

SNOW LEOPARDS IN A POST-COVID-19 WORLD

Understanding and Managing the Increasing Risk
of Emerging Infectious Diseases in Asia's High Mountains



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POLICY BRIEF 12

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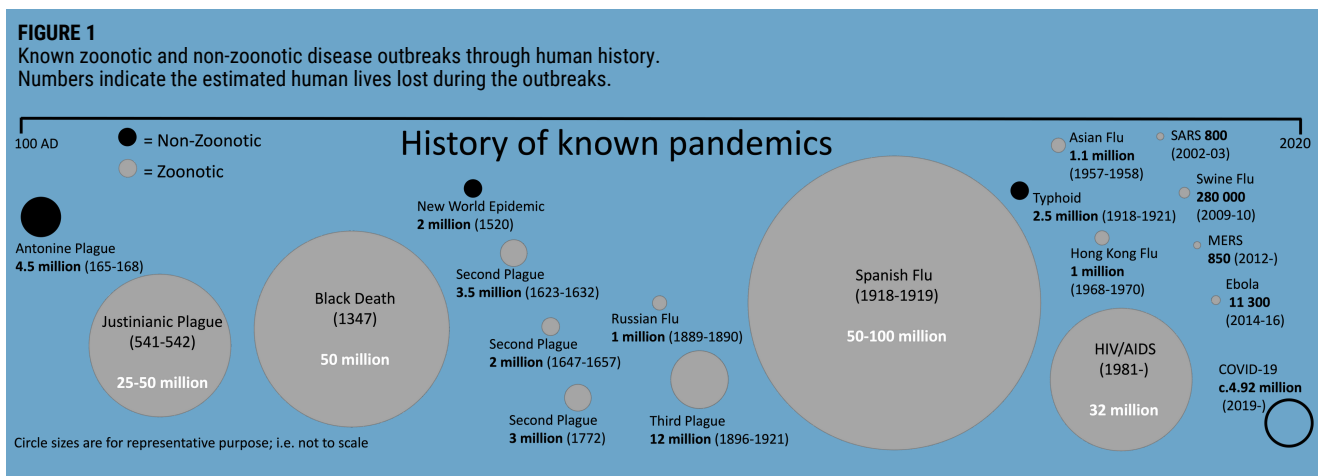
Asia's High Mountains, including the Himalayas, Hindukush, Karakoram, Pamirs, Tien Shan, and Altai – home to the magnificent snow leopard and unique pastoral cultures – have been long considered low-risk for emerging infectious diseases. However, the fast-changing social, ecological, and economic conditions, interacting with climate change, are increasing the risk of disease outbreaks in these regions. This policy-brief, adapted from the scientific paper by Mishra et al. (2021), describes the factors leading to increasing disease risk in snow leopard landscapes and provides recommendations for effective disease management.

Adapted from: Mishra, C., Samelius, G., Khanyari, M., Srinivas, P.N., Low, M., Esson, C., Venkatachalam, S. and Johansson, Ö., 2021. Increasing risks for emerging infectious diseases within a rapidly changing High Asia. *Ambio*, pp.1-14.

1.1 DISEASE OUTBREAKS IN HUMAN HISTORY

As highlighted by the ongoing COVID-19 pandemic and other outbreaks such as avian influenza, emerging infectious diseases (EIDs) are a serious risk for humans, wildlife, and domesticated species. An estimated 75% of all EIDs are thought to be zoonotic, which means they can be transmitted from animals to humans and vice-versa (reverse zoonosis). Disease transmission, in its simplest form, involves a single host species such as humans, and a pathogen that causes the disease -- such as SARS-CoV-2 in the case of COVID-19 -- that is transmitted between individuals of the host species. In more complex forms, it can involve multiple pathogens and multiple hosts (e.g. humans and different wildlife or domestic species).

Pathogens in animals can occasionally “jump” the species barrier and infect humans, and in some of these cases, they go on to manifest as disease transmissible among humans. These zoonotic diseases can sometimes grow to become epidemics or pandemics, i.e. infectious diseases that spread regionally or globally, respectively, and can have devastating impacts on humanity, as evidenced by the known zoonotic disease outbreaks through human history (Figure 1).



