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DOMESTIC ANIMALS INFECTED BY SARS-COV-2: ANOTHER DIMENSION OF THE PANDEMIC

ANIMAIS DOMÉSTICOS INFECTADOS PELO SARS-COV-2: OUTRA DIMENSÃO DA PANDEMIA

ANIMALES DOMÉSTICOS INFECTADOS CON SARS-COV-2: OTRA DIMENSIÓN DE LA PANDEMIA

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ABSTRACT

The Coronavirus Pandemic had multiple implications in different aspects of society. Here we summarize another dimension of consequences, by investigating case reports of Sars-CoV-2 in domestic animals. For this, we performed a systematic literature review and scientometrics analysis. We obtained 428 reports, involving cats, dogs, ferrets, hamsters, and minks, from 34 countries. Cats were the most affected animals. The United States presented the highest number of reports. Considering the evidence of reverse transmission, where people have been infected following minks on some farms in the Netherlands, and the potential risk of virus mutation involving animals, it is important to understand the role of susceptible pets and farm animals in transmission dynamics. Minks appear to be a suitable model for evaluating the effectiveness of drugs and vaccines against COVID-19.

KEYWORDS

Pandemic; COVID-19; pets; farming animals; Reverse Transmission.

RESUMO

A pandemia do Coronavírus teve múltiplas implicações em diferentes aspectos da sociedade. Aqui resumimos outra dimensão de consequências, investigando relatos de casos de Sars-CoV-2 em animais domésticos. Para isso, foi realizada uma revisão sistemática da literatura e análise cienciométrica. Obtivemos 428 relatos, envolvendo gatos, cães, furões, hamsters e visons, de 34 países. Os gatos foram os animais mais afetados. Os Estados Unidos apresentaram o maior número de relatos. Considerando as evidências de transmissão reversa, onde pessoas foram infectadas após os visons em algumas fazendas na Holanda e o risco potencial de mutação do vírus envolvendo animais, é importante compreender o papel dos animais de estimação e dos animais de produção suscetíveis na dinâmica de transmissão. Os visons parecem ser um modelo adequado para avaliar a eficácia de medicamentos e vacinas contra a COVID-19.

PALAVRAS-CHAVE

Pandemia; COVID-19; Animais de companhia; Animais de produção; Transmissão reversa.

RESUMEN

La pandemia de Coronavirus ha tenido múltiples consecuencias en diversos aspectos de la sociedad. Aquí, presentamos otra dimensión de sus efectos, investigando informes de casos de Sars-CoV-2 en animales domésticos. Para ello, hemos realizado una revisión sistemática de la literatura y un análisis cienciométrico. Hemos recopilado 428 informes que involucran a gatos, perros, hurones, hámsters y martas, de 34 países. Los gatos fueron los animales más afectados. Estados Unidos presentó el mayor número de informes. Teniendo en cuenta la evidencia de transmisión inversa, donde las personas han sido infectadas siguiendo martas en algunas granjas de los Países Bajos, y el riesgo potencial de mutación del virus que involucra a animales, es importante comprender el papel de las mascotas y los animales de granja susceptibles en la dinámica de transmisión. Las martas parecen ser un modelo adecuado para evaluar la eficacia de fármacos y vacunas contra la COVID-19.

PALABRAS CLAVE

Pandemia; COVID-19; animales de compañía; animales de producción; Transmisión inversa.

1 INTRODUCTION

SARS-CoV-2 is the third zoonotic coronavirus to cause epidemic outbreaks in the last two decades (SHARUN *et al.*, 2020). The virus was likely introduced into the human population at a seafood market in Wuhan, China reportedly on the 7th of February 2020 (BOGOCH *et al.*, 2020). The primary intermediate host is suspected to be the Malay pangolin (*Manis javanica*) (BOGOCH *et al.*, 2020). The similarity between the receptors, known as angiotensin-converting enzyme 2 (ACE2), from pangolins and humans, possibly favored the process of zoonotic transmission, allowing the virus to spread rapidly in the human population (LIU *et al.*, 2020).

The infection by SARS-CoV-2 occurs when the virus binds to the receptor ACE2, which is expressed in several vertebrate species (WAN *et al.*, 2020). The virus adapted then quickly, spreading among people around the world through direct contact and aerosol droplets (LI *et al.*, 2020). Although most cases of infection involve transmission between humans, other mammals, including pets, may be susceptible to the virus (SIT *et al.*, 2020).

