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Household Pets and Zoonoses

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Summary

- In addition to dogs and cats, the popularity of exotic animals, such as geckos, bearded dragons, and African Dwarf Frogs is increasing; the greatest increase is ownership among children. It is estimated that approximately 75% of emerging infectious diseases are zoonotic.[1,2] The implications of these two trends are of concern to the public health community.

- A review was conducted of household pet zoonoses, comprising:
  - studies published from 2004 to the end of March 2011; English language citations that included North America, Great Britain, France, and Australia;
  - key stakeholder consultations with Canadian experts and authors on pet-related zoonoses in Canada;
  - a scan of provincial and territorial public health agencies in Canada for policies and protocols on household pet zoonoses;
  - trends in pet ownership as well as risks of disease transmission, burden of illness, and current public health practices pertaining to pet zoonoses;
  - policy and intervention gaps, as well as future opportunities for research and collaboration by the public health and veterinary community.

- Pets remain a primary source of numerous reportable and non-reportable diseases:
  - Outbreaks include: salmonellosis, tularaemia, cutaneous larvae migrans, and Human Lymphocytic Chorimeningitis Virus (HLCV) infections.
  - Household pets, such as cats, dogs, turtles, ornamental fish, baby chicks, gerbils, frogs, and lizards have been associated with outbreaks of zoonotic diseases in the United States and Canada.
  - Pet treats and pet foods, such as frozen rodents, raw-hide pet treats, and raw food diets have been cited as potential sources of zoonotic diseases.
  - Children under 5 years of age and immunocompromised individuals have ben noted as the highest risk groups for acquiring pet zoonoses. Risk settings for the transmission of pet zoonotic diseases included: daycare, elementary and secondary school, university, acute care hospital, summer camp for children, veterinary hospital, and the home.

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    - Improper handling of pets and improper hand hygiene have been identified as primary risk factors for the majority of pet-associated infections, e.g., disposing pet waste and water in kitchen sinks.
    - Failure to screen organ donors has been cited as the risk factor for a 2005 outbreak of HLCV. Numerous surveillance, regulatory, knowledge and research gaps were noted during the course of this research.

- Continued growth of the pet industry will necessitate interventions by public health, veterinary, and regulatory communities to mitigate the impact of pet zoonoses on the public. These interventions should include: enhancement of the current surveillance systems, regulations to address existing gaps in the pet food industry, development of policies and protocols at the provincial and federal levels of government, public education regarding the risks associated with handling pets, and greater collaboration among the human and animal health sectors.

Introduction

Pet zoonoses are an emerging public health issue, especially as pet ownership increases and pet definitions expand to include new and exotic animals. There are many companionship and psychological benefits to human contact with pets; however, pets are known reservoirs of zoonotic diseases. Many pet owners are often unaware of the risks their pets may pose and, as a result, engage in husbandry and hygiene practices that increase the likelihood of acquiring diseases.

Global travel, animal trade, population growth, urbanization, climate change, antibiotics, pesticides, increased pet populations, and greater animal product usages have been cited as contributing factors to the emergence and re-emergence of zoonoses.[1-4] Recent zoonotic outbreaks have helped to highlight many additional risk factors related to pets, such as poor animal husbandry, poor hygiene, and sanitation precautions.

This document provides an overview of the incidence of pet zoonoses, including: transmission, risk factors, population at risk, high risk settings, and pet ownership trends. Also provided is an analysis of the activities of public health agencies and their partners in tracking and mitigating the impact of pet zoonoses. The conclusion provides recommendations to improve these practices.

Pet Zoonoses in Canada

Pets have been the source of numerous human infections, such as salmonellosis, tularensis, murine typhus, monkeypox, cutaneous larvae migrans, and Human Lymphocytic Chorimeningitis Virus (HLCV) infections. Additional pet-associated zoonotic infections, both notifiable and non-notifiable, involving household pets that have been identified in Canada can be found in Tables 1, 2, and 3. The tables include routes of transmission and corresponding human health outcomes. Currently, an estimated 75% of emerging infectious diseases are zoonotic; mainly viral and likely to be transmitted by vectors.[1,2] Between 2002 and 2010, numerous outbreaks of reportable and non-reportable zoonotic diseases were identified and found to be associated with household pets (Table 4). A key example is the monkeypox

outbreak, involving prairie dogs and Gambian rats; taking place in the United States in 2004. . Other outbreaks, occurring in Canada, the U.S.A., the United Kingdom, and Australia, are listed in Table 4. Some of these outbreaks crossed international borders.

Risk Assessment

Pet Ownership

It is estimated that more than 50% of American households own at least one pet, while the number of exotic pet businesses is increasing.[5] Approximately 40,000 primates, 4 million birds, 640,000 reptiles, and 350 million tropical fish are live-traded worldwide each year.[6]

In the United States there are over 72 million dogs and nearly 82 million cats.[7] The American Veterinary Medical Association 2007 *Pet Ownership and Demographics* sourcebook shows that American households, with fish as pets, have increased by one-third and the number of combined households with snakes, turtles, lizards, and other reptiles has increased by approximately one-third, as well. In the U.K., there is an increasing trend in the ownership of reptiles; there are more reptiles owned than dogs.[8]

More importantly, a 2009 Canadian survey estimated that approximately 56% of Canadian households have at least one cat or dog; 23% owning cats, 20% dogs, 13% both dogs and cats, 12% fish, 5% birds, 2% rabbits and hamsters, and 1% owning other pets, such as lizards, horses, guinea pigs, snakes, frogs, turtles, ferrets, or gerbils.[9] The Statistics Canada 2006 Census results estimated that over 8 million cats and over 6 million dogs live in Canadian households.[9] In addition, a Canadian survey found that 50% of cats and 22% of dogs did not visit a veterinarian in the past year.[9] Annual physical examinations, vaccinations to protect pets against rabies and leptospirosis, and annual fecal tests are examples of routine veterinary procedures and tests that can detect or prevent disease in household pets and lower the risk of disease transmission to the pet owner.

Burden of Illness

The majority of reported zoonotic disease outbreaks involve people developing salmonellosis through direct or indirect contact with various household pets, pet food, or their associated fomites (Table 4). However, the true burden of illness associated with zoonoses is difficult to determine, due to the complex dynamic relationship between the host pathogen and the environment. Overall, it is estimated that there are approximately 1.4 million cases of *Salmonella* infections, including 400 deaths in the U.S., annually for all causes.[10] In Canada, approximately 5,500 cases of *Salmonella* infections are reported annually.[11] A population survey, conducted by Thomas et al., estimated 13-37 cases of *Salmonella* infections in Canada for every case reported.[12] Based on this review, cases associated with outbreaks involving multi-drug resistant *Salmonella* had higher hospitalization rates, ranging from 33% to 48%, (Table 4). Sources of zoonotic pathogens involved in outbreaks included: pet rodents, such as hamsters, gerbils and prairie dogs; baby chicks; reptiles, including snakes, lizards, turtles; amphibians; cats; dogs; ornamental fish; and pet food, including feed for reptiles and food and treats for dogs and cats (Table 4). Studies to identify the burden of illness, attributed to pet ownership and zoonoses, were not identified in the existing literature.

Risk Factors for Transmission

The risk of infection in humans can be difficult to predict, based solely on the pets' clinical presentation. It is common for a household pet to carry a zoonotic disease and be asymptomatic or demonstrate non-specific symptoms.[13-15] For example, a dog that is positive for *Salmonella* may not present with clinical illness. However, these animals may contaminate the surrounding environment through intermittent fecal shedding.

