Jurnal Info Kesehatan
Vol. 21, No. 2, June 2023, pp. 316-324
P-ISSN 0216-504X, E-ISSN 2620-536X
DOI: *10.31965/infokes.Vol21.Iss2.1225*
Journal homepage: *https://jurnal.poltekkeskupang.ac.id/index.php/infokes*

RESEARCH Open Access

Spatial Analysis of the Occurrence of Multi-Drug Resistance (MDR) Escherichia coli in Pet Dogs in Kupang City

Novalino H.G. Kallau[1a*], Maxs U.E. Sanam[1b], Tri Utami[2c], Yeremia Y. Sitompul[2d]

[1] Department of Animal Diseases and Public Health, Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Kupang, East Nusa Tenggara, Indonesia
[2] Department of Clinical, Reproductive, Pathology and Nutrition, Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Kupang, East Nusa Tenggara, Indonesia

[a] Email address: novalino.kallau@staf.undana.ac.id
[b] Email address: sanam@yahoo.com
[c] Email address: utami.t@staf.undana.ac.id
[d] Email address: yeremia.sitompul@staf.undana.ac.id

Received: 14 June 2023 Revised: 28 June 2023 Accepted: 30 June 2023

Abstract

Antibiotic resistance is an important health problem and a threat to public health. Dogs as pets can be both spreaders and reservoirs of antibiotic-resistant bacteria. Based on spatial analysis, this study aims to determine the distribution pattern of multi-drug resistance (MDR) Escherichia coli found in pet dogs in Kupang City. The spatial analysis method is based on the convex hull technique, elementary analysis of disease, and the Nearest Neighbour Index (NNI). Information on antibiotic-resistant E. coli has been obtained from the laboratory analysis results, and secondary data was obtained for spatial analysis. The results of this study have shown that the distribution pattern of the incidence of MDR E. coli in the City of Kupang in 2020 is a clustered pattern with the Nearest Neighbor Index (NNI) value of 0.783, which is higher than the NNI AMR E. coli in the City of Kupang of 0.763. The incidence of MDR E. coli that has occurred in domesticated dogs takes place with a prevalence rate of 35% in an area of 5079 Ha. These results have shown that the incidence of MDR E. coli has spread to several areas in Kupang City and is a threat to public health. It requires appropriate prevention and control measures by implementing good hygiene and sanitation in the relationship between humans and their pets.

Keywords: *Escherichia coli*, Kupang City, MDR, Pet dog, Spatial Analysis.

Corresponding Author:

Novalino H.G. Kallau
Department of Animal Diseases and Public Health, Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Kupang, East Nusa Tenggara, Indonesia
Email: novalino.kallau@staf.undana.ac.id

1. INTRODUCTION

Antibiotic resistance has become an important issue again at the beginning of the 21st century (O'Neill, 2016) predicts the tendency of AMR to become a threat to world health in 2050. This condition is accelerated and expanded by the misuse and overuse of antibiotics (Gochez, 2019; Awosile et al., 2018; Patel et al., 2020). Another reason for the spread of resistant bacteria is the increasing interaction between humans and pets, which is caused by not prioritizing hygiene and sanitation in the surrounding environment (Bouki et al., 2013). Pets such as dogs have a close relationship with humans (Budinegara, 2018) and tend to spread resistant bacteria to humans and others (Pomba et al., 2017). Increasing antibiotic resistance in society and the world of animal health is a very important public health problem (Laxminarayan et al., 2013).

Many people keep pets as pets; one of the most common types is dogs, besides cats. Dogs have shown better interactions with humans when compared to other pets (Westgarth et al., 2019). The social aspects of the community that support the existence of dogs in the environment encourage many people to keep dogs in their home environment. The number of dogs and the degree of closeness between dogs and humans is an aspect of health studies related to resistance that is important to know (Butaye et al., 2003). Several zoonotic health threats can arise from this interaction if hygiene and sanitation are not considered in the maintenance of these animals. Diseases caused by parasites, bacteria, and those caused by other microorganisms can be transferred from animals to humans (WHO 2014).

The more intensive maintenance of dogs as pets has resulted in more and more attention being paid to handling dog health; on the other hand, antibiotics are increasingly used in animals. This tendency is one of the factors for the emergence of resistant bacteria in dogs (Carvalho et al., 2016). The emergence of resistant bacteria in dogs is not only due to the use of antibiotics but can also occur due to contact with humans. The incidence of resistance can increase with the emergence of bacteria that are resistant to more than three classes of antibiotics, which is often called Multi-drug resistance (MDR) (Magiorakos et al., 2012) (Sweeney et al., 2018).