The first report of reverse zoonosis, i.e., human-to-animal transmission, occurred between a patient with COVID-19 and a domestic dog that tested positive for SARS-CoV-2 multiple times, in Hong Kong, China (SIT *et al.*, 2020). At the beginning of the virus spread, transmission was not well understood, and there were concerns about pets as vectors, leading to the panic-driven abandonment of animals on the streets of Wuhan after the lockdown, as well as cases of animals allegedly being thrown from apartment windows (QIAO HUANG *et al.*, 2020).

Since then, the knowledge about COVID-19 in animals has been restricted to similar case reports. Therefore, in order to design strategies both for the prevention of reverse transmission and for the protection of susceptible species, one useful approach is to compile the scientific knowledge on the subject. Through serological investigation of domestic animal populations living near humans, it is possible to prevent the emergence of other CoVs similar to SARS-CoV-2 in the future (DHAMA *et al.*, 2020). Another important factor is to analyze the pandemic potential of the new coronavirus by gathering knowledge about its spread in animal species, including domestic animals. Thus, this study aimed to survey case reports of COVID-19 in domestic animals after the beginning of the pandemic, in February 2020, worldwide, through a scientometrics approach.

2 MATERIAL AND METHODS

Scientometrics is a method based on the collection of data available in the literature, aiming to analyze and map studies and case reports on a specific subject. Here, we consulted Google Scholar and ResearchGate, and searched the indexed databases Scielo and PubMed for works reporting cases of SARS-CoV-2 in domestic animals.

We considered both pets and farm animals as such. We used the keywords “SARS-CoV-2”, “COVID-19”, “pandemic”, “transmission”, “animals”, “domestic animals”, “farm animals”, “pets” and “cat-

tle". As an additional source of data, we used reports from the Program for Monitoring Emerging Diseases (PROMED, 2021b) and from the US Animal and Plant Health Inspection Service (APHIS, 2021). We used reports published immediately after the emergence of the first recorded case of COVID-19, in December 2019 (WHO, 2020) until May 2022.

For inclusion, we considered articles reporting SARS-CoV-2 positivity in pets or farm animals. The documents should have been published between December 1, 2019, and May 31, 2022. Conversely, studies without a title, abstract, and keywords, as well as studies not addressing COVID-19 in domestic or production animals, were excluded.

Approximately 4.180 articles were found in the initial search, and only 51 addressed the main topic of the research, containing 177 animals reported with SARS-CoV-2. In addition to the articles, we found 149 reports from ProMED and 192 from APHIS. From these articles and reports obtained, the following data were recorded: affected species; period and location of the record; period of publication of the article or report; whether the animal lived in a residential or rural environment; symptoms in the animal; whether the disease caused the animal's death; and, if available, whether the owner contracted the disease through contact with the animal. All measured categories were represented using bar graphs, quantifying the number of articles for each species. The analyses and graphs were prepared using R software, utilizing the "vegan" and "ggplot2" packages (R CORE TEAM, 2020).

3 RESULTS

Worldwide, by May 2022, we obtained 428 reports of domestic animals infected with SARS-CoV-2, including cats (60.3%; N = 258) (*Felis catus* (Linnaeus, 1758)), dogs (35.7%; N = 153) (*Canis lupus familiaris* Linnaeus, 1758), ferrets (2.1%; N = 9) (*Mustela putorius furo* Linnaeus, 1758) and hamsters (1.9%; N = 8) (*Mesocricetus auratus* Waterhouse, 1839), as well as several farm minks (*Martes* sp.), distributed in 34 different countries and three continents (Table 1; Figure 1). The minks were not quantified because they are usually living in farms with hundreds of individuals, and as several animals were infected, in some cases, the whole farm was culled. Considering, then, the number of individuals affected, except farm minks, almost half of the occurrences were reported in the USA (N = 212; 49.5%), followed by China (9.8%; N = 42), Turkey (6.5%; N = 28), Spain (4.7%; N = 20) and Brazil (4%; N = 17).

