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THE VETERINARIAN IN SARS PANDEMY - CoV-2 (COVID-19): BACKGROUND AND ATTRIBUTIONS

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ABSTRACT

In December 2019, the world watched in disbelief as a viral epidemic, originating in Wuhan, Hubei Province, China, took on frightening proportions. On January 30, 2020, the World Health Organization (WHO) declared the outbreak of the disease caused by the new coronavirus (SARS-CoV-2) to be a public health emergency of international importance, the highest level of alert of the Organization, as provided in the International Health Regulations (IHR, 2016). On March 11, 2020, the epidemic was declared a pandemic by the WHO. Despite the rapid distribution of the new virus, many countries were reluctant or slow to comply strictly with the prophylactic methods suggested by those who had already experienced the whole situation of threat to the health of their populations.

Keywords: unique health; veterinary Medicine; coronavirus

DEVELOPMENT

The coronaviruses belong to the order *Nidovirales* and family *Coronaviridae*. The subfamily *Coronavirinae* is composed of the genera *Alphacoronavirus* and *Betacoronavirus*, which infect mammals and *Gammacoronavirus* and *Deltacoronavirus*, which infect both birds and mammals (WOO et al, 2012; ZHU et al, 2020). The International Committee on Taxonomy of Viruses (ICTV) has adopted severe acute respiratory syndrome 2 (SARS-CoV-2) as the name for the new virus causing COVID-19 (DUARTE, 2020; WHO, 2020).

This is the sixth time in history that a public health emergency of international importance has been declared (PAHO, 2020). In contexts of disasters or emergencies, human beings seem to repeat the same anthropocentric behavioral pattern, of believing that it is possible to avoid the whole and that, to a certain degree, they are immune to the world's adversities. The current experience allows us to have new perspectives and to be more self-critical in terms of the way humanity has been leading with regard to attitudes towards its fellow human beings, making it clear how susceptible we are in general.

In this moment of more uncertainties than scientific facts, we direct our professional effort, while veterinarians, to some roles mostly attributed to our profession, since the veterinarians' performance as clinicians or surgeons is commonly mentioned. However, there are several acting niches that are usually neglected, and this is more easily noticed in situations

such as the one we live in now. The veterinary doctor is trained throughout his education to draw up epidemiological strategies to combat and control various diseases, especially when we are facing zoonoses. In the case of COVID-19, the veterinary doctors, would be professionals of great help to prevent the increase in the number of cases.

In situations of endemics, epidemics and pandemics, veterinarians have a huge responsibility, besides exemplary training to act intensively in an event that may have a worldwide impact. One of the duties of this profession, with such a broad spectrum of action, is to provide information of interest to public health and not to use or propagate false data, nor misrepresent the scientific interpretation of others. In addition to fighting fake news vehemently, veterinarians have scientific, social, moral and ethical responsibility to elucidate and clarify the population, as well as contribute to the guidance and implementation of therapeutic, control and prevention measures in the face of any endemic. Veterinary medicine looks after animal health, but it also looks after public health and collective well-being within the broad concept of unique health, launched by the UN in 2008. Indeed, an incontestable fact of the importance of this concept is that 60% of infectious diseases in humans are zoonoses, i.e. diseases transmitted from animal to man and vice-versa.

During their university training, veterinary doctors are trained in epidemiology, diagnostic methods both in animal and public health, in addition to training in principles of biosecurity and biocontainment of communicable diseases. Therefore, these professionals can contribute greatly in supporting public health services. Acknowledging the importance of interdisciplinary action in the health field, the Ministry of Health took a major step towards the integralization of public health care when it recognized that veterinary medicine should work hand in hand with human medicine (MAPA, Resolution No. 287 of October 8, 1998).

The insertion of veterinary doctors in the teams of the Family Health Support Center - NASF materializes the recognition of Veterinary Medicine as a health profession (MAPA, Ordinance No. 2.488, October 21, 2011). However, the attributions of these professionals in NASF are being built slowly and gradually, since the performance of veterinarians in public health is still neglected in Brazil. It should be emphasized that the participation of these professionals in interdisciplinary work groups, public health or offering community training in different contexts, may occur at different levels. An example would be acting as an integral part of government advisory groups for strategic decision-making, as claimed by the Collegiate Veterinary Organization of Spain to its government or, as has been the case in Germany, where the strategic plan to combat the COVID-19 pandemic is led by the president of the institute Robet Koch, Dr. Lothar Wieler, veterinary doctor.