A spatial approach is used to improve the analysis of animal diseases further; this is done using Geographic Information System (GIS) software (Samkhan et al., 2013; Davis et al., 2014). Monitoring through disease mapping can provide information about the incidence of disease in an area, especially the incidence of antibiotic resistance (Achmad, 2009) or environment-based (Nuckols et al., 2004; Sunaryo, 2015). This research aims to determine the spread of MDR E. coli in pet dogs based on a spatial approach.

2. RESEARCH METHOD

The research was carried out using the cross-sectional study method, which was carried out from April to November 2020. Rectal swab sampling/feces samples have been taken from pet dogs in the Kupang City community. Laboratory testing, namely the isolation and identification of antibiotic-resistant E. coli as well as antibiotic sensitivity tests, was carried out at the Laboratory of Bacteriology and Veterinary Public Health, Faculty of Veterinary Medicine Universitas Nusa Cendana.

Sampling has been done by simple random sampling (simple random sampling). Data was collected by observing swab/feces samples from dog-owning households in Kupang City. Swab/feces samples have been taken, and as much as one sample per farm household comes from sick or healthy dogs. The feces samples that have been obtained are then isolated and identified to determine the presence of E. coli. The E. coli isolates obtained were then confirmed by biochemical tests (Kallau et al., 2020). Testing the sensitivity of E. coli to antibiotics using the Kirby-Bauer method (CLSI 2014).

After going through the data collection stage, the data that has been collected will be analyzed using a descriptive analysis model to link whether there is an incidence of antibiotic-resistant E. coli contamination in dogs in Kupang City. The data is presented in tables and figures to describe the point of spread of antibiotic-resistant E. coli, extent, and pattern of spread of E. coli resistance in pet dogs in Kupang City. Spatial data has been analyzed to determine the distribution (elementary analysis of disease), pattern of distribution (nearest index/NNI), and extent of distribution (convex hulls) of E. coli on pet dogs in Kupang City. Furthermore, the classification of the prevalence rate of E. coli, the assessment of the pattern of spread of resistance, and the assessment of the extent of the spread of E. coli have been carried out, according to Kallau et al. (2019).

3. RESULTS AND DISCUSSION

This research was conducted on 57 samples of domestic dogs in the city of Kupang, with the location of the distribution of samples as shown in Figure 1. Researchers have obtained an overview of the results of laboratory tests for antibiotic resistance, as shown by Kallau et al. (2020) earlier.