Table 1 – Number of domestic animals reportedly infected by Sars-CoV-2 worldwide from February 2020 to May 2022 per country. It is showed the number of individuals followed by the percentage of occurrence

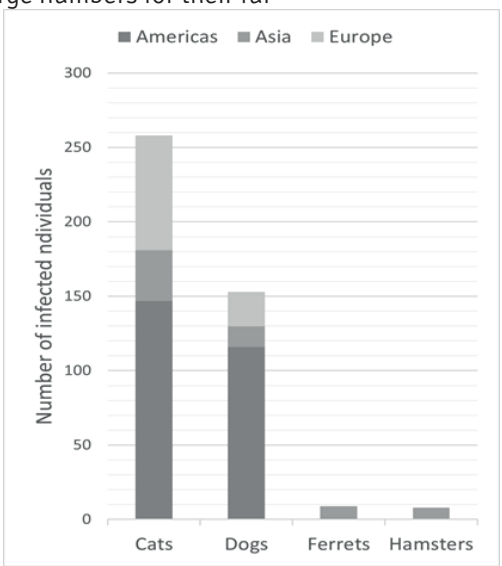
Country	Cats (Felis catus)	Dogs (Canis lupus familiaris)	Ferrets (Mustela putorius furo)	Hamsters (Mesocricetus auratus)
Asia				
China	29 (11.24)	5 (3.27)		8 (100)

Country	Cats (Felis catus)	Dogs (Canis lupus familiaris)	Ferrets (Mustela putorius furo)	Hamsters (Mesocricetus auratus)
Iran	1 (0.39)			
Japan		4 (2.61)		
Myanmar		1 (0.65)		
South Korea	2 (0.78)			
Thailand	2 (0.78)	4 (2.61)		
Europe				
Belgium	1 (0.39)			
Bosnia and Herzegovina		1 (0.65)		
Croatia	1 (0.39)	4 (2.61)		
Denmark*		1 (0.65)	2 (22.22)	
Estonia	1 (0.39)			
Finland		1 (0.65)		
France*	10 (3.88)	1 (0.65)		
Germany	2 (0.78)			
Greece*	2 (0.78)			
Italy*	9 (3.49)	2 (1.31)		
Latvia*	1 (0.39)			
Lithuania*				
Netherlands*	3 (1.16)	3 (1.96)		
Poland*				
Russia	2 (0.78)			
Slovenia			6 (66.67)	
Spain*	9 (3.49)	5 (3.27)		
Sweden*				
Switzerland	3 (1.16)			
Turkey	28 (10.85)			
United Kingdom	5 (1.94)	5 (3.27)		

Country	Cats (Felis catus)	Dogs (Canis lupus familiaris)	Ferrets (Mustela putorius furo)	Hamsters (Mesocricetus auratus)
North America				
Canada*				
United States*	113 (43.8)	98 (64.05)	1 (11.11)	
South America				
Argentina	6 (2.33)	8 (5.23)		
Brazil	8 (3.1)	9 (5.88)		
Chile	3 (1.16)			
Peru	16 (6.20)			
Uruguay	1 (0.39)	1 (0.65)		
Total	**258 (100)**	**153 (100)**	**9 (100)**	**8 (100)**

Cases recorded in Moscow and Saint Petersburg, were considered as located in the European part of Russia. Countries reporting infections in farm minks are marked with an asterisk (*). In these instances, sources do not provide the exact number of cases due to the high number of affected individuals.
Source: Research data

Figure 1 – Domestic animals reportedly infected by Sars-CoV-2 from February 2020 to May 2022 per continent. Minks are not shown because most of studies do not inform the number of affected individuals, as they are bred in large numbers for their fur



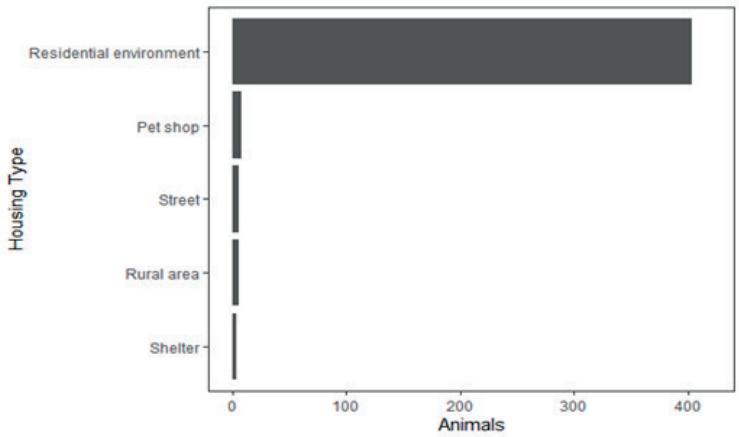
Source: Research data

The highest number of infected cats were reported in the Americas, particularly in the USA (N = 113), with additional records in Argentina, Brazil, Chile, Peru, and Uruguay. The affected cats in Europe correspond to 29.8% (N = 77) of total, distributed in 14 countries (Germany, Belgium, Croatia, Spain, Estonia, France, Greece, Netherlands, Italy, Latvia, United Kingdom, Russia, Switzerland, and Turkey). In Asia, we registered 13.2% (N = 34) of the cases involving cats, across four distinct countries (China, South Korea, Iran, and Thailand).