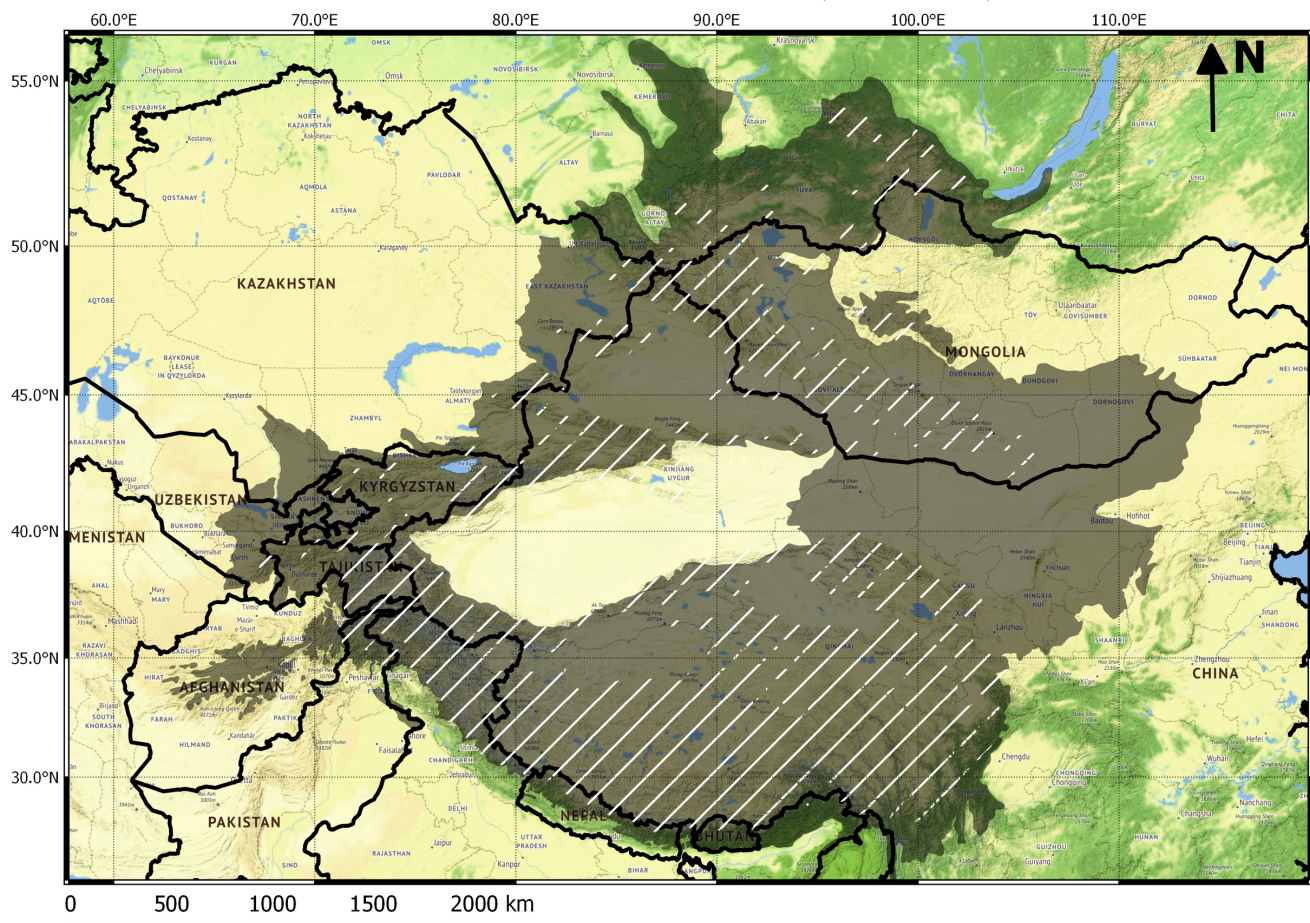
1.2 ARE EMERGING INFECTIOUS DISEASES INCREASING?