Furthermore, Faculties of Veterinary Medicine and veterinary services can contribute on several fronts of action, such as the adaptation of veterinary laboratories to support the diagnosis of Sars - Cov-2, as indicated by the OIE in a publication of 2 April 2020, entitled "Support of veterinary laboratories in the public health response to COVID-19" (OIE, 2020). In addition to the adequacy of spaces, professionals who already work routinely in diagnostic laboratories, an area of intense activity at a time of pandemic, can give great support to performing tests, optimizing the processing of samples. A larger number of accredited and active laboratories would contribute positively to a faster and more effective epidemiological study, as well as contribute to put an end to the underreporting of cases, given the high demand from the still few laboratories authorized to perform diagnostic tests.

In addition, support for information analysis that generates measures of impact on the disease, identification of risk factors, spatial analysis, and modelling of the speed of disease transmission can also be efficiently supported. Similarly, contributions to research on the virus and its pathogenesis to assist in its control and prevention are perfectly plausible and welcome. This has been a reality in Cornell and Louisiana Colleges of Veterinary Medicine, among others in the world.

We cannot fail to mention that veterinary services have been declared essential by the OIE and by different veterinary medical associations around the world. It remains active, in a continuous way, both preventive and curative, and also focusing on ensuring food security for the population through attention to the health of farm animals. Therefore, the provision of emergency services should be continued for pets, farm and zoo animals, and also guiding society on the COVID-19 pandemic, ensuring the bilateral security of human-animal relations.

It is worth noting that, as stated by the World Organisation for Animal Health, the current propagation of COVID-19 is the result of transmission from human to human. To date, there is not enough evidence that pets play a significant role in the spread of the disease. Therefore, there is no justification to take action against these animals that could compromise their welfare (OIE, 2020).

In direct contact with the tutors of dogs and cats, the veterinary doctors should be attentive to the owners that, perhaps, present symptoms of flu or which are compatible with the COVID-19, giving them the proper orientation. Still, as already mentioned, they should inform tutors that their animals are not subject to the infection, thus decreasing the risks of abandonment or mistreatment. They can also, with competence, instruct tutors on prophylactic measures to reduce their risk of infection (such as strengthening the need for basic hygiene habits, for example).

Rescuing the issue of fake news and the role that certain animals have in the panorama of the distribution of the new coronavirus, the way the information was initially conveyed was relatively hasty. In the eagerness to generate news, many times the vocabulary used did not result in conceptually correct facts. On the contrary, the lack of knowledge has given rise to social movements that are quite harmful to wildlife, resulting, therefore, in a phenomenon of lethal and rampant attack by suspicious species, some at risk of extinction, and often killed with cruelty.

Initial research revealed that the genomes of Sars-CoV-2 (initially called WHCV, later 2019-nCoV, and finally Sars-CoV-2) and those present in bats are 96% identical. However, the bat virus is not capable of causing the disease in humans, which leads to the need for an intermediate host (IH). For some time, it was thought that the snake would be this IH, but this hypothesis was discarded. After ample verification, in several wild species, it was found that the viral genomes studied in the pangolin, mammal of the order *Pholidota*, presented high similarity to those of patients infected by the coronavirus in Wuhan, the city of origin of the pandemic.

As with armadillo meat in Northeastern Brazil, pangolin meat is much appreciated in Asia and Africa, and its scales are used in the manufacture of medicines, making it the most trafficked animal in the world and widely traded in free markets on these continents, even though these acts are considered crimes by local authorities. This context made to jump the suspicions that the animal would be the intermediary host in which the virus would mutate and, if transmitted to the human being, would promote the disease.