Among dogs, 75.8% (N = 116) of the cases were reported in four countries in the Americas (USA, Argentina, Brazil, and Uruguay), with the USA being again the most heavily affected (64%; N = 98). In Europe, where 15% of the infected dogs were recorded, nine countries reported infections (Bosnia and Herzegovina, Croatia, Denmark, Spain, Finland, France, the Netherlands, Italy, and the UK). In Asia, China, Japan, Myanmar, and Thailand reported together 9.2% of the cases involving dogs. Additionally, six of the infected ferrets lived in Spain, two in Slovenia, and one in the USA. Moreover, all eight of the infected hamsters were found exclusively in China.

As for the housing type of animals infected, the majority (94.4%; N = 404) were living in a residential environment. Eight individuals were living in pet shops, six were street animals, six lived in a rural area, and four were in a shelter. The farm minks reported are all considered to be from rural areas (Figure 2).

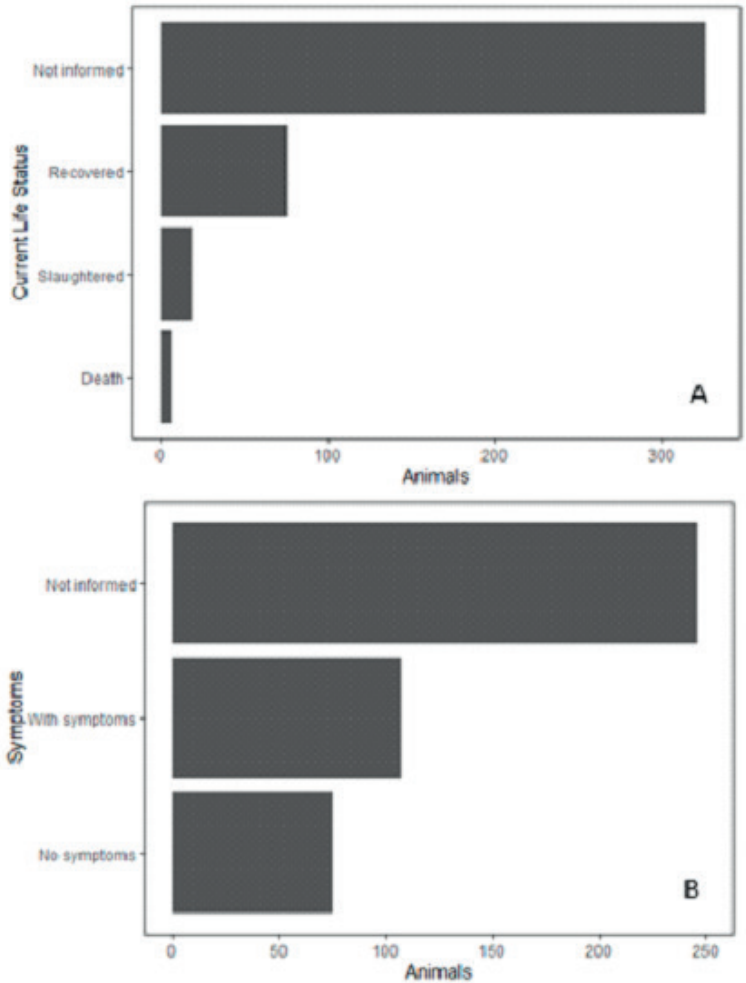
Figure 2 – Number of domestic animals with SARS-CoV-2 in the world, classified according to their housing type: residential, pet shop, street, rural and shelter, between the years 2020 and 2022



Source: Research data

Most of the reports (57.5%; N = 246) were lacking information on the symptoms of affected individuals. In 25% (N = 107), though, symptoms were described and in 17.5% (N = 75) the infected animal was reported as asymptomatic (Figure 3a). The current life status of the individual was not informed in most of the studies (76.2%; N = 326) and full recovery was reported in 17.7% of the cases (N = 76). Affected animals were slaughtered in 4.5% of the cases (N = 19) and 1.6% (N = 7) died due to the infection (Figure 3b).

