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Spatial and Temporal Analysis of Rabies Cases in Rabies-Carrier Animals in Banjarbaru City

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Keywords: rabies, rabies-infected animals, incidence rate, region, risk.

Abstract

Rabies remains one of the most dangerous zoonotic diseases due to its high fatality rate and ability to spread from rabies-transmitting animals to humans. The persistence of rabies cases is influenced by various factors, including the population density of rabies-infected animals, vaccination coverage, and the effectiveness of disease control programs. This study aimed to analyze the spatial and temporal distribution patterns of rabies cases among rabies-infected animals in Banjarbaru City, South Kalimantan, during 2015–2019. This research employed a descriptive approach with a case series design using secondary surveillance data obtained from the Banjarbaru Veterinary Center and the Food Security, Agriculture, and Fisheries Service. Data on rabies-positive animals, animal bite cases, vaccination records, and incidence rates were analyzed using Microsoft Excel and Quantum Geographic Information System (QGIS) to visualize the distribution patterns of rabies cases. The results showed that 56 positive rabies cases were identified during the observation period, with a continuous increase in cases, particularly during 2018–2019. Spatial analysis indicated that North Banjarbaru and Landasan Ulin Districts were categorized as high-risk areas, with incidence rates of 27 and 22 cases per 100,000 animal-years, respectively. The findings demonstrate that spatial–temporal mapping can support rabies surveillance and assist authorities in determining priority areas for intervention. In conclusion, strengthening vaccination programs, animal population control, surveillance systems, and integrated One Health-based strategies are necessary to reduce rabies transmission and support sustainable rabies elimination efforts in Banjarbaru City.

INTRODUCTION

Rabies, also known as mad dog disease, is one of the zoonotic diseases that can be transmitted from animals to humans through bites from rabies-infected animals, such as dogs, cats, and monkeys (Cavadi, 2025; Manjunatha et al., 2023; Mathew & Sunil, 2026; Shroff, 2025). Rabies has posed a threat to public health for centuries. The disease is caused by the rabies virus, which is acute and affects the central nervous system of warm-blooded animals and humans (Directorate General of PKH, 2019). Rabies is almost invariably fatal once clinical signs appear, with a case fatality rate (CFR) approaching 100%, affecting individuals of all ages and sexes (Jackson, 2013).

Animals infected with rabies may become aggressive and attack without provocation (furious rabies) or develop paralysis and difficulty walking due to partial or complete paralysis (paralytic rabies) (Cavadi, 2025; Manjunatha et al., 2023; Mathew & Sunil, 2026; Shroff, 2025). Infected animals may also exhibit behavioral changes, and hypersalivation or foaming at the mouth may occur (Purnamasari & Putra, 2017). Rabies infection cannot be confirmed solely based on clinical signs; therefore, laboratory examination of brain tissue samples from suspected animals is required (Directorate General of PKH, 2019).

The global economic losses caused by rabies are estimated at US$8.6 billion annually (WHO, 2015). The overall economic impact of rabies in Indonesia has not been scientifically documented comprehensively to date. However, economic losses associated with rabies outbreaks have been reported in several regions, including East Nusa Tenggara during 1998–2007, amounting to approximately 14.2 billion rupiahs annually, and Bali during 2008–2011, amounting to approximately 230 billion rupiahs annually. These estimated economic losses were calculated based on the disease burden, including mortality, healthcare expenditures, hospitalization costs, medication costs (including anti-rabies vaccines and other treatments), and productivity losses due to inability to perform normal activities. Additionally, other economic losses considered include costs associated with rabies prevention, control, and eradication programs (Directorate General of PKH, 2019).