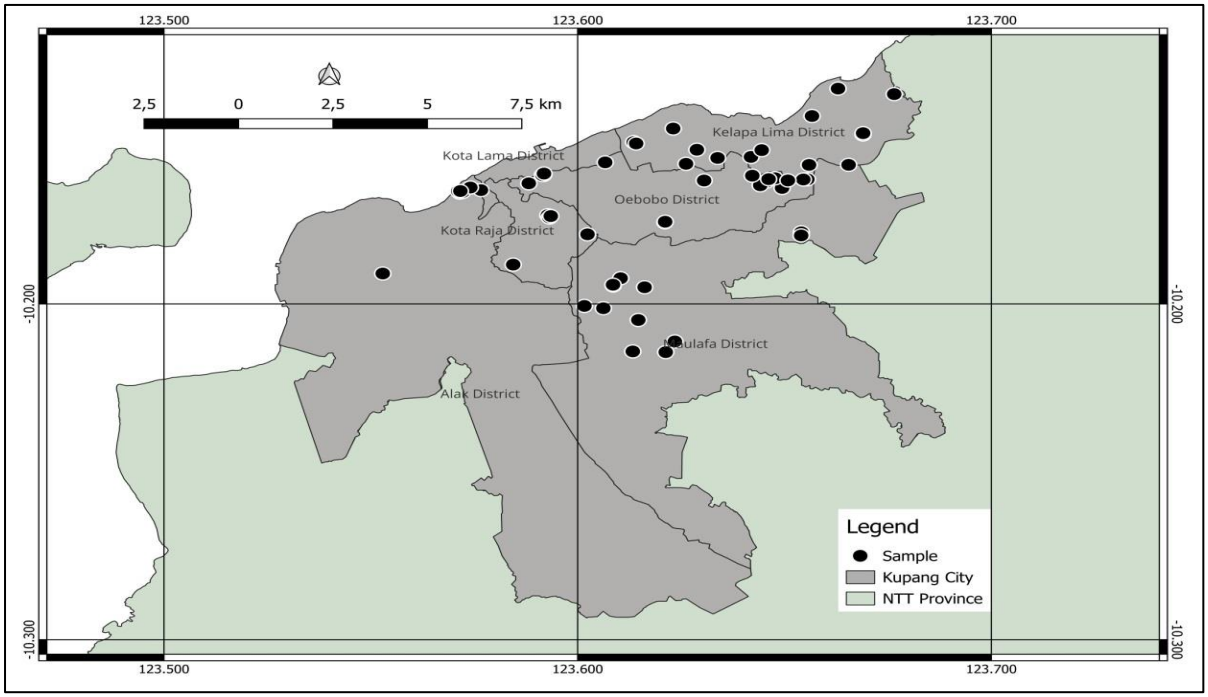
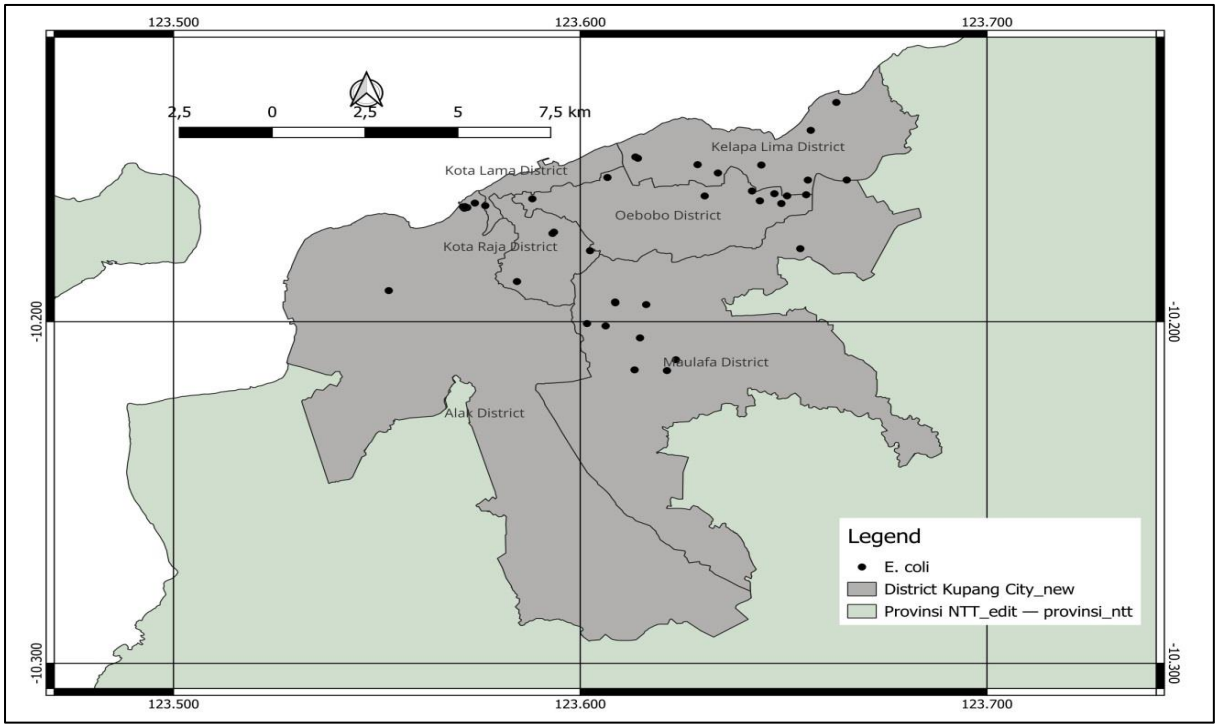


Figure 1. Sampling locations in Kupang City (Elementary analysis of disease).