The known outbreaks of EIDs appear to be increasing in frequency as human-wildlife interactions are altering, creating conditions that cause pathogens to “jump” from animals to humans more easily. Some of these conditions include people-mediated disturbance of ecosystems, biodiversity loss, poaching and illegal wildlife trade, consumption of wildlife, and use of wildlife in traditional medicine. The increased use of antibiotics, anthelmintics, and pesticides can also lead to resistance in pathogens, thereby decreasing the efficacy of disease treatments, which allows for increase in pathogen transmission and virulence. Two important characteristics of globalization also facilitate disease transmission: (a) the unprecedented scale of movement of people, animals, and goods and therefore pathogens; and (b) reduced ecosystem resilience because of homogenization of species.

2. RISK OF EMERGING INFECTIOUS DISEASES AND ZOOZOSES IN SNOW LEOPARD LANDSCAPES

The snow leopard, *Panthera uncia*, is an apex predator found in the mountainous landscapes of Central and South Asia, across 12 countries (Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Russia, Tajikistan, and Uzbekistan). The mountainous snow leopard landscapes represent a smaller fraction of the larger dry alpine ecosystems that cover about 6.4 million square kilometers and 8 mountain ranges of Asia (Figure 2). Both humans and wildlife share space across the range of the snow leopard, with pastoralism and agriculture being the main forms of land use.

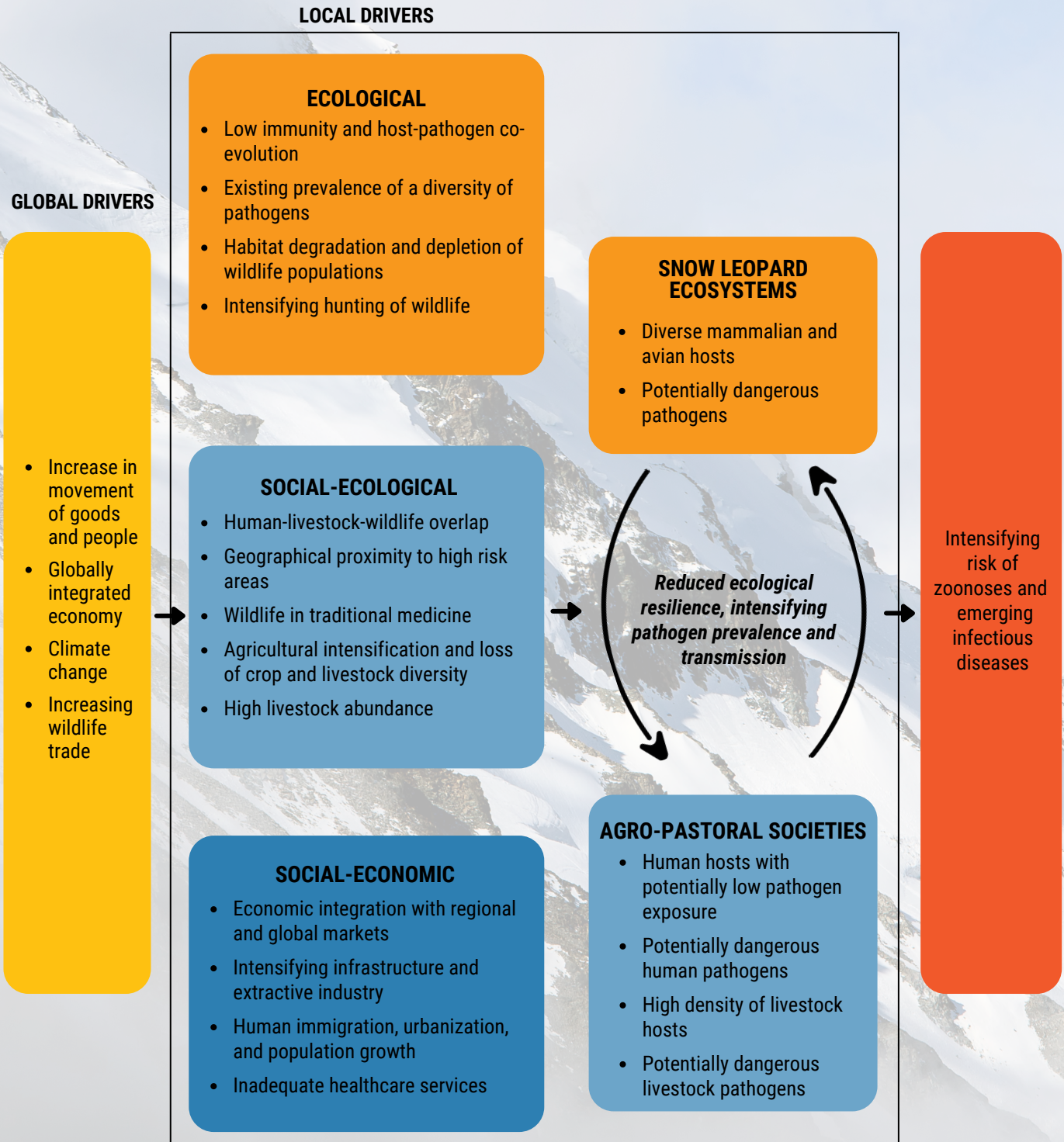
FIGURE 2: DISTRIBUTION OF SNOW LEOPARDS (STRIPED AREA)



