Tackling Rabies in a Rapidly Urbanising World

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One summer night, Joseph Meister, a nine-year-old boy terribly mauled by feral dogs, was brought to the laboratory of a scientist named Louis Pasteur. Pasteur, already a public figure, had been struggling to develop a vaccine for rabies for quite some time. He used a weakened form of the virus potion, called attenuated virus, that he had prepared by serial passage of the virus through rabbit hosts, to treat the boy. Joseph never developed any symptoms and the ferocious rabies virus had met its match. This epochal incident occurred 133 years ago. One would believe that 133 years would be enough to eradicate a deadly disease, but rabies still continues throw its weight around with a global death burden of 59,000 deaths a year, or about 160 a day, according to a study published in 2015 in the scientific journal 'PLoS Neglected Tropical Diseases'. India, with its ingloriously large stray dog population, has the most rabies deaths – almost 21,000 a year.

Largely eliminated from developed nations and island states, rabies kills thousands in Africa and Asia. Dogs, the anti-heroes of this story, account for 99% of rabies deaths in India. This has major implications for a situation that is unique to India – we harbour a largely free-ranging, 'stray dog', population that occurs at high densities throughout the country. A whopping 58 million dogs (~6% of the global dog population) inhabit our country, for a comparison, the size of tiger population in India is 2,226. While international efforts now focus on achieving a global target of zero human deaths from dog-transmitted rabies by 2030, public health experts believe that India

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is far away from accomplishing this task. We do not even have the data to know the extent of the disease in spite of the serious public health threat of rabies in India.

The world's most abundant carnivore, dogs, thrive in big cities, small towns, and villages across the Indian landscape. Human-dominated urban and semi-urban areas support very high densities of dogs as most Indian cities have extremely poor garbage management and disposal system – an endless food supply for these scavengers. In addition to being a public health concern, stray dogs pose a major threat to local wildlife. Research work suggests that outbreaks of rabies can severely endanger wildlife. Studies have shown that the Ethiopian wolf population in the early 1990s in Serengeti National Park declined due to successive outbreaks of rabies. In the Indian scenario, stray dogs roam freely, unvaccinated, posing a huge threat to the wildlife in rural areas. Rural areas in India have thriving populations of several animals of conservation importance, such as foxes, jackals, leopards, snow leopards, lions, tigers, and wolves, that come in regular contact with dogs. Currently, we have no idea of the extent of danger that rabies transmission poses to this wildlife that shares the landscape with stray dogs. Stray dogs form the apex of the dog-wildlife-human rabies triangle that we urgently need to study to estimate the extent of this complex problem in India.

When biologists encounter a complex phenomenon, they like to develop models that capture the essence of that particular phenomenon. Models are abstractions of the real world that can give important insights. For example, Google Maps application on our smartphones provides us with a simplified model of an area, desirable for navigation. It would not be useful to construct this map with all the information about every tree, animal, and house. Similarly, to understand complex phenomenon of how rabies might spillover from stray dogs to wildlife and humans, scientists build models to simulate rabies spread in a virtual space and over imaginary time. Existing models of understanding the spread of rabies are not supported by field data and lack mechanistic details, meaning the details of how the spread might occur. For example, models are not able to accurately predict if the spread of rabies occurs through several long-distance dog movements or through a slow spread from an epicentre of the disease. Currently available models are too simple and inadequate in explaining how rabies is being transmitted and maintained in dog populations. With advancement in computational methods, researchers studying spread of diseases have started using a class of sophisticated models called 'individual-based models'. In these models, researchers define a set of rules for individuals (in this case, animals) to live and interact in a virtual world and then record emergent properties of this 'virtual world'. In my research work, I am building such models of rabies spread using the current best understanding of the system.

At our main field site in Baramati (Pune district, Maharashtra), work carried out to monitor stray dog population densities suggests that dog densities are higher in urban areas and there is risk of spillover of disease into adjacent rural areas. Rural areas of Baramati have thriving populations of foxes and jackals that overlap with human habitations. Our research team has put tracking devices (GPS collars) on 35 dogs, 18 foxes and 8 jackals to monitor animal movement. GPS collars are really neat devices. Based on the Global Positioning System technology (that is also used in our mobile phones), these devices record the animal's exact location and store the readings at preset intervals. These locations get logged and can be downloaded remotely sitting in our office in Bengaluru. From our work, we now know that foxes, jackals and dogs use the same area (degree of spatial overlap) and come in direct contact (contact rates) with each other. Interestingly, the animal tracking data shows that dogs, jackals and foxes utilise the human-modified landscape in their own peculiar ways. When humans modify the landscape by building roads, railway lines and residential colonies, animals respond to these changes in the landscape. For example, we found that a pair of jackals that we were tracking never cross the railway tracks to enter other's territory. The important role of geography in disease spread was also showed in a study published in 2018 in the scientific journal 'Moleculer Ecology' where scientists showed that while rivers could act as potential barriers to rabies transmission, roads acted as facilitators for the same. In my research, I use the information from animal movement data from Baramati to build the simulation models of rabies outbreak.

The great advantage of modelling disease spread using simulations (such as 'individual based models') is that one can tweak this model to test the performance of different kinds of rabies control methods that policymakers might employ. In my research, I test efficacy of different control methods, such as 50% and 100% dog vaccination coverage, reducing dog densities through animal birth control (ABC) programs, restricting dog movements in fox-jackal habitats, or fox/ jackal vaccination. This information is extremely valuable for environmental/ wildlife managers and policymakers to make informed decisions to contain the spread of rabies.

The current strategy for the control of rabies in India is based on studies that were not conducted in India. To reduce the spread of rabies in the dog population, we rely on the World Health Organisation's guideline of vaccinating 70% of the dog population annually. Dog-catchers, risking dog-bites, continue to vaccinate and sterilise dogs as part of animal birth control programs. Over a hundred years have passed ever since Louis Pasteur developed the rabies vaccine, but rabies remains. India's rabies problem is unique to her and policies and strategies based on scientific evidence through such studies conducted in India alone can tackle the problem of rabies.