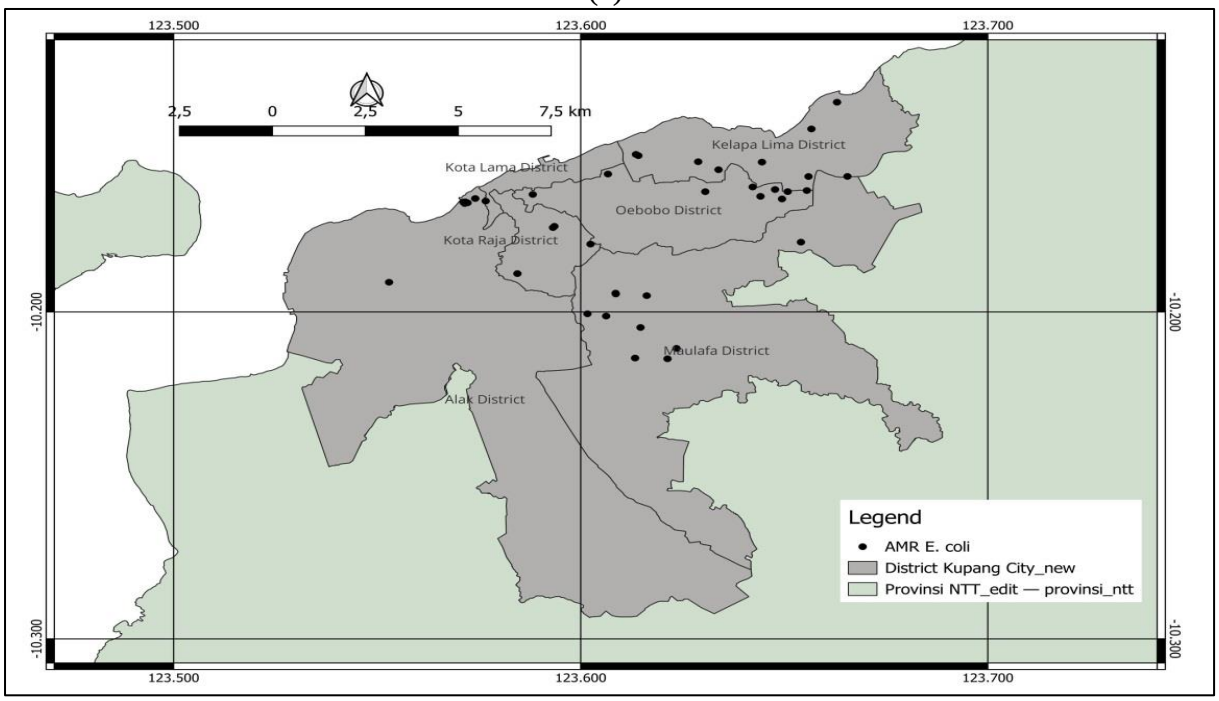
Figure 1 shows that pet dogs can be found throughout the City of Kupang, which is spread over six Districts (Kepala Lima District, Kota Lama District, Oebobo District, Kota Raja District, Maulafa District, and Alak District).

Test results data from Kallau et al. (2020) show that E. coli has a prevalence of 65% (37/57). The spread of E. coli in domestic dogs in Kupang City can be seen in Figure 2a. E. coli has been found in Kelapa Lima District, Oebobo District, and Maulafa District. The spatial analysis results of the spread of E. coli are shown in Table 1. The area of distribution based on the convex hull test was 5983 Ha, and the NNI value was 0.763, which illustrates that the distribution pattern is a random—Z-score value of -2.821. The spatial analysis results of AMR E. coli in Table 1 and Figure 2b also show the same value. All E. coli samples that have been tested have varied resistance from 1-7 types of resistance (Kallau et al., 2020). These results are similar to data from E. coli research on pigs (Kallau et al., 2018).

