

The Evolving Role of Veterinarians in Public Education and Communication About Parasites

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Abbreviations

CAPC Companion Animal Parasite Council

Abstract

Parasitic zoonoses, which are rising in the wake of climate change, impact the interface of human and animal health. In this perspective paper, a historical analysis is presented regarding the role veterinarians have played from the 1990s to 2022 in addressing parasitic infections. Utilizing a thematic analysis of popular veterinary science articles and a discussion of the peer-reviewed literature, a need is demonstrated for both veterinarians and physicians to contribute to the education of clients/patients, as well as the general public, about zoonotic parasites and prevention practices. In order to mitigate parasitic zoonoses via improved health communication and education, it is critical for veterinarians to be aware of public perceptions and misconceptions about parasites, to augment their professional training on best practices for communicating about parasites, and to advocate for the vital role of veterinarians in integrated, One Health-centric conversations. While broad-scale campaigns directed at disease education and prevention are often delivered by public health agencies and non-profit organizations, the explicit pleas in the *Veterinarian's Oath* to promote public health and benefit society serve as tangible reminders of the opportunities for veterinary professionals to communicate and educate about parasitic zoonoses.

Introduction

Multiple sources have named veterinarians as public health professionals, and this role is explicitly noted in the *Veterinarian's Oath* (1–4). While certain aspects of this role are more tangible, such as the reporting of certain infectious diseases, other roles for veterinarians in public education and communication are more nebulous and evolving. Historical trends and precedents exist for veterinarians to play a public health communication role regarding parasitic zoonoses. Using both a thematic analysis of popular veterinary scientific literature and a discussion of the peer-reviewed literature, the authors outline how the role of veterinarians in communication about parasitic zoonoses has evolved from the 1990s to the present. While a One Health-centered, multifaceted approach has been discussed in recent years, defining the specific role of veterinarians in these conversations warrants more attention (5–6).

One Health is a collaborative, interdisciplinary effort that seeks to promote optimal health for people, animals, and the environment. The concept of One Health recognizes that problems such as climate change and zoonotic disease often impact more than 1 of these 3 sectors, often working at their interface. One Health also calls for multifaceted approaches involving stakeholders from several domains: community members,

public health officials, climate scientists, environmental engineers, veterinarians, physicians, policymakers, and more (7). Ultimately, an ongoing dialogue among a large selection of professionals including biologists, epidemiologists, physicians, pharmacists, and veterinarians will be important to evoke positive change. Questions and needs existing in the field are identified to guide veterinarians in continuing to play active roles in client education as part of integrated prevention plans for these zoonoses in both animals and humans.

Parasitic Zoonoses

Zoonoses are diseases or infections transmissible from vertebrate animals to humans. Zoonotic disease accounts for 75% of all emerging infectious disease and can be devastating to human and animal health on a global scale (8). Zoonotic parasites include both protozoa (for example, *Cryptosporidium* spp, *Toxoplasma gondii*, *Leishmania* spp, and *Trypanosoma* spp) and helminths (*Fasciola* spp, *Paragonimus* spp, *Echinococcus* spp, *Taenia* spp, *Angiostrongylus* spp, *Anisakis* spp, *Ascaris* spp, *Calodium hepaticum* [syn *Capillaria hepatica*], *Toxocara* spp, and *Trichinella* spp) (6, 9–10). Interfacing with these parasites is not new for veterinarians, but globalization and climate change will inevitably have a tremendous impact on their expansions and changing distributions. These pathogens are effective at modifying their epidemiological patterns and ecological niches in response to ever-changing biotic and abiotic parameters (6). For climate-related impacts in particular, it is known that increased humidity often favors the survival of parasite eggs, larvae, and cysts/oocysts in the environment (6). Hotter temperatures can also increase the habitable zones for parasite vectors such as sand flies that carry the zoonotic protozoa *Leishmania* spp (11). Parasitic zoonoses thus represent a classic example of the One Health model in which humans, animals, and the environment all affect, or are affected by, the transmission of these parasites.

Zoonotic parasites have markedly different routes of infection, and some obtain entry into human hosts by way of multiple mechanisms. Some groups, including protozoa and helminths, serve as umbrellas for certain pathogens responsible for global water- and foodborne illnesses, and these organisms pose a prominent risk to human health (5–6). For example, toxoplasmosis can be acquired from exposure to sporulated oocysts in cat feces, through the ingestion of undercooked meat, or even other mechanisms. Conversely, other diseases may develop after the host encounters an arthropod vector harboring a zoonotic pathogen or ingests an infectious

parasitic life-stage present in contaminated food or water (9, 12). Hygiene measures may be more effective at disrupting transmission of parasites with direct life cycles, in contrast to those that must utilize intermediate hosts. Our understanding of zoonotic risks as they relate to certain genera is also evolving, due to molecular advancements and research on the genetic diversity of organisms. While the zoonotic potential of *Giardia* spp and *Sarcoptes scabiei* has been highlighted, much of the recent literature suggests a higher degree of host specificity than was once assumed (10, 12–14).

