



Enhancing community health: Veterinary services for underserved areas in Costa Rica with a One Health Approach

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ABSTRACT

In underserved areas of Costa Rica, community veterinary services aim to provide comprehensive care for companion animals, covering preventive, therapeutic, and surgical medicine. Emphasizing a One Health approach, our model focuses on animal welfare, health, and public well-being in vulnerable regions. The project's goal is to ensure the overall well-being of animals, people, and the environment by collaboratively addressing animal health issues and recognizing their interconnected impact on optimal health. Limited resources in underprivileged areas, including restricted access to veterinary care for pets, pose challenges to overall health. Despite its global health benefits, the absence of companion animal veterinary care in these regions has been largely overlooked. Our One Health approach not only addresses animal health but also has a significant impact on human and environmental health, economies, and social factors. This innovative strategy is a pioneering effort to tackle complex health issues in Costa Rica.

1. One Health through veterinary services in underserved areas

The dynamics of relationships and interactions among humans, animals, and environments are interconnected, where actions in one domain affect the others. The One Health approach aims for collaborative resolution of complex health issues, acknowledging the inherent interconnection within this components [1,2]. Human, animal, and environmental health should not be approached in isolation. Instead, collaborative and multidisciplinary teams are needed to address complex health issues [3]. Worldwide, humans and animals relate in multiple contexts, generating positive outcomes among populations [4]. Therefore, ensuring the health of one will benefit the other components.

The relationship between dogs and humans is one of the oldest on record [5]. It has been an ongoing symbiotic relationship to the present day. Dogs have become extremely adept at bonding with humans but have also become highly dependent on them. This dependency includes basic needs like food, shelter, and health care. In the case of cats, unlike dogs, they retain much of their wild behavior despite domestication, making them more independent [6]. In Costa Rica, in the last survey carried out ten years ago, 66% of households have a pet; 55.7% have a dog as a pet, while 15% have, and 29.3% a non-traditional pet [7].

In the last decade, an increasing number of families have opted to

incorporate pets into their households, expanding the average number of pets per home. This underscores the significance of safeguarding the health of these animals and recognizing their potential contributions to both indirect and direct aspects of human health. The manifold benefits of having pets extend to reducing blood pressure, cholesterol levels, and triglyceride levels, as well as alleviating feelings of loneliness, anxiety, and symptoms of post-traumatic stress disorder. Additionally, the presence of pets provides enhanced opportunities for physical activity and outdoor pursuits, improved cognitive function, and increased socialization opportunities [8].

In Costa Rica, the underserved communities are distributed throughout the country: in the great metropolitan area, rural areas, and tourist domains. Populations living in these communities generally have limited resources. This generates a disparity such as access to health services, insufficient financial resources to pay for diagnostic tests and treatments, and limited access to education that informs about health, nutrition and disease prevention [9]. These disparities are not restricted to people, but the scenario is doubled in their pets and access to veterinary care. Understanding the multiple factors influencing access to quality healthcare is extremely complex and requires a multidisciplinary approach [10]. The veterinary care of domestic animals in underserved communities, although little explored, plays an important role in

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articulating One Health and mitigating complex health problems in animal populations and their owners [10,11]. The veterinary profession contributes significantly to the enhancement of ecosystems and public health at the animal-human-environment interfaces by comprehending the effects of improving the health in domestic animals and reducing the risk of disease transmission [10,12]. This article discusses how a university extension project dedicated to providing veterinary care through a One Health approach in underserved communities positively impacts Costa Rica's health.

2. A model of community clinical care in underserved communities in Costa Rica

The Veterinary Services to Underserved Communities project was created in the 90s to provide free veterinary care through preventive and curative medicine in companion animals, aiming at animal welfare and health in Costa Rica. Among the selection criteria of beneficiaries included communities with severe socio-economic problems that did not have a nearby veterinarian to provide their services regularly. Also, communities where the population does not have enough resources to access veterinary care due to economic limitations to pay for them, transportation to mobilize their animals, or limited education on the importance of animal health. Until 2023, more than 80 communities were visited throughout the country, in all seven provinces, including urban, rural, and tourist locations, and caring for more than 7000 companion animals for free. Also, when national emergency situations have arisen, such as earthquakes, hurricanes, extreme floods, wildfires, house fires, and extreme drought events, the project has provided veterinary services to the affected communities.

