



Review Article

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Epidemiological trends of rabies and control strategy in China: A narrative review

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ABSTRACT

Rabies is widely prevalent worldwide, and China is among the countries most affected. To achieve the goal of zero human deaths from dog-mediated rabies by 2030, dog management and immunization must be improved and comprehensive prevention and control measures must be adopted. We analyze the epidemiological profile of rabies in China in the past 30 years to clarify the origins of China's high prevalence, and propose a comprehensive rabies prevention and control concept based on "One Health" by drawing on successful international control efforts.

KEYWORDS: Rabies; Epidemic status; Dogs; Immunity

1. Introduction

Rabies is an acute, fatal zoonotic disease with a mortality rate close to 100%[1], causing approximately 59 000 global deaths[2] and imposing a significant economic burden of \$124 billion on public health systems annually[3]. Since 2007, the overall rabies epidemic in China has been declining every year with significant prevention and control effects. However, China remains one of the high-risk countries for rabies exposure identified by the World Health Organization[4]. In recent years, rabies in China has shown a trend of spreading to the central, western, and northern regions, with a rebound of outbreaks in some areas. There is still a gap to overcome before achieving the goal of zero human rabies deaths by 2030. As economic globalization continues to deepen, rabies prevention and control efforts face additional challenges. This paper aims to analyze the current status of the rabies epidemic in China, investigate risk factors of the rabies outbreaks, and offers a scientific framework for elimination of rabies in China.

1.1. Pathogenesis

Rabies is mainly shown as a zoonotic central nervous system infection caused by lyssa viruses with fear of wind, fear of water, pharyngeal muscle paralysis, and progressive paralysis as the main clinical symptoms[1,4]. The fatality rate of rabies is virtually 100%[5].

The World Health Organization(WHO) has identified 18 rabies virus species based on their antigenic properties and genealogical relationships, which are divided into genetic lineage I (12 kinds), lineage II (three kinds) and lineage III (three kinds)[4]. The rabies virus currently prevalent in China can be divided into six groups from China I to China VI, of which China I is most widespread[6].

The rabies virus is typically found in the salivary glands and saliva of diseased animals, and is transmitted to humans through animal bites, scratches on the skin, or licking of mucous membranes. Rabies virus has a broad host spectrum of infection, and in China, dogs are the primary host animal, followed by cats. In addition, wild animals such as ferret badgers, bats, raccoons, wolves, and foxes are also involved in rabies transmission. In terms of geographic distribution of infection sources, wolves, bats, foxes, and raccoons dominate in northeastern and northwestern China, while bats are mainly distributed in southern China, and ferret badgers dominate in the southeastern region. This is directly related to the geographic distribution of these wild animals[7].

2. Epidemiology

2.1. Temporal pattern

Rabies is widespread in more than 150 countries, with 95% of

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cases occurring in Africa and Asia, especially in rural areas with low levels of economic development[8]. Since the 1950s, there have been three peaks of the rabies epidemic in China. The first peak occurred in the mid-1950s when the annual number of reported deaths exceeded 1 900, the second peak occurred in the early 1981 with 7 037 deaths reported nationwide, also the highest number of reported deaths since the founding of People’s Republic of China. The number of rabies cases then bottomed out before rebounded again in 1997, after which declined again in 1998 and 2005[9,10], and finally increased once more to the third peak in 2007, when the number of reported deaths climbed to 3 300[11]. Subsequently, China has adopted a series of comprehensive measures, such as strengthening dog management, immunization, standardizing post-exposure prophylaxis (PEP), strengthening human and animal surveillance, popularizing health education to curb rabies, and achieved a more significant prevention and control approach, with the number of reported rabies cases and incidence rate maintaining a 14-year downward trend to a historical low (157 cases, 0.011/100 000) in 2021[12], as shown in Figure 1.

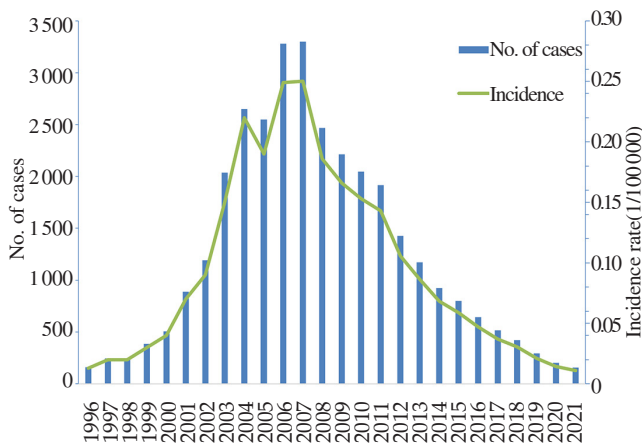


Figure 1. The incidence and number of human rabies cases reported in mainland China, 1996-2021.