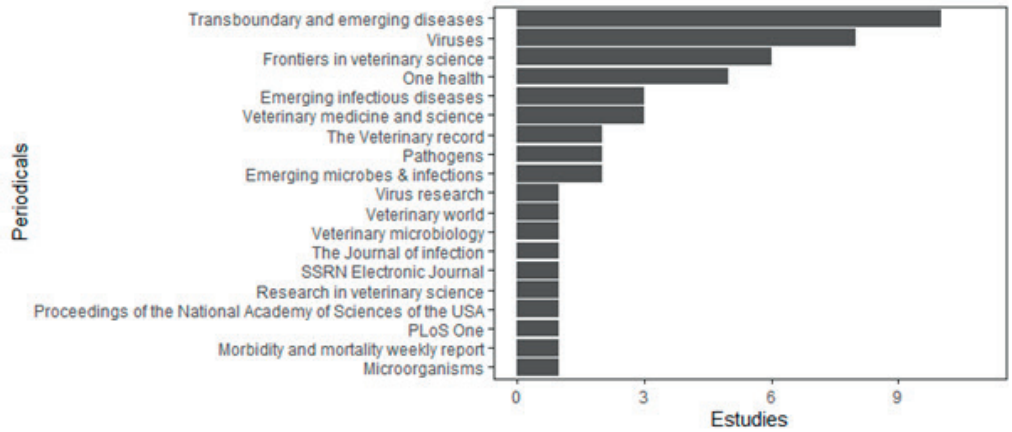
Figure 3 – Number of domestic animals with SARS-CoV-2 at a global level, classified: a) according to symptomatology (not informed, with symptoms and no symptoms); b) regarding the current state of life (not informed, recovered, slaughtered and death), between the years 2020 and 2022



Source: Research data

The data source from which we obtained the largest number of reports was APHIS (37.1%; N = 192). Scientific journals made up 34.2% (N = 177) of this corpus and the remainder, 28.7% (N = 149) was obtained from ProMED. Among scientific journals, the one that published the most case reports was Transboundary and Emerging Diseases (ISSN 1865-1682), with 19.6% (N = 10) of the 51 scientific publications obtained. Most reports were published in 2021 (60.8%, N = 31) (Figure 4).

Figure 4 – Number of scientific articles on SARS-CoV-2 in domestic and production animals worldwide, published in journals between 2020 and 2022



Source: Research data

4 DISCUSSION

The Coronavirus pandemic has brought untold damage to humanity, from loss of lives to economic and social negative consequences. The harms to animal welfare related to COVID-19 include acts of violence, both threatened and carried out, against animals, which were considered suspected causal agents of the disease's spread (QIAO HUANG *et al.*, 2020). Our study demonstrates an additional dimension in which the pandemic has affected the world, pointing to a potential set of still undetermined consequences both to the affected animals and to humans.

The most affected animals were cats and dogs, the most common pets in homes, that have frequent close contact with their owners. The higher prevalence of records in domestic cats could be associated with the way of life of these animals since they are very active, move more freely through different locations, and are not as easily contained as dogs (TAN *et al.*, 2020). In addition, another factor that may have influenced this phenomenon is the similarity between the ACE2 of humans and cats, which is higher when compared to dogs, for example, making these animals more susceptible to the virus (STOUT *et al.*, 2020).

Considering the scarcity of available information on this subject, it was necessary to get information from different data repositories, which may have created some biases in our results. For instance, ProMED publishes reports with detailed information about the infection, mainly contributing to our data on the lifestyle, symptoms, and prognosis of the affected animals. These animals were assessed with respiratory symptoms, lethargy, vomiting, and diarrhea (PROMED, 2020a, 2020b, 2021a). APHIS reports, on the other hand, do not specify most of this information. Cases reported in scientific publications do not always provide details, as it depends on the study's aims.

When symptoms were present, dogs and cats showed diarrhea, vomiting, difficulty breathing, coughing, dyspnea, weakness, and severe myocarditis (GARIGLIANY *et al.*, 2020; FERASIN *et al.*, 2021; MIRÓ *et al.*, 2021). Thus, even though our study shows a prevalence of cases worldwide, the consequences of infection in animals that live close to humans are still uncertain, as well as the potential consequences for the individual's health, the chain of transmission of the virus, and the prevalence of COVID-19 in humans.

The records involving farm minks did not discriminate the exact number of individuals affected, as these animals are normally raised in farms that may hold hundreds of minks, explored for the fur trade. It is, therefore, difficult to individually diagnose the affected ones. In eight countries (USA, Canada, Denmark, Spain, France, the Netherlands, Latvia, and Lithuania), out of twelve where infected minks were reported, the entire farming had to be culled. Viral RNA was detected in the inhalable dust and in droplets in the air of this mink farms (ORESHKOVA *et al.*, 2020), evidencing the imminent risk of exposure and transmission to the workers that had contact with the animals on the farm (ENSERINK, 2020).