Once the community was selected and the visit approved, commitment and communication channels were established with the community leaders to learn about their resources, their main deficiencies, the support they can provide, and their primary animal and public health needs. With this information, we continued our quest for the medical supplies, animal feed and drugs, mostly funded by the Hospital de Especies Menores y Silvestres (HEMS) (Small Species and Wildlife Hospital). Additionally, both public and private organizations contributed following the medical demands.

Costa Rica receives commendation as a trailblazer in formulating policies and implementing payment structures for ecosystem services aimed at safeguarding its biodiversity and ecosystems. This exemplary approach has not only inspired global policies but has also mobilized funds dedicated to environmental conservation within the country [13]. Similar praise is extended to Costa Rica's public health system, the Caja Costarricense del Seguro Social. Comprising hospitals, clinics, comprehensive teams, and dedicated professionals, this institution is strongly endorsed by the Costa Rican government, offering medical services to the insured population [14]. However, there is a notable absence of a public health system or payment services for veterinary care of animals. Veterinary medical services for companion animals are predominantly private, with some NGOs subsidizing spay/neuter campaigns. This results in many animals lacking access to veterinary health services, particularly in underserved communities. This project is sustained by the profits from the Hospital and the Universidad Nacional de Costa Rica's support, allowing free veterinary services to these populations.

In these communities, veterinary care campaigns allowed the general health evaluation of pets as well as more complex procedures such as surgical sterilization of pets, sampling procedures for diagnostic tests (feces exams, blood tests for complete blood count and biochemistry profiles, PCR for infectious diseases, biopsies, cytology, scrapings of skin, cultures of infectious agents, antibiograms, serological tests, among others), vaccination, acquiring images and their interpretation (x-rays and ultrasounds), prophylactic and curative treatment of diseases. Also, if any animal required specialized hospitalization, it was transferred to HEMS, and once discharged, the patient returned home.

Educational materials and informative discussions were provided

during our visits to these communities. The topics covered encompassed One Health, animal health, disease prevention, zoonoses, animal welfare, fundamental animal care, awareness and prevention of mistreatment, abandonment, and animal cruelty. Additionally, discussions included information about animal-related legislation, social interrelation, environmental health, ecosystem conservation, and promoting humanist principles and values for fostering harmonious coexistence among people, animals, and the environment. The educative activities were mostly interactive, encouraging the active participation of the community members and building trust and community engagement. By engaging in these experiences, we underscore that they form a crucial part of the process to enhance the participants' health and the well-being of their pets and the environment. Each campaign culminated in a meeting where the results from each beneficiary were reviewed, aiming to enhance future campaigns and elevate community and public awareness regarding animal health, thereby promoting the principles of One Health.

3. Health impact through community clinical care in underserved communities

According to the owners, most of these animals had not been previously evaluated by a veterinarian. Regarding preventive medicine, in the case of canines, few had been vaccinated, including essential vaccines such as parvovirus, distemper, and rabies. Regarding deworming, most owners mentioned that they purchased the deworming medication. However, it was not a procedure that they performed frequently. Animals were not weighed, and medications were not based on a copro-parasitological exam or veterinary recommendation. Nearly all the cats had not been vaccinated nor dewormed. The animals presented for clinical attention were dewormed, vaccinated, and vitaminized when required.

Among veterinary procedures, surgical sterilizations garnered the highest interest from pet owners. Yet, we observed that certain individuals hold cultural or personal beliefs that dissuade them from neutering their pets. It is important to note that castrations mitigate health issues and enhance reproductive control, decrease mistreatment of roaming animals in the community, and reduce the risk of injuries [14]. Among its benefits are the reduction of risks of incidence and mortality from reproductive diseases (for example pyometra, prostatic diseases, venereal transmissible tumor, mammary, ovarian and testicular neoplasms), diseases associated with parturition, help to control of undesired populations, and increase in the life expectancy of animals [15]. Through sterilizations, the community benefits by preventing diseases that can result in emergencies and complex surgeries and require veterinary attention that is not available and that generally includes high economic costs. Likewise, by controlling the number of animals defecating in the environment, the problem of pathogen pollution can be mitigated. Exposure to infectious agents from free-ranging animals that leave litter in the community can affect humans, domestic animals, and wildlife, leading to illness and the spread of infections [16]. The health care of companion animals impacts wildlife health as well. Given that some underserved communities are adjacent to wildlife conservation zones makes it easier for dogs and cats to enter these areas representing a greater chance that diseases could spread from one to another. In these settlements where most cats and dogs have outdoor access and no one usually collects their feces, surgical sterilizations provide a feasible approach to managing these populations and reducing the fertility rate. Managing free-range domestic cats and dogs may help lower the burden of *Toxoplasma gondii* oocysts, *Toxocara canis*, *Toxocara cati*, *Ancylostoma* spp., *Cryptosporidium* sp., *Giardia* sp. and possibly other environmental pathogens. This would help to mitigate water pollution associated with the development of the human population and urbanization, which could have major effects on environmental and public health [17–19]. We aim to reduce the pathogen pollution burden and the risk of pathogens spreading within the