Disease forecasting models suggest snow leopard landscapes as being low risk for EIDs as these models are based on past outbreaks, none of which are known to have originated in these mountainous habitats. Further, there has been limited disease research in high mountain landscapes compared to the tropics. However, changing socio-ecological conditions in these regions are increasing the risks for EIDs in snow leopard landscapes.

INTENSIFYING RISK OF DISEASE EMERGENCE IN SNOW LEOPARD LANDSCAPES

Multiple ecological, socio-ecological, and socio-economic factors are presumably interacting with climate change and globalization to create conditions that could cause emerging infectious disease outbreaks in snow leopard landscapes.



2.1 LOCAL AND GLOBAL FACTORS INFLUENCING THE RISK OF DISEASE IN SNOW LEOPARD LANDSCAPES

LOCAL ECOLOGICAL FACTORS

Pathogens and immune systems

- Snow leopard landscapes are thought to have a lower species diversity and abundance of pathogens as compared to warmer regions. However, there is limited information on the pathways that lead to disease outbreaks, and the relevance of the abundance of pathogens to the emergence of EIDs is largely unknown. Further, lower exposure to pathogens can result in naive immune systems for both people and animals which have not been previously exposed to these pathogens, making them more susceptible to infections.

Snow leopards

- Health and disease aspects of wild snow leopards have received limited attention. However, snow leopards have some characteristics that may increase their chances of encountering and spreading disease, and make them vulnerable to risks. For example, snow leopards have large home ranges with adult males reported to have average home ranges of 220 km² and adult females 130 km², implying that individuals cover large areas. They also frequently come into contact with each other through interactions such as traveling together or sharing kills, and frequently come in contact with wild and domestic ungulates, as they are their main prey. Snow leopards have a slow reproductive rate compared to other felids, which could reduce the ability of populations to recover from disease-caused declines.

Prey species

- Important wild prey species of the snow leopard, such as ibex, *Capra sibirica*, and argali, *Ovis ammon*, can potentially spread disease to domestic ungulates or contract diseases from them, as they are taxonomically similar, share the same pastures and water sources, and eat similar plants. Prey species might also be more susceptible to disease as they move in herds and their body condition and general health is often seasonally compromised because of long, harsh winters and competition with livestock.

Rodents and lagomorphs

- These animals pose a risk of disease transfer as they live in close proximity to people, and are known to carry over 60 zoonotic pathogens that can have serious effects on human health. They are also a prey species of the snow leopard, and can potentially transfer disease to snow leopards and other species.

Birds

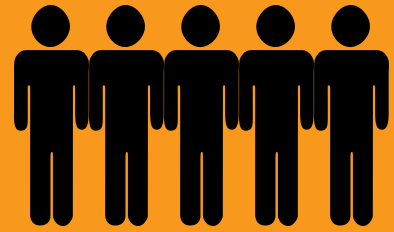
- Bird migrations are an important risk factor in the spread of EIDs. Two of the eight main flyways for migratory birds, the Central Asia Flyway and the East Africa-West Asia flyway, cross snow leopard landscapes. Birds using these flyways are traveling across densely populated regions in South-West Africa and Southern India, potentially transferring disease. These birds use snow leopard landscapes as stopover sites during their migration, and occur in high densities at local water sources that are also used by resident wildlife, livestock, and people. Some migratory birds also use these landscapes as their breeding grounds.