Improper handling of pets, along with improper hand hygiene, was identified as the primary risk factor for the majority of pet-associated infections (Table 4). In numerous outbreaks, disposing pet waste and water in kitchen sinks was consistently identified as a cause of human infection (Table 4), representing an additional source of bacterial exposure for food and kitchen surfaces. This was noted particularly for outbreaks involving pet turtles. Failure to wash hands after handling pets and before eating was also repeatedly identified (Table 4).

Sleeping with pets and allowing kissing and licking are activities that increase the risk and opportunity for disease transmission; noted among children who handled turtles. An estimated 14% to 62% of pet owners allow their dogs and cats into their beds.[16] Several outbreaks involved cases where owners reported directly kissing their pets and inserting smaller pets into their mouth (Table 4).

In 2005, four cases of HLCV occurred as a result of organ transplants from an infected donor, who acquired the illness from a pet rodent; three of the organ recipients died due to acquiring this virus. With organ and tissue donors, inadequate screening for pet exposure history was identified as a risk factor for the transmission of this disease.[17]

Other risk factors, identified for the transmission of zoonoses, include feeding pets raw food diets and pet treats made from animal parts.[18-20] Animal-assisted interventions (AAI) in long-term care and other health care facilities have also been identified as a risk factor for pets acquiring diseases from, and introducing infectious agents to, hospitalized patients.[18,21,22] *Clostridium difficile,* the most commonly diagnosed cause of antimicrobial- and hospital-associated diarrhoea, and methicillin-resistant *Staphylococcus aureus* (MRSA), considered the leading cause of hospital-associated infections, can be transmitted through contact with AAI dogs.[21-24]

Population at Risk

In a matched case control study conducted with Michigan children, there was an association between salmonellosis in the children and contact with reptiles and cats.[23] Population-based case control studies conducted in the U.S., looking at the relationship between reptiles, amphibians, and human salmonellosis, led to the estimation that approximately 6% of the 1.4 million cases of the salmonellosis cases occurring in the U.S. each year are acquired from pet reptiles, with 11% of these cases being less than 21 years of age.[25]

Children less than 5 years of age, immunocompromised individuals,[2,14,23,24,26-30] the elderly,[27,28] and pregnant women[28] have been identified as being at the greatest risk of acquiring zoonotic diseases. This was particularly notable for children exposed to reptiles[5,28] and baby chicks.[28] The risk among these various group increases with improper handling and husbandry practices and can be minimized if appropriate restrictions and practices are in place.[31]

Relevant to immunocompromised individuals, *Toxoplasma gondii, Cryptosporidium* spp*., Salmonella* spp*., Campylobacter jejuni, Bartonella henselae, Giardia intestinalis, Bordetella bronchiseptica*, and *Capnocytophaga* spp*.* have been identified as important pet zoonoses.[22] Immunocompromised people are often at a higher risk of zoonotic disease, may suffer more severe sequelae, endure symptoms for longer durations or experience more severe or unexpected complications than immunocompetent individuals.[22]

Risk Settings

Transmission of zoonotic diseases were reported in daycare settings, elementary and secondary schools, a university, an acute care hospital, summer camps for children, veterinary hospitals, and the home (Table 4). During the monkeypox outbreak in 2003, transmission of the disease occurred in a home daycare and a veterinary hospital. Two of the monkeypox infected prairie dogs were also brought into two elementary schools; however, no confirmed cases were reported in these settings.[32,33] Elementary and high school settings have been linked to other serious outbreaks involving reptiles, baby chicks, and owl fecal pellets.[34-36]

Although no outbreaks involving long-term care homes[22] and healthcare settings were identified in this review, they have been identified as high-risk settings[19,21] for both the acquisition and transmission of zoonotic diseases via pets used for visitation purposes. Currently, there are no screening requirements for therapy animals that may be exposed to long-term care homes before and during infectious disease outbreaks.[19] During the severe acute respiratory syndrome (SARS) outbreak in 2003 and the H1N1 pandemic in 2009, quarantine protocols were implemented for human cases, but pets and the role they can play in these outbreaks was not identified.[37,38]

Current Practices

Current Regulatory Practices in Canada

There are limited guidelines, protocol, and best practices documents pertaining to the management of pet zoonoses across Canada. An environmental scan was conducted for public health policies available at the provincial and national levels. Guidance documents on the management of household pets could not be found in any province. In some jurisdictions, there are guidelines or factsheets for specific diseases, such as avian chlamydiosis; however, there are no general guidelines tailored to the management of household pets. Guidelines on preventing pet-related zoonoses in schools, nurseries, long-term care, and group homes or other high-risk settings where at-risk groups live, work or play were either too general or contained outdated and inaccurate information.

Several non-governmental Canadian references, that provided specific information on pet zoonoses, are summarized in Table 5. Table 6 provides a summary of non-Canadian guidance documents.

In Canada, approximately one-third of household-associated pet zoonoses are listed as notifiable, while the other two-thirds remain unreported (Tables 1,2,3). Most animal pathogens, for which surveillance programs exist, relate to farm animals with few to no programs specifically aimed at wildlife[1] or household pets, with the exception of rabies.[38] At the present time, many of the non-reportable vector-borne zoonoses are considered low risk to public

health, although many are now considered to be re-emerging or emerging diseases.[4,39] Routine public health investigations of infectious diseases typically exclude in-depth query regarding certain pets, such as fish or gerbils, that are perceived to be free of zoonotic pathogens.

Currently there is no central database in which positive cases of non-reportable and reportable infectious diseases are reported. In Canada, the Canadian Network for Public Health Intelligence links the Animal Health Laboratory to the Canadian Food Inspection Agency, facilitating the sharing of surveillance data pertaining to bovine spongiform encephalopathy (BSE) and avian influenza. Efforts are also underway to explore other options for the sharing of human and animal health data.[40] The Canadian Animal Health Surveillance Network is currently being developed to improve the capacity to detect and respond to emerging zoonoses and minimize public health risk.

Pets can be important sentinels for emerging infectious diseases. During the 2003 outbreak of West Nile Virus (WNV) in the U.S., the disease was first identified in animals one month prior to the report of the first human case.[1] Pets can also serve as potential vectors for emerging diseases. During the 2003 SARS outbreak, coronavirus was identified as an agent that was transmissible from civet cats to humans and to other feline species,[41] including the household cat. Yet, public health failed to conduct surveillance of these household pets for exposure to this virus. Emergent strains of the influenza H1N1 and H5N1 virus, along with the global H1N1 pandemic, have resulted in greater recognition of public health implications of emerging zoonotic diseases.[42]

Failure to enforce legislation pertaining to the sale of pets, such as the red-eared slider turtle, has been identified as a contributing factor to several outbreaks of salmonellosis involving these animals (Table 4). Challenges to enforcement include the sale of pets via novel or non-traditional venues, such as the internet, souvenir shops, and flea markets (Table 4).

Unregulated Sectors (current practices)

The sale of rodents for reptile feed,[36] canine raw food diets,[19] pet food diets,[43] and pet treats[44] is unregulated. During the 2008 outbreak of multi-drug resistant *Salmonella* Typhimurium in the UK, the investigation was hampered by the lack of international regulations pertaining to importation of frozen rodents, originating in the United States.[8]

The Canadian Food Inspection Agency (CFIA) regulates pet food imports and related products, to prevent animal diseases from being introduced into Canada. Pet food, pet treats, and some pet chews are regulated under the *Health of Animals Regulations.* The recall of rodents used as pet feed do not fall within the mandate of the CFIA, the agency responsible for food recalls in Canada. Numerous regulatory gaps exist in the enforcement of legislation pertaining to the sale and distribution of pets, such as pet frogs and turtles.[45,46]

Regulations governing the manufacture and sale of commercial raw diets for companion animals do not exist.[18] The CFIA is not obligated to recall certain types of pet food products. During outbreak investigations, contaminated pet foods, such as pet treats and raw pet foods associated with confirmed cases of human illness, have been recalled on the basis of reported human illnesses and not on the grounds that these products are contaminated. Response to issues involving pet foods are done on a case-by-case basis and not in accordance with established protocols or policies.

Gaps and Recommendations

Numerous surveillance, regulatory, knowledge, and research gaps were noted during the course of this research.

Surveillance

Pet zoonoses are inadequately identified and managed by public health agencies at the local, provincial/territorial, and national levels, as many diseases of importance are not reportable and cases are inadequately screened for pet and pet food exposures. The inability to appropriately quantify the burden of illness associated with pet zoonoses will lead to ongoing categorization of this issue as a low priority.

Canada has a relatively robust surveillance system for reportable diseases, such as rabies and influenza A; information is collected and amalgamated. Similar mechanisms are needed for non-reportable diseases, as two-thirds of pet zoonoses fall into this category.

There is no active companion animal zoonotic disease surveillance or syndromic surveillance programs currently in practice by public health. Information pertaining to pets or pet ownership is not routinely collected by health care practitioners. This information, if collected, would help expedite diagnosis. All pets should be scrutinized, even if there is no previous history of disease transmission involving a particular pet. Although it is not possible to link laboratory results with a specific animal from a given herd, it would be possible for companion animal veterinary clinics to carry out this type of activity for household pets. Greater collaboration between health care practitioners and veterinarians will create a more integrated sentinel surveillance system for zoonotic disease.[47]

Physicians, veterinarians, and public health care professionals are also uniquely positioned to actively collect information and laboratory results that can be analysed and interpreted to identify trends in companion animal zoonoses. This information can be used to educate the public on measures of how to prevent disease and promote health.[22,29] This is a missed opportunity and is of particular significance for high-risk individuals.[22] It is not common practice for veterinarians to discuss or document the health status of the pet owner and how it could increase the risk of zoonotic infections.

Regulatory

Identification, management, and prevention of zoonotic disease outbreaks, such as those involving pet foods and treats, do not fall within the regulatory framework at national and international levels. Development and enforcement of legislation to govern this market could help minimize the risk of disease transmission and burden of illness on humans. Provincial quarantine legislation should include the quarantine of household pets during zoonotic disease outbreaks.

Public health policies are needed to minimize the risk of pet zoonoses; however, they must be balanced with the benefits of the human animal bond that has been proven to have its own health benefits.[19] The human-animal bond could strongly influence the public's willingness to abide by any new government regulations to prevent disease transmission.[2]

Knowledge

Knowledge gaps have been identified with pet owners and pet distributors who do not understand the disease risks associated with these animals.[45,46] Inadequate understanding among daycare staff, school teachers, and healthcare practitioners, pertaining to the screening and safe handling of pets and the risks of disease transmission, is also an identified knowledge gap.[23,29,33,48,49] Healthcare practitioners should be encouraged to provide a greater level of information and education to their patients, given the lack of public awareness of zoonoses associated with pets. This should also include collaboration with veterinarians who are well versed in zoonotic disease and comparative medicine.[5,47] Additionally, veterinarians should have some understanding of the health and well-being of a pet's owner and family members, to prevent or mitigate future potential health risks.

Partner agencies, key stakeholders, and any other interested parties of the pet zoonoses policy community should be invited to participate in a public health community of practice. This is a group of peers who share a concern, a set of problems or a passion for pet-zoonoses and public health. Human and animal health professionals have recognized the need to collaborate and adopt a *One Health* approach that identifies linkages that exist among human health, animal health, and ecosystem health domains.[5,47] *One Health* is a team approach that may lead to an improved understanding of pet-associated infections and may be an effective and efficient framework for health, to enhance clinical efforts and detect and prevent disease in humans.[5] This enhancement of communication could shift the policy community toward the *One Health* concept and may help to bridge some of the communication gaps identified in surveillance, regulatory and research sectors, as well as knowledge gap.

Research

There are few publications on pet zoonoses outbreak investigations in Canada. A number of factors may contribute to this, including litigation activities, staff turn-over, human resources issues, and other bureaucratic issues within various government agencies. The Canadian public health community should be encouraged to document and submit more journal articles, share the knowledge acquired, as well as inform each other of experiences. Emerging issues, such as sale of pets via the internet, international trade, recall effectiveness, and health impact of raw food diets for pets require further research.

Evidence-based information on pet zoonoses trends and risks should drive public health policy changes. A nationwide central database, collecting and sharing data on all zoonoses, would provide a better understanding of their incidence and prevalence. This knowledge would help develop risk management strategies in zoonotic disease prevention. Risk management procedures need to be developed for health care facilities and institutions, schools and nurseries, and the general public. Other groups, with whom this information should be shared, include humane societies, animal shelter facilities, grooming houses, and others that may serve as an interface between pets and pet owners. This knowledge also needs to be translated into policies and procedures at various levels of government.

Conclusion

As pet ownership continues to grow, pet owners and public health will continue to face the ongoing challenges of pet zoonoses. Preventive strategies must be put in place to ensure that the risk of these diseases, and their impact on the health of the public, are mitigated.

Consideration should be given to enhancing the surveillance of non-reportable diseases, as well as active surveillance of pets linked to confirmed cases of diseases. Regulators must address the current gaps that exist regarding the raw pet food industry. New strategies should be developed to monitor the sale and distribution of pets from non-traditional venues, such as flea markets and the internet. Public health agencies, as well as the pet industry, need to provide public information on handling of pets and risks of acquiring illness, particularly among children less than five years of age, the elderly, pregnant women, and the immunocompromised. Public health policies are also necessary, in a number of high-risk settings, to decrease the risks of disease transmission associated with pets. These settings include, but are not limited to, day nurseries, schools, and rehabilitation and long-term care facilities. One Health approaches that focus on collaborative efforts between human and animal health professionals will contribute significantly to zoonotic infectious disease management and can generate innovative solutions to these complex problems.

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Appendix A – Definitions

Zoonoses: is defined as bacterial, viral, fungal, or parasitic infections which are naturally transmissible from vertebrate animals to humans.
(WHO: http://www.who.int/topics/zoonoses/en)

Household pets include any pet that lives with and is cared for by people, for the primary purpose of companionship; including domestic dogs and cats, exotic pets, reptiles, amphibians, fish, and birds.

Exotic pets: (also termed *pocket pets*) include rabbits, rodents (rats, mice, guinea pig, prairie dog), hamsters, hedgehog, and ferrets.

Reptiles include non-venomous snakes, iguanas, geckos, lizards, and turtles.

Amphibians include frogs, toads, newts, and salamanders.

Birds include baby chicks and ducks, pet birds (e.g., parakeet, canary, love bird, parrot).

Appendix B- Methodology

Appendix A: Literature Search Strategy

B.1 Databases / Indices / Search Tools

The literature search employed the following databases/indices:

Web of Science: An online catalogue of citations that includes the Science Citation Index, the Arts and Humanities Citation Index, and the Social Sciences Citation Index http://apps.isiknowledge.com;

PubMed: PubMed comprises more than 20 million citations for biomedical literature from MEDLINE, life science journals, and online books http://www.pubmed.gov;

CabDirect: CAB Direct is the most thorough and extensive source of reference in the applied life sciences, incorporating the leading bibliographic databases CAB Abstracts and Global Health. Over 9 million bibliographic and full text applied life science http://www.cabdirect.org/;

A.2 Search Terms and Date Ranges

Utilizing the databases listed in A.1, text word searches for article titles and abstracts were conducted using the search terms: pets, zoonoses, public health, and outbreaks. Combinations of these primary keywords were combined with: Canada, United States, United Kingdom, Australia, North America, canine, feline, rabbits, birds, reptiles, hedgehogs, ferret, aquatic, ornamental, incidence, and common. Additionally, existing research and reports from leading organizations, including the Center for Disease Control, the World Health Organization, International Society of Feline Medicine Congress, and the Canadian Veterinary Journal, were accessed to identify relevant data and research.

Reference lists of the articles included in this review were manually searched. Articles citing other relevant studies are included in our bibliography.

An environmental scan of federal and provincial policies on household pets was conducted through a manual search of the websites of all provinces and territories, using combinations of the terms “pets, policy, guidance, protocol, best practice.” Representatives from some jurisdictions were contacted by email and search results were verified.

The literature search was conducted in January and February 2010 and updated through to the end of March 2010. Citations published since 2004 were included, although various outbreaks would have occurred prior. Higher interest was placed on outbreaks which occurred in Canada and the United States.

Several Canadian experts and authors were consulted on pet-related zoonoses in Canada. Subjects discussed included: current trends, emerging issues, gaps identified, research, outbreaks in Canada, and legislation. We held face-to-face meetings with the following list of health professionals:

- Dr. Scott Weese, Department of Veterinary Medicine, University of Guelph;
- The Public Health Agency of Canada, Centre for Food-borne, Environmental and Zoonotic Infectious Diseases;

• Dr. Malcolm Weir, University of Guelph, who has conducted research on zoonoses associated with ornamental fish. Dr. Weir provided references cited on ornamental fish;

• Dr. Grant Maxie, Director of the Animal Health Lab, Guelph, Ontario on laboratory surveillance of animals;

• The Canadian Food Inspection Agency on policies related to the recall of pet food in Canada.

B.3 Inclusion Criteria

All papers, identified by the search, were initially screened for relevance using the title and/or abstract. Literature was restricted to only those written in English language. In addition to Canada, the United States of America, the United Kingdom, France, and Australia engage similar public health systems and standards so were included.

B.4 Exclusion Criteria

Groups that included petting zoo, zoo animals, and food production animals are not addressed here, to provide higher focus to the groups included. Rabies was not discussed in any detail in this document. Rabies is an important notifiable disease that remains an important global issue and deserves to be addressed exclusively in a future document. Human infections are rare, now that this disease is no longer endemic in North America; however, rabies continues to infect many animals around the world; millions of people requiring post exposure treatment and thousands more killed.

B.4 Literature Organization / Storage

Management of the bibliographic data, for the electronic literature obtained through the above methods, were entered into RefWorks, a web based bibliography (http://www.refworks.com/).

Appendix C

Table 1: Zoonoses in Canada: Companion Animals

Pathogen	CFIA: Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Dog (D) Cat I	Transmission Route	Clinical Manifestations in Humans
Bacterial					
Anaplasma spp.[49,50]	-	N	D,C	Vector-borne: tick bite	Febrile, flu-like; low mortality
Bartonella henselae (Cat Scratch disease)[5,39,51-55] *Bartonella* spp.[53]	-	N	C,D	Cat scratches and bites. Direct contact or contaminated fomites	*B. henselae* can cause Bacillary angiomatosis, fever, lymphadenopathy, endocarditis, bacillary peliosis. *Bartonella* spp. Can cause a wide range of symptoms; pathology occurs in multiple organ systems with chronic infection. Immunocompromised- increased risk of systemic infection; can be fatal.
Bordetella bronchiseptica[53]	-		D	Exposure to respiratory droplets or direct contact, including contact with canine modified live intranasal vaccine	Mild to severe respiratory disease in children with lung transplants.
Borrelia burgdorferi (Lyme disease)[5,53]	-	Y	D	Vector-borne: tick bite	Rash, fever, headache, arthritis, carditis
Brucella canis (Brucellosis)[5,53]	R	Y	D	Contact with infected fluids or secretions, with aborted fetuses, mucous membranes, abraded skin	Aymptomatic to fever lethargy and general malaise, splenomegaly; potentially more serious in immunocompromised persons.
Campylobacter spp. Including C. jejuni, C upsaliensis, C. coli, C. lari[5,19,53,55,56]	Y	N	D,C	Fecal-oral, direct contact	Gastroenteritis, arthritis, □epticaemia, meningitis, □epticaemi uremic syndrome, Guillain-Barre syn., immunoproliferative myocarditis, cholecystitis
Clostridium difficile[57]	-	N	D,C	Fecal-oral, licking	Diarrhea+/- blood
Coxiella burnetti (Q fever)[53,55,58,59]	N_A	N	D,C	Direct contact with infected animals, food or fomites, inhalation, aerosolization, rare via tick bite	Acute or chronic, flu-like symptoms
Ehrlichia spp.[19,50]	-	N	D,C	Vector-borne: tick bite	Febrile, flu-like; low mortality
Francisella tularensis (Tularemia)[5,50,51,53,56,60]	N_A	Y	C	Cat bites and scratches, inhalation, aerosolization, flea and tick bites, ingestion of contaminated food or water	Ulcer glandular form, □epticaemia, oropharyngeal, atypical pneumonia

Pathogen	CFIA: Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Dog (D) Cat I	Transmission Route	Clinical Manifestations in Humans
Helicobacter spp.[22,55]	-	N	D,C	Fecal-oral	Gastritis +/- ulcers, risk for development of gastric carcinoma or B-cell lymphoma
Leptospira spp. (Leptospirosis)[5,55]	-	N	D	Contact with infected urine or contaminated water or soil, infected tissues	Weil syndrome (liver and kidney failure), disseminated intravascular coagulation(DIC), bleeding, aseptic meningitis, respiratory failure, cardiac involvement, uveitis
Mycobacterium spp.[50,51,54] (except *M. tuberculosis*)	-	N	D,C	Inhalation/respiratory secretions, entry into skin or ingestion	Respiratory disease, systemic disease, cutaneous lesions
Oral Flora: Aerobic: *Pasteurella* spp., *Streptococcus* spp., *Staphylococcus* spp., *Moraxella* spp. Anaerobic: *Capnocytophaga canimorsus, Fusobacterium* spp., *Bacteroides* spp., *Porphromas* spp.[5,50,52,54]	-	N	D,C	Primarily via dog or cat bite, licking	Wound infection and the following in immunocompromised persons: osteomyelitis, arthritis, sepsis, endocarditis, peritonitis, meningitis
Riskettsia rickettsii R.typus, R felis [54]	-	N	D	Vector-borne: tick bite or flea bite	Rocky Mountain Spotted Fever, possible death
Salmonella enterica spp.[5,52,54]	-	Y	D,C	Fecal-oral either direct or contaminated food, fomites	Gastroenteritis, arthritis, □epticaemia, meningitis, osteomyelitis, persistent bacteremia secondary to infected atherosclerosis, aneurysms
Staphylococcus spp. Including Methacillin-resistant *Staphylococcus aureus*.(MRSA)[5,51,53,55]	-	N	D,C	Direct contact, bites scratches	Community –associated pathogen: Severe soft tissue infections, endocarditis, osteomyelitis, septic arthritis, pneumonia
Yersinia pestis (Plague)[53,55,58]	-	Y	D,C	Flea bite, handling infected animal tissues, inhalation	Plague – bubonic, septicemic and pneumonic
Viral Infections					
Cowpox – vaccinia virus[51,52,55]	-	N	D,C	Direct contact, scratches, bites after hunting rodent reservoirs	Cutaneous and mucous membrane lesions, cellulitis and regional necrotizing lymphadenitis

Pathogen	CFIA: Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Dog (D) Cat I	Transmission Route	Clinical Manifestations in Humans
Influenza A (H5N1, H1N1)[22]	R	Y	C	Direct contact, ingestion, aerosolization	Flu-like symptoms, progresses rapidly to respiratory failure and distress, can be followed by cardiac and renal failure and death
Rabies (Rhabdoviridae)[5,29,55,61]	R	Y	D,C	Bites, scratches, direct contact with infected saliva	Rabies – furious or dumb form
Helminths					
Ancylostoma spp., *Uncinaria* spp.[5,51,52]	_	Y	D,C	Larva penetrating tissues	Cutaneous larval migrans, eosinophilic enteritis
Baylisacaris procyonis[53,62]	-	N	D	Fecal-oral	Neurological, ocular and visceral larval migrans
Dipylidium caninum[5,53,55]	-	N	D,C	Fecal-oral	Anal pruritis, passage of proglottids in feces
Dirofilaria immitis[22]	-	N	D,C	Vector-borne: mosquito indirectly from canine reservoir host	Pulmonary vasculitis, tumors, cysts, and granulomas often mistaken as a malignancy. Possible eye, nervous, adipose, liver and testicular tissues.
Echinococcus multiocularis and *E. granulosus*[5,53,55]	-	N	D,C	Fecal-oral, ingestion of infected meat	Enlarging alveolar or liver cysts or brain – often fatal
Toxocara canis, T. cati[5,53,55]	-	N	D,C	Fecal-oral	Visceral and ocular larval migrans
Protozoa					
Cryptosporidium parvum, C. canis, C. felis, C. hominis[5,53,55]	-	Y	D,C	Fecal-oral, contaminated food or water, inhalation	Asymptomatic, non-specific or flu-like symptoms. Primarily species specific, but all strains considered potentially zoonotic; elderly, very young, immunocompromised at higher risk.
Giardia spp.[5,53,55]	-	Y	D,C	Fecal-oral	Diarrhea, gastroenteritis; primarily species specific – immunocompromised at risk.
Leishmania spp.[55]	-	N	D,C	Vector-borne: sand fly bites	Cutaneous and visceral leishmaniasis
Toxoplasma gondii[5,53,55]	N_A	N	C	Fecal-oral: contact with contaminated kitty litter	Congenital toxoplasmosis, abortion, encephalitis, lymphadenopathy
Ectoparasites					
Cheyletiella spp.[51,52]	-	N	D,C	Direct contact	Uticarial papules, erythema, pruritis – self limiting
Ctencephalides felis[51,52]	-	N	D,C	Direct contact	Pruritic uticarial papules

Pathogen	CFIA: Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Dog (D) Cat I	Transmission Route	Clinical Manifestations in Humans
Otodectes spp.[52]	-	N	D,C	Direct contact	Pruritis
Notodres cati[51,52]	-	N	C	Direct contact	Pruritic papulovesicles
Sarcoptes scabei[5,51,52]	-	N	D,C	Direct contact	Tiny red bumps, pruritis
Fungal					
Cryptococcus neoformans[53]	-	N	D,C	Indirect contact with infected pet	Headache, fever and possible infection of lung, brain and spinal cord. Healthy persons may be asymptomatic.
Malassezia spp.[52,53,55]	-	N	D,C	Direct contact	Dermatitis, cutaneous granuloma
Microsporum canis (Ringworm)[5,51,53,55]	N_A	Y	D,C	Direct contact with infective lesions, skin, hair, fomites	Multifocal alopecia, crusting lesions
Sporothrix spp. (Sporotrichosis)[51,53,55]	N_A	N	C	Cat scratches and bites, direct contact with infected cat	Ulcerated nodules and papules, disseminated dz.
Trichophytum spp. (Ringworm) [5,51,53,55]	N_A	Y	D,C	Direct contact with infective lesions, skin, hair, fomites	Follicular pustules, erythema, or interdigital lesions, onychomycosis

[a] Diseases based on information outlined in the *Health of Animals Act and Regulations*; significantly important to human or animal health, enforced by the Canadian Federal Inspection Agency (CFIA).
[b] Diseases exotic to Canada for which there are no control or eradication programs and only Laboratories are required to notify the CFIA.
[c] Public Health Agency of Canada (PHAC) mandate is to enforce the *Public Health Agency of Canada Act*, from the human health perspective.

Table 2: Zoonoses in Canada: Exotic/Pocket Pets

Pathogen	Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Rodent[†] I; Rabbit (L); Hamster (H); Hedgehog (He); Ferret (F); Gerbil (G)	Transmission Route	Clinical Manifestations in Humans
Bacterial Infections					
Anaplasma spp.[50,63]	-	N	L	Vector-borne: tick bite	Febrile, flu-like; low mortality
Babesia spp.[50,63]	-	N	L	Vector-borne: tick bite	Febrile, flu-like; low mortality
Bartonella spp.[53,62]	-	N	R	Flea or tick bite, scratch	Fever, lymphadenopathy, endocarditis, bacillary angiomatosis
Borrelia burgdorferi (Lyme disease)[49,62]	-	Y	L	Vector-borne: tick bite	Rash, fever, headache, arthritis, carditis
Campylobacter spp.[22]	-	Y	R, H, F	Fecal-oral, direct contact	Gastroenteritis, arthritis, □epticaemia, meningitis, □epticaemi uremic syndrome, Guillain-Barre syn., immunoproliferative myocarditis, cholecystitis
Chlamydophila psittaci[64]	N_I	N	He	Direct contact	Flu-like symptoms, pneumonia, fatal if not treated; immunocompromised at risk
Coxiella burnetti (Q fever)[64]	N_A	N	He	Direct contact with infected animals, food or fomites, inhalation, aerosolization	Asymptomatic to fever, lethargy and general malaise; potentially more serious in immunocompromised persons
Francisella tularensis (Tularemia)[50,53,59,62]	N_A	Y	R, L, H, G	Bites and scratches, inhalation, aerosolization, flea and tick bites, ingestion of contaminated food or water	Tularemia (Ulcer-glandular form, epticaemia, oropharyngeal), atypical pneumonia
Leptospira spp.[53,62]	-	N	R	Contact with infected urine or contaminated water or soil, infected tissues	Weil syndrome (liver and kidney failure), disseminated intravascular coagulation (DIC), bleeding, aseptic meningitis, respiratory failure, cardiac involvement, uveitis
Mycobacterium spp, specically *M. marinum*[52,64]	-	N	He	Inhalation/respiratory secretions, entry into skin or ingestion	Respiratory disease, systemic disease, cutaneous lesions
Pasteurella multocida[62]	-	N	R, L, H	Animal bite, wound contamination	Wound infection
Salmonella enterica spp.[62,64]	-	N	R, H, He, G	Fecal-oral, contact with infected food, water, fomites	Gastroenteritis, arthritis, □epticaemia, osteomyelitis, persistent bacteremia