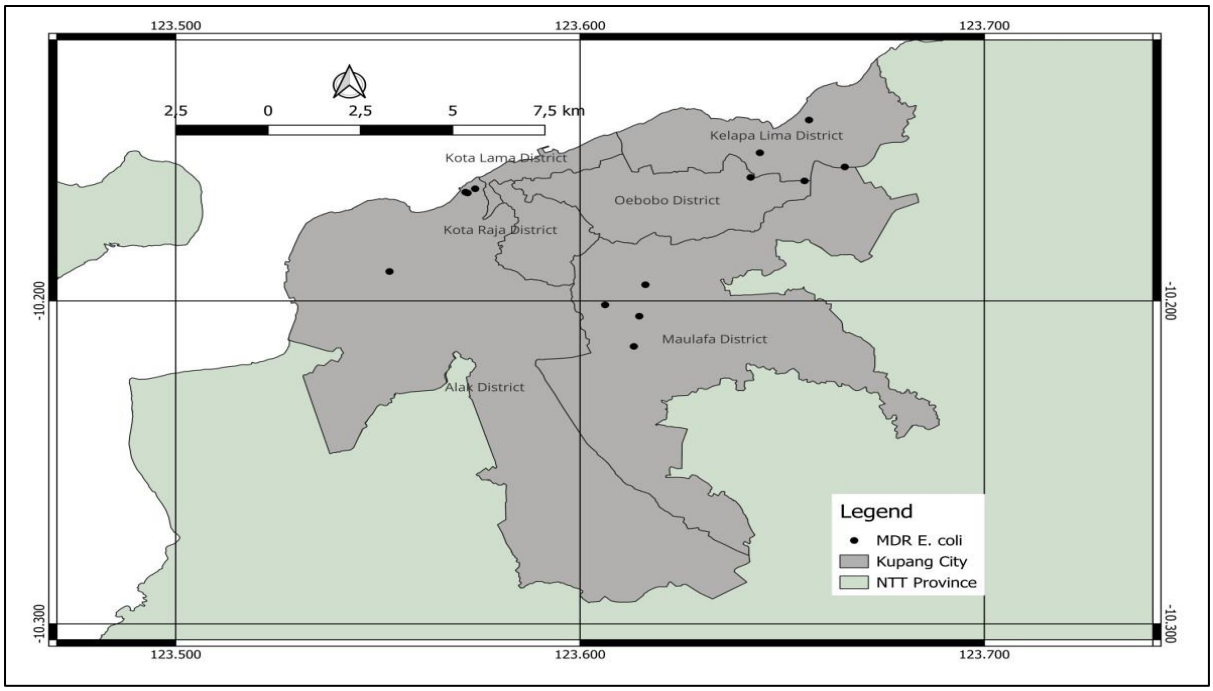
Table 1 and figures (2c and 3) provide spatial analysis data on MDR E. coli. The distribution area of 5079 Ha covers 13 positive samples for MDR E. coli. The NNI value shows a value of 0.783 with a random distribution pattern and a Z-score result of -1.495.



(a)



(b)



(c)

Figure 2. Map of the distribution of E. coli (a), AMR E. coli (b), and MDR E. coli (c) in domestic dogs in Kupang City (Elementary analysis of disease).

Table 1. The pattern of spatial analysis results of the spread of E. coli, AMR E. coli, and MDR E. coli in pet dogs in Kupang City.

Parameters	E. coli	AMR E. coli	MDR E. coli
Distribution area (Ha)	5983	5983	5079
Number of AMR E. coli case points	37	37	13
NNI	0,763	0,763	0,783
Spread pattern	Random	Random	Random
Z-score	-2,821	-2,821	-1,495

Data on the distribution of E. coli in domestic dogs in Figure 2a shows that E. coli is spread over six subdistricts in Kupang City, with the highest levels found in Kelapa Lima District (13 points) and Maulafa District (10 points). The results of the distribution of E. coli did not differ much from the AMR E. coli data shown in Table 1 and Figure 2b. This study has shown that AMR occurs in every sample of E. coli (37 samples) that has been found. The results are in line with research conducted by Kallau et al. (2018), Kallau et al., (2019), and Kallau et al., (2020). The incidence rate of antibiotic resistance in Kupang City can be influenced by several factors, such as the high level of dog ownership, as has been shown by ownership of local dogs and breeds that continue to grow in Kupang City (Yanuartono, 2008; Kallau et al., 2020). The number of pet shops and veterinary clinics that have sprung up indicates that more and more people are raising animals and are starting to prioritize the health quality of their pet dogs.

The z-score results for AMR E. coli have shown negative results. This result has shown that the level of resistance events at that location is lower than the general average in the same area. This outcome is also related to areas with a lower level of risk or areas where effective interventions have started in the use of antibiotics to control the incidence of antibiotic resistance. Interventions using antibiotics in animal hospitals/animal clinics and practicing veterinarians can help reduce the incidence of resistance (Wayne et al., 2011).