communities by providing surgical sterilizations.

Vaccination is one of the most effective methods to prevent infectious diseases in pets. It also represents a way to improve the health of people who live with these pets [20]. Multiple examples can be cited in which vaccinations improve animal and human health. For example, rabies control and elimination programs is an excellent method to prevent human rabies in underserved communities [21] and the fight against antimicrobial resistance [22]. Likewise, vaccines reduce morbidity and mortality in pets, help prevent diseases that generate high economic costs for treatment for owners [23], prevent infectious diseases in wildlife [24], generate herd immunity among animals in the community, increase the life expectancy of pets [25], and decrease the economic costs of addressing outbreaks of vaccine-preventable infectious diseases [26]. However, the rise of canine vaccination hesitancy constitutes a severe public health threat [27]. Due to disinformation and misinformation, Costa Rica faces this challenge, too. Community engagement and educational efforts were critical to address this issue and achieve an extensive immunization status. The high vaccine acceptability reached was mainly attributed to collaboration between social scientists, educators, and veterinarians. These multidisciplinary efforts to tackle vaccination hesitancy in companion animals lead to a One Health benefit for these communities.

Ectoparasite infestation and dermatological diseases, such as skin tumors, pyodermas, scabies, and skin mycoses, were among the most significant concerns. Dermatological problems are easily perceived by companion animals' owners. Individuals often focus on the outward appearance of their pets rather than addressing the root cause. Frequently, animals may have an underlying medical condition that needs to be addressed to effectively resolve dermatological issues. This may include endocrine disorders such as iatrogenic Cushing's disease, which can result from the prolonged use of corticosteroids, as well as conditions caused by the long-term toxicity of medications. Likewise, owners incur unnecessary economic expenses that may affect their economic stability when looking for desperate solutions. Empirical treatments to control clinical signs like itch, infection, and inflammation are commonly administered in these communities. This results in the empirical administration of drugs that can lead to global health problems like antimicrobial resistance [28] and pesticide exposure [29]. Easy access and inadequate use of antibiotics and ecto- and endoparasite treatments in pets by the habitants of these communities could represent a risk due to environmental contamination, leading to ecosystem and environmental health imbalances [29,30]. The effect on ecosystem health is unclear due to unrestricted access to veterinary medications for pets in Costa Rica. To address antibiotic resistance and environmental exposure to pesticides, more evidence-based strategies are needed to create public policies emphasizing veterinary drug control and expanding veterinary services.

Skin diseases such as dermatophytosis (due to *Microsporum canis*, *T. rubrum* complex, *Trichophyton mentagrophytes* complex and *Nannizzia gypsea*) and scabies (due to *Sarcoptes scabiei* var. *canis* and *Notoedres cati*), might have a zoonotic component [31–34]. Fleas and ticks can act as vectors for infectious zoonotic agents, posing a health risk to both humans and other animals in the vicinity [35]. Often, individuals are unaware of the potential health risks of these ectoparasites and skin lesions. In some instances, owners of pets diagnosed with dermatophytosis also exhibit skin lesions consistent with tinea, which are clinical manifestations of zoonotic dermatophytosis in humans [36]. While further studies are required to conclusively demonstrate the transmission of dermatophytes to humans, reported cases suggest that such cases can occur [31–34]. Addressing dermatologic diseases, particularly neglected zoonoses like dermatophytosis, can be a proactive measure for prevention. Educating individuals about skin diseases in animals and adopting the correct approach can lead to the alleviation of problems related to animal, environmental, and public health [30,37]. In Costa Rica, dermatological diseases in pets residing in underserved communities pose a multifaceted neglected issue, encompassing health,

environmental, and socioeconomic aspects that necessitate innovative One Health solutions.

Another important condition identified was the low body condition score in some animals. The possible causes were multifactorial, including concomitant diseases like parasitism, heart and/or kidney disease, and endocrine or oncological pathologies. In addition, nutritional aspects such as poor-quality feed (including only leftover food from home and trash) or inadequate portions (due to ignorance or economic limitations) also contribute. There was a lack of knowledge about what was considered an appropriate body condition for their pets. Nutrition and access to potable water are one of the cornerstones of animal health. Proper nutrition can enhance and extend an animal's quality of life [35]. Providing guidance and education on animal nutrition for companion animals can positively affect global health.

4. Challenges and their assessment

Community engagement makes it possible to recognize strengths and weaknesses in developing a healthy human-animal-environment interface. We recognized that to enhance people's health, it is imperative to expand the scope of pet patients and keep strengthening the relationships. A vital factor for success was the respect shown to their beliefs and culture. To provide a positive experience, the veterinary team must communicate assertively and show empathy when bringing their pets for evaluation [36].

From a One Health perspective and the veterinary services offered, it is necessary to keep improving and incorporating innovative ideas to face challenges. The project has run into obstacles in the university and its bureaucratic model. Similar problems have been reported in the human health system [37]. However, it has surpassed these obstacles to sustain itself throughout time, given its necessity and beneficial solution to underprivileged populations' issues. Effective communication with stakeholders plays a key role. It is critical to thoroughly explain the project's goals and provide encouraging outcomes to demonstrate their benefits to all parties involved. With the economic and administrative challenges that the human health system suffers in Costa Rica [37], creating intra- and inter-institutional links to access funds to generate multidisciplinary projects that pursue global health is urgent. Similarly, forming partnerships among organizations focusing on animal health can give these populations access to medical care at a low cost or even free. Reassessment and follow-up visits should be more frequent to continue to improve their health. Self-evaluations are crucial to maintaining quality service by the care provided.

Ecological determinants can be essential in shaping infectious and non-infectious disease presentation. The risks of being exposed might be increased or decreased by socioeconomic factors. Poor housing conditions can contribute to the spread of vector-borne diseases such as arboviruses, heartworms, Chagas disease, Leishmaniasis and pollution exposure [38–40]. Neglected tropical zoonotic diseases involving companion animals are a crucial aspect addressed by this effort, as these diseases are endemic in the locations we visited. In Latin America, vector-borne diseases are complex and frequently underestimated. A strong call for disease prevention in companion animals through a One Health approach is needed [41]. We hypothesized that the health outcomes of these underprivileged groups could be significantly impacted by their environmental and housing conditions. It is crucial to study the ecological and social factors that influence these communities and how they could impact human and animal health. In Costa Rica, actions to support safe and healthy environments for people and their pets in these communities must be addressed in a multisectoral national health security plan. Providing health education towards a One Health approach should positively impact personal hygiene, housing conditions, and community waste management, to support ecosystem health.

5. One Health initiatives towards the future in underserved communities of Costa Rica

A long-term objective is to incorporate and engage various disciplines that can collaborate to realize One Health for One Costa Rica. Infectious diseases and pollutants do not adhere to social and economic boundaries. Preventing zoonotic and non-infectious diseases in underserved communities can benefit not only those communities but also medium- to high-socioeconomic ones, particularly in densely populated areas like the great metropolitan region. The growth and well-being of human and animal populations and the ecosystems they share are facilitated through interdisciplinary and multisectoral efforts. Physicians, anthropologists, social scientists, dentists, microbiologists, pharmacists, nutritionists, economists, agronomists, communicators, engineers, psychologists, biologists, ecologists, social and environmental scientists, and data scientists are among the potential collaborators, though the list is not exhaustive. It would depend on the needs of each community and the issues faced. Although these professionals have occasionally helped, certain areas where veterinarians lack experience require improvement with a methodical work plan and continuous support from other disciplines.

In the future, data collected from these animals could be useful in investigating risk factors for infectious and non-infectious diseases using them as sentinels [10,38]. Acquiring information, identifying risk factors, and carrying out epidemiological and ecological studies will provide proof to support the creation of public policies that will enhance people's quality of life while safeguarding the environment.