A genomic study indicates that these people were infected after the minks in some farms in the Netherlands, pointing to a process of reverse transmission (OUDE MUNNINK *et al.*, 2021). Nevertheless, minks appear to be a suitable model to evaluate the efficacy of drugs and vaccines against COVID-19, because virus replication in the upper and lower respiratory tract culminates in human-like lesions and one vaccine tested in these animals successfully prevented replication of the pathogen (WEST *et al.*, 2021).

The main form of transmission of Sars-CoV-2 is between infected and susceptible individuals. However, there is a potential risk of the development of new variants of the virus, originating from mutations in the spike protein. This structure plays a major role in the process of infection, facilitating viral transmission and reducing neutralization from antibodies (SHUAI *et al.*, 2020). It is a glycoprotein fundamentally responsible for providing interactions with the host cell receptor ACE2, for viral binding and penetration into target cells during the infection process, and due to these extremely important functions, it is one of the most likely targets for therapeutic research against COVID-19 (CORREIA, 2022).

There is an increased risk for the development of new variants potentially resistant to vaccines that are already available, because the very presence of the virus in different organisms can already favor the occurrence of mutations in glycoprotein S (spike), which enable an increase in the ability to interact with ACE2 (CORREIA, 2022). It is also worth mentioning that each variant of SARS-CoV-2 contains its respective mutations in the "spike" proteins that help optimize the virulency due to the increased affinity by the ACE2 receptor (SALLEH *et al.*, 2021). Thus, continuous monitoring of emerging variants with mutations, including those that could originate in animals, is important to maximize public health measures to mitigate the effects of Coronavirus in human populations.

Vaccines generate more specific and controlled immune responses, which proves to be the safest strategy to prevent severe forms of COVID-19, as well as its future variants (BRANCO, 2021). Thus, after the vaccination of a large part of the global population, even with the gradual return to activities, a natural decrease in the transmission of SARS-CoV-2 to animals is expected. Moreover, the efforts to understand specific aspects of Sars-CoV-2 can be expanded, since there is more freedom to do research.

Human beings are primarily responsible for increasing interaction with animals based on simple activities such as handling, hunting, consumption and contact with body fluids, factors that can cause disease on both sides (DAMASCENO, 2021). It should also be noted that limited access to basic education

and health services, which is relatively more prevalent in rural areas, can lead to inadequate coexistence between people and farm animals, especially in the context of a zoonosis (AVELAR *et al.*, 2019).

To understand how new zoonotic outbreaks arise throughout human history, it is necessary to analyse factors such as environmental degradation, the evolution of pandemic and epidemic cases, the nature of pathogens, human culture, the socioeconomic context, poverty, health issues, and globalization, because these aspects directly influence the emergence of new diseases and possible future pandemic outbreaks (ANDRADE; LOPES, 2021). According to Paim and Alonso (2020), it can be said that these outbreaks are the result of human negligence since they could have been avoided due to the advancement of scientific studies in this area.

The increase in the loss of global biodiversity and deforestation to make way for urban areas are examples of environmental impacts caused by anthropic action that are closely related to the emergence and spread of diseases. However, global warming favours the emergence of viruses, bacteria and future pandemics (LAYRARGUES, 2020). In fact, urban and peri-urban areas may be particularly susceptible to the emergence and dissemination of zoonoses, especially when minimal life conditions, such as basic sanitation and housing are not properly provided. This reality associated with inadequate coexistence with domestic animals can substantially contribute to the development and spread of zoonoses (DAMASCENO, 2021).

The COVID-19 pandemic highlighted the importance of the One Health approach, a multisectoral and multidisciplinary perspective essential for addressing global health threats with complex causes (WAKIMOTO, 2024). It is important to note that the rapid growth of the human population has caused significant impacts on global health, generating intense pressure on the agricultural sectors for food production and invading the natural habitats of various species, resulting in ecosystem imbalances, and that the risks of pandemics have become more critical due to the spread and emergence of epizootics, zoonoses, and epidemics (DESTOUMIEUX-GARZÓN *et al.*, 2018).

In this context, the health of people and animals is threatened by antimicrobial resistance, environmental pollution, and the development of multifactorial and chronic diseases, highlighting the globalization of health risks and the importance of studies at the human-animal-environment interface (DESTOUMIEUX-GARZÓN *et al.*, 2018).