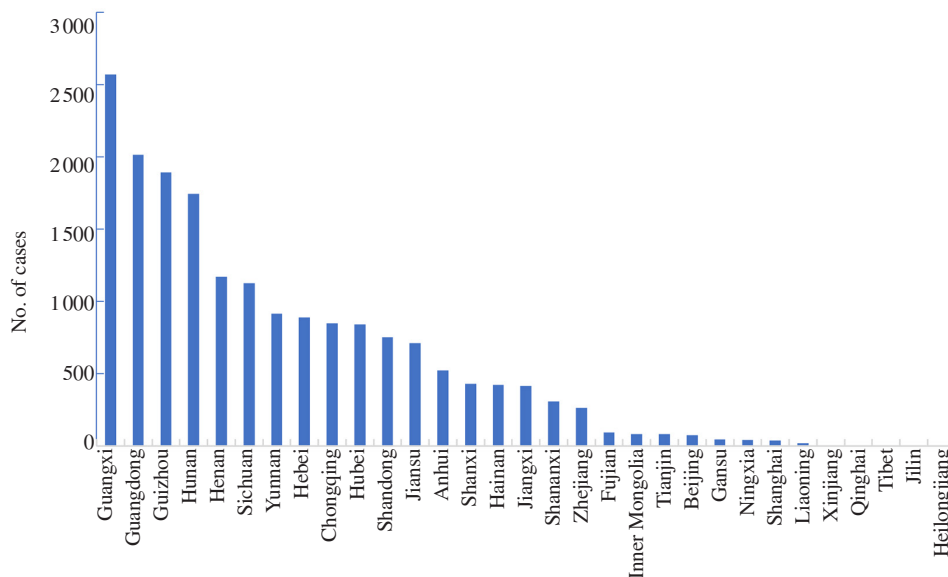


Figure 2. Regional distribution of the cumulative number of reported cases of rabies from 2007 to 2020.

2.2. Geographical distribution

Historically, rabies was mainly concentrated in the southern and central-eastern regions of China. The top four provinces in the country in terms of cumulative reported cases of rabies from 2007 to 2020 were Guangxi, Guangdong, Guizhou, and Hunan, with the combined number of reported cases accounting for 44.99% of the total number of cases in the same period[13,14], as shown in Figure 2. The causes of this geographic distribution are complex. The first factor is climate change. Rabies-prone provinces are mainly located in China’s subtropical area of monsoon climate, where the local four-season climate is warm and humid, which is conducive to the survival and reproduction of rabies hosts and infectious agents[15]. Second, people have changed how they keep dogs as pets. In the high-risk area, the majority of families have dogs guarding houses in the backyard and have a lack of immunization coverage. Thus, rabies exposure and infection opportunities are relatively high[16]. The third factor is dietary habits in these provinces. People living in some areas such as Guangxi Yulin, Guizhou Huajiang, and Hunan Xiangnan, have the habit of consuming dog meat, increasing the risk of rabies exposure. The fourth reason is human traffic patterns. With increasingly convenient transportation becoming available, the range of activities of dogs increased and this migration of dogs speeds up the spread of rabies[17]. In contrast, the northeast and southwest regions of China are sparsely populated, with low population and dog densities, inconvenient transportation, and long winters, which lead to relatively few opportunities for human-dog contact, hence a significant factor for low incidence of rabies[18].

After 2007, the rabies epidemic in China was effectively controlled, but there were elevated differences in rabies epidemics in different regions. Guangxi, Guangdong and Guizhou provinces achieved remarkable progress in rabies control through a combination of measures, including popularizing rabies health education, strengthening dog management, optimizing PEP clinic settings and

incorporating some PEP costs into the social insurance system[14]. By 2020 the number of reported cases in these provinces decreased by more than 97% compared to that in 2007. However, Hunan Province—a province with chronically high rabies prevalence—has seen less decline (82.34% in 2020 compared to that in 2007). There were also several outbreaks in the last decade. Since 2016, Hunan Province ranked first in the country in terms of the number of rabies cases reported each year[12], and by 2021 its number of reported cases is 31.85% of the total number of cases nationwide.