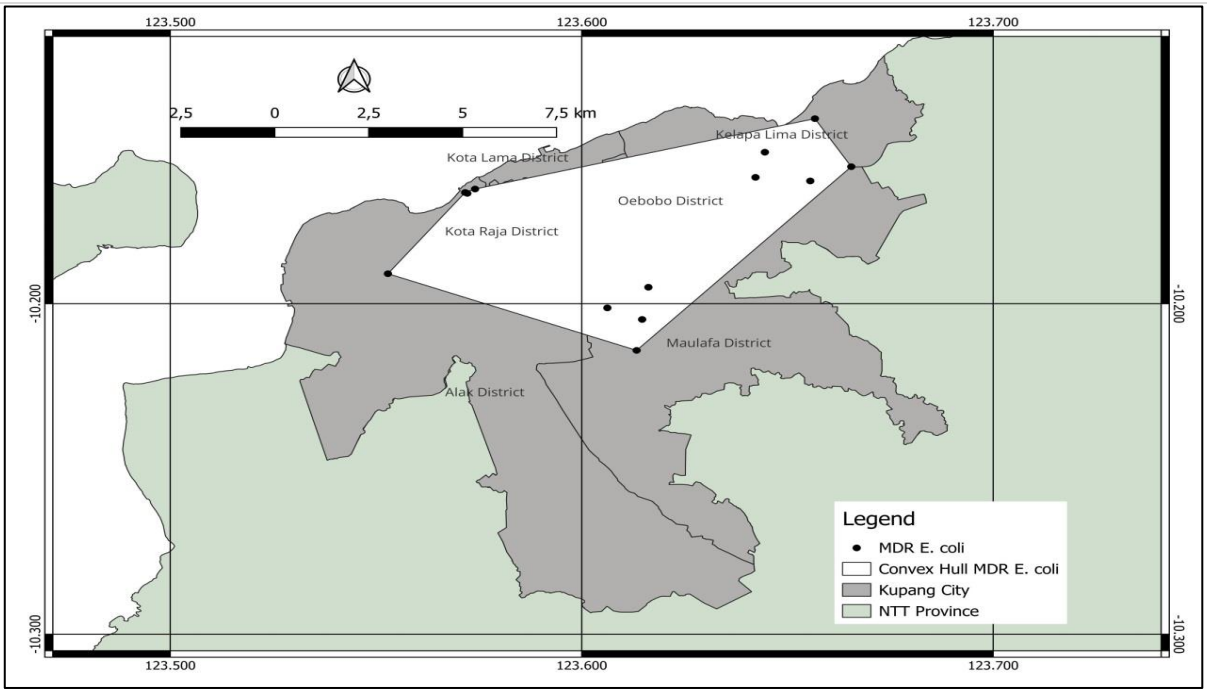


Figure 3. Map of MDR E. coli distribution area in domestic dogs in Kupang City (convex hull analysis).

The MDR E. coli data displayed in this study illustrates the distribution of the number of points of occurrence of MDR E. coli with a low level of 13/37 (35% prevalence). The distribution area of MDR E. coli is 5.079 Ha with a random distribution pattern based on NNI. The Z-score value has shown -1.495. The area of distribution can be seen in Figure 3. The area of distribution of MDR E. coli is still lower than the AMR of E. coli, but this has shown a tendency for the point of presence of MDR E. coli to be in a large area pattern. This finding is almost in line with the research conducted by Kallau et al. (2019) on pig farms. Srivani et al. (2017) showed that geographic disease distribution patterns can vary due to differences in location and management of animal rearing. Besides that, there are also differences in resistance patterns related to the use of types of antibiotics, regional differences, and different management systems (Bywater et al., 2004).

As with the results of the z-score for the AMR E. coli, the Z-score results that the spread of MDR E.coli has shown a negative result (-1.495); this has provided information that the level of resistance events that occurred at that location was higher lower than the general average within the same area. This discovery is also related to areas with a lower risk of resistance or the existence of certain areas with effective interventions in controlling the incidence of antibiotic resistance. Management of animal diseases from pets can be supported by implementing dog population control management as part of planning and implementation (Acosta-Jamett et al., 2010).

Spatial studies indicate the distribution of MDR E. coli, which is close to the human population. Interaction between humans and pets (dogs) has provided a higher chance of contact and encouraged wider spread. In general, the risk of spreading resistant bacteria from domestic dogs to humans is still difficult to predict, and the spread pattern is complex and requires further research (Pomba et al., 2017). Several patterns of the spread of zoonotic diseases of animal origin to humans can be through several ways, namely direct contact with resistant animals or indirect contact such as through vectors, consuming contaminated food (specific diseases of bacterial origin) (Khairiyah, 2011), The spread of MDR E. coli has been

expanded in Kupang City due to the sale of tank water originating from groundwater sources. The possibility of spreading occurs with access to water sales throughout Kupang City through water tankers (Kallau et al., 2019). Hygiene and sanitation measures must be implemented to reduce this rate of spread (Kallau et al., 2018). This research needs to be continued by looking at other risk factors that encourage the emergence of multi-drug resistance to the relationship between pet dogs and dog owners.

4. CONCLUSION

MDR E. coli has a low number of events (35% prevalence) and a distribution area of 5079 Ha with a random distribution pattern. The observed Z-score value is -1.495. Results This dissemination has provided information for implementing preventive measures to suppress the wider spread of MDR by increasing understanding of the prudent use of antibiotics and the principles of hygiene and sanitation that need to be properly applied between animal owners and their pets.