FACTORS THAT INCREASE THE RISK OF DISEASE EMERGENCE



Image: Bob Comix

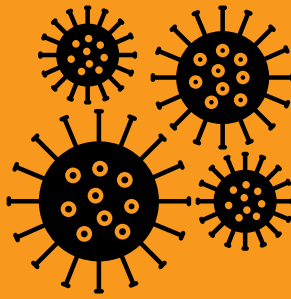
- Large home range and movement distances
- Predation on livestock and retaliatory killing



- Seasonal migration
- Transition towards sedentization
- Urbanization and tourism



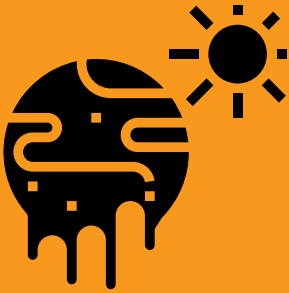
- Rodent consumption for meat and medicine
- High interactions between people and rodents in houses



Lower immunity against pathogens



Increasing abundance of feral dogs in the landscape



- Global warming
- Increasing precipitation and glacial melt



- High abundance of livestock and close association with humans
- High overlap in habitat use by livestock and wildlife



- Wild ungulates taxonomically similar to livestock
- Large home ranges, migratory behavior
- Hunting and consumption



Increasing infrastructure development, mining, pesticide use, and integration with lowlands



- Demand for pelt, bones and other tissues
- Significant use of wild species in traditional medicinal systems



High proportion and large congregations of migrating bird species

LOCAL AND GLOBAL FACTORS INFLUENCING THE RISK OF DISEASE IN SNOW LEOPARD LANDSCAPES

LOCAL SOCIO-ECOLOGICAL FACTORS

Agro-pastoral systems

- Snow leopard landscapes represent one of the largest rangeland systems in the world, and livestock production is one of the main livelihood strategies for the local communities. Conditions for pathogen spread are created by the high abundance of livestock, seasonal migration of people in some areas, and close proximity between people, livestock, and wild animals.

Tourism and other influx of people

- Newer economic opportunities, especially related to tourism, have increased the immigration and movement of people in snow leopard landscapes.

Traditional medicine systems

- There is a high dependence on traditional medicine systems in snow leopard landscapes, some of which use wild animal parts.

Poaching and trade

- Poaching and wildlife trade are increasing in many snow leopard landscapes. This can impact disease through two pathways. One, people come directly in contact with wildlife which can increase the risk of pathogen transmissions. Two, lower species diversity which can disrupt natural ecosystem interactions and increase movement and species turnover in the system, resulting in increased risk. Therefore, species eradication programs undertaken in several snow leopard landscapes, that are often targeted at rodents, lagomorphs, and even large mammals to reduce potential vectors, can actually increase the risk of EIDs.

Changing agricultural practices

- The ongoing intensification and homogenization with new areas being brought under cropland, reduction in crop and livestock species diversity, and increasing livestock densities, can lead to enhanced risk of EIDs in snow leopard landscapes.

Antibiotic and anthelmintic resistant strains

- Modern livestock management practices can lead to antibiotic resistant bacterial strains and anthelmintic resistant worms, which can be transmitted to wildlife, especially to omnivorous, anthropophilic and carnivorous species because of their close interactions with livestock.

LOCAL AND GLOBAL FACTORS INFLUENCING THE RISK OF DISEASE IN SNOW LEOPARD LANDSCAPES

LOCAL SOCIO-ECONOMIC FACTORS

Urbanization and population growth

- Across snow leopard landscapes, there is rapid urbanization and population growth. Local and national economies are fast integrating, thereby increasing the movement of people and goods between the mountains and low-lying areas. Nearly 42.5% of the world's human population lives in the 12 snow leopard range-countries, of which some include tropical and temperate areas, which generally harbour more diseases compared to snow leopard landscapes. Therefore, EIDs that originate in other parts of the snow leopard range countries can easily be transmitted to snow leopard landscapes.