Veterinary schools teach medicine under ideal healthcare conditions. Future veterinarians must receive community services training to be able to develop skills to face complex challenges after graduation. The extension programs, upon learning about social problems, give rise to research initiatives aimed at creating solutions. Undergraduate and graduate courses leverage problems and their solutions for the training of future professionals. The convergence of extension, research, and teaching—which forms the cornerstone of Costa Rica's public universities—must be emphasized. This clinical model positively impacts underserved communities in Costa Rica from a One Health perspective. Improving and advocating for holistic solutions to current or upcoming issues is a duty that public institutions must have for their nation. Under the direction of experts, community members must take the lead in some activities related to healthy community development. However, for specific aspects, the presence and supervision of professionals is a necessity that must increase in quantity and quality. This project dedicated to providing veterinary care in underserved areas in Costa Rica has an outstanding One Health impact placing it as a pioneering model to address complex issues in Costa Rica.

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Declaration of competing interest

The authors declare no conflict of interest.

Data availability

Data will be made available on request.

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References

- [1] J.S. Mackenzie, M. Jeggo, The one health approach—why is it so important? *Trop. Med. Infect. Dis.* 4 (2019) 88, <https://doi.org/10.3390/tropicalmed4020088>.
- [2] R. Gunvaldsen, One health case studies: addressing complex problems in a changing world, *Can. Vet. J.* 58 (2017) 1223.
- [3] R.R.N. Alves, S.I. da Policarpo, Chapter 13 - animals and human health: Where do they meet?*, in: R.R. Nóbrega Alves, U.P. Albuquerque (Eds.), *Ethnozology*, Academic Press, 2018, pp. 233–259, <https://doi.org/10.1016/B978-0-12-809913-1.00013-2>.
- [4] J.-L. Rault, S. Waiblinger, X. Boivin, P. Hemsworth, The Power of a Positive Human–Animal Relationship for Animal Welfare, *Front. Vet. Sci.* 7 (2020). <https://www.frontiersin.org/articles/10.3389/fvets.2020.590867> (accessed May 13, 2023).
- [5] G. Larson, E.K. Karlsson, A. Perri, M.T. Webster, S.Y.W. Ho, J. Peters, P.W. Stahl, P. J. Piper, F. Lingaas, M. Fredholm, K.E. Comstock, J.F. Modiano, C. Schelling, A. I. Agoulnik, P.A. Leegwater, K. Dobney, J.-D. Vigne, C. Vilà, L. Andersson, K. Lindblad-Toh, Rethinking dog domestication by integrating genetics, archeology, and biogeography, *Proc. Natl. Acad. Sci. USA* 109 (2012) 8878–8883, <https://doi.org/10.1073/pnas.1203005109>.
- [6] K. Compitus, A Brief History of the Human–Animal Bond, in: K. Compitus (Ed.), *The Human–Animal Bond in Clinical Social Work Practice*, Springer International Publishing, Cham, 2021, pp. 7–14, https://doi.org/10.1007/978-3-030-87783-5_2.
- [7] C. Solís, A. Ramírez, Tenencia y cuidado de mascotas en las viviendas. https://www.ucr.ac.cr/medios/documentos/2013/estadistica_ucr_actualidades_2013.pdf, 2013 (accessed April 13, 2023).
- [8] Centers for Disease Control and Prevention (CDC), How to stay healthy around pets. Healthy pets, Healthy People (2022). <https://www.cdc.gov/healthypets/keeping-pets-and-people-healthy/how.html> (accessed April 25, 2023).
- [9] J.F. Dovidio, L.A. Penner, T.L. Albrecht, W.E. Norton, S.L. Gaertner, J.N. Shelton, Disparities and distrust: the implications of psychological processes for understanding racial disparities in health and health care, *Soc. Sci. Med.* 67 (2008) 478–486, <https://doi.org/10.1016/j.socscimed.2008.03.019>.
- [10] J.M. Sweeney, P. Zielinska Crook, N. Deeb-Sossa, B. Tu, J.D. Dear, J.A.K. Mazet, Clinical one health: a novel healthcare solution for underserved communities, *One Health* 6 (2018) 34–36, <https://doi.org/10.1016/j.onehlt.2018.10.003>.
- [11] P. Rabinowitz, L. Conti, One health and emerging infectious diseases: clinical perspectives, *One Health: Human-Animal-Environ. Interf. Emerg. Infect. Dis.* 365 (2012) 17–29, https://doi.org/10.1007/82_2012_263.
- [12] World Veterinary Association, WVA Declaration of Incheon on the Role of the Veterinary Profession in One Health and EcoHealth Initiatives. https://worldvet.org/uploads/news/docs/wva_declaration_of_incheon_final.pdf, 2018 (accessed January 27, 2024).
- [13] G.A. Sánchez-Azofeifa, A. Pfaff, J.A. Robalino, J.P. Boomhower, Costa Rica's payment for environmental services program: intention, implementation, and impact, *Conserv. Biol.* 21 (2007) 1165–1173, <https://doi.org/10.1111/j.1523-1739.2007.00751.x>.
- [14] T.H.A. Vendramini, A.R. Amaral, V. Pedrinelli, R.V.A. Zafalon, R.B.A. Rodrigues, M.A. Brunetto, Neutering in dogs and cats: current scientific evidence and importance of adequate nutritional management, *Nutr. Res. Rev.* 33 (2020) 134–144, <https://doi.org/10.1017/S0954422419000271>.
- [15] M. Root Kustritz, Effects of surgical sterilization on canine and feline health and on society, *Reprod. Domest. Anim.* 47 (2012) 214–222, <https://doi.org/10.1111/j.1439-0531.2012.02078.x>.
- [16] H.A. Dabritz, E.R. Atwill, I.A. Gardner, M.A. Miller, P.A. Conrad, Outdoor fecal deposition by free-roaming cats and attitudes of cat owners and nonowners toward stray pets, wildlife, and water pollution, *J. Am. Vet. Med. Assoc.* 229 (2006) 74–81, <https://doi.org/10.2460/javma.229.1.74>.
- [17] S.R. Loss, T. Will, P.P. Marra, The impact of free-ranging domestic cats on wildlife of the United States, *Nat. Commun.* 4 (2013) 1396, <https://doi.org/10.1038/ncomms2380>.
- [18] S. Zhu, E. VanWormer, K. Shapiro, More people, more cats, more parasites: human population density and temperature variation predict prevalence of toxoplasma gondii oocyst shedding in free-ranging domestic and wild felids, *PLoS One* 18 (2023) e0286808, <https://doi.org/10.1371/journal.pone.0286808>.
- [19] C. Castro, J.B. Oliveira, J. Hernández, A. Jiménez, M. Jiménez, Contaminación por parásitos gastrointestinales de caninos en dieciocho playas del Pacífico Central de Costa Rica: implicaciones para la salud pública, *Ciencias Vet.* 27 (2009) 47–56.
- [20] P.P. Pastoret, P. Jones, Veterinary vaccines for animal and public health, *Dev. Biol. (Basel)* 119 (2004) 15–29.
- [21] S. Cleaveland, S.M. Thumbi, M. Sambo, A. Lugelo, K. Lushasi, K. Hampson, F. J. Lankester, Proof of concept of mass dog vaccination for the control and elimination of canine rabies, *Rev. Sci. Tech.* 37 (2018) 559–568, <https://doi.org/10.20506/rst.37.2.2824>.
- [22] F. Micoli, F. Bagnoli, R. Rappuoli, D. Serruto, The role of vaccines in combatting antimicrobial resistance, *Nat. Rev. Microbiol.* 19 (2021) 287–302, <https://doi.org/10.1038/s41579-020-00506-3>.

- [23] American Veterinary Medical Association, Vaccinations, American Veterinary Medical Association. <https://www.avma.org/resources-tools/pet-owners/petcare/vaccinations>, 2023 (accessed May 14, 2023).
- [24] R. Almuna, A.M. López-Pérez, R.E. Sarmiento, G. Suzán, Drivers of canine distemper virus exposure in dogs at a wildlife interface in Janos, Mexico, *Vet. Rec. Open* 8 (2021) e7, <https://doi.org/10.1002/vro2.7>.
- [25] C.M.C. Rodrigues, S.A. Plotkin, Impact of vaccines; health, economic and social perspectives, *Front. Microbiol.* 11 (2020). <https://www.frontiersin.org/articles/10.3389/fmicb.2020.01526> (accessed May 14, 2023).
- [26] S. Shwiff, K. Hampson, A. Anderson, Potential economic benefits of eliminating canine rabies, *Antivir. Res.* 98 (2013) 352–356, <https://doi.org/10.1016/j.antiviral.2013.03.004>.
- [27] M. Motta, G. Motta, D. Stecula, Sick as a dog? The prevalence, politicization, and health policy consequences of canine vaccine hesitancy (CVH), *Vaccine* 41 (2023) 5946–5950, <https://doi.org/10.1016/j.vaccine.2023.08.059>.
- [28] L. Guardabassi, P. Damborg, I. Stamm, P.A. Kopp, E.M. Broens, P.-L. Toutain, ESCMID study Group for Veterinary Microbiology, diagnostic microbiology in veterinary dermatology: present and future, *Vet. Dermatol.* 28 (2017) 146–e30, <https://doi.org/10.1111/vde.12414>.
- [29] C.J. Little, A.B. Boxall, Environmental pollution from pet parasiticides, *Vet. Rec.* 186 (2020) 97, <https://doi.org/10.1136/vr.m110>.
- [30] S.I. Polianciuc, A.E. Gurzău, B. Kiss, M.G. Ștefan, F. Loghin, Antibiotics in the environment: causes and consequences, *Med. Pharm. Rep.* 93 (2020) 231–240, <https://doi.org/10.15386/mpr-1742>.
- [31] M. Wilson, N. Lountzis, T. Ferringer, Zoonoses of dermatologic interest, *Dermatol. Ther.* 22 (2009) 367–378, <https://doi.org/10.1111/j.1529-8019.2009.01248.x>.
- [32] J.L. Gallegos, I. Budnik, A. Peña, M. Canales, M. Concha, J. López, Sarcoptico mange: report of an outbreak in a family and their pet, *Rev. Chilena Infectol.* 31 (2014) 47–52, <https://doi.org/10.4067/S0716-10182014000100007>.
- [33] K.A. Moriello, K. Coyner, S. Paterson, B. Mignon, Diagnosis and treatment of dermatophytosis in dogs and cats.: clinical consensus guidelines of the world Association for Veterinary Dermatology, *Vet. Dermatol.* 28 (2017) 266–e68, <https://doi.org/10.1111/vde.12440>.
- [34] B. Moroni, L. Rossi, C. Bernigaud, J. Guillot, Zoonotic episodes of Scabies: a global overview, *Pathogens* 11 (2022) 213, <https://doi.org/10.3390/pathogens11020213>.
- [35] A.K. Shoveller, G. Bosch, L. Trevizan, J.J. Wakshlag, D.A. Columbus, Editorial: nutrition and Management of Animals we Keep as companions, *Front. Vet. Sci.* 8 (2021) 748776, <https://doi.org/10.3389/fvets.2021.748776>.
- [36] L.R. Kogan, V.H. Accornero, E. Gelb, M.R. Slater, Community veterinary medicine programs: pet Owners' perceptions and experiences, *Front. Vet. Sci.* 8 (2021). <https://www.frontiersin.org/articles/10.3389/fvets.2021.678595> (accessed May 29, 2023).
- [37] M.L. Ávila-Agüero, La problemática de la Caja Costarricense de Seguro Social desde la óptica de los determinantes de la salud, *Acta Med. Costarric.* 55 (2013) 139–142.
- [38] American Public Health Association, Advancing a “One Health” Approach to Promote Health at the Human-Animal-Environment Interface. <https://apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2018/01/18/advancing-a-one-health-approach>, 2017 (accessed January 14, 2024).
- [39] L. Wei, P. Kelly, K. Ackerson, H.S. El-Mahallawy, B. Kaltenboeck, C. Wang, Molecular detection of *Dirofilaria immitis*, *Hepatozoon canis*, *Babesia* spp. *Anaplasma platys*, and *Ehrlichia canis* in dogs on Costa Rica, *Acta Parasitol.* 60 (2015) 21–25, <https://doi.org/10.1515/ap-2015-0003>.
- [40] O. Jaramillo-Antillón, A. Espinoza-Aguirre, R. Lobo-Philp, Estado actual de la leishmaniosis en Costa Rica, *Acta Med. Costarric.* 51 (2009) 158–164.
- [41] R.G. Maggi, F. Krämer, A review on the occurrence of companion vector-borne diseases in pet animals in Latin America, *Parasit. Vectors* 12 (2019) 145, <https://doi.org/10.1186/s13071-019-3407-x>.