapoxvirus OR parasit* OR Pasteurell* OR Phlebovirus OR Plague OR PrPvCJD OR Rabies OR "Rat Bite" OR "Rift Valley" OR "Rocky Mountain" OR Rotavirus OR Salmonell* OR Sarcocyst* OR SARS OR schistosom* OR Shigell* OR Spirometra OR "Spongiform encephalopathies" OR Sporotrich* OR Streptococco* OR Taenia* OR Toxocar* OR Toxoplasma* OR Trichin* OR trichinell* OR Trichuri* OR "Trypanosoma" OR "Variant Creutzfeldt-Jakob disease" OR Vibrio OR virus* OR "West Nile Virus" OR "Yellow fever" OR Yersinia OR Zika OR Zoonotic). From the 397 articles retrieved, we excluded publications that only mentioned wildlife as reservoir and did not perform scientific diagnosis of the pathogens.

After these processes, only 36 articles on zoonotic diseases related with Bolivian wild mammals were retrieved. Most of the research (82.8%) was published in the last 20 years, with an average of 1.3 publications per year during the last decade. The most frequently wild hosts studied were rodents (52.6% of studies), marsupials (23.7%) and carnivores (21.0%). The most diagnosed pathogens are protozoans (47.4%), viruses (42.1 %) and helminths

(31.6%). Most research (60% of studies) came from non-protected areas (e.g. peri-urban, agricultural-livestock, forests with anthropic intervention), 26% of studies were conducted in protected areas (all in the tropical Amazon region), while 14% does not specify provenance. Independently of the studies' habitat, 37% of studies collected the samples opportunistically, that means animals were trapped for purposes other than zoonotic studies or were found dead on roads.

The topic of investigation varied broadly. Largely, studies simply report a pathogen in a wildlife host (54.4%), fewer centered on the ecological aspects of host-pathogen interactions or ecology of the host that influence disease transmission (20%). The rest of the studies focused on phylogeny or taxonomy of pathogens (17.1%), laboratory experiments on pathology (2.8%) and regional literature review about diseases (5.7%).

The participation of Bolivian researchers in studies of zoonotic diseases in the country is low. Only 42 out of 155 researchers involved are Bolivians, while most are from USA (52 researchers). On the same vein, foreign entities fund most of the research. Bolivian agencies funded 13% of published research compared to international agencies that fund 90%. Only 3% of studies were co-funded. Similarly, Bolivians accounted for 47.4% of publications. Additionally, when Bolivian and foreign authors work together, the first author is mostly foreigner (67%).

It is worrying that the focus of the publications about the hosts taxa only partially match world-wide main observed hosts, which includes rodents, chiropterans and primates (Han *et al.* 2016), despite Bolivia is a species-rich country for these groups (Anderson 1997). Also, the most studied pathogens disagree with the more cited EID's causal agents (bacteria, virus and protozoan) (Jones *et al.* 2008). Therefore, the current research seems to be only partially focused on key hosts and zoonotic pathogens.

The spatial location of studies showed that the researchers focused their research in perturbed areas that may imply a higher disease risk for humans compared to studies in non-anthropogenic habitats, which might act as baselines for wildlife-borne diseases. However, as many publications do not report the location of the study, and most studies are based on opportunistically sampled individuals, this suggest that studies location is not prioritized according the risk nor are zoonosis in wild mammals being systematically studied. Thus, despite a growing interest in EIDs world-wide (Jones *et al.* 2008, and the ongoing initiatives that integrate disease prevention in a One Health framework in Bolivia (Alandia *et al.* 2012), information to deal with potential outbreak is not been gathered. Currently, research about zoonosis in Bolivian mammals has been scarce (expressed in scientific publications), focused on topics other than worldwide

priority issues, carried out opportunistically, with a handful of Bolivian researchers, usually junior authors on publications, with scarce national funding. Thus, the question arises, does Bolivia have professionals to engage in EID research?

Focusing only in Veterinary Medicine, as a participant discipline in a "One Health" perspective, nation-wide, there are 17 Bolivian universities that offer undergraduate programs in Veterinary Medicine. However, the relevance of wildlife-borne zoonoses in these programs is minimum. For example, none of the curricula offered by the three veterinary schools that also account for most of the enrollment (Universidad Mayor de San Simón - UMSS, Universidad Autónoma Gabriel René Moreno and Universidad Autónoma José Ballivián) contain a single subject dealing exclusively with zoonoses, wildlife or conservation medicine. The same is seen in the biology schools, and the human medicine schools are only focused on the human side of the zoonosis. Additionally, the proportion of veterinarians working in wildlife diseases is low. Currently, according to the Bolivian Veterinary Associations, only 1% of veterinarians working in the three most populated Bolivian cities (La Paz, Cochabamba and Santa Cruz) deal with wildlife. This scenario suggests that Bolivia does not have yet human resources for the required EID research, but exhibits a significant potential to do so. In fact, just one of the three largest schools of veterinary medicine (UMSS) graduates more than 50 professionals per year. Hence, Bolivia has the potential to engage more young scientists in the study of wildlife-borne zoonoses. If just a minor fraction of Bolivian veterinarians devoted themselves to wildlife diseases, Bolivia would better off to deal with potential wildlife-borne EIDs. We plea for such a change.

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