Law enforcement challenges

- Law enforcement is difficult due to the remoteness of most snow leopard landscapes which increases the possibility of illegal hunting for consumption and trade, creating conditions for EIDs.

Feral dogs

- Feral dog populations are increasing in snow leopard landscapes in several countries, which can increase pathogen transmission between urban centres and remote habitats.

Inadequate investments into locally relevant health care

- As snow leopard landscapes often lie at the fringes of most of the countries where they occur, public human and veterinary health services are often not well developed and suffer from inadequate investments, which hinder the ability to prepare for or prevent possible outbreaks.

GLOBAL FACTORS

Climate change

- Snow leopard landscapes are among the most vulnerable to climate change and are warming at more than twice the average rate in the northern hemisphere. Warming climate and changes in species distributions expose snow leopards and other animals to new diseases to which they have not been previously exposed, leading to increased risk of disease outbreaks.

Economic and infrastructure development

- Increasing extractive economies and infrastructure development, such as mining and construction of dams and roads, are opening up these once remote regions, and increasing movement of people between these regions and low-lying areas. They also bring other issues of globalization and development such as pollution, new markets for wildlife trade, and introduction of foreign pathogens and vectors.

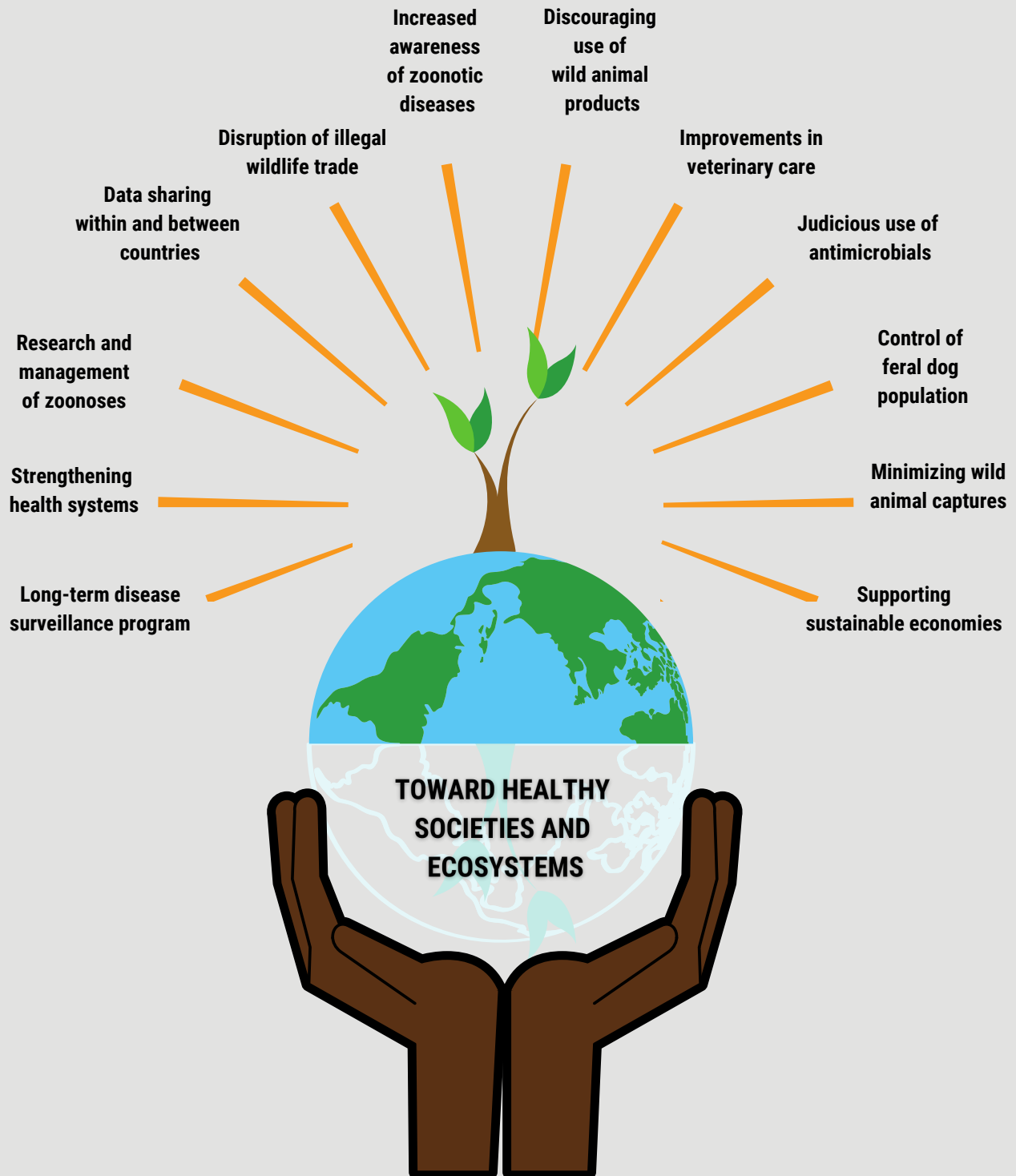
2.2 PATHOGEN PREVALENCE IN SNOW LEOPARD LANDSCAPES

From the information available on disease outbreaks in snow leopard landscapes, albeit limited, it is evident that several pathogens that have the potential to cause considerable harm are already present in the system.

TABLE 1: PATHOGENS KNOWN TO OCCUR IN SNOW LEOPARD LANDSCAPES

Disease	Pathogen	Main hosts	Mode of transmission
VIRUSES			
Rabies	<i>Rabies viruses</i>	Carnivores and bats	Bites and saliva
SARS	SARS-coronavirus	Bats and possibly small carnivores	Airborne droplets
MERS	MERS-coronavirus	Bats and possibly camels	Airborne droplets
COVID-19	SARS-coronavirus 2	Likely bats	Airborne droplets
Avian influenza	Influenza A virus subtype H5N1	Birds	