A suite of challenges exists that makes the detection and control of zoonotic parasites difficult. Some species might be overlooked as etiological agents of food- or waterborne disease due to the amount of time between infection and the observance of clinical signs or symptoms (5). Alteration of human behaviors such as the proper cooking of food (with its cultural and social significance), control of stray and feral pet populations, and hygiene practices can be difficult to implement and often require complex approaches to client and/or community-based education and outreach programs (10).

The Role of Veterinarians in Addressing Parasitic Zoonoses

In 1999, a report concerning the business market for veterinarians noted that traditional approaches may not meet changing demands in public health and the global food system due to increases in zoonotic diseases and other threats. As such, there has been a growing movement to encourage wildlife veterinarians to play a role in a multifaceted, One Health-centric approach to combatting zoonoses (15–16).

While veterinarians could play multiple roles within the One Health model, such as coordinating with wildlife and agricultural stakeholders or working with community members who collect data about animal disease, there is a particular interest in the communication and education roles veterinarians play in addressing parasitic zoonoses (15, 17–18). To assess these evolving aspects, a dual approach of analyzing popular veterinary science sources as well as peer-reviewed literature was utilized in this review.

A Thematic Analysis of Popular Veterinary Science Literature on Parasitic Zoonoses

Popular veterinary science literature discussing parasitic zoonoses published online or in print beginning in the 1990s to the present was analyzed for themes related to the roles of veterinarians in public health (Table 1) (19–57).

Table 1: Popular veterinary science articles analyzed for themes

Author	Publication	Article Title	Year	Reference
Peter M. Schantz	Topics in Veterinary Medicine	Zoonosis of Enteric Parasitism	1990	19
Edward Roberson	Pet Veterinarian	Rx Update: What Internal Parasiticides Make Sense for Your Practice	1991	20
Tim Philips	Pet Veterinarian	Tick-borne Zoonoses	1991	21
Peter M. Schantz	Pet Veterinarian	Neglected Zoonosis	1992	22
unstated	pamphlet: Recommendations for Veterinarians	How to Prevent the Transmission of Intestinal Roundworms from Pets to People	1994	23
Bayer Co.	Veterinary Forum	Bayer Booklet	1996	24
James F. Wilson, Charlotte Lacroix, Candace Allert	Veterinary Forum	Zoonotic Parasitic Diseases: A Legal and Medical Update	1996	25
Bayer Co.	pamphlet	Parasitic Zoonoses	1998	26
Fort Dodge Animal Health	pamphlet	Update: Giardia	1999	27
Arden Moore	Veterinary Practice News	Parasites Remain a Zoonotic Concern	2000	28
Wendy S. Meyers	Veterinary Practice News	Protecting Clients from Zoonotic Diseases	2002	29
Anthony P. Carr	Veterinary Practice News	Here to Protect	2003	30
CAPC (Companion Animal Parasite Council)	Capcvet.org website	CAPC	2004	31
Mark Cantrell	Veterinary Practice News	Vets on the Front Lines of Zoonotic Awareness	2005	32
Peter M. Schantz	Veterinary Messenger	Preventing <i>Toxocara</i> Infection in Humans: A Challenge and Opportunity for Veterinarians	unstated	33
Kevin R. Kazacos	DVM 360	CAPC Guidelines Offer Best Practices for Parasites	2006	34
unstated	DVM 360	3 Tips for Talking about Parasites	2006	35
Dwight Bowman	DVM 360	Keep Families Healthy	2006	36
Anthony P. Carr	DVM 360	Parasitic Zoonoses: What You Don't Know Can Hurt You	2008	37
Scott Weese	Worms & Germs Blog	<i>Baylisascaris</i> and Dogs	2010	38
Scott Weese	Worms & Germs Blog	Infectious Disease Considerations for Fostering Pets	2010	39
Scott Weese	Worms & Germs Blog	Toddler Risks Losing Eye to Dog Parasite...Maybe	2010	40
Melissa Andrasik	DVM 360	Your Role in Parasite Prevention and Treatment	2011	41
Rachael Zimlich	DVM 360	CAPC To Direct Efforts to Consumer Education	2011	42
CAPC	CAPC	The Nonprofit Parasite Authority Issues Its Second-ever Parasite Forecast for Ticks and Lyme Disease	2012	43
Wendy S. Myers	Veterinary Practice News	Why You Should Communicate the Value of Preventive Care	2014	44
American Animal Hospital Association (AAHA)	NEWStat	CAPC-Bayer Study Reveals Veterinary Practice Opportunities via Parasites Education and Testing	2015	45
Don Jergler	Veterinary Practice News	Best Practices for Pet Parasites	2016	46
CAPC	CAPC	CAPC Forecasts 2017 to Be a Hotbed for Heartworm	2017	47