Rabies was first reported in Indonesia in 1884 by Esser, who identified a case involving a buffalo in West Java. In Indonesia, approximately 98% of rabies cases in animals are caused by dogs, while the remaining 2% are attributed to cats and monkeys (Andasari, 2017). The annual number of human deaths caused by rabies in Indonesia remains relatively high, ranging from 100 to 156 cases per year. Indonesia consists of 34 provinces, of which only eight provinces have been declared rabies-free, while the remaining 26 provinces remain rabies-endemic. Historically, the rabies-free provinces include the Riau Islands, Bangka Belitung, Papua, West Papua, DKI Jakarta, Central Java, Yogyakarta, and East Java. Reported cases of rabies-transmitting animal bites during the last five years (2015–2019) reached 404,306 incidents, resulting in 544 human deaths due to rabies (Directorate General of PKH, 2019).

Kalimantan Island had not been declared rabies-free by 2019. Controlling this disease remains challenging, both in interrupting transmission chains and preventing further spread. South Kalimantan Province was included in the high-risk zone for rabies virus transmission due to the presence of large populations of free-roaming dogs, monkeys, and cats. As of September 2018, 55 positive rabies cases had been reported in South Kalimantan, primarily associated with bites from rabies-infected animals. The rabies positivity rate also increased fivefold compared with 2017 (IMAKAHI, 2019). In Banjarbaru City, 279 suspected rabies cases were recorded between 2013 and 2018 and became part of rabies surveillance activities. Among these cases, 189 were successfully examined through 14-day observation periods or laboratory testing of brain samples submitted to the Banjarbaru Veterinary Center (Parlina & Pujiatmoko, 2018).

Rabies is a disease that can be controlled through surveillance systems involving continuous disease detection to identify animals infected with the rabies virus (Ditkeswan, 2015). Spatial and temporal analysis is one of the surveillance data analysis methods that is useful for identifying and evaluating disease incidence patterns based on location and time. This analysis produces visual representations, such as disease distribution maps, which provide information regarding spatial relationships and patterns of disease occurrence. Such information can serve as baseline data for surveillance systems, early warning indicators, and the development of rabies prevention and control strategies in Banjarbaru City.

Research Objectives

This study aims to analyze the incidence data of rabies cases based on spatial patterns by describing the distribution of diseases and temporal by mapping the area of the spread of rabies cases in Banjarbaru City, South Kalimantan Province in 2015-2019.

Research Benefits

The results of this study are expected to be used as input for the agency in charge of livestock and animal health in efforts to control and eradicate rabies cases based on spatial and temporal patterns, as well as a map of the spread of rabies cases in Banjarbaru City.

METHOD

Research Time and Place

Data collection was conducted from November 2021 to March 2022 at the Banjarbaru Veterinary Center and the Banjarbaru Food Security, Livestock, and Agriculture Service (DKP3) in Banjarbaru City, South Kalimantan Province.

Research Design

This study uses a descriptive method. Descriptive research is research that is intended to collect information about the status of an existing symptom, namely the state of symptoms as they are at the time the research is conducted (Saputra 2016). This study is a non-experimental study that uses a series case study design with a sample of all rabies-positive patients such as regional origin, bite case history, number of rabies-infected animal populations, and vaccination data per sub-district recorded at the Banjarbaru Veterinary Center and the Banjarbaru Food Security, Livestock, and Agriculture Service (DKP3) from 2015 to 2019. The collected data is then analyzed spatially and temporally.

Data Source

The data used in this study is in the form of secondary data. Secondary data is data obtained indirectly in the form of evidence, records, or reports compiled in archives (Nazir 2003). The secondary data used came from a summary of the surveillance results of the Banjarbaru Veterinary Center and the Banjarbaru Food Security, Livestock, and Agriculture Service (DKP3) in 2015-2019.

How Data Is Collected

The secondary data used came from the annual data recording of rabies disease in the work area of the Banjarbaru Veterinary Center and the Banjarbaru Food Security, Livestock, and Agriculture Service (DKP3) in 2015-2019. The data that has been collected is entered into the Microsoft Excel application and then the data is analyzed spatially and temporally.

Data Analysis

The data results are presented in the form of tables, graphs, geographical maps of the region, and are presented descriptively according to their respective parameters. The data collected were such as the number of rabies-infected animal populations, rabies vaccination per sub-district, bite cases per sub-district, positive cases of rabies per sub-district, and data on the spread of rabies cases from 2015 to 2019 which were depicted using a map. The collected data was then analyzed to describe the spread of rabies cases during 2015-2019 which was depicted using a map.