REFERENCES

Achmad, U. F. (2009). Manajemen Penyakit Berbasis Wilayah. *Kesmas*, 3(4): 147-153. https://doi.org/10.21109/kesmas.v3i3.228

Acosta-Jamett G, Cleaveland S, Cunningham AA, Bronsvoort BM, (2010). Demography of domestic dogs in rural and urban areas of the Coquimbo region of Chile and implications for disease transmission. *Preventive veterinary medicine*. 94(3-4), 272-281. https://doi.org/10.1016/j.prevetmed.2010.01.002

Awosile, B. B., McClure, J. T., Saab, M. E., & Heider, L. C. (2018). Antimicrobial resistance in bacteria isolated from cats and dogs from the Atlantic Provinces, Canada from 1994–2013. *The Canadian veterinary journal*, *59*(8), 885-893.

Bouki C, Venieri D, Diamadopoulos E, (2013). Detection and fate of antibiotic resistant bacteria in wastewater treatment plants: a review. *Ecotoxicology and environmental safety*. 91(1-9. https://doi.org/10.1016/j.ecoenv.2013.01.016.

Budinegara, S. (2018). Kasih Tak Bersyarat: Konstruk Pemaknaan Hubungan Manusia-Anjing Peliharaan. *Calyptra*, *7*(1), 2554-2570.

Butaye P, Devriese LA, Haesebrouck F, (2003). Antimicrobial growth promoters used in animal feed: effects of less well known antibiotics on gram-positive bacteria. *Clinical microbiology reviews*. 16(2), 175-188. https://doi.org/10.1128/CMR.16.2.175-188.2003.

Bywater, R., Deluyker, H., Deroover, E., De Jong, A., Marion, H., McConville, M., ... & Walters, J. (2004). A European survey of antimicrobial susceptibility among zoonotic and commensal bacteria isolated from food-producing animals. *Journal of Antimicrobial Chemotherapy*, *54*(4), 744-754. doi:10.1093/jac/dkh422. https://doi.org/10.1093/jac/dkh422

Carvalho, A. C., Barbosa, A. V., Arais, L. R., Ribeiro, P. F., Carneiro, V. C., & Cerqueira, A. M. F. (2016). Resistance patterns, ESBL genes, and genetic relatedness of Escherichia coli from dogs and owners. *brazilian journal of microbiology*, *47*, 150-158. https://doi.org/10.1016/j.bjm.2015.11.005

CLSI. (2014). *M100-S24 Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Fourth Informational Supplement [Internet]*. Clinical and Laboratory Standards Institute.

Davis GS, Sevdalis N, Drumright LN, (2014). Spatial and temporal analyses to investigate infectious disease transmission within healthcare settings. *The Journal of hospital infection*. 86(4), 227-243. https://doi.org/10.1016/j.jhin.2014.01.010

Góchez, D., Raicek, M., Pinto Ferreira, J., Jeannin, M., Moulin, G., & Erlacher-Vindel, E. (2019). OIE annual report on antimicrobial agents intended for use in animals: methods used. *Frontiers in Veterinary Science*, 317. https://doi.org/10.3389/fvets.2019.00317

Kallau, N. H. G., Wibawan, I. W. T., Lukman, D. W., & Sudarwanto, M. B. (2018). Detection of multi-drug resistant (MDR) Escherichia coli and tet gene prevalence at a pig farm in Kupang, Indonesia. *Journal of Advanced Veterinary and Animal Research*, *5*(4), 388. https://doi.org/10.5455/javar.2018.e289

Kallau, N. H. G., Sanam, M. U. E., Utami, T., & Sitompul, Y. Y. (2020). Study of Multidrug Resistance (MDR) E. coli On Pet Dogs In Kupang City. Di dalam: Meha MPM, editor. *The 1st International Conference on Veterinary and Animal Science*; 76-81. Retrieved from https://ejurnal.undana.ac.id/JKV/issue/view/272/PDF

Kallau, N. H. G., Wibawan, I. W. T., Lukman, D. W., & Sudarwanto, M. B. (2018). Analisis Hubungan Antara Pengetahuan dan Sikap Terhadap Praktik Penggunaan Antibiotika oleh Peternak Babi di Kota Kupang Provinsi Nusa Tenggara Timur. *Jurnal Sain Veteriner*, *36*(2), 200-212. https://doi.org/10.22146/jsv.33184

Kallau, N., Wibawan, I. W. T., Lukman, D. W., & Sudarwanto, M. B. (2019). Studi Pemetaan Multi-drug Resistant (Mdr) Escherichia Coli pada Peternakan Babi di Kota Kupang. *Jurnal Kajian Veteriner*, *7*(1), 70-79. https://doi.org/10.35508/jkv.v7i1.946

Khairiyah, K. Zoonosis dan Upaya Pencegahannya (Kasus Sumatera Utara). *Jurnal Penelitian dan Pengembangan Pertanian*, *30*(3), 117-124.