Swine influenza	Influenza A virus subtype H1N1	Pigs	Airborne droplets
Hantavirus	Hantavirus	Rodents	Airborne transmission
Japanese encephalitis	Japanese encephalitis virus	Birds and possibly pigs	Vectors
Influenza	Influenza A virus	Birds	Airborne droplets
BACTERIA			
Anthrax	<i>Bacillus anthracis</i>	Ungulates	Air and ingestion
Plague	<i>Yersinia pestis</i>	Rodents	Arthropod vectors
Tuberculosis	<i>Mycobacterium</i> spp.	Birds, mammals, and reptiles	Airborne droplets and aerosols
Brucellosis	<i>Brucella</i> spp.	Ungulates	Ingestion
Leptospirosis	<i>Leptospira</i> spp.	Rodents and other mammals	Ingestion, broken skin
Tularemia	<i>Francisella tularensis</i>	Mammals and birds	Vectors, ingestion, and air
Cat-scratch disease	<i>Bartonella</i> spp.	Rodents and felids	Vectors
Q fever	<i>Coxiella burnetii</i>	Ungulates and other mammals	Airborne aerosols
Lyme disease	<i>Borelia burgdorferi</i>	Rodents and ungulates	Arthropod vectors
PARASITES			
Ecchinococcosis	<i>Echinococcus</i> spp.	Canids, rodents, and ungulates	Ingestion
Giardiasis	<i>Giardia duodenalis</i>	Mammals and birds	Ingestion
Toxoplasmosis	<i>Toxoplasma gondii</i>	Mammals and birds	Ingestion
Cryptosporidiosis	<i>Cryptosporidium</i> spp.	Mammals and birds	Ingestion

RECOMMENDATIONS TO CONTAIN THE RISK OF EMERGING INFECTIOUS DISEASE IN ASIA'S HIGH MOUNTAINS



3. RECOMMENDATIONS TO CONTAIN THE RISK OF EMERGING INFECTIOUS DISEASE IN ASIA'S HIGH MOUNTAINS

Long-term Disease Surveillance Programs

- Inter-sectorial (human and animal health, agriculture, and conservation) and long-term disease surveillance programs are needed across snow leopard landscapes. These surveillance programs need to focus on spatio-temporal distribution and trends in EIDs, zoonoses of concern, and endemic disease within livestock and wildlife. The programs should also include monitoring of risk factors that increase risk of EIDs. This can help prepare, predict, and thereby potentially prevent serious disease outbreaks, as well as help understand the pathways of transmissions of EIDs between people, wildlife, and livestock. Local communities can be integrated into the surveillance programs to monitor and report on the dynamic risk factors that are also likely to be influenced heavily by climate change and the ever-increasing network of linear infrastructure.