Regarding dog management, one survey showed that the off-leash rate of dog in rural areas of Hunan Province was 15.38% in 2011 and increased to 41.58% in 2014 before dropping to 10.61% in 2018[19, 20]. Specifically, dog immunization rate in rural areas of Hunan was only 2.1% in 2001 and 7.18% in 2018[20,21]. Analysis of injured animals in Hunan Province from 2009-2010 showed that only 16.67% of injured animals had a clear history of immunization[22]. Neither survey indicated that Hunan was close to 70% immunization coverage. Another survey by Ping Luo and Hao Yang *et al.* found a higher rabies exposure rate in rural Hunan Province in 2018 (2.18/100 persons) than that in 2014 (1.28/100 persons), which also suggests that the number of dogs in Hunan Province may have increased significantly in recent years[19,20]. Furthermore, an investigation in Hunan's Xiangxi region and Wugang city revealed apparently healthy-looking dogs carry rabies virus positive with a prevalence of 10.5% and 13.13% respectively[23,24]. These two findings suggest that there is likely an insidious risk of rabies transmission in Hunan Province. There has been an abundance of evidence to support that the lack of dog management and immunization implementation in Hunan Province caused a higher risk of rabies transmission which led to a rebound of rabies epidemic. In terms of PEP, surveillance data showed that only 6.33% of the rabies-exposed population in Hunan Province had their wounds treated at PEP clinics, which was significantly lower than the remaining five monitored provinces (Guizhou, Guangxi, Anhui, Jiangsu, Shandong) [25]. Moreover, the use of human rabies vaccine and immunoglobulin after exposure was also low. It should be added that Hunan Province has had much of its land closed for

reforestation in recent years and the ecology there was thus restored. The improved wildlife habitat facilitates the reproduction of wildlife hosts such as ferret badgers, wolves and bats, which also facilitates the spread of human-animal infectious diseases such as rabies among hosts, partially contributing to the rebound of rabies epidemic in Hunan Province.

Similarly, Yunnan and Hainan provinces experienced a large rebound of the epidemic in 2008, which may be closely related to the development of local tourism and population movement. In the last decade, rabies epidemics in Henan, Jiangsu, Anhui and Shaanxi have also rebounded or fluctuated slightly, which suggests that after years of intense rabies prevention and control efforts, there may be retraction in prevention and control in some areas. At the same time, it should be alarming that provinces with no or low incidence of rabies in the past, such as Ningxia, Liaoning, Heilongjiang, Tibet and Qinghai, also saw new cases during 2010-2017[26,27]. Heilongjiang, Jilin and Liaoning in the northeast and Xinjiang, Tibet and Qinghai in the west have continuously maintained zero reported case in the last 3-5 years. However, the trend of rabies spreading to the central, western and northern regions cannot be ignored[14], as the outbreak has spread across China(Figure 3), the reason of which lies in convenient transportation that expands the range of dogs and helps the spread of rabies. Further, the RABV strains isolated from Heilongjiang, Hebei, Jilin, and Liaoning in recent years are highly homologous with that of Inner Mongolia[28], suggesting a risk of cross-border transmission of rabies. Rabies prevention and control in China still faces a severe test, calling for strengthening in rabies animal and strain surveillance. Therefore, rabies was identified as one of the five priority zoonotic diseases in China in 2019[29], reflecting the necessity and enormity of rabies elimination.

Although rabies is circulating in 31 provinces and cities in China, it mainly occurs in rural areas—over 70% of human cases were farmers[12-14]. One reason is that rural dwellers have the habit of raising dogs to protect their families and for consuming dog meat[31]. Dog management is difficult with such high density and widespread free-ranging of dogs. Secondly, the economic burden of dog