Data processing was carried out using the help of Microsoft Excel applications and *Quantum Geographic Information System* (QGIS) applications to view and describe maps of case distribution in Banjarbaru City. In addition, it uses *the incidence rate (IR)* or incidence rate which is a benchmark of the average speed of disease spread. Incidence describes the number of cases that occur within a population over a period of time. The *incidence rate* of a disease is calculated by knowing in advance the number of new sufferers and the number who may be affected by the new disease (*population at risk*) (Cameron 1999).

$$IR = \frac{\text{Jumlah kasus baru penyakit dalam kurun waktu tertentu}}{\text{Rataan jumlah hewan berisiko x kurun waktu}}$$

The incidence rate can be grouped based on the *incidence rate* (IR) value of each sub-district for 5 years which has been calculated using *Microsoft Office Excel*, then the determination of the case distribution rate uses *the highest incidence rate* value which is then divided by 3. The distribution rate of rabies cases is divided into 4 levels, namely negligible, low, moderate, and high. The level of negligible occurrence is not included because the IR value of negligible is 0. The grouping of the distribution of rabies cases based on *the incidence rate* can be seen in Table 1.

Table 1. Grouping of the distribution of rabies cases by *incidence rate*

Incidence rate	***Incidence rate* (Cases/ 100 000 heads-year)**
Negligible	0
Low	1 - 9
Medium	10 - 18
Height	19 - 27

RESULTS AND DISCUSSION

Number of Rabies Infectious Animals (HPR) population

The Banjarbaru City area consists of 5 sub-districts, namely Liang Anggang District, Landasan Ulin District, South Banjarbaru District, North Banjarbaru District, Cempaka District. Data on the number of rabies-infected animal populations in Banjarbaru City can be seen in Figure 2.

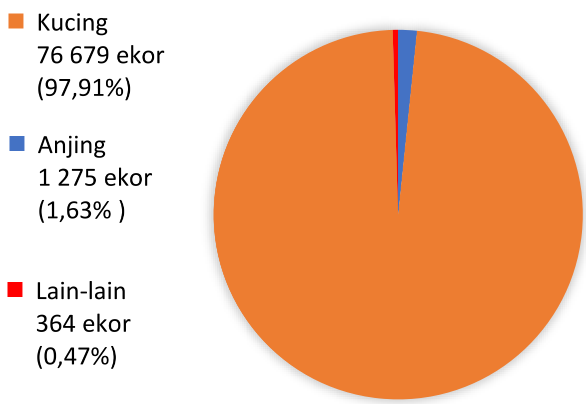

Figure 2. Population of rabies-infected animals in Banjarbaru City in 2019

There are many factors that cause rabies disease to persist in an area, one of which is the uncontrolled population of rabies-infected animals. The factor that causes the increase in cases of Rabies-Infected Animal Bites (GHPR) is the large number of HPR populations in Banjarbaru City. The number of HPR populations in 2019 recorded in DKP3 was 78,318 heads. Based on HPR population data in Banjarbaru City in 2019 (Figure 2) also shows that the HPR population in Banjarbaru City is dominated by cats larger than dogs, which is 97.91% (76,679 heads), while dogs are 1.63% (1,275 heads), and other HPR is 0.47% (364 heads). According to Mau and Desato (2011), the more HPR population, the more GHPR cases. The large density of the HPR population in rabies-endemic areas affects positive cases in each HPR bite (Hamdani and Puhilan, 2020). This indicates a tendency to relate the number of HPR populations to an increase in HPR bite cases in Banjarbaru City.

The large number of cat populations can be the beginning of rabies transmission that comes from the condition of wild cats that are not properly maintained, then multiply quickly and are difficult to control. The large number of cat populations can be caused by several factors such as public acceptance of the existence of cats, the availability of food sources, and the fertility level of cats (Jatikusumah *et al*. 2014). Wild cats have the potential to travel from one place to another which can be a factor in the spread of zoonotic diseases such as rabies (Taetzsch *et al*. 2018). The habit of people who take stray cats to keep at home also has a risk of rabies. Wild cats are also likely to interact with bats/animals that have contracted rabies, so it is one of the factors in the incidence of rabies in cats (Ribiero *et al*. 2018). According to Roebling *et al*. (2013), stated that it is very important to educate pet owners about the responsibilities of pet ownership including the importance of regular vaccination and limiting pets from being released as well as sterilization to suppress the population from increasing.

Approaches taken in HPR population management include surgical sterilization of rabies-infected animals, both male and female, construction of animal shelters for non-owned animals, control of access to food sources by better waste management and waste disposal (*trash management*)), shackle or tie animals and not let them roam outside the house, as well as selective elimination by paying attention to the principles of animal welfare (Ditkeswan 2015).

Rabies Vaccination in Rabies-Infected Animals

The Banjarbaru City Food Security, Agriculture, and Fisheries Service (DKP3) carried out vaccination activities on rabies-infected animals during 2015-2019. Data on the number of rabies-infected animals vaccinated against rabies per sub-district in Banjarbaru City can be seen in Figure 3.

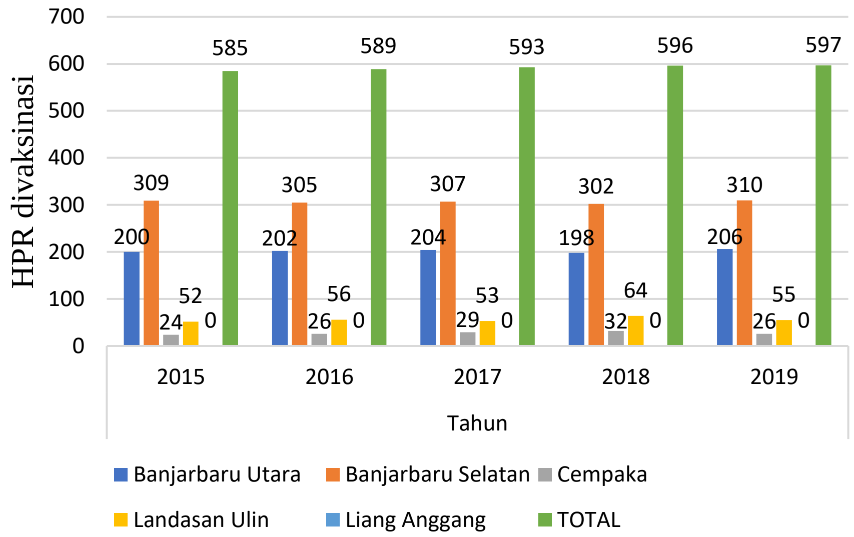

Figure 3. Number of animals vaccinated against rabies per sub-district in Banjarbaru City in 2015-2019

There are many factors that cause rabies disease to persist in an area, one of which is vaccination of rabies-infected animals. Vaccination status also plays an important role in the incidence of rabies in Banjarbaru City. The results of the study show that the HPR vaccination graph in Banjarbaru City in 5 years tends to be stable. The HPR vaccinated in 2015 was 585 heads, in 2016 as many as 589 heads, in 2017 as many as 593 heads, in 2018 as many as 596 heads, and in 2019 as many as 597 heads. The vaccination carried out by the Banjarbaru Food Security, Livestock, and Agriculture Service (DKP3) is likely to be active and passive vaccinations so that there is a difference in the number of vaccinations per sub-district. Passive vaccination is carried out by visiting clinics located in official offices to carry out vaccinations, while active vaccination is in the form of mass vaccination, namely service officers go to the field to vaccinate rabies-infected animals. According to Purnamasari and Putra (2017), mass vaccination is considered the most cost-effective and effective strategy to prevent rabies in humans, as the mass vaccination of dogs carried out in Bali showed that the number of rabies cases in humans decreased by 90% in 2010-2012 and in dogs decreased by 86% in 2011.

HPR vaccination carried out when compared to the number of HPR population is still relatively low. Low vaccination against HPR can lead to an increased risk of HPR contracting rabies. One of the efforts that is considered the most cost-effective and effective strategy to prevent rabies is to carry out HPR vaccination with a minimum coverage of 70%. HPR vaccine coverage in Banjarbaru City must be increased because the coverage is less than 70%. Increasing vaccination coverage can cause *herd immunity* which is an important factor in rabies control and prevention (Mamoto *et al*. 2021).

Vaccination is needed for rabies disease control in an area. The poor quality of the vaccine given to HPR causes neutralizing antibodies to fail to maintain the level of persistence against rabies. High cases of rabies transmission from HPR to humans are also caused by poor maintenance systems such as allowing pets to roam freely so that they are vulnerable to contact with other HPRs, especially stray dogs that are not vaccinated (Gerhold and Jessup 2012).

According to Dibia *et al*. (2015), dogs that are not vaccinated have a greater chance of being infected with rabies by 19.13 times greater than dogs vaccinated against rabies. Dogs that are not vaccinated are especially susceptible to rabies infection because dogs do not have antibodies to the rabies virus. One of the factors that can cause rabies in an area is animals that do not carry out anti-rabies vaccination (Kongkaew *et al*. 2004).

Vaccinated cats, the invading virus is neutralized early during the incubation period, while unvaccinated cats can produce an antiviral immune response, but it is too late to prevent disease. Laboratory experiments have shown that early protection after infection is provided by the original immune system with interferon plays an important role (Johnson *et al*. 2006).

According to *the Food and Agriculture Organization-Emergency Center for Transboundary Animal Disease* (FAO-ECTAD) (2019), the increase in cases that occur can be caused by several obstacles in the implementation of mass vaccination, including the speed of vaccination and the daily target of mass vaccination that is not optimal so that vaccination coverage is less and the length of time for mass vaccination implementation. In addition, post-vaccination surveys as monitoring the progress of vaccination and the implementation of emergency vaccination as a quick response to cases, are not carried out optimally.

Cases of Bites by Rabies Transmitting Animals (HPR) in Humans

Rabies is one of the diseases that is important to control because it is included in the strategic infectious animal disease (PHMS). Data on rabies-infected animal bite cases in Banjarbaru City per year can be seen in Figure 4.

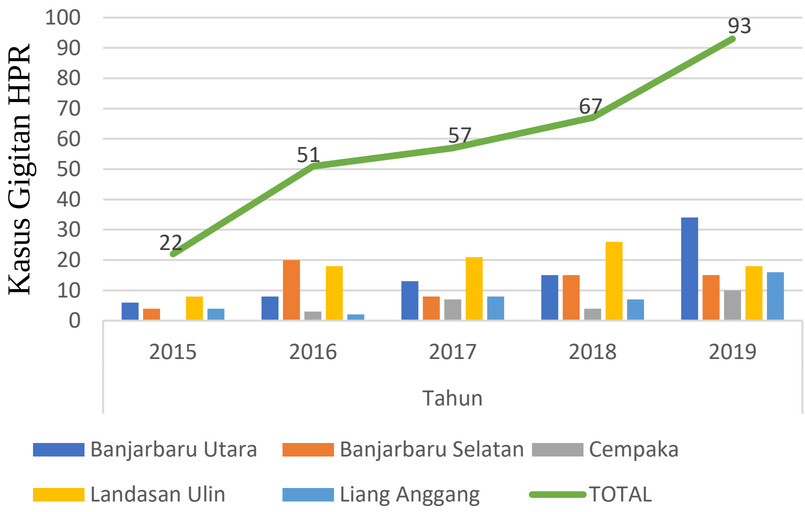

Figure 4. Number of cases of HPR bites in humans per sub-district in Banjarbaru City in 2015-2019

Rabies can affect animals and humans, transmission and spread lie in animals, especially types of animals that behave like to bite. Cases of rabies transmission basically all occur through bite wounds. Rabies transmission can also occur through the saliva of animals infected with rabies and enter through wounds (Akoso 2010). Based on the data in Figure 4, HPR bite cases in Banjarbaru City per sub-district over a period of 5 years have a varying number of cases. The sub-district with the highest cases of HPR bites in South Banjarbaru District in 2019 was 34 bite cases, while in the previous year it tended to be few and decreased. The GHPR case in Figure 4 shows an increase from 2015 to 2019, which is 290 HPR bites. The results of the study show that the number of bite attacks in 2015 was 22 cases with the highest sub-district, namely 8 cases in Landasan Ulin, in 2016 as many as 51 bite cases with the highest sub-district being 20 cases in South Banjarbaru, in 2017 as many as 57 cases with the highest sub-district being 21 cases in Landasan Ulin, and in 2018 as many as 67 cases with the highest sub-district being 26 cases in Landasan Ulin.

Quick and good handling is always carried out in the event of a bite to a human. Good coordination between the Banjarbaru City Food Security, Agriculture, and Fisheries Office with the local health center and the Banjarbaru Veterinary Center in handling bite cases is the key to the success of handling HPR bites so that they do not cause human casualties. The reported cases are likely to be far below the actual incidence rate, this is due to the public's unfamiliarity with the importance of vaccinating animals (Sopi and Mau 2013).

The peak of HPR bite cases in Banjarbaru City occurred in 2019. The high number of GHPR cases in an area shows that the rabies eradication program implemented in the area is still not able to break the chain of transmission of rabies, meaning that the programs implemented both vaccination and elimination are still not optimal. The vaccination and elimination program of rabies-infected animals is the main factor that is very effective in reducing GHPR cases (Hamdani and Puhilan 2020).

According to Suatha *et al*. (2015), the cases of dog bites that occurred in Bali Province increased along with the dog mating season which occurred around March and September every year. The incidence rate of rabies transmission risk is higher in male animals than in female animals because male animals roam outside the house a lot and allow fights between males, especially during the mating season. However, climate change or weather does not have much effect on the incidence of rabies, so rabies outbreaks can occur anytime and anywhere as long as there is still exposure from animals infected with rabies. The tendency of rabies dogs to wander aimlessly due to memory loss can trigger the spread of the disease when animals enter foreign areas (Akoso 2010).

Positive Cases of Rabies

The Banjarbaru City Food Security, Agriculture, and Fisheries Service (DKP3) in collaboration with the Banjarbaru Veterinary Center during 2015-2019 found as many as 56 rabies positive samples. Positive cases of rabies in rabies-infected animals per year during 2015-2019 are presented in Figure 5.

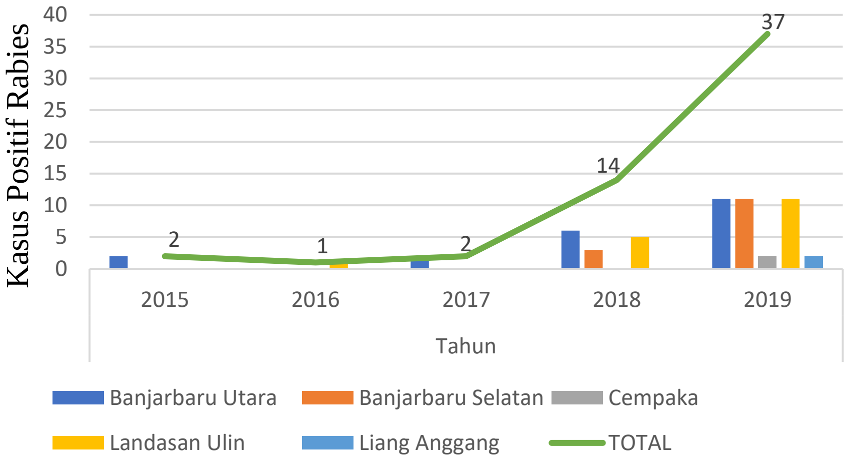

Figure 5. Positive cases of rabies per sub-district in Banjarbaru City in 2015-2019

According to a report by the Banjarbaru City Food Security, Agriculture and Fisheries Service (DKP3), rabies cases in 2015 occurred in North Banjarbaru District, Banjarbaru City. Rabies cases occurred in a pet cat that took a bite on humans, then a brain sample was taken to the laboratory of the Banjarbaru Veterinary Center and the results showed positive for rabies by *the Fluorescent Antibody* Technique (FAT) test. Rabies cases began to spread to other sub-districts and reached its peak in 2019 which occurred in 3 sub-districts at once, namely North Banjarbaru, South Banjarbaru, and Landasan Ulin Districts with 11 positive cases of rabies each. Rabies cases per year observation (Figure 5) show a pattern of significant increase. Several studies have stated that the increase in rabies cases is related to the mating season, during the mating season there is direct contact between HPR individuals or their groups, thus allowing the possibility of an increase in bite cases and the risk of rabies transmission (Mau and Desato 2011).

A comparison of the number of cases per year (Figure 5), shows a decrease in cases in 2016 to 1 case, but increased again in 2017 by 2 cases and there was a fairly extreme increase in 2018 and 2019 as many as 51 cases. According to Septiani *et al*. (2018), there is a relationship between the level of seroprotective and the proportion of rabies cases in Bali Province. A decrease in the level of seroprotective also occurs in the proportion of rabies cases, and vice versa. In 2017, there was a decrease in seroprotective followed by a resurgence in the proportion of rabies cases. This is due to the presence of factors that affect the formation of protective antibodies in the field which is characterized by a decrease in seroprotective results, even though the results of tofu vaccination coverage in 2017 are slightly more than the previous year. Likewise, in 2018 and 2019, the decrease in the level of serorevelence was followed by an increase in the proportion of rabies cases.

The incubation period for rabies in dogs is 10-15 days, and in other animals 3-6 weeks. The incubation period sometimes lasts very long 1-2 years. The symptoms caused in all animals are almost the same, including cats with a ferocious and calm form (Subronto 2010). There are two types of clinical symptoms of rabies in cats in Banjarbaru City, namely malignant and calm types. The ferocious type attacks the owner suddenly, while the calm type has been found several cats with weak symptoms such as hiding in a garbage dump by showing symptoms of drooling then taken for FAT testing and the results were positive for rabies. Wild animals such as foxes, these animals are believed to be very sensitive to rabies and have a high sensitivity to exposure through respiration or orally. The clinical period indicated is very short. The final stage of the animal becomes incoordination and seizures until it finally dies (Beran and Steele 1994).

Rabies Case Distribution Map

Banjarbaru City administratively consists of 5 sub-districts, namely North Banjarbaru District, South Banjarbaru District, Cempaka District, Landasan Ulin District, and Liang Anggang District. The incidence of rabies spreads in each sub-district and has different *incidence rates*. Data on the incidence of rabies cases in rabies-infected animals in Banjarbaru City in each sub-district can be seen in Table 2.

Table 2. Grouping of rabies incidence based on the *incidence rate* in Banjarbaru City in 2015-2019

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The highest *incidence rate* occurred in North Banjarbaru District with 27 cases per 100,000 head-year and Landasan Ulin District with 22 cases per 100,000 head-year. South Banjarbaru District has a moderate *incidence rate* of 18 cases per 100,000 head-years. The lowest *incidence rate* with 3 cases per 100,000 head-year is in Cempaka and Liang Anggang Districts.

The *incidence rate* value is then categorized to get the rate of distribution of rabies cases. The incidence rate can be classified into 4 types, namely negligible cases, low cases, moderate cases, and high cases. The incidence rate per sub-district that has been known can then be seen by depicting it on the map of the spread of rabies cases in Banjarbaru City which can be seen in Figure 6.

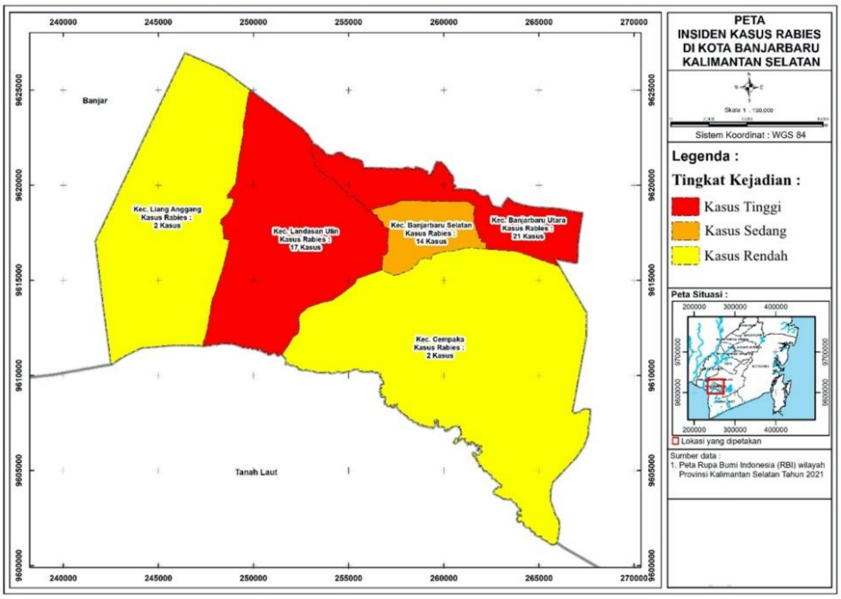

Figure 6. Map of the spread of rabies cases in Banjarbaru City

There are 2 sub-districts that are included in the areas with high incidence of cases, namely North Banjarbaru District and Landasan Ulin District. There is 1 sub-district that is included in the area with moderate case incidence, namely South Banjarbaru District. Other sub-districts are included in areas with low incidence of cases, namely Cempaka District and Liang Anggang District. HPR population control and vaccination have a great influence on the spread of rabies cases (Ditkeswan 2015).

The principles of rabies control and control can be carried out through mass vaccination as the main strategy for rabies eradication, surveillance, traffic surveillance, population management, and Information and Education Communication (KIE) by looking at cultural conditions through a specific approach to each region (Ditkeswan 2015). North Banjarbaru and Ulin Landasan districts need to be intensified and prioritized for control actions because they are included in areas with high incidence of cases.

CONCLUSION

This study concludes that rabies cases among rabies-infected animals in Banjarbaru City occurred across all districts during the 2015–2019 observation period, with a consistent increase in positive rabies cases over time. The spatial and temporal analysis revealed that North Banjarbaru District and Landasan Ulin District were identified as high-risk areas, with the highest incidence rates reaching 27 and 22 cases per 100,000 animal-years, respectively. Meanwhile, South Banjarbaru District was categorized as a moderate-risk area, whereas Cempaka and Liang Anggang Districts showed lower incidence rates. The findings indicate that variations in rabies distribution were closely associated with the population density of rabies-transmitting animals, limited vaccination coverage, and the effectiveness of rabies control programs. The spatial mapping approach applied in this study provided an important contribution by identifying priority areas for surveillance, vaccination, animal population management, and targeted intervention strategies. Therefore, strengthening integrated rabies control through collaboration among veterinary services, public health institutions, and local communities is essential to reduce transmission risks and support sustainable rabies elimination efforts in Banjarbaru City.

Future research should expand the analysis by incorporating additional epidemiological, environmental, and socio-behavioral factors that may influence rabies transmission, such as animal movement patterns, vaccination compliance among animal owners, community awareness, land-use characteristics, and interactions between domestic and stray animals. Further studies using advanced spatial statistical approaches, such as spatial regression, hotspot analysis, and predictive modeling, are recommended to improve the accuracy of rabies risk prediction and early warning systems. Longitudinal studies using updated datasets are also needed to evaluate the effectiveness of rabies control interventions, particularly vaccination programs and animal population management strategies. In addition, future research should consider a One Health approach that integrates animal health, human health, and environmental factors to develop more comprehensive policies for rabies prevention and eradication.

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