Table 1: Popular veterinary science articles analyzed for themes, continued

Author	Publication	Article Title	Year	Reference
David W. Ramsey	Veterinary Practice News	Four Important Internal Parasites to Consider	2017	48
AAHA	2019 AAHA Canine Life Stage Guidelines	Zoonoses and Human Safety	2019	49
Rhonda Brooks	Bovine Veterinarian	Zoonotic Diseases Contribute to Collaboration Between DVMs, MDs	2020	50
Anne French	Veterinary Practice News	Heartworms in Dogs: An Ever-present Global Problem	2020	51
unstated	Vet Practice	New Research Reveals Dog Owner Understanding of Parasites and Zoonotic Diseases	2020	52
Julia Burke	DVM 360	3 Pointers for Parasite Prevention Education	2021	53
Wendy S. Myers	Veterinary Practice News	Are You Ready for a Potential Spike in Intestinal Parasites?	2021	54
David Katz	The Daily Pennsylvanian	Penn Vet Establishes Institute for Infectious Zoonotic Diseases	2021	55
unstated	Veterinary Practice News	Vector-borne Diseases Likely a Higher Risk This Year	2022	56
Bob Alaburda	DVM 360	Projections and Direction in Parasite Protection	2022	57

Thematic analysis is a useful method for identifying, analyzing, and reporting patterns within a set of qualitative data (58). It was employed to identify patterns in contemporary messaging used for veterinary health communications. Classifications of themes from the documents were formulated by first reviewing the text and graphics of the articles for understanding, then closely examining the material for specific content related to the communication strategies employed to discuss zoonoses (Table 2). Finally, emergent themes were verified through discussion amongst the investigators. Articles were collected until saturation of themes in various time periods was reached. Relevant topics included specific messaging to clients surrounding zoonoses, risk factors for disease, and identification of key spokespersons within the field. The fluctuation of themes within these topics over time is shown in Figure 1.

Encouraging physician involvement in collaboration with veterinarians is raised in 5 of the 39 articles examined, with an increase in frequency since the late 1990s (25, 30, 32, 37, 50). According to a 1996 article in the journal *Veterinary Forum*, physician awareness of the threat posed by zoonotic infections is belated but growing (24). This sentiment was echoed in another veterinary magazine from the same year, which stated that although zoonotic infections can have devastating consequences in humans, medical practitioners may not understand the importance of patient education (25). Collaboration across disciplines supports the One Health approach to tackling parasitic zoonoses by engaging a range of actors in disease mitigation.

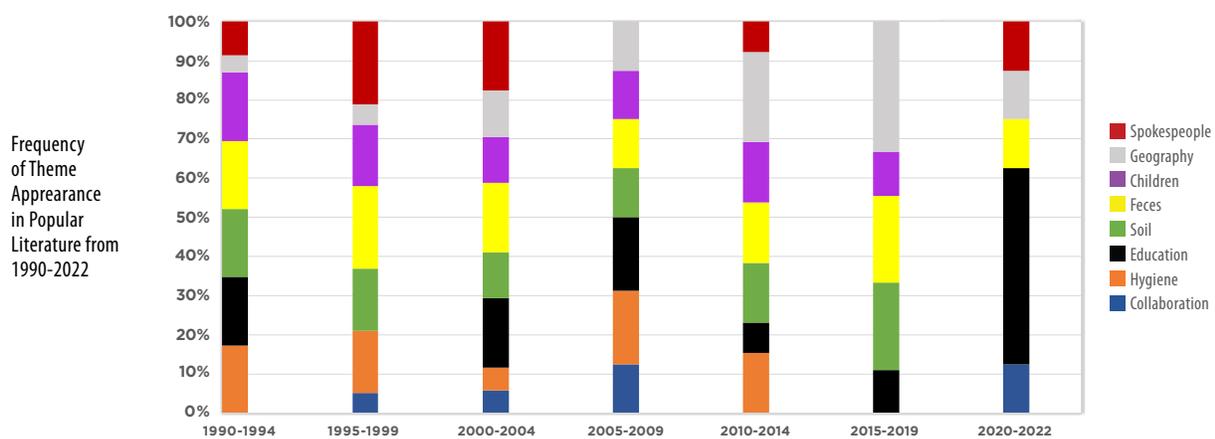
As summarized from the articles, more educational materials are needed for human medicine practitioners for the rapid recognition, proper diagnosis, and improved health care of individuals with parasitic zoonoses. This theme was explicitly present in 16 of the 39 publications, but the remaining articles that did not use the word *education* still included information on conveying key biological features or transmission cycles relevant to the transmission of parasites, either in words or in images (ie, life cycle flow charts, microscopy images, or photos of infection sites). It can be inferred that all of the articles analyzed included the use of education as a tool for reducing the rates of parasitic zoonoses occurring in pets and people. Despite being a theme across all publications, the need for education was rarely supported with information on specific best practices or direct solutions to knowledge gaps pet owners might have on how to protect their animals and themselves. Articles published online after the year 2000 had the added benefit of including links to additional resources, which acts as a step toward client education.

Of the 39 documents analyzed, 15 mentioned that children, who often are unable to modify their health behaviors to avoid parasite exposure, are disproportionately at risk for infection with a zoonotic disease due to play habits (such as from playing in a sandbox or consuming dirt). Case studies of infected children presenting with ocular disease, rashes, or other clinical signs were included in several articles; overall, stories about children were more common than those describing adults. Despite not

Table 2: Themes about parasitic zoonoses identified in popular veterinary science articles

Main Theme	Sub Theme	Examples and Associated Topics	Frequency
Veterinarians' responsibilities in public health	Collaborate with physicians	More exposure to zoonoses training and diagnostics; work together for client care	5/39
	Emphasize that proper hygiene is necessary	Pet and owner hygiene; handwashing, cleaning to prevent fomites	13/39
	Veterinarians as educators	Treat pets but also educate the pet owners	16/39
Risk factors for parasitic zoonoses	Environment	Enforce leash laws and clean up after pets; potential for water- or foodborne parasites; fomites in soil	16/39
	Fecal Contamination	Animal feces as a means of surveillance or diagnosis; fecal-oral route as main transmission	19/39
	Children	Disproportionately at risk due to behaviors such as exposure to soils by consuming dirt, or not having control over their own cleanliness	15/39
	Geography	Prevalence dependent on where diseases are reportable and how often reported; Southeast United States is susceptible due to the humid, temperate environment	14/39
Spokespeople for parasitic zoonoses	Candace Allert: the need for legal protection	Veterinarians at risk for litigation if pet owners become ill	2/39
	Peter Schantz: the need for awareness	Medication schedules for pets provided by CDC	7/39
	Wendy Myers: client engagement	Messaging and intentional communications with clients are needed	3/39

Figure 1.



Frequency of theme appearance in popular science articles over time, as a proportion of the total documents analyzed from that time period

reaching a high enough prevalence level to constitute a theme, it is of note that some documents listed the following individuals as being at higher risk for zoonoses because of personal health status or occupation: the immunocompromised, veterinary staff, electricians, plumbers, beachgoers, and others who may have contact with soil or infected animals.

Contaminated soil and feces as the primary means of parasite transmission to animals or people was heavily emphasized in the literature, appearing in 16 of 39 (soil) and in 19 of 39 (feces) publications, respectively. Feces can be a means of either surveillance or diagnosis, but the fecal-oral route is also a well-known mode of transmission for parasites. The articles analyzed highlighted the transmission of parasites from the feces of

animals ranging from puppies and kittens to raccoons and horses. Contaminated environments increase the potential for water- or foodborne parasites, or for fomites in soil. Improved disease surveillance has appeared to increase during the years 1999 to 2010 in specific geographical regions tied to communications on parasitic zoonoses (Figure 1). Although environmental risks are prevalent for these diseases, simple preventative measures can be encouraged by veterinarians for both their clientele and the public, including hand-washing, upholding leash laws, cleaning up after pets, and other basic hygiene steps. The observation of best hygienic practices for both pets and owners was blatantly expressed as a key preventive measure in 13 of the 39 articles, and alluded to in others, albeit less frequently after 2014 (Figure 1).

In the analyzed articles, a few individuals were regularly featured as authors or sources for relevant information related to parasitic zoonoses and the role of veterinarians. Peter M. Schantz, VMD from the CDC stood out as a spokesperson for zoonoses, namely for *Toxocara* spp infections in humans and the associated zoonotic risks including visceral and ocular larval migrans. In the *Veterinary Messenger* article *Preventing Toxocara spp Infection in Humans: A Challenge and Opportunity for Veterinarians*, authored by Schantz, he states his belief that by providing information and helpful advice on prevention of pet-borne zoonoses, the veterinarian achieves positive reinforcement of the veterinarian-client bond (33). This statement echoes what Schantz's voice maintains in the 7 articles he authored or in which he was mentioned—that veterinarians need to be engaged in the education of others about parasitic zoonoses (13, 19, 24, 28–30, 33).