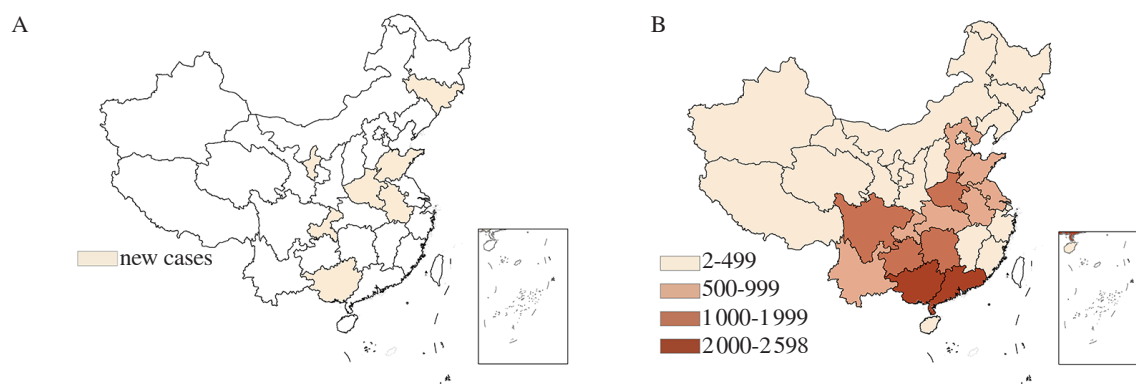


Figure 3. Spatial and temporal dynamics of human rabies in China. A: distribution of human rabies 1990-2000[30] (Colors indicate new cases in the province during this period); B: distribution of human rabies 2007-2020.

immunization and PEP disposal is steep for low-income farmers. Finally, Compared to urban residents, villagers lack awareness of the dangers of dog injuries, resulting in low compliance with the norms of disposal[32].

Based on the epidemiological situation and geographical evolution of rabies, it is important to strengthen the prevention and control of the epidemic in areas with a high incidence of rabies, such as the south and the central east. Additionally, more attention should be paid to areas where the epidemic has rebounded in recent years.

3. Current status of infectious source control

3.1. Dogs

Studies have shown that more than 95% of human rabies is caused by infected dogs, and the fundamental measure to prevent rabies is to strengthen the management of dogs[4, 33]. In the past, large-scale culling methods had been adopted at home and abroad, but the results proved to be ultimately ineffective. Bali slaughtered over 200 000 stray dogs in 2008-2009, with significant public outcry, after which rabies remains rampant[34]. China launched a unified dog eradication campaign in 1951 with brief success, but the epidemic rebounded by the mid-1970s. Clearly, inhumane mass culling of dogs is not an effective measure to prevent and control rabies[34–36]. Dog immunization is the core and key measure to prevent rabies, which is also unanimously recommended and recognized by International Epizootic Office, Food and Agriculture Organization of the United Nations and other international organizations[8].

The price of each veterinary rabies vaccine in China is about 50-100 RMB and only one dose is required per year while the human rabies vaccine costs about 100-300 RMB and requires 4-5 doses for full vaccination. Class III exposed people also need to be injected with immunoglobulin at a price of about 1 000 RMB, which can only protect the vaccinated individual. Therefore, canine immunization is clearly a more cost-effective strategy compared to PEP. It is estimated that the number of dogs in China reached 130 million in 2012[37, 38], bringing about 40 million dog bites or scratches each year[30]. The Chinese government spends more than 10 billion RMB a year on rabies prevention, consuming the largest share of the world's rabies vaccines, yet inexplicably large amounts of this budget are spent on humans instead of dogs. Some experts have suggested that China may be targeting vaccinations of wrong people, which may explain why China has been slow to reach 70% effective dog immunization coverage, and has even seen a decline[39]. Data show that the overall immunization rate of Chinese dogs slipped from 43.63% in 2013 to 30.89% in 2017 and continued to hover near 30% by 2020[14]. For rural areas (with high prevalence), the dog immunization rate is even lower, A survey of rural dogs in Shandong, Guizhou, Guangxi

and Hebei Provinces showed the positive rate of virus neutralizing antibody present was ranging from 1.2% to 2.8%[38]. This may be the power of capital behind the vaccine manufacturers at work, as there is more profit margin for human rabies vaccine and immunoglobulin compared to veterinary rabies vaccine.