Therefore, the increasing interaction between people, animals, and the environment has created a new dynamic where the health of each group is interconnected. Thus, the One Health approach involves major international institutions responsible for public and animal health, including the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organisation for Animal Health (OIE) (UCHTMANN *et al.*, 2015).

5 CONCLUSION

Globally, the animals most affected by the SARS-CoV-2 were cats and dogs, the most popular pets found in households and those with frequent contact with their owners, with the majority of reported

cases in the United States. Our work sheds light on the importance of the continuous construction of scientific knowledge to strategically promote the human population's health, as we show potential evidence of another dimension to be considered regards COVID-19. The Coronavirus pandemic brought catastrophic consequences for humanity. However, the production of scientific knowledge throughout these years raised not only hope for the resumption of collective activities but also has been highlighting the role of humans and society in the emergency and spread of diseases. Moreover, research can be directed to better understand the dynamics of transmission of this and other viruses between humans and pets, precisely because of the close coexistence with these animals.

REFERENCES

ANDRADE, C. D. R.; LOPES, G. A. H. Brasil República: uma história de surtos, pandemias e epidemias. **Bol Conj (BOCA),** v. 5, n. 14, p. 70-92, 2021.

APHIS. Animal and Plant Health Inspection Service. **List of SARS-CoV-2 Cases Dashboard.** 2021. Disponível em: https://www.aphis.usda.gov/sars-cov-2. Acesso em: 12 abr. 2021.

AVELAR, A. C. S. *et al*. Revisão integrativa das principais zoonoses de ocorrência brasileira. XI Encontro Internacional de Produção Científica (EPCC). **Anais [...],** Maringá, 2019.

BRANCO, S. A. B. **SARS-CoV-2: mecanismos de patogênese da COVID-19**. (Dissertação) Mestrado Integrado em Ciências Farmacêuticas – Universidade de Lisboa, Lisboa, Portugal, 2021.

BOGOCH, I. I. *et al*. Pneumonia of unknown aetiology in Wuhan, China: Potential for international spread via commercial air travel. **J Travel Med,** v. 27, n. 2, p.1-3, 2020.

CORREIA, S. E. G. **Estudos de interação entre lectinas do tipo ConA e glicanos presentes na proteína Spike do novo Coronavírus.** (Dissertação) Mestrado em Biotecnologia de Recursos Naturais – Universidade Federal do Ceará, Fortaleza, CE, 2022.

DAMASCENO, J. S. **Como as ações antrópicas estão favorecendo o surgimento de doenças zoonóticas no Brasil?** 2021. (Monografia) Curso de Medicina Veterinária) – Centro Universitário UniAGES, Paripiranga, BA, 2021.

DESTOUMIEUX-GARZÓN, D. *et al*. The One Health concept: 10 years old and a long road ahead. **Front Vet Sci,** v. 5, a. 14, 2018.

DHAMA, K. *et al*. SARS-CoV-2 jumping the species barrier: Zoonotic lessons from SARS, MERS and recent advances to combat this pandemic virus. **Travel Med Infect Dis,** v. 37, p. 101830, 2020.

ENSERINK, M. Coronavirus rips through Dutch mink farms, triggering culls. **Science,** v. 368, n. 6496, p. 1169. 2020.

FERASIN, L. *et al*. Infection with SARS-CoV-2 variant B.1.1.7 detected in a group of dogs and cats with suspected myocarditis. **Vet Rec,** v. 189, n. 9, p. e944, 2021.

GARIGLIANY, M. *et al*. SARS-CoV-2 Natural transmission from human to cat, Belgium, March 2020. **Emerg Infect Dis,** v. 26, n. 12, p. 3069-3071, 2020.

LAYRARGUES, P. P. Pandemias, colapso climático, antiecologismo: Educação Ambiental entre as emergências de um ecocídio apocalíptico. **Rev Bras Educ Amb,** v. 15, n. 4, p. 1-30, 2020.

LI, Q. *et al*. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. **New Engl J Med,** v. 382, n. 13, p. 1199-1207, 2020.

LIU, P. *et al*. Are pangolins the intermediate host of the 2019 novel coronavirus (SARS-CoV-2)? **PLOS Pathog,** v. 16, n. 5, e1008421, 2020.

MIRÓ, G. *et al*. SARS-CoV-2 Infection in one cat and three dogs living in Covid-19-positive households in Madrid, Spain. **Front Vet Sci,** v. 8, p. 779341, 2021.