Laxminarayan R, Duse A, Wattal C, Zaidi AK, Wertheim HF, Sumpradit N, Vlieghe E, Hara GL, Gould IM, Goossens H *et al.*, (2013). Antibiotic resistance-the need for global solutions. *The Lancet Infectious diseases*. 13(12), 1057-1098. https://doi.org/10.1016/S1473-3099(13)70318-9

Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, Harbarth S, Hindler JF, Kahlmeter G, Olsson-Liljequist B *et al.*, (2012). Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. *Clinical Microbiology and Infection*. 18(3), 268-281. https://doi.org/10.1111/j.1469-0691.2011.03570.x

Nuckols JR, Ward MH, Jarup L, (2004). Using geographic information systems for exposure assessment in environmental epidemiology studies. *Environmental health perspectives*. 112(9), 1007-1015. https://doi.org/10.1289/ehp.6738

O'Neill J, (2016). Tackling Drug-Resistant Infections Globally: Final Report And Recommendations.

Patel SJ, Wellington M, Shah RM, Ferreira MJ, (2020). Antibiotic Stewardship in Food-producing Animals: Challenges, Progress, and Opportunities. *Clinical therapeutics*. 42(9), 1649-1658. https://doi.org/10.1016/j.clinthera.2020.07.004

Pomba C, Rantala M, Greko C, Baptiste KE, Catry B, van Duijkeren E, Mateus A, Moreno MA, Pyorala S, Ruzauskas M *et al.*, (2017). Public health risk of antimicrobial resistance transfer from companion animals. *The Journal of antimicrobial chemotherapy*. 72(4), 957-968. https://doi.org/10.1093/jac/dkw481

Samkhan, Susanta DH, & Isnaini MF, (2013). Analisis Spasial Penyakit Hewan Menular Strategis Dengan Menggunakan Geographic Information System (GIS) Program Pemetaan Quantum GIS Versi 1.8 Lisboa. *Buletin Laboratorium Veteriner*, 13(3), 1-20.

Sunaryo. (2015). *Spatial Analysis for Environment-Based Diseases*. National Seminar on Regional-based Disease Control Efforts. Semarang: Poltekkes Kemenkes Semarang.

Srivani M, Reddy YN, Subramanyam KV, Reddy MR, Rao TS, (2017). Prevalence and antimicrobial resistance pattern of Shiga toxigenic Escherichia coli in diarrheic buffalo

calves. *Veterinary world*. 10(7), 774-778. https://doi.org/10.14202/vetworld.2017.774-778

Sweeney MT, Lubbers BV, Schwarz S, Watts JL, (2018). Applying definitions for multidrug resistance, extensive drug resistance and pandrug resistance to clinically significant livestock and companion animal bacterial pathogens. *The Journal of antimicrobial chemotherapy*. 73(6), 1460-1463. https://doi.org/10.1093/jac/dky043

Wayne, A., McCarthy, R., & Lindenmayer, J. (2011). Therapeutic antibiotic use patterns in dogs: observations from a veterinary teaching hospital. *Journal of Small Animal Practice*, *52*(6), 310-318. https://doi.org/10.1111/j.1748-5827.2011.01072.x.

Westgarth, C., Christley, R. M., & Christian, H. E. (2022). A cross-sectional study of factors associated with regular dog walking and intention to walk the dog. *BMC Public Health*, *22*(1), 1-17. https://doi.org/10.1186/s12889-022-12902-w

WHO. (2014). *Antimicrobial Resistance: Global Report on Surveilance*. Geneva: WHO.

Yanuartono, Y. (2008). Monitoring Penggunaan Amoksisilin, Ampisilin Dan Kloramfenikol Pada Kucing Di Rumah Sakit Hewan-fakultas Kedokteran Hewanuniversitas Gadjah Mada Tahun 2005-2007. *Indonesian Journal of Veterinary Science*, *26*(2), 140226.