Candace Allert, DVM, featured in 2 of the 39 analyzed articles, wrote a 1996 *Veterinary Forum* piece in support of legal protection for veterinary professionals in the event of negative consequences when pet owners are unaware or uneducated about zoonotic threats. A consent or release form is a good suggestion (25). Wendy Myers, mentioned in 3 of 39 articles, was also a source of specific messages or

deliverables (like pamphlets) that could be used by veterinarians and clinic staff for clients. Spokespeople for the field have remained a presence in popular literature since the 1990s (Figure 1). The reliance on select individuals as speakers for the entire field may be a weakness, as momentum may not be continued after those individuals transfer out of particular roles. However, having a recognizable authority and source of reliable information can also be a strength.

The Role of Veterinarians in Communication About Parasitic Zoonoses: An Analysis of the Peer-reviewed Literature

The peer-reviewed literature shows there has been strong historical public support for the veterinary profession's focus on large-scale societal needs, such as food animal health and the health of animals used for transportation (59). The One Health concept is not new, but under its umbrella a new generation of veterinarians, physicians, ecologists, biologists, and social scientists is shaping the concept in novel ways (60). While the concept was embraced in the 19th century, collaboration between human and veterinary medicine was relatively diminished in the 20th century (61). In the United States, the attacks of September 11, 2001, and contemporaneous anthrax scares have both been implicated in contributing to heightened interest in public health and zoonotic risks; however, references to the shift of veterinarians away from fields associated with public health roles were being highlighted at the same time (3). In fact, some papers specifically discussed the emerging dichotomy between public and private practice and the urgent need to strengthen the public practice component of the profession (59). At the outset of the 21st century, a survey of physicians and veterinarians in Wisconsin concluded that communication between veterinarians and physicians about zoonotic disease was largely absent (62).

In more recent years, the role of veterinarians in communications surrounding zoonoses has undergone somewhat of a reframing with the advent of a One Health approach to disease. It has been in this emerging body of literature, including peer-reviewed sources, that interdisciplinary collaboration has been strongly highlighted, and discussion of the role of veterinarians in public health and education has resumed. A plea for the close collaboration between veterinary and public health professionals within the One Health concept has been described and often emphasizes veterinarians' strong foundations in health, comparative medicine, and preventive medicine (15, 63–64). Moving forward, it is likely we will see more transdisciplinary



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collaborations, integrative research, and capacity building among universities, government agencies, non-governmental organizations, policymakers, practicing physicians, veterinarians, and the general public (65). More calls are being heard for collaboration among veterinarians, physicians, and public health officials in the areas of individual health, population health, and comparative medicine research for the control of zoonoses. This is important as the veterinary profession moves forward (64).