Pathogen	Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Rodent[†] I; Rabbit (L); Hamster (H); Hedgehog (He); Ferret (F); Gerbil (G)	Transmission Route	Clinical Manifestations in Humans
					secondary to infected atherosclerotic, aneurysms
Staphylococcus spp.including Methacillin-resistant *Staphylococcus aureus*(MRSA)[52]	-	N	R, H, He, G	Direct contact, bites, scratches	Severe soft tissue infections, endocarditis, osteomyelitis, septic arthritis, necrotizing pneumonia
Streptobacillus spp. And *Spirillium* spp.[62]	-	N	R	Rodent bite, contact with infected urine, water, fomites, ocular or nasal charge of a rat	Rat bite fever, flu-like symptoms, endocarditis, pericarditis, pneumonia, meningitis
Yersinia pestis (Plague)[53,62,64]	-	Y	R, L, He	Flea bite, handling infected animal tissues, inhalation	Plague – bubonic, septicemic and pneumonic
Yersina pseudotuberculosis[64]	-	N	He	Direct contact	Gastroenteritis, self limiting lymphadenitis, mimics appendicitis; post infections-arthritis, erythema nodosum
Viral Infections					
Herpes virus[64]	-	N	He	Direct contact	Herpes simplex-cold sores
Avian Influenza (H5N1, H1N1)[22]	R	Y	F	Direct contact, ingestion, aerosolization	Flu-like symptoms, progresses rapidly to respiratory failure and distress, can be followed by cardiac and renal failure and death
Lymphocytic choriomengitis virus[5,53]	-	N	R, H	Contact with feces, urine, saliva, or from rodent bites	Meningitis, encephalitis. Immunosuppressed and pregnant persons at high risk.
Monkey Pox virus[51-53]	-	N	R	Animal bites, direct contact with infected lesions, blood, fomites and all body fluids/secretions	Similar to smallpox – fever, malaise, pustular lesions, lymphadenopathy
Poxvirus[51-53]	-	N	R	Cat scratches and bites, direct contact	Cutaneous and mucous membrane lesions, cellulitis and regional necrotizing lymphadenitis
Rabies[29,63,64]	R	Y	He, F	Bites, scratches, direct contact with infected saliva	Rabies – furious or dumb form

Pathogen	Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Rodent† I; Rabbit (L); Hamster (H); Hedgehog (He); Ferret (F); Gerbil (G)	Transmission Route	Clinical Manifestations in Humans
Protozoa					
Cryptosporidium parvum[62,64]	-	Y	R, L, He, F	Fecal-oral	Gastroenteritis, flu-like symptoms
Encephalitizoan cuniculi[62]	-	N	R, L	Contact with infected urine	Respiratory, neurological, gastrointestinal, renal and ocular disease
Giardia spp.[53,62]	-	Y	R, L, F	Fecal-oral	Diarrhea
Toxoplasma gondii[62,64]	-	N	He	Fecal-oral	Congenital toxoplasmosis, abortion, encephalitis in AIDS patients, lymphadenopathy
Ectoparasites					
Cheyletiella spp.[52]	-	N	L	Direct contact	Papules, erythema, pruritis-self limiting
Ctencephalides felis[52]	-	N	L, He, F	Direct contact	Pruritic uticarial papules
Liponyssus bacoti[52]	-	N	R	Direct contact	Non-specific pruritic □eptica dermatitis
Notodres cati[52]	-	N	He	Direct contact	Pruritis
Otodectes cyanotis[52]	-	N	F	Direct contact	Skin infestation
Sarcoptes scabei[52,62]	-	N	R, L, He, F	Direct contact	Tiny red bumps, pruritis
Fungal Infections					
Microsporum spp.[52]	N_A	Y	R, L, He, F	Direct contact	Multifocal alopecia, crusting lesions
Trichophytum spp.[52]	N_A	Y	R, L, He, F	Direct contact	Multifocal alopecia, crusting lesions

[a] Diseases based on information outlined in the *Health of Animals Act and Regulations*; significantly important to human or animal health, enforced by the Canadian Federal Inspection Agency (CFIA).
[b] Diseases exotic to Canada for which there are no control or eradication programs and only Laboratories are required to notify the CFIA.
[c] Public Health Agency of Canada (PHAC) mandate is to enforce the *Public Health Agency of Canada Act*; from the human health perspective.
† Includes Guinea pigs, Mice and Rats, Prairie Dog

Table3: Zoonoses in Canada: Reptiles, Amphibians, Birds

Pathogen	Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Snakes (S) Turtles (T) Gecko/Lizards (G) Iguana (I) Birds (B) Frogs (F), Fish (Fsh)	Transmission Route	Clinical Manifestations in Humans
Bacterial					
Aeromonas spp.[64,65]	-	N	Fsh	Direct contact via contaminated water	Healthy individuals may develop skin lesions or gastroenteritis
Campylobacter spp.[22,66]	-	Y	S, T, G, B	Fecal-oral, direct contact	Gastroenteritis, arthritis, □epticaemia, meningitis, □epticaemi uremic syndrome, Guillain-Barre syn., immunoproliferative myocarditis, cholecystitis
Chlamydia psittici[5,29,53,62,67]	N_I	N	B	Contact with nasal or feces of infected birds	Flu-like symptoms, pneumonia, fatal if not treated.
Coxiella burnetti (Q fever)[59,66]	N_A	Y	B	Direct contact with infected animals, food or fomites, inhalation, aerosolization; rare via tick bite	Acute or chronic, flu-like symptoms
Enterobacteriaceae (*Klebsiella, Edardsiella, Salmonella, Echerichia* spp.)[65]	-	N	Fsh	Direct contact, ingestion	Infection of previous wounds, gastroenteritis if ingested, possible meningitis from any point of entry
Erysipelothrix rhusiopathiae[29,51,65,66]	-	N	Fsh, B	Direct contact, entry into previous wound	Local skin infection, can spread, or become systemic and cause endocarditis
Escherichia coli[65,67]	-	N	I, F	Direct contact	Gastroenteritis
Mycobacterium marinum, M avium, M. chelonei, M. fortuitum[62]	-	N	S, T, G, I, B, Fsh	Inhalation/respiratory secretions, ingestion, direct contact with fish or tank water	Respiratory disease, systemic disease, granuloma lesions +/- ulcerative
Salmonella enterica spp.[29,62]	-	Y	S, T, G, I, F, B,Fsh	Fecal-oral, contact with infected food, water, fomites	Gastroenteritis, arthritis, □epticaemia, osteomyelitis, persistent bacteremia secondary to infected atherosclerosis, aneurysms
Streptococcus inae[29,65]	-	N	Fsh	Direct contact- entry into previous wound	Ranges: Cellulitis, septic arthritis, endocarditis, meningitis, possible death.
Vibrio spp.[29,65]	-	N	Fsh	Through puncture wounds or ingestion	Necrotizing fasciitis, edema at site, risk of □epticaemia when ingested

Pathogen	Reportable[a] in Canada =R, Immediately Notifiable[b]= N_I Annually Notifiable = N_A in Canada	PHAC[c]: Notifiable In Canada Yes = Y No = N	Snakes (S) Turtles (T) Gecko/Lizards (G) Iguana (I) Birds (B) Frogs (F), Fish (Fsh)	Transmission Route	Clinical Manifestations in Humans
Viral					
Avian Influenza (H5N1, H1N1)[22]	R	Y	B	Direct contact, ingestion, aerosolization	Flu-like symptoms, progresses rapidly to respiratory failure and distress, can be followed by cardiac and renal failure and death
Flavivirus-West Nile Virus[66]	-	Y	B	Vector-borne – mosquito	Asymptomatic to flu-like symptoms, to life threatening
Protozoa					
Cryptococcus neoformans[66]	-	N	B	Fecal-oral, inhalation	Respiratory symptoms, meningitis , cutaneous lesions, ocular lesions, prostatic dz
Cryptosporidium serpentensis[62]	-	Y	S, B	Fecal-oral	Have not been shown to be zoonotic at this point; tests are cost prohibitive and not clinically practical.
Giardia spp.[62,66]	-	Y	S, B, I	Fecal-oral	Diarrhea

[a] Diseases based on the information outlined in the *Health of Animals Act and Regulations*; significantly important to human or animal health, enforced by the Canadian Federal Inspection Agency (CFIA).
[b] Diseases exotic to Canada for which there are no control or eradication programs and only Laboratories are required to notify the CFIA.
[c] Public Health Agency of Canada (PHAC) mandate is to enforce the *Public Health Agency of Canada Act*; from the human health perspective.

Table 4 – Summary of Outbreak and Case Series

Publication Dates	Outbreak or Case Series Type	Pet	# People Ill	Location or Setting	Source	Gaps	Findings or Recommendations
2004	Monkeypox Outbreak[68]	Prairie Dogs	72 suspected or confirmed cases	Swap meet; pet store – U.S.A.	Prairie dogs transported with ill Gambian giant rats imported from Ghana	Unknown if the monkeypox has now spread to mammalian species in North America	Issues identified included: appropriate quarantine; infection control; personal protective equipment; environmental sanitation; one child was infected; person-to - person transmission was not ruled out; In 2003, the FDA banned the importation of all rodents from Africa, as well as the sale, release, and distribution of prairie dogs.
2005	Monkeypox Outbreak - Indiana[32]	Prairie Dogs	9 cases: 70 people were investigated as exposed	Daycare settings and 2 elementary schools,	Prairie dogs transported with ill Gambian giant rats imported from Ghana	Routes of transmission -more evidence needed; other routes besides direct transmission could not be ruled out. Knowledge of risks of exposure of exotic pets included home daycare, elementary schools.	Information needed on the risks of disease transmission and injury pertaining to wild or exotic pets being brought into a child care facility or other public settings.
2007	Monkeypox Outbreak-Wisconsin[33]	Prairie Dogs	19 confirmed cases: 5 probable; 3 suspect cases	Veterinary clinic:2 staff; Pet store;2 pet staff'; Pet distributors: 2 individuals	Prairie dogs transported with ill Gambian giant rats imported from Ghana	Issues identified included inadequate quarantine measures; infection control; personal protective equipment; environmental sanitation.	Standard veterinary infection control guidelines -very important. Education of pet store owners and pet suppliers in infection control practices.
2005	Multi-drug resistant *S.* Typhimurium[69]	Pet Rodents	28 cases: 15 had known exposure to rodents (median age 16 years); 40% hospitalized	Home/pet stores; Multi-state	Hamsters, mice or rats - a single source of rodents was not identified	Pet rodents may be under-recognized as source of multi-drug resistant Salmonella; Prophylactic usage of antibiotics in pet industry; poor husbandry and sanitation practices	The bacteria were resistant to ampicillin, chloramphenicol, streptomycin, sulfisoxazole and tetracycline. Public health should consider pet rodents as a source of multi-drug resistant salmonellosis. Prophylactic usage of antibiotics by the pet industry may have contributed to the

Publication Dates	Outbreak or Case Series Type	Pet	# People Ill	Location or Setting	Source	Gaps	Findings or Recommendations
							disease in colonized animals.
2005	Human Lymphocytic Chorimeningits Virus Infections[17]	Pet Rodents	4 cases: organ donor recipients; 1 was an organ donor	Hospital: organ transplant recipients - 3 of the 4 died - U.S.A.	Pet hamster and guinea pig; organ donor's pets - obtained from pet shop	Organ donation questionnaire should ask about pet ownership	Although LCMV is known to infect hamsters and guinea pigs, data are insufficient to determine the potential for infection of other rodent species (e.g., chinchillas, dwarf hamsters or gerbils). Husbandry practices in breeding facilities, distribution centers, and pet stores make cross-contamination with LCMV of other species a possibility.
2005	Tularaemia[70]	Pet Rodent	1 case: 3 year old	Home	Pet hamster bite	Pet hamsters not previously identified as a source of tularaemia	Healthcare and public health practitioners should be aware that pet hamsters might be a source of tularaemia.
2008	*S*. Typhimurium[36,71]	Frozen, vacuum - packed rodents /reptiles	21 cases: median age of 13 years	School -science classroom, home- multi-state, U.S.A.	Frozen vacuum-packed rodents used to feed snakes; pet snakes; contaminated surfaces	No regulations available for pet feed rodents; lack of awareness of risk of *Salmonella*; internet-based supplier	Strong oversight of the commercial industry recommended.
2010	Multi-drug Resistant *Salmonella* Typhimurium DT 191a [8,26]	Frozen vacuum packed rodents reptiles snakes raptors	420 cases: of 55 cases studied during initial investigation, median age was 11 years; ranging from four months to 69 years	Pet shops; home/university – U.K.	Frozen reptile feeder mice; possibly the reptiles as well Cross-contamination: only 3/14 cases with reptiles reported direct contact	Imported from the U.S.A.; there were no regulations in Europe covering frozen mice The U.K. has no official guidelines covering risks of reptile handling; Ownership in relation to *Salmonella* infection.	Children aged <5 years appear to be particularly at risk of being infected with Salmonella from reptiles. Reptiles should be kept out of homes with children less than 5 years old.

Publication Dates	Outbreak or Case Series Type	Pet	# People Ill	Location or Setting	Source	Gaps	Findings or Recommendations
2005	*Salmonella* Kingabwa[72]	Lizards	Of the six patients, four (67%) were ≤1 year old (range was from <1–53 years), four were male, two were hospitalized, and none died.	Purchased from pet stores and travelling reptile show; handled at home or while visiting with someone who owned a pet - U.S.A.	Lizards -bearded dragon and water dragon		The findings support recommendations that reptiles should not be kept in homes with children less than five years of age.
2007	*Salmonella* I 4, [5], 12:i- Infections[73]	Red-ear slider turtle	Four cases: ages ranged from 7 years to 45 years	Home – U.S.A.	Pet shop, flea markets,	Illegal sale of turtles; flea market sales	Improved prevention and public education needed.
2007	*Salmonella* Pomona[73]	Pet turtles	19 cases: 1 case died	Home – U.S.A.	Pet shop, flea markets,	Illegal sale of turtles; flea market sales	Improved prevention and public education needed.
2010	*Salmonella* Typhimurium[74]	Pet turtles	135 cases: 45% ≤5 years old; of the 83 patients, 35 (42%) had bloody diarrhea and 29 (35%) were hospitalized; 20 were child-care attendees	3 Child-care settings; Home – U.S.A.; secondary transmission also occurred in childcare settings through contact with confirmed case; 12 children in the day nurseries who had contact with the turtles were less than 2 years of age. All 12 acquired salmonellosis.	Small turtles sold in pet shops, street vendors, flea markets and internet, although a ban on the sale exists; Knowledge gaps pertaining to the prevention of salmonellosis in childcare settings	Lack of awareness of link between *Salmonella* and contact with reptiles; Public education about the risks involved is needed.	Enforcement of small turtles law lax - public education needed.

Publication Dates	Outbreak or Case Series Type	Pet	# People Ill	Location or Setting	Source	Gaps	Findings or Recommendations
2009	*Salmonella* Paratyphi var Java[45,75]	Pet turtles	107 cases: median age 7years old; 33 % hospitalized	Home – U.S.A.	Retail pet shops, flea markets, gift shops, street vendors, internet	Lack of awareness of link between Salmonella and contact with reptiles; Some children inserted the turtles into their mouths; Public education about the risks involved is needed.	Small turtles continue to be sold and pose a health risk, especially to children; "many people remain unaware of the link between Salmonella infection and reptile contact"; Continued enforcement on ban of turtles is needed.
2006	Multi-drug Resistant *Salmonella* Java [S. Paratyphi b var Java][76]	Tropical ornamental fish	18 cases: the median age of cases was three years; range 4 months - 48 years	Home - Australia	Tropical freshwater fish including: guppies, goldfish, tetras fish aquarium	Disposing of aquarium tank waste in laundry and kitchen sinks	
2005	*Salmonella* Paratyphi var Java[77]	Imported ornamental fish	53 cases: 17 children under 11 years of age; over 50% of cases required hospitalization	Home - Canada	Ornamental fish/ tanks	Lack of awareness of link between *Salmonella* and ornamental fish; public education about risks involved is needed	Owning aquariums may be risk factor for acquiring *Salmonella*. Pet shops should provide information to customers on the risks involved and on safety precautions.
2010	*Salmonella* Typhimurium[46]	Aquatic frogs	85 cases	Home – U.S.A.	African dwarf frog purchased from pet shops	Only 31% of cases knew that *Salmonella* can be acquired from amphibians; while 53% were aware of link with reptiles, amphibians were not associated with previous outbreaks	African dwarf frog purchased from pet shops.
2005	Tularaemia[78]	Pet dog	15 cases	Airborne transmission- at a home gathering - France	Fur of dogs	Knowledge of the disease and risk factors; hygiene precautions	"Tularaemia should be considered in cases of pneumonia of unexplained origin, especially if risk from exposure has been reported." Mandatory reports required when an unusual phenomenon, such as tularaemia cases, is observed must be submitted to health authorities urgently to

Publication Dates	Outbreak or Case Series Type	Pet	# People Ill	Location or Setting	Source	Gaps	Findings or Recommendations
							facilitate investigation and expedite rapid action. The transmission of F. tularensis by inhalation may be prevented by wearing protective equipment (goggles, gloves, masks), mainly used by professionals (gardener, farmer, etc.). Basic hygiene measures can help prevent transmission of the disease from pets, e.g., washing pets (avoid splashing) before they enter the house if they have been rolling in mud or have been in contact with dead animals. Thorough hand washing is recommended for all people after contact with any animals, including pets.
2006	*Salmonella* Thompson[79,80]	Pet treats	9 cases	Home - Canada/U.S.A.	Cats and dogs	No processing steps to kill bacteria; no label with instructions on handling	CDC and PHAC have recommendations to reduce *Salmonella* when handling pet treats.
2006	Cutaneous Larva Migrans[81]	Cat feces	22 cases	Summer camp for children – U.S.A.	Cats or dogs Hookworm	Improper cleaning of sandbox; poor hygiene - cat sandbox	Lack of awareness of sanitation measures for sandboxes, to prevent the transmission of the disease.
2007 2008	*Salmonella* Schwarzengrund[43,82,83]	Dogs	79 cases: median age 3 yrs; range from one month to 85 years 48% were less than 2 years	Home – U.S.A.	Dry dog foods	Dry dog food not removed from homes even though recall was issued; Recall effectiveness among consumers for shelf stable products	Hand washing after handling pet foods; consideration be given to location in the home where pet foods are stored; Handling by children <5 years should be prohibited; "illness among infants was associated with feeding pets in the kitchen."
2008	Leptospirosis[82]	Dogs	3 cases	Home – U.S.A.	Dogs		

Publication Dates	Outbreak or Case Series Type	Pet	# People Ill	Location or Setting	Source	Gaps	Findings or Recommendations
2008	Murine Typhus[84]	Cats, dogs, opossum - probable vectors	33 cases	Home – U.S.A.	Fleas on animals	Lack of awareness of the disease and methods of prevention	Increased awareness of the public re. treatment of animals exposed to other wild animals with exposure to fleas.
2009	Tularaemia[60]	Infected cat	1 case	Home – U.S.A.	Scratched by infected dog	Lack of awareness of disease and methods of prevention	Effective communication between human and animal health ensured rapid identification of the disease; rapid case identification and treatment. This case demonstrated the effectiveness of the *One Health* concept.
2009	*Brucella canis*[14]	Dogs	1 case: HIV patient	Home	Dogs	Immunocompromised individual; pet not recognized as a risk factor for the disease; insufficient testing	Veterinarians should inform pet owners of the risk posed for diseases such as *B. canis*. Insufficient testing of patients for brucellosis; true incidence of the disease unknown.
2005	*Salmonella* Typhimurium- from owl pellets[34]	Owl	26 cases	2 school /cafeteria tables – U.S.A.	Owl pellets-dissection	Proper hygiene precautions were not followed. After-school child care was also provided in the cafeteria where the pellets were dissected.	Animal and animal products used for educational activities should be excluded from food preparation areas.
2007	Three outbreaks of *Salmonella* - serotypes 4,5,12,i:-., *S* Montevideo, *S.* Ohio[35]	Baby poultry	41 cases	Home, farm, classroom, petting zoo, agric feed store – U.S.A.	Hatcheries: baby chicks, baby ducklings, goslings, turkey	Chicks purchased from feed stores	Feed stores urged to provide warnings and provide educational materials on the risk involved with baby poultry. Children less than 5 years should not be allowed to handle baby poultry.

Publication Dates	Outbreak or Case Series Type	Pet	# People Ill	Location or Setting	Source	Gaps	Findings or Recommendations
2009	*Salmonella* Montevideo --2 outbreaks PFGE patterns 1 and 2s[85]	Baby chicks	129 cases	Multiples states – U.S.A.	Chicks purchased from feed stores and by mail ordered had contact with backyard poultry; Baby chicks sold through mail order or internet	The outbreak involved 2 different genetic patterns: Pattern 2 occurred in 70% of children who had contact with chicks; Sixty-two percent of infections occurred around the spring/Easter time; Pattern 1 - 60% adults occurred at other times of the year	Children less than 5 years of age should not be allowed to handle baby poultry. Proper hygiene precautions when handling poultry should be enhanced; collaboration with industry to address problem.

Table 5 – Canadian Pet Zoonoses Guidance Documents
❖ General recommendations for reducing zoonotic pathogen transmission from pets to immunocompromised individuals[22]
❖ Guidelines for animal-assisted interventions in health care facilities[86]
❖ PIJAC – on line guidelines on pet ownerships and appropriate hygiene to prevent transmission of zoonoses[87]

Table 6 – Non-Canadian Pet Zoonoses Guidance Documents
❖ AAHA- American Animal Hospital Association: HealthyPet.com. Disease fact sheets, transmission routes for pets and people, and disease prevention strategies[88]
❖ U.S. Centers for Disease Control and Prevention (CDC) 1. Update: Interim Guidance for Minimizing Risk for Human Lymphocytic Choriomeningitis Virus Infection Associated with Pet Rodents[89] 2. Compendium of Measures to Prevent Disease Associated with Animals in Public Settings, 2009 National Association of state Public Health Veterinarians, Inc. USA, National Association of state Public Health Veterinarians. 2009. Morbidity and Mortality Weekly Report 2009 Vol. 58 No. RR-5; pp. 1-21[90]
❖ Guidelines for Prevention of Human Diseases from Non-traditional Pets at Home and Exposure to Animals in Public Settings[29]
❖ Family Daycare- Australia -Animals and Domestic Pets[91]

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