However, recent research indicates that there may have been fallout in this conclusion, as the percentage of similarity referred only to a part of the viral genetic code, the sequence responsible for encoding the spike proteins of the viral crown, which is used to parasitize cells hostesses (CARBINATTO, 2020). Namely, the four main structural genes of the coronavirus encode the nucleocapsid protein, spike protein, membrane protein, and glycoprotein (ROTTIER, 1995). The complete genome of the coronavirus mapped in the pangolin shows 90.3% similarity to the human virus. It seems a lot, but it is still insufficient to state that it was surely the origin of the disease. To make such an assertion, similarity of 99% or more would be necessary. Other studies have found similarity values ranging from 85.5% to 92.4%, again, a low percentage to affirm that pangolin is the origin of the disease (CARBINATTO, 2020; GRUBER, 2020).

On the other hand, numerous uncertainties permeate the food sector, with little guidance on the subject, whether at the level of production, distribution, marketing or household preparation (OLIVEIRA et al., 2020). Veterinarians working in health and epidemiological surveillance should pay attention and guide the general public in terms of food care, its packaging, places of sale and exposure of foodstuffs, as occurs in markets and free trade fairs, which may be sources of infection. Although not yet proven, there is the possibility of contamination of food by contact with other surfaces during the preparation of meals. It is known that plastic, metal, glass and paper can be vehicles of coronavirus contamination. Thus, food packaging should be sanitized with soap and water, 70% alcohol or 0.1% sodium hypochlorite solution (DOREMALEN et al., 2020; KAMPF et al., 2020).

With regard to food, the adoption of good hygiene practices already established is advisable. Food must be submitted to the appropriate cooking process (reaching 70ºC in all its extension), and those consumed raw must be previously washed and sanitized with 0.1% sodium hypochlorite solution and later rinsed with drinking water (CFN, 2020; KAMPF et al., 2020). It should be noted that the handling of various objects, such as the mobile phone, at mealtime can bring additional risks of contamination. An important aspect rarely mentioned is the reuse of plastic shopping bags. This practice should be avoided, since they are also vehicles of contamination or vomit (CUNHA et al., 2020; REPP e KEENE, 2020).

Psychosocial responses to unknown epidemics include fear, stigma and action based on little information available (STRONG, 1990). Unfortunately, well-known media with a notorious media reputation use guilt language. This approach, however, is potentially harmful and has serious implications. It contributes to responses that directly affect wild populations around the world, especially the slaughter of thousands of animals, as has previously occurred in other pandemic situations.

It is known that coronaviruses cause respiratory infections, such as COVID-19, and gastrointestinal infections. In past situations, other betacoronaviruses caused SARS (severe acute respiratory syndrome) in 2003 and MERS (Middle East respiratory syndrome) in 2012. Both SARS-CoV and MERS-CoV originated from the bat, but at the time, it was suggested that civets, an African carnivorous mammal of the vivarium family, would be intermediate hosts for SARS-CoV while, dromedary and camels, for MERS-CoV. On the basis of the research then released, which later proved inconclusive and to some extent erroneous, the Chinese government decided to shoot down more than 10,000 civets. What is regrettable is that since then, in various parts of the world, such as Indonesia and Peru, there have been aggressions or attempts to kill these animals by beating or burning them alive, among other cruelties. It should be noted that subsequent research (WU et al., 2005) has even found that the virus may have mutated in humans and then been transmitted to the civets, which were susceptible to developing disease when they acquired the virus from human strains.

Thus, several species in the world have been assaulted and killed by a media press, which is often based on controversial facts. The irony is that later, when the right questions are asked, we realize that in fact, the blame for the origin of the virus and the rise in speed of transmission was the product of the exploitation, without criteria, of natural resources on our part. In other words, humanity has increasingly invaded its natural habitats and strained relations, significantly compromising animal welfare. Should we not ask ourselves about the interference we cause on the biodiversity around us? What is the root of the socio-environmental problem that brings to light epidemics and even pandemics? If we continue to follow the current behavioral pattern, will we be free from other pandemics yet to come? The much talked about "respect for nature" is today, more than ever, less cliché than ever before. This respect, based on current technical-scientific knowledge, invites us to look in a broad and applied way at the urgency to reestablish the limits, safe to both populations, with our non-human neighbors.

With this new understanding that we would be abusing ecological relations, as can be seen in the Wuhan market, animals have gone from being guilty to being victims. Other species are being affected. Recently scientists reported the susceptibility of cats to SARS-CoV-2 (CHI et al., 2020). Shi et al. (2020) corroborated the findings of Chi et al. (2020) and found that in addition to cats, ferrets are highly susceptible to SARS-CoV-2, while dogs have low susceptibility, and that farm animals such as pigs, chickens and ducks were not susceptible to the virus.

Cases of COVID-19 were also reported in two dogs, a 17-year-old German Spitz and an ageless German Shepherd in Hong Kong. Since then, the city's Department of Agriculture, Fisheries and Conservation has guided people in the region not to abandon their animals. Although they emphasized that currently there is no evidence that pets can be a source of the virus for humans, biological risks due to mutations are always possible. Therefore, the guideline is that owners should not abandon their animals, which are also in social isolation, as well as the other members of the family.

More recently, a case of COVID-19 in a 4-year-old female tiger from the Bronx Zoo in New York has been released. The animal, as well as other cats from the zoo, tested positive for the new SARS-CoV-2 coronavirus, in a diagnosis performed by the U.S. Department of Agriculture's National Veterinary Services Laboratory (USDA). Local public health authorities believe these cats became ill after acquiring the infection from an asymptomatic zoo official (REIS, 2020).

Cases such as this one put all conservation efforts to the test, especially when we think of wild cats, because that would lead to another questioning. What would happen to apes, gorillas, chimpanzees and orangutans that already face advanced processes of extinction, habitat loss and anthropozoonoses? As well pointed out by Wilson (1994), "The concept of microorganisms as causing disease is inadequate and incomplete. Human actions are the factors that most influence the emergence of diseases.

Currently, and perhaps more than ever, it is of vital importance that we stop endorsing the vision that imposes tradition and culture on scientific evidence. We must rethink the role of human actions, which contribute to the emergence and re-emergence of diseases, whether infectious or not. Despite all the focus given to infectious diseases by the current conjuncture, we cannot shy away from rethinking the impacts and all the diseases that are the result of the environmental homeostasis break that we have continuously generated.

With this in mind, another role for the vet jumps out at you. Environmental education measures, besides informing, make the population aware of behaviors and habits that have long been incorporated and considered cultural manifestations. Despite this, several of these traditions are no longer technically recommended. Many of them expose the population to unnecessary risks. In Brazil, although we are not in the habit of consuming raw meat from wild animals, in some regions of the country it is common to capture and transport these animals to the homes, as occurs in the Northeast with animals of the Cingulata Order, known as armadillos. These animals are bred for slaughter and own consumption. This in itself would expose these people to viruses that cause serious diseases, as initially occurred in China with the Sars - CoV-2.

If we expand this line of reasoning, we should pay attention to the fact that people with less education and access to quality information often crowd together without the proper preventive measures for contagion. Soon after, they return to their tasks in the field, to manage animals that will also be sold, slaughtered or even be part of the coexistence of other families. And so, once again, we are faced with the possibility that these animals will potentially be carriers of microorganisms, including viruses, initiating possible new outbreaks of the disease.

Despite all this, direct communication between the Ministry of Agriculture, Livestock and Supply (MAPA) and the Ministry of Health (MS) in Brazil is not perceived, so that this

role of educating the population about risks and prevention measures is effectively and efficiently adopted. If a direct line of communication were established between the agencies mentioned, the development of a better action plan to mitigate the number of new cases, contributing to the control of the spread of the virus, would be optimized. In addition, through programs linked to the Ministry of Health, socio-educational projects could be implemented, such as virtual lectures and conferences, following the example of other countries, the development of information campaigns and services, together with health agents in the communities, for the correct clarification of the population on the importance of prophylaxis and effective modes of disease prevention.

Until then, veterinary doctors in Brazil are being called to update their data with the Federal Council of Veterinary Medicine (CFMV – *Conselho Federal de Medicina Veterinária*) and register on the website of the Ministry of Health of Brazil, by the Strategic Action "Brazil counts on me - Health Professionals", through Ordinance 639, March 31, 2020. In this program, a short virtual course is held in which basic guidelines on compulsory notification of new cases are transmitted to the municipal health departments. Orientations are also passed on regarding the care of patients suspected of COVID-19 in basic health care, and pre-hospital and hospital environments. However, this type of training does not seem to keep logic when it is known that it will not be the veterinary doctor who will do this type of evaluation or screening of human patients. This reality is very similar, if not the same, to other countries in Latin America and the world.