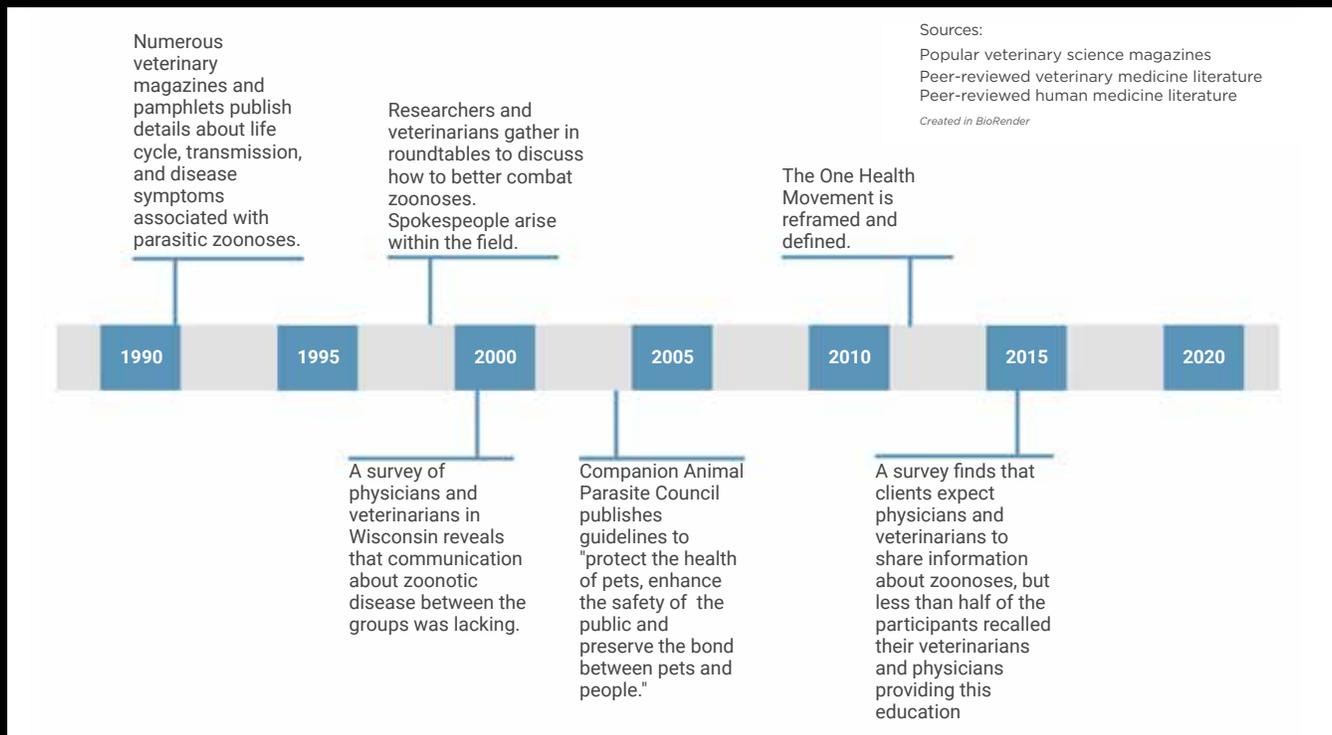
Physicians have historically viewed veterinarians as well-suited for a role in providing education on zoonoses to the public. Interestingly, this role is heavily discussed in human medical journals (62, 66-67). The importance of health communication is well-recognized in the medical community, but according to some, is at times relatively underappreciated in veterinary medicine (68). In the aforementioned study conducted by Grant and Olsen, a survey of physicians and veterinarians in Wisconsin was carried out to assess the risk for and prevention of zoonotic diseases in immunocompromised persons (62). The authors found that the views held by veterinarians and physicians about the risks posed by certain infectious agents and species of animals were dramatically different, and in reality, both types of medical professionals communicated very little about zoonotic issues. The study also verified the belief of physicians that veterinarians should be involved in

many aspects of zoonotic disease prevention, including patient education (62).

In a survey of veterinary clients performed by Steele and Mor, most respondents (84.1%) subscribed to a view that veterinarians have a primary responsibility for providing information about zoonoses, yet less than half (48.1%) recalled ever receiving information from their veterinarian (69). Nearly half of the respondents indicated that medical professionals played a role in providing information about zoonoses, yet less than one-fourth recalled receiving information from their doctor (Figure 2) (69). Despite these discrepancies, there seems to be good support from clients for education delivered by the veterinary professional. Many studies have reported on a number of public health concerns relating to client awareness. Owners are not always thought to be fully aware of the zoonotic parasites that can be carried by their pets or the modes of transmission; therefore, the need for veterinarians to play a greater role in client education is underscored (70).

These studies present an interesting juxtaposition to the findings from the thematic analysis of the popular veterinary science articles, in which veterinarians felt that physicians should increase communication with patients about parasitic zoonoses. This perceived disconnect

Figure 2.



The role of veterinarians in addressing parasitic zoonoses: a summarized timeline

warrants further exploration. Veterinarians may be relatively less aware of the importance of zoonoses than is desirable, and physicians may fail to recognize zoonoses or concentrate on treating the individual patient rather than emphasizing disease control. Nonetheless, there are numerous opportunities for improved dialogue and reporting (71). There is a role for both veterinary and human medical practitioners to communicate about zoonotic diseases in order to improve public awareness and animal and human health. Physicians and veterinarians have many opportunities for partnership to promote the wellbeing of people and their pets (12). Control and prevention of zoonoses are perhaps best achieved by enhancing communication between physicians and veterinarians themselves in order to facilitate better communication with clients and patients (12).

As an example of the synergistic momentum that can occur with interdisciplinary collaboration, the CDC has partnered with the American Academy of Ophthalmology to determine how often cases of ocular toxocariasis were occurring (72). Outreach to medical professionals led to improved awareness and decreased incidence of unrecognized cases. Partnerships with state and local health departments have produced tangible improvements in areas such as community approaches to pet hygiene. Taken by themselves, these measures may seem fragmented or insignificant. Utilizing a One Health approach can result in comprehensive positive change by providing improved and diverse communication, collaboration, prioritization of awareness, and a means to address misconceptions.

A Path Forward: Remaining Questions

The popular veterinary science literature emphasizes the role of veterinarians in educating clients about hygiene in order to protect the health of their pets and children. Both the popular and peer-reviewed literature emphasize the need for veterinarians and physicians to collaborate in communication and education in order to decrease transmission of parasitic zoonoses. There are remaining gaps and questions that must be addressed in order to achieve the goal of an integrated and communicative approach.

What changes in public perception, awareness, and knowledge about parasites are occurring?

In 2017, researchers in Qatar surveyed 150 cat and dog owners regarding parasitic zoonoses. Only 54% of owners were aware of transmissible diseases between animals and humans. The terms *zoonosis* and *zoonotic disease(s)* were unknown by 88% of the respondents, and almost 25% had no knowledge of transmission pathways associated with parasitic diseases (73). Practices such as the feeding of

raw meat that has not undergone proper handling and preparation to render it noninfectious reflect pet owners' lack of understanding of potential zoonotic diseases (73). A 1986 study in the state of Georgia revealed that only 63% of pet owners knew that their pets could transmit diseases to humans (74). Just 54% of survey respondents in a 2008 study in Texas were aware that dogs can transmit worms to humans (75). A need exists for raising awareness. A survey of Zimbabwean pet owners revealed that while only 33% had experienced veterinarians initiating discussions about parasitic zoonoses, 90% wanted their veterinarians to do so (76). Veterinarians should not assume that clients are aware of these diseases, much less the hygiene practices necessary to protect themselves, their children, and their pets. Veterinary practitioners must have training in cultural sensitivity, needed for discussions in areas such as cooking and food preparation practices. Overall, veterinary clinic visits must provide the opportunity for client education in addition to examination and treatment of the pet (77).

Are we devoting a sufficient amount of time to providing this education during professional training programs?

Given the lack of public awareness of parasitic zoonoses coupled with increasing transmission of these diseases, there is arguably a growing need for veterinarians to help educate clients about not only the diseases themselves but also hygiene practices and other approaches to preventing transmission and/or disease. It is worth considering whether veterinarians are getting the training needed to have these conversations. Do veterinarians emerge from professional programs with a sound understanding of parasitic life cycles as well as a solid plan for broaching discussions with clients? Some, even outside of the United States, have argued that the significance of zoonoses and the public health implications are often ignored, and relatively limited resources are invested in investigating them (64). In 2003 the American Association of Veterinary Medical Colleges called for the profession to increase veterinary students' awareness of public health careers and promoted programming designed to encourage students to pursue opportunities in the areas of food safety, research, and ecosystem health (59). Previous research has also pointed out that links between veterinarians and human medical professionals could be fostered on a broader scale through combined veterinary/medical student training and continuing education, which would contribute to an improved consensus on zoonotic risks and prevention (62).

At an undergraduate level, courses in basic epidemiology (including outbreak investigation and disease surveillance), population medicine, infectious and parasitic

diseases (especially new and emerging or re-emerging zoonoses), and ecology should be part of the pre-veterinary core curriculum. Foreign diseases, especially zoonotic ones, need to be included in veterinary-focused curricula. Furthermore, students should learn the principles of ecology and ecosystems, either during pre-veterinary studies or at the beginning of formal veterinary training. At the post-graduate level, Master's degrees in preventive veterinary medicine, ecology and environmental health, or public health with an emphasis on infectious diseases can be offered to veterinarians seeking job opportunities in public health and/or wildlife management (78). Students should also acquire skills to enable understanding of the social sciences, an expertise that can potentially influence community participation and response to disease control (79).

Development of veterinary curricula centered on or incorporating communication practices in general should continue to be prioritized. Additionally, training on the proper manner in which to discuss zoonotic disease with clients would be helpful. These recommendations also apply to the training of human medicine professionals. Certainly, the clinical history taken in the primary care office should include questions about pets and occupational or other exposure to pet animals. Increased communication between primary care physicians and veterinarians could improve treatment and prevention strategies for various pathogens and disease conditions (12, 80).

There has been a shift over time in the definition of what comprises successful tools and approaches for client and public education. A community-based intervention comparing the effectiveness of pamphlets versus videos as education material found that videos led to increased adoption of health behaviors (81). In other study results, veterinarians (89% to 92%) and online information (39% to 51%) were the highest client-reported resources for vaccine and parasite education (82). The increasing effectiveness of videos and other technology-enabled tools in today's public health communication milieu should be coupled with effective veterinarian-client conversations in the clinic. It is important to note that breakdowns or gaps in communication can also have an adverse effect on the veterinarian-client relationship (83).

With in-person conversations with clients, different decision-making models exist for veterinarian-client and physician-patient interactions. The *4E* communication model (engagement, empathy, education, and enlistment) from human medicine may also be useful in the

veterinary medical space (84). In particular, with regard to zoonotic parasites, providing education about disease and empowering clients to make changes in hygiene, cooking, or other practices are important components.

How and why do veterinarians collaborate with others?

A health professional trained to provide care for both human and nonhuman species is a valuable asset as the world attempts to navigate cross-species transmission concerns, identification of infections, and recommendations for interactions with companion animals (85). However, such dual-trained professionals are in the minority, and facilitating collaboration between veterinarians and physicians and others is challenging. There are nonetheless many practical possibilities for improving and increasing these collaborations. Activities related to the One Health concept, particularly in universities, are being developed in recent years as evidenced by the creation of centers for One Health and the broader promotion of training exercises focused on zoonotic diseases of both viral and parasitic etiologies (60). Worldwide, symposia have provided opportunities for cross-sector collaboration among educational and research institutions, and this could help mitigate the impact of zoonoses on human health in low-resource areas (79). Specifically, conferences in which human and veterinary medical professionals are in attendance are often promoted as being beneficial in bridging the goals of different groups (61). Social networking opportunities are inherent at scientific meetings and conferences, and email distribution lists can aid in maintaining relationships (86).

Anholt et al in 2012 discussed the findings of a workshop in which 16 experts involved in interdisciplinary collaboration were in attendance. It was determined that relationships critical to interdisciplinary collaboration are best fostered in the presence of a third-party broker serving as a trusted intermediary between professionals (86). Participants were presented with detailed scenarios with a wildlife, food animal, companion animal, and/or environmental component which enabled them to focus on important elements of interdisciplinary topics in the realm of zoonotic disease.

In recent years, One Health case study examples (rabies, plague, climate change) have also been implemented in evolving curricula to provide inter-professional opportunities for veterinary and medical school students to engage with one another (87). For example, parasitic zoonoses such as echinococcosis have been presented as models for collaboration to bridge knowledge gaps as

well as develop integrated control strategies (79). On a more practical note, simple implementable strategies at the level of clinical care are becoming more accessible and more widely articulated, including 1) education between medical professionals and the public on transmission dynamics of zoonotic disease in situations where a human or animal in the household may be immunosuppressed, 2) advisement that wild species should not be kept as pets, and 3) education on risk management of zoonotic disease in the occupational setting (61).

The adaptation of new strategies by veterinarians in response to changing public awareness, and effective training in parasitology and communication are all necessary but insufficient to achieve the synergistic, One Health-style approaches that are optimal. Policies that expand the roles and the workforce of veterinarians in public health are needed (3). While veterinarians can do a lot of work by themselves to tackle public health education and communication topics, they must also learn to advocate for the profession and forge needed collaborations and alliances in the longer term.

Final Thoughts

The question of how health professionals can all be better stewards with regard to public and client education is important and ongoing. In the age of the internet and with a growing body of misinformation, especially in the sciences, it becomes critical to both identify public misconceptions and to build more bridges between humans and animals, veterinarians and the public, and human and veterinary medical professionals. Misconceptions surrounding zoonotic parasitism have been discussed previously in the highly witty, poignant, and well-written publication entitled *Eating Dirt* (88). The author, Callahan, points out that contaminated soil is a major source of *Toxocara* spp infection, but then highlights that the EPA has estimated that children may consume as much as 200 to 800 mg of dirt per day. He humorously alludes to the real-life challenges faced by parents when attempting to curtail a child's fascination with dirt and speaks artfully on the topic of educating clients on issues of public health in a way that both mitigates risk and also avoids feeding public hysteria. The brilliantly chosen examples in the article remind us that health guidelines created and promoted in the public realm should be evidence-based, but sometimes fail to be.

There is a wealth of public information to be found on global prevalence of parasites, parasitic exposure, routes of transmission, and biology. Zoonotic roundworms are

a good example. There are also extensive reviews on the veterinary and public health aspects of this parasite.

One such article about toxocariasis highlights the fact that since endemic environmental contamination with *Toxocara canis* eggs cannot be substantially reduced, it is especially critical for veterinarians to educate the public about personal hygiene, hygiene practices (eg, removing pet feces from public areas in a timely manner), preventing children from consuming dirt, and other practices that emphasize the importance of prevention of parasitic disease. Additionally, there is a lack of standardized diagnostic criteria for human toxocariasis (63). This presents an opportunity for veterinarians to collaborate with physicians to create such criteria which will lead to healthier outcomes for both humans and animals. Communication by veterinarians is a key to accomplishing all of these goals, from educating and protecting one client's family to effecting change and better health outcomes on a societal and public health level.

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