Strengthening of health systems

- Investments to strengthen health care systems that are adapted to local conditions are important for preparedness, earlier detection and management of EIDs in snow leopard landscapes.

Data sharing within and between countries

- Along with establishing disease-surveillance programs and strengthening the local health system, data sharing mechanisms within and between countries, especially along open borders, need to be established to help with early detection and integrated response during disease outbreaks.

Research and management of zoonoses

- There needs to be more investment into research and management of zoonoses on priority in snow leopard landscapes.

Disruption of illegal wildlife trade

- The growing threat of illegal wildlife trade needs to be disrupted through better law enforcement and cooperation among governments, conservationists, and local communities. Law enforcement can be improved through training, incentives, as well as increased personnel in these remote regions.

Increasing awareness

- Sustained awareness programs are needed in snow leopard landscapes that inform about the risk of disease transmission, zoonoses, and actions to reduce the risks. Local community members and local governance institutions need to be involved in disease monitoring and surveillance programs.

RECOMMENDATIONS TO CONTAIN THE RISK OF EMERGING INFECTIOUS DISEASE IN ASIA'S HIGH MOUNTAINS

Discouraging use of wild animal products

- Discouraging the use of wild animal products might help reduce disease risk. In areas where the use of animal products in traditional medicine is socially and legally accepted, encouraging safe and hygienic handling practices might be helpful.

Improving veterinary care

- Access to good veterinary infrastructure and care across snow leopard landscapes can help reduce disease risk significantly.

Encouraging judicious use of antimicrobials in livestock and agriculture

- Judicious use of antimicrobial agents can prevent the emergence of antimicrobial resistance pathogens, which can be detrimental to humans, domestic, and wild species. Improving hygiene, health standards, and the overall resilience of the ecosystem can decrease the need for the use of antimicrobials.

Managing feral dog populations

- Feral dog populations need to be controlled and immunised using a range of interventions such as sterilizations, vaccination, and garbage management.

Avoiding capture of wild animals

- The capture and keeping of wild animals causes immense stress in the animals due to the stress of capture as well as the stress of transport, which can include being caged with or next to other species, close proximity to people, rough handling, inadequate food and water, poor hygiene, etc. Constant stress can physiologically cause a decreased immune response by the body when challenged by a pathogen.

Linear infrastructure

- Linear intrusions in mountainous regions can intensify the risk of disease through habitat degradation, population fragmentation, improved access, and pollution. Policies and guidelines for linear infrastructure in snow leopard landscapes are critically important, and can follow a mitigation hierarchy including avoidance or prevention, realignment to avoid vulnerable habitats, mitigation, and habitat restoration.

Supporting sustainable economies

- Sustainable economies built on the conservation of biodiversity and the sustainable use of ecosystem services in snow leopard landscapes need to be encouraged to improve the resilience of ecosystems. These can be promoted by encouraging practices such as organic farming, green economies, and green infrastructure.

SNOW LEOPARDS IN A POST-COVID-19 WORLD



Changing socio-ecological and socio-economic conditions, together with climate change in Asia's high mountains, are increasing the risk of EID's in a region that has long been considered low risk. This necessitates integrating people and livestock health with conservation efforts to ensure a secure future for people, livestock, and wildlife. Intensifying disease surveillance and research is crucial toward building robust health systems. Early detection of disease outbreaks and knowledge exchange among snow leopard range countries is critical for wildlife and local people, Asia's mountainous regions, and, indeed, the rest of the world. The GSLEP Secretariat could be tasked with coordinating national efforts and intergovernmental cooperation to help reduce the risk of disease in snow leopard landscapes.



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