In terms of a more holistic and integrated view of the current pandemic situation which, once again, has been discovered, we continue to deal with diseases in a simplistic manner. We take into account the etiological agent, its pathogenesis, the affected organisms, and indicated therapies, excluding the various factors of influence surrounding its emergence, establishment and development. There are many more complex interactions in the trophic networks of certain situations than we are used to considering. A clear example is the context we are experiencing with COVID-19.

Although the whole situation begins with the consumption of animals carrying the virus, the relationship of influence between animals and man is more complex and begins with social and cultural processes, invasion of ecosystems, and establishment of monocultures that affect the natural habitats of animals forcing them, ultimately, to migrate. This migration puts them at risk and generates an environment of greater interaction with domestic species, with which, in their normal niche, they would not have contact.

It is valid to reaffirm that these unhealthy conditions, generated by human beings, culminate in a series of misadventures, commonly portrayed in a sectorized manner, in causative agent and affected agent, excluding the entire socio-environmental context that resulted in the outcome. Consequently, the focus of the problem resolution is also misguided. Currently, the world is in search of an effective vaccine. This is obviously an effective immediate resolution strategy. However, in the long run it will not solve other pandemics to come, precisely because the primary problem has not been solved. It is imperative that we reflect and re-evaluate precisely how we will conduct these social and environmental relationships from now on.

Looking to the future, new generations of veterinary doctors will have the difficult task of facing new pandemics in a reality of multi-resistant micro-organisms and accelerated genetic mutations. This premise obliges Faculties of Veterinary Medicine and Zootechnics of the world to institute changes in their teaching-learning process, with the ultimate goal of training more capable professionals to reestablish order in human-animal-human relations and thus reduce the risk factors for the development of new pandemics and zoonoses in the world.

REFERENCES

CARBINATTO, B. Papel do pangolim na pandemia de Covid-19 ainda permanece misterioso. **Revista Super Interessante**. Coluna Ciência. Março, 2020. Disponível em: https://super.abril.com.br/ciencia/papel-do-pangolim-na-pandemia-de-covid-19-ainda-permanece-misterioso/. Acesso em: 08/05/2020.

CFN - Conselho Federal de Nutricionistas. Recomendações do CFN: boas práticas para atuação do nutricionista e do técnico em nutrição e dietética durante a pandemia de coronavírus. Disponível em: https://www.cfn.org.br/wp-content/uploads/2020/03/nota_coronavirus_3-1.pdf. Acesso em: 08/05/2020.

CUNHA CBC, MORAES FR, MONTEIRO VS, FEITOSA FGMA, SILVA ITC. Microbiological evaluation of the cell phones of the professionals of a Surgical Center in a beneficent Hospital. **Journal of Epidemioly and Infectious Control**. v. 6, p. 120-124. 2016.

DUARTE, P.M. COVID-19: Origem do novo coronavírus. **Brazilian Journal of Health Review**. v.3, n.2, p.3585-3590. mar/apr, 2020. DOI:10.34119/bjhrv3n2-187

GRUBER, A. A origem do Sars-CoV-2. **Jornal da USP.** abril, 2020. Disponível em: https://pfarma.com.br/coronavirus/5439-origem-covid19.html. Acesso em: 08/05/2020.

IHR, **International Health Regulations (2005)**, Disponível em: https://www.who.int/ihr/publications/9789241580496/en/. Acesso em 08/05/2020. 84p. 2016.

KAMPF G, TODT D, PFAENDER S, STEINMANN E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. **Journal of Hospital Infections**. v.104, p. 246-251. 2020.

Ministério da Saúde. Surtos de doenças transmitidas por alimentos no Brasil. https://portalarquivos2.saude.gov.br/images/pdf/2018/janeiro/17/Apresentacao-Surtos-DTA-2018.pdf (acessado em 19/Mar/2020).

OIE – Organização Mundial de Saúde Animal (World Organisation for Animal Health). Questions and Answers on the COVID-19. Disponível em: https://www.oie.int/en/scientific-expertise/specific-information-and-recommendations/questions-and-answers-on-2019novel-coronavirus/. Acesso em: 08/05/2020.