On this issue, Yan Jiaxin, a leading rabies expert in China, believes that there is a root problem in China's rabies prevention and control strategy[40]. The concept of "neglecting dog immunization and emphasizing PEP" is the fundamental reason why rabies has not been eliminated in China. The surface phenomenon is that "dogs under the control of the Ministry of Agriculture have bitten people under the control of the Ministry of Health", but in fact it reflects the lack of clarity of the main body of epidemic prevention. Dog management, immunization issues involving public security, city management, the Center for Disease Control and Prevention, and other departments. For a long time, various departments have lacked an effective linkage mechanism, which is not conducive to effective rabies control. This has led to a lack of synergy and enforcement of immunization at the grassroots level[41]. In response, some studies have raised the importance of multi-sectoral collaboration in dog management[29, 42].

Another phenomenon is the polarization of dog management in China. Relative to urban areas with higher economic income levels, residents have stronger awareness of disease prevention and relatively higher rates of pet dog registration and immunization. Nevertheless, stray dogs lack supervision and most have immunization gaps, making them an important source of rabies risk in cities. When Beijing tested stray dog brain tissue for the rabies virus during 2015-2016, some 30% of the samples were found to test positive[43]. This result suggests a high risk of rabies infection in urban stray dogs. In rural areas where the economic level is low, villagers are not aware of the hazards of dog injuries. Dogs are mostly free-range, and it is difficult to organize large-scale dog immunization.

In addition to vaccination coverage, we should also look at the strains of virus covered by the vaccine. The vaccine strains of veterinary rabies vaccines currently used in China all belong to genetic spectrum I, which is closely related to the vaccine production strain CTN-1V. Therefore, existing vaccines may not provide protection against other serotypes of viral infections outside the genetic spectrum I[7, 44]. Thus, targeted veterinary rabies vaccines should be selected for the differences in rabies prevalent strains in different regions of China to further improve the vaccine immunization effect .

3.2. Cats

The management of cats, the second largest source of rabies transmission in China, is also important. In 2020, 2.44% of rabies deaths in China were due to cat infection, and the proportion of

injuries caused by cats in the exposed population was also as high as 32%. The average immunization rate for cats was only 17.25% according to one survey[45], which was much lower than the immunization coverage rate for dogs. To date, China has also not developed a strategy for cat-mediated rabies management and immunization. The regulation of pet cats needs to be strengthened.

3.3 Wildlife

In addition to dogs and cats, there is an increasing number of wild animals involved in the spread of rabies[46]. In northern China, foxes are the main source of transmission after dogs[47]. Wild animals such as camels, bats, badgers, or raccoon dogs are infected with rabies virus in Inner Mongolia, Xinjiang and Jilin[12,48,49]. The sources of rabies transmission have become complex and diverse. In addition, a rapid geographic expansion of genetic spectrum I (China type I), which dominates rabies transmission in China, has been identified[50–52]. The risk of spillover to the northwest is increasing. With the progress of global economic integration, rabies virus in the wild among the cross-species transmission, and cross-border transmission is more and more complex[26, 28]. The prevention and control situation is problematic. No oral rabies vaccine for wildlife is currently in use in China. Given the difficulty of immunizing wild animals, the development of a new inexpensive, safe, and effective oral vaccine is paramount.

4. Infection source control initiatives

4.1. China

The Chinese government is increasingly concerned that dog management is a key measure in the elimination of rabies. To effectively promote dog management and immunization, the “China Animal Epidemic Prevention Law” was officially implemented in 2021. The law makes clear provisions on dog breeding behavior, dog circulation, immunization, quarantine, and the sheltering of stray dogs. The prevention and control of rabies entered the era of legalized management[53]. However, the implementation of the “China Animal Epidemic Prevention Law” has not played a significant effect so far, due to lax law enforcement without clear punishment. The China Animal Epidemic Prevention Law stipulates that dogs kept without regular rabies vaccination must be vaccinated within a certain period, otherwise, the owners would be fined up to 1000 RMB. Regarding dog breeding behavior, it only mentions wearing dog tags and leashes as required, without clear punishment, which is obviously not mandatory enough.

Some positive steps have occurred. Different regions of China are actively exploring the implementation of fruitful prevention and control measures. From 2013 to 2017, China carried out pilot

work on integrated rabies prevention and control in Anhui, Shaanxi and Guizhou provinces (Red Collar Project). The pilot provinces implemented immunization, monitoring, publicity and training measures according to local conditions and the dog immunization coverage rate in these areas increased up to 70%[54]. Guangxi runs the “immunization demonstration area” model, Yunnan implements the “control, exemption, extermination” dog management policy[37], while Shenzhen, Zhongshan and other cities carry out free veterinary rabies vaccination work. In addition, cities such as Beijing, Shanghai, Xi’an, and Hohhot have effectively reduced the number of stray dogs and ownerless dogs by establishing electronic ID cards for dogs. This electronic management can take the initiative to send vaccination information to dog breeders and improve the immunization rate of dogs registered.