ORESHKOVA, N. *et al*. SARS-CoV-2 infection in farmed minks, the Netherlands, April and May 2020. **Eur Comm Dis Bul,** v. 25, n. 23, 2001005, 2020.

OUDE MUNNINK, B. B. *et al*. Transmission of SARS-CoV-2 on mink farms between humans and mink and back to humans. **Science,** v. 371, n. 6525, p. 172-177, 2021.

PAIM, C.; ALONSO, W. **Pandemia, saúde global e escolhas pessoais.** Alfenas: Cria, 2020.

PROMED. Program for Monitoring Emerging Diseases of the International Society for Infectious Diseases (ISID). **PRO/AH/EDR> COVID-19 update (445): animal, Thailand, UK, dog, cat**. 2021a. Disponível em: https://promedmail.org/promed-post/?place=8700502,40#promedmailmap. Acesso em: 6 jan. 2022.

PROMED. Program for Monitoring Emerging Diseases of the International Society for Infectious Diseases (ISID). **PRO/AH/EDR> COVID-19 update (169): Netherlands (NB) animal, farmed mink,**

spread, rabbit susp. 2020a. Disponível em: https://promedmail.org/promed-post/?place=7316646,1250#promedmailmap. Acesso em: 9 abr. 2021.

PROMED. Program for Monitoring Emerging Diseases of the International Society for Infectious Diseases (ISID**). PRO/AH/EDR> COVID-19 update (552): USA, animal, cat, dog, snow leopard**. 2020b. Disponível em: https://promedmail.org/promed-post/?place=8042405,8655#promedmailmap. Acesso em: 9 abr. 2021.

PROMED. Program for Monitoring Emerging Diseases of the International Society for Infectious Diseases (ISID). **Latest on COVID-19.** 2021b. Disponível em: https://promedmail.org/coronavirus/. Acesso em: 9 abr. 2021.

QIAO HUANG, Q. *et al*. COVID-19 pandemic: stop panic abandonment of household pets. **J Travel Med,** v. 27, n. 3, p. taaa046, 2020.

R CORE TEAM. **R: A language and environment for statistical computing**. Viena: R Foundation for Statistical Computing, 2020

SALLEH, M. Z. *et al*. Structural evaluation of the Spike Glycoprotein variants on SARS-CoV-2 transmission and immune evasion. **Int J Mol Sci**, v. 22, n. 14, 7425, 2021.

SHARUN, K. *et al*. Coronavirus disease 2019 (COVID-19) in domestic animals and wildlife: advances and prospects in the development of animal models for vaccine and therapeutic research. **Hum Vacc Immunother,** v. 16, n. 12, p. 3043-3054, 2020.

SHUAI, L. *et al*. Replication, pathogenicity, and transmission of SARS-CoV-2 in minks. **Natl Sci Rev,** v. 8, n. 3, nwaa291, 2020.

SIT, T. H. C. *et al*. Infection of dogs with SARS-CoV-2. **Nature,** v. 586, p. 776-778, 2020.

STOUT, A. E. *et al*. Coronaviruses in cats and other companion animals: Where does SARS-CoV-2/COVID-19 fit? **Vet Microbiol,** v. 247, p. 108777, 2020.

TAN, S. M. L. *et al*. Uncontrolled outdoor access for cats: an assessment of risks and benefits. **Animals (Basel)**, v. 10, n. 2, 258, 2020.

UCHTMANN, N. *et al*. Barriers to, efforts in, and optimization of integrated One Health surveillance: a review and synthesis. **EcoHealth**, v. 12, n. 2, p. 368-384, 2015.

WAKIMOTO, M. D. Saúde Única e a resposta à COVID-19 e outras zoonoses. In: 5.º Congresso Luso-Brasileiro de História da Medicina Tropical. **Anais Inst Hig Med Trop**, v. 23, n. 1, p. 36-43, 2024.

WAN, Y. *et al*. Receptor recognition by the novel coronavirus from Wuhan: An analysis based on decade-long structural studies of SARS coronavirus. **J Virol**, v. 94, n. 7. p. 1-9, 2020.

WEST, A. P. *et al*. Detection and characterization of the SARS-CoV-2 lineage B.1.526 in New York. **Nature Comm**, v. 12, n. 1, 4886, 2021.

WHO. World Health Organization. **Coronavirus disease (COVID2019) situation reports**. 2020. Disponível em: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports. Acesso em: 7 abr. 2021.

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