OPAS - Organização Pan-americana de Saúde. Folha informativa – COVID-19 (doença causada pelo novo coronavírus). Disponível em: https://www.paho.org/bra/index.php?option=com_content&view=article&id=6101:covid19&Itemid=875. Acesso em: 08/05/2020.

REIS, F. Tigre do zoológico de Nova York testa positivo para coronavírus. Disponível em: https://pfarma.com.br/coronavirus/5395-tigre-covid19.html. Acesso em: 07/05/2020.

REPP, K.K.; KEENE, W.E. A point-source norovirus outbreak caused by exposure to fomites. **Journal of Infectious Diseases**. v. 205, p.1639-41. 2012.

ROTTIER, P.J.M. The Coronavirus Membrane Glycoprotein. In: Siddell S.G. (eds) The Coronaviridae. The Viruses, Springer, Boston, MA; 1995. Disponível em: https://link.springer.com/chapter/10.1007/978-1-4899-1531-3_6. Acesso em: 22 abr. 2020.

SHI, J.; WEN, Z.; ZHONG, G.; YANG, H.; CHONG, W.; LIU, R.; HE, X.; SHUAI, L.;

SUN, Z.; ZHAO, Y.; LIANG, L.; CUI, P.; WANG, J.; ZHANG, X.; GUAN, Y.; CHEN, H.; BU, Z. Susceptibility of ferrets, cats, dogs, and different domestic animals to SARS-coronavirus-2. **Science**. 2020.

STRONG, P. Epidemic psychology: A model. **Sociology of Health and Illness**, v.12, n.3, p. 249-259. 1990.

Van DOREMALEN N, BUSHMAKER T, MORRIS D, HOLBROOK M, GAMBLE A, WILLIAMSON B, et al. Aerosol and surface stability of HCoV-19 (SARS-CoV-2) compared to SARS-CoV-1. medRxiv 2020; 9 mar. https://www.medrxiv.org/content/10.1101/2020.03.09.20033217v2. [Links]

WOO, P.C.Y.; LAU, S.K.P; LAM, C.S.F.; LAU, C.C.Y.; TSANG, A.K.L.; LAU, J.H.N.; BAI, R.; TENG, J.L.L.; TSANG, C.C.C.; WANG, M.; ZHENG, B.; CHAN, K.; YUEN, K. Discovery of seven novel Mammalian and avian coronaviruses in the genus deltacoronavirus supports bat coronaviruses as the gene source of alphacoronavirus and betacoronavirus and avian coronavirus as the gene source of gammacoronavirus and deltacoronavirus. **Journal of Virology**, v.86, n.7, p.3995-4008, 2012.

WORLD HEALTH ORGANIZATION. Coronavirus disease (COVID-19) outbreak. 2020. Disponível em: https://www.who.int/emergencies/diseases/novel-coronavirus-2019. Acesso em: 08/05/2020.

WU, D; TU, C.; XIN, C.; XUAN, H.; MENG, Q.; LIU, Y.; YU, Y.; GUAN, Y.; JIANG, Y.; YIN, X.; CRAMERI, G.; WANG, M.; LI, C.; LIU, S.; MING, L.; FENG, L.; XIANG, H.; SUN, J.; CHEN, J.; SUN, Y.; GU, S.; LIU, N.; FU, D.; EATON, B.T.; LIN-FA, W.; KONG, X. Civets Are Equally Susceptible to Experimental Infection by Two Different Severe Acute Respiratory Syndrome Coronavirus Isolates. **Journal of Virology**. v.79, n.4, p. 2620-2625. Jan, 2005. DOI: 10.1128/JVI.79.4.2620-2625.2005

ZHANG, L.; SHEN, F. M.; CHEN, F.; LIN, Z. Origin and evolution of the 2019 novel coronavirus. **Clinical Infectious Diseases**. An Official Publication of the Infectious Diseases Society of America, 2020. Disponível em: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7167049/.

ZHANG, T; WU, Q; ZHANG, Z. Probable Pangolin Origin of SARS-CoV-2 Associated with the COVID-19 Outbreak. **Current Biology**, v.30, n.7, p.1346–1351, 2020.

ZHU, N. et al. A novel coronavirus from patients with pneumonia in China, 2019. **N Engl J Med**, v.382, n.8, p.727-733, 2020.