4.2. Global

Dog management and immunization involves multiple functional departments, including the Animal Husbandry and Veterinary Administration, the Ministry of Agriculture and Rural Affairs, the CDC, the Ministry of Industry and Commerce, and the Ministry of Transportation, etc., among which it requires interdisciplinary, intersectoral, and interregional collaboration. Today the links among humans, animals and the environment have become closer, leading to increasingly complex patterns of rabies transmission. In this context, the concept of prevention and control of human-animal infectious diseases, such as rabies, based on “One Health” was born[55]. “One Health” aims to optimize human, animal and environmental health through multidisciplinary, multisectoral and multilocal collaboration. WHO also advocated “One Health” collaborative model for rabies elimination at its third rabies expert forum[4].

In addition, WHO has recommended that dog population management be included in rabies prevention and control priorities. Dog population management includes measures to optimize the dog population such as vaccinating dogs, controlling food supply, dog registration, reproductive control, and setting up rehoming areas etc[56]. We have also seen rabies elimination efforts in countries such as Mexico, the United States, and Japan that have focused their prevention and control efforts on infectious source management.

Mexico has conducted mass, intensive and free dog immunization since 1990, achieving 80% dog immunization coverage. Mexico also conducts regular dog and cat sterilization, provides timely and effective post-exposure immunization services. In 2019 Mexico became the first country to be recognized as free of dog-transmitted rabies, which affirms the critical role of mass dog vaccination and scientific dog population management in the elimination of rabies[57, 58].

The U.S. has successfully eliminated rabies using various successful initiatives, including mandatory pet vaccination, regulation of the pet trade, strict penalties for injury to humans, and enhanced epidemic surveillance etc. In the United States, pets must be vaccinated and

carry health certificates and identification tags before they can be sold. Some local regulations also stipulate that cats or dogs over six months of age must be spayed or neutered to prevent uncontrolled breeding and the spread of disease. In addition, unvaccinated domestic animals and pets exposed to rabies are immediately euthanized or placed in mandatory quarantine for six months and vaccinated one month prior to be released. In terms of wildlife management, the United States has successfully controlled the spread of raccoon rabies to the west through oral rabies vaccination of raccoons and wildlife surveillance[59]. Similarly for countries in Western and Central Europe where rabies is mediated by foxes, oral rabies vaccination of foxes has also been very successful[60].

Bangladesh had also implemented a large-scale dog culling program, which unfortunately ended up in a failure. The country implemented a cost-effective rabies elimination program in 2010 that included effective measures such as managing dog bites, widespread dog vaccination, and stray dog surveillance. As a result, rabies cases were reduced from more than 2000 cases per year before 2011 to less than 200 cases in 2016[35, 61].

Neighboring Japan enacted the Rabies Prevention Law as early as 1950. The law imposes fines of up to 200000 yen for unregistered or unvaccinated pet owners, which is equivalent to about 10000 RMB. Japan imposes fines or detentions for uncivilized dog ownership, which is far more severe than those in China. In Japan, stray dogs are temporarily brought back to the health center for unified management. If stray dogs are not adopted after the adoption period, euthanasia will be arranged. With such strict laws, it is difficult to see a stray dog on the streets of Japan. There have been no local rabies cases in Japan since 1958.

India is the country most affected by rabies. The reasons for the high incidence of rabies in India are similar to those in China, namely insufficient dog immunization rates and PEP[62]. In the past, India used dog slaughter as the main method of rabies control, yet rabies continued to ravage the country. An optimal dog management model was later adopted in parts of India, effectively curbing the spread of rabies. For example, the city of Chennai has implemented a “Neuter-Vaccinate-Release” program for wild animals since 1996. As a result, the city’s rabies outbreak dropped from 120 cases per year to five cases per year. Some of these strategies for rabies prevention and control may be valuable in China.

5. Recommendations

Large-scale canine vaccination is critical for the global rabies elimination strategy. It was also clearly proposed that “animal immunization comes first in the elimination of human rabies” in the 2021 China Annual Rabies Conference[63]. To achieve the goal of “eliminating canine-to-human rabies” by 2030, we should focus on dogs, establish a multidisciplinary and multisectoral collaborative mechanism. We make five recommendations for improving rabies

control in China.

First, the top-level design in building a prevention and control system based on the concept of “One Health” should be strengthened. International experience in the elimination of rabies has prompted us that rabies prevention and control need to be coordinated nationwide, through the establishment of a flexible government-supported “One Health” collaboration mechanism to form a group prevention, group treatment, joint prevention, joint control effect[1, 30, 64, 65]. Among them, the public security department is responsible for the management of urban dogs, including handling of illegal dog breeding injuries, controlling wild dogs and rabid dogs. The animal husbandry and veterinary department is responsible for the supply of veterinary rabies vaccine, canine rabies vaccination, the registration and issuance of domestic dog immunization certificates, and canine rabies epidemic monitoring. The health department is responsible for rabies vaccination, case treatment, and human rabies epidemic monitoring. Finally, the drug supervision department is responsible for the supervision and management of the quality of veterinary and human rabies vaccines, and etc.

Our second recommendation is to ensure 70% effective immunization coverage of dogs. Currently, China’s dog immunization coverage is low, and dog management is weakly binding. First, the “China Animal Epidemic Prevention Law” must be fully implemented, and dog immunization must be mandatory. Second, each region can must consider the relevant economic and cultural factors to develop local rabies regulations. Areas with high levels of economic development and rabies prevalence, greater penalties can be considered. Rural areas or the combination of urban and rural areas, relying on township veterinary stations to establish vaccination points can be established by township veterinary stations. Urban areas, pet treatment institutions and joint street communities may promote immunization together. Third, “electronic ID cards” for dogs could be utilized, with continuous tracking of dog immunization. The dog management system can take the initiative to notify due vaccination. Fourth, for localities, the level of economic development and the risk of rabies incidence can be taken into account to explore the inclusion of veterinary rabies vaccine in the scope of medical insurance as a way to improve vaccination coverage.

Our third recommendation is for proactive monitoring and scientific assessment of spillover risks. Currently, rabies surveillance in China focuses on humans rather than animals, which is not conducive to scientific and effective assessment of rabies risk. By building a cross-sectoral, interdisciplinary, and cross-regional surveillance system at the human-animal-environment interface, we can monitor the prevalence, virus types and geographical distribution of rabies in domestic and wild animals[66]. Relevant responsible departments should pay close attention to collapsing species and

cross-border transmission dynamics. It is necessary to regularly assess the risk of spillover and move from a reactive to a proactive approach[67–70].

Fourth, we recommend accelerating the research and application of veterinary rabies vaccines and conducting neutralizing antibody assays for veterinary rabies vaccines as a necessary procedure for pet dogs prior to obtaining a breeding license. In situations where the source of infection cannot be limited or captured, such as in rural and wilderness areas, we may use the scientific broadcast of an oral bait vaccine as an important complementary measure to interrupt virus transmission.

Fifth and finally, it is highly recommended to promote healthy behavior by utilizing popularized science. By carrying out health education, the rate of rabies disease awareness and behavior formation of the population can be improved. At the same time, the awareness of the main responsibility of dog owners can be improved and dog-keeping behavior can be regulated. The advanced experience of the project area and demonstration area should be vigorously promoted to guide local implementation according to local conditions.

6. Conclusions

At present, rabies prevention and control has achieved significant progress, with annual deaths greatly reduced and continuing a downward trend year by year. In response to the global initiative to achieve “Zero by 2030” and to promote rabies elimination in China, a flexible “One Health” multi-sectoral collaborative mechanism supported by the government should be established. We should work closely around the 70% or more immunization coverage rate of dogs. To achieve optimal dog management, we should strengthen proactive surveillance to achieve forward movement of targets and scientific assessment of spillover risks. This review is written with hope of contributing Chinese solutions and Chinese wisdom to the elimination of global rabies.

Conflict of interest statement

The authors claim there is no conflict of interest.

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Authors' contributions

Lu JH, Lu JY and Li YF discussed the framework of this article. Zhao LX was responsible for the literature collection and manuscript writing. Liao CH assisted in chart making. Kiesel A and Xia Y embellished the linguistic aspects.

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