International Journal of Pathogen Research

4(3): 17-31, 2020; Article no.IJPR.57959
ISSN: 2582-3876

Zoonotic Risks from Domestic Animals in Ghana

Papa Kofi Amissah-Reynolds[1*]

[1]Department of Science Education, Faculty of Science and Environment Education, College of Agriculture Education, Asante-Mampong, University of Education, Winneba, Ghana.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/IJPR/2020/v4i330113
Editor(s):
(1) Dr. Mayada Mosad Ahmed Gwida, Mansoura University, Egypt.
Reviewers:
(1) Ehsan Gharib Mombeni, Shahid Chamran University of Ahwaz, Iran.
(2) Abu Hasan Sarkar, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57959

Review Article

Received 02 April 2020
Accepted 08 June 2020
Published 20 June 2020

ABSTRACT

Zoonoses are diseases or infections which are naturally transmitted from vertebrate animals to humans and vice versa. These infections account for more than half of human infections worldwide, with most cases reported in developing countries like Ghana. The Government of Ghana recently launched the "Rearing for Food and Jobs Campaign", an initiative to bridge the glaring deficit in protein supply. This has resulted in increased livestock production nationwide in response to the increasing demand for animal protein. Increase in both human and livestock population in the country have implications for transmission of zoonotic diseases, as it allows for more frequent interactions between the two within a limited space. Multiple animals are kept in various homes at varying levels of confinement. Security concerns, particularly in urban areas, have resulted in an increased reliance on dogs, while financial considerations have mainly driven a rapid increase in livestock production both at commercial and smallholder levels. Taking into account that the pandemics in the past few decades have animal origins, this growing human-animal interconnection is of concern. Albeit an increased household-human-animal ratio, there is a paucity of epidemiological data on domestic animals in Ghana. Several zoonotic diseases have been reported in Ghana, including rabies, toxocariasis, toxoplasmosis, Q-fever, hepatitis E and brucellosis. Risk factors such as close contact with animals, poor hand hygiene, poor sanitation, and unvaccinated, free-ranging animals have been linked with zoonotic transmissions. Zoonoses have been recorded in homes, slaughterhouses, and on farms in farm workers, butchers, and vulnerable groups, including children, pregnant women, and HIV patients. A 'One-Health' approach, which comprises well-coordinated activities of both health and veterinary services, will facilitate timely diagnosis and effective control of zoonoses in Ghana.

**Corresponding author: Email: kofireynolds@gmail.com;*

Keywords: Zoonotic risks; domestic animals; Zoonoses; livestock population.

1. INTRODUCTION

Animals are kept in Ghanaian homes for both personal and commercial purposes. Dogs and cats are kept for companionship, breeding purposes, and security, while ruminants and poultry are bred to supplement family income and provide food [1,2]. Globally, livestock production is increasing to meet the ever-growing demand for animal protein. Increase in both human and livestock populations have implications for transmission of zoonotic diseases, as it allows for more frequent interactions between the two within a limited space [3,4]. Such close associations pose a threat to public health, particularly in developing countries with poor animal husbandry practices. The fact that zoonoses account for more than 60% of all human diseases worldwide [3] further highlights the need to limit human-animal interactions.

Contact with animal fur/hair, excrement and the use of animal droppings as farm manure are some possible sources of infections [5]. According to health reports, most emerging/re-emerging infectious diseases are of zoonotic origin [6,7], with recent pandemics (COVID-19, H1N1, H5N1 & Ebola Virus Disease) all affirming this assertion [8]. Data from parts of the country have reported multiple zoonotic agents in domestic animals [1,9-11], coupled with poor animal management practices by owners who lack adequate knowledge of animal care. Given, the frequent movement of people, animals, and animal products, diseases can spread rapidly across the globe [12]. A collaborative, multisectoral approach under a 'One-Health' concept is therefore needed to prevent the occurrence of future pandemics. In this write-up, the zoonotic risks associated with keeping domestic animals are discussed.

2. TYPES OF ANIMALS KEPT

A wide array of animals such as dogs, cats, poultry, pigs, and ruminants are kept in Ghanaian homes. Dogs and cats serve as pets, biological control agents for rodents, also used in hunting, and/or for security. The population of dogs in urban areas is increasing because of security concerns [13]. Other animals like poultry, pigs, and ruminants are kept largely for commercial purposes. The frequency and distribution of these domestic animals vary from place to place, with the availability of space, income levels, and religious beliefs all influencing the types of animals kept [14]. For instance, in Islamic communities/homes, dogs and pigs are not reared, although they favor keeping of sheep, goats, and cows, which they mostly use for their religious celebrations.

2.1 Animal Husbandry Practices

Three types of housing styles are employed by animal owners. These are intensive, semi-intensive, and extensive systems. Of the three, only the intensive system ensures strict confinement of animals, yet this is the least practiced as it is more capital intensive. This suggests that most animal owners allow their animals to be nomadic within the communities, polluting the environment through indiscriminate defecation.

Owing to financial constraints, smallholder farmers/ animal owners tend to raise their animals under makeshift structures, some of which are; sheds, yards, stalls and shades, and feed their animals off household wastes or allow them to scavenge for food. Meanwhile, commercial farmers often house their animals in a permanent shelter, where they provide concentrates to bolster productivity [15]. Generally, deworming and vaccination of animals are poor among smallholder farmers. This is evident from helminthiasis accounting for a third of losses of small ruminants and the spikes in the incidence of rabies nationwide. Poor husbandry practices and lack of treatment of animals aid zoonotic transmissions from animals to humans [16].

2.2 Policies on Domestic Animals, Availability of Animal Hospitals and Diagnostic Tools

Sources of animals may include family/friends, breeding stations, open markets [15] and farms. Others may acquire animals through the adoption of stray animals or theft. Animals introduced into homes are often of unknown health status and there is rarely any form of rigorous medical screening by veterinary officers, preceding purchase. As such the purchase of animals may introduce zoonotic agents into homes/herds. Lack of strict confinement of these animals in our communities further exacerbates the risk of zoonotic transmissions to the general public.

Although there are policies governing the types of animals permitted close to human settlements, these are largely unenforced [4]. Compared to best practices elsewhere, where all pets are accompanied outside their homes, while animal farms are sited further away from human settlements, stray animals feature prominently in our communities and on our streets. Although large animal farms are mostly situated in rural areas, functional animal laboratories and clinics are non-existent in these settings. Laboratory facilities in the urban centers, however, lack adequate diagnostic tools which also affects the timely detection and management of diseases. For instance, in the diagnosis of helminthiasis microscopy remains the conventional method in these animal clinics. Such tests, however, have low specificity, considering similarities between the ova of parasite species. Therefore, infections may be misdiagnosed and/or underestimated. Additionally, there remains a paucity of data on the efficacy of drugs used in the treatment of these animals. Considering the wide array of domestic animals kept, epidemiological studies are needed to protect both public and animal health.

3. ZOONOTIC INFECTIONS IN DOMESTIC ANIMALS

3.1 Zoonotic Transmissions from Companion Animals

Dogs are among the most commonly kept animals in Ghanaian homes. These animals cut across all social classes and are found in all types of settlements. More than 70% of the dogs in Ghana are kept for security reasons, with a similar proportion of these animals being allowed to roam about freely within the communities [1, 17]. Dogs also serve commercial purposes as they are sold as pets or for food. In some parts of the country, dog markets are well-established and these animals serve as a delicacy for many [18].

One of the most commonly reported zoonoses in dogs in Ghana is rabies, a viral disease with a high fatality rate [2]. Human infections occur primarily through dog bites. In addition to the injury, pain, and trauma which often accompany the bites, victimsmay also experience hypersalivation, hyperventilation, hydrophobia, fever, headaches, and aggression. Ghana has initiated several campaigns in the past to curb rabies, with a seemingly lack of well-coordinated surveillance between public health and veterinary services [19]. Scarcity of human vaccines and immunoglobins [20], high cost of vaccines [21], the indifference of dog owners, and cultural beliefs towards vaccination have all contributed to failed attempts in the past at reducing rabies-related morbidity. In Ghana, more than half of human-rabies cases result from stray dog bites [22], indicating the need for stricter enforcement of policies on pet keeping. Reports of spikes in rabid bites country-wide [23] suggest increasing dog-human contact, lack of confinement, and poor vaccination practices among owners. Mass canine vaccination is key to meeting the Global Target of “zero human rabies deaths” by 2030 [24]. However, with less than 30% of dogs in the country vaccinated, increased dog roaming population, and high dog to a household-human ratio [9], Ghana appears to be missing out on this target.

Apart from rabies, free-ranging dogs are likely to transmit multiple zoonotic parasites, including *Toxocara canis, Ancylostoma caninum, Diphyllobothrium latum*, *and Dipylidium caninum.* Of these, *Toxocara canis* and *A. caninum* are the most frequently reported parasites of both veterinary and public health importance.

Human toxocariasis occurs through the ingestion of embryonated *Toxocara* eggs, with the passing out of parasite-infested excreta by free-ranging dogs facilitating transmission. Apart from dogs and cats, the main biological transmitters of toxocariasis, zoonotic transmission of toxocariasis is possible through the consumption of pig or poultry viscera [25]. Human infections are usually classified into three forms (visceral larva migrans, ocular or covert toxocariasis), with the severity of disease based on the part of the body infected. Worldwide, the varying prevalence of *Toxocaracanis* have been reported, at less than 50% in Europe and the Americas, and over 50% in Africa [26]. A study on human toxocariasis in Ghana reported a prevalence of 53.5% in children, with pet keeping, geophagia, and poor hand hygiene being significant risk factors [26]. Cases of human infections in Ghana may be underestimated given that serological tests that offer accurate results with high sensitivity and specificity [27] are not available in the rural areas where infection rates are significantly higher. The presence of *Toxocara* eggs in vegetable farm soils suggests that consumption of unwashed, fresh vegetable products may be a source of infections [28]. Contact with the hair of dogs may also be a mode of transmission of toxocariasis [29,30].

Table 1. Summary of studies on zoonotic infections in Ghana highlighting study location, transmitting animals and key findings

Author	Year	Study category	Location	Microbe/ disease	Animals involved	People Involved	Key findings	Ref. Number
Adomako et al	2018	Retrospective review	Eastern Region	Rabies	Dogs	Rabies victims	Most cases of rabid bites in children under 10 years Lack of collaboration between health and veterinary services in management of rabies	[19]
Adu	2017	Epidemiology	Lower Manya-Krobo, Eastern region	*Cooperia* spp., *Haemonchus* spp., Hookworms and *Trichostrongylus* spp.	Cattle		Recovery of four genera of helminths Hookworms and *Trichostrongylus* identified as predominant helminth species on farms Possible bovine, zoonotic transmission to humans	[11]
Amemor et al	2016	Epidemiology	North Tongu, Volta region	*Mycobacteriumbovis*	Cattle	Herdsmen	Prevalence of 19% of BTB in cattle Only cows were infected with BTB, but no infection in bulls Significant association between seropositivity in cows and kraal density	[44]
Amissah-Reynolds et al	2016	Epidemiology	Mampong-Ashanti	*Toxocara canis, Dipylidium caninum* and *Diphyllobothrium latum*	Dogs	Dog owners	Presence of zoonotic parasites in dogs Age of dog and location as significant risk factors of infection High number of stray dogs, Poor pet management, lack of vaccination and knowledge on zoonosis	[1]
Amissah-Reynolds et al	2020	Epidemiology	Mampong-Ashanti	*Toxocaracanis*, *Fasciola* spp.	N/A	N/A	Risk of zoonotic transmission from consumption of fresh vegetables and salads Zoonotic parasites in farm soils and irrigation water	[28]

Author	Year	Study category	Location	Microbe/ disease	Animals involved	People Involved	Key findings	Ref. Number
Antwi et al	2018	Seroepidemiology	Kumasi	*Toxoplasmagondii*	Goats		First report of toxoplasmosis in goats Nearly half (42%) of goats infected Higher infections in males and adults	[60]
Arko-Mensah	2000	Seroepidemiology	Ghana	*Toxoplasma gonidii*	Pigs		National prevalence of 39% in pigs Seroprevalence varies with ecological zone	[61]
Asante et al	2016	Descriptive survey	Greater Accra Region	HPAI H5N1	Poultry		Outbreak of strain possibly from Nigeria Frequent movement of humans and birds across the border implicated in the outbreak	[68]
Asare et al	2019	Case report	Elmina	*Dipylidiumcaninum*		Pregnant woman	Report of zoonotic dipylidiasis in a pregnant woman	[31]
Awuni et al	2019	Descriptive survey	Upper East Region	Rabies		Dog owners	Knowledge of rabies associated with sex, occupation, educational level and district of residence of owners District of residence, educational level, knowledge on rabies, occupation and religion were associated with canine rabies vaccination	[21]
Ayim-Akonor	2020	Risk analysis	Ghana	Poultry zoonosis		Poultry farmers	Limited knowledge on zoonotic poultry diseases Poor attitudes towards use of PPEs Raising of multiple species may allow for animal to animal transmissions	[37]
Bentum et al	2019	Seroepidemiology	Kumasi	*Toxoplasma gondii*	Sheep and goats		Consumption of raw/undercooked meat products from goats and	[59]

Author	Year	Study category	Location	Microbe/ disease	Animals involved	People Involved	Key findings	Ref. Number
							sheep can be a source of zoonotic toxoplasmosis	
Folitse et al	2014	Epidemiology	Dormaa and Kintampo Districts	Tuberculosis and Brucellosis	Cattle		Increase in infection rates of both diseases with age	[43]
Folitse et al	2020	Seroepidemiology	Kumasi	*Coxiellaburnetii*	Small ruminants		Higher risks in goats than in sheep Risk of infections to abattoir workers	[40]
Jarikre et al	2015	Seroepidemiology	Northern, Ashanti & Greater Accra Regions	Brucellosis	Sheep and goats		Female animals appear more susceptible to infections Higher infection rates in Ashanti compared to two other regions	[42]
Johnson et al.	2015	Epidemiology	Greater Accra Region		Dogs	Dog owners	Increasing dog population in urban areas for security reasons Presence of zoonotic agents in dogsPoor pet management practices	[17]
Johnson et al.	2016	Epidemiology	Greater Accra Region	*Cordylobia anthropohaga,Dermatobia hominis*	Dogs		Two species of insects identified as cause of myiasis Possibility of dog to human myiasis transmission	[13]
Johnson et al	2019	Seroepidemiology	Volta Region	*Coxiella burnetii*	Cattle, sheep and goats	Farm workers	Seropositivity rate of 21.6% in ruminants No knowledge of Q-fever by farm workers and veterinary technical staff Risk of infections in children who assist in farm activities Q-fever is a possible cause of abortions in animals	[49]
Kobbe et al	2008	Sero-epidemiology	Ashanti Region	Q-fever		Children	Early exposure of children to *C. burnetii*.	[52]

Author	Year	Study category	Location	Microbe/ disease	Animals involved	People Involved	Key findings	Ref. Number
							Possible overestimation of malaria given similar clinical manifestations	
Kubuafor	2000	Seroepidemiology	Akwapim South	Brucellosis	Cattle	Humans	Age of animal is a significant risk factor Brucellosis implicated in abortion and placental retention in cows	[46]
Kyei et al	2015	Seroepidemiology	Central Region	Toxocariasis		Children	Higher infection rates in rural areas, Age, educational level, pet keeping, geophagia and hand washing with soap as significant risk factors of infection	[26]
Laryea et al	2017	Review	Kumasi	Rabies	Dogs	Humans	Stray dogs accounted for more than half of dog bites 100% case fatality from rabid dog bites No post-exposure prophylaxis for one-third of patients who reported to health facilities	[22]
Majekodunmi et al	2019	Seroepidemiology	Greater Accra & Upper East regions	Hepatitis E virus, *Taenia solium* and *Trichinella spiralis*	Pigs	Pig handlers, General public	Regional variation in infection rates, High infection rates in pig handlers compared to other community members in Accra Possible pig-related zoonoses transmission along the pork value-chain	[4]
Otupuri	2000	Descriptive survey	Kumasi	Brucellosis, Tuberculosis Cysticercosis Fascioliasis Mange		Butchers	Frequent detection of zoonotic diseases at slaughterhouse Unsafe meat handling practices by butchers Lack of formal training of butchers General belief that religion confers	[74]

Author	Year	Study category	Location	Microbe/ disease	Animals involved	People Involved	Key findings	Ref. Number
							protection from contracting infections	
Owusu	2015	Sero-epidemiology	Greater Accra Region	*Babesia* spp.	Dogs, cattle	Malaria patients	Possible zoonotic transmission for dogs and cattle Possible misdiagnosis of Babesiosis as malaria	[32]
Punguyire et al	2017	Review	Techiman	Rabies	Dogs	Humans	100% case fatality from rabid dog bites Nearly half of dog bites among children aged 1-15 years	[2]
Squire et al	2013	Epidemiology	Southern Ghana	*Cryptosporidium parvum*	Cattle	Farmers	Possible bovine transmission of Cryptosporidium to humans and other animals Infection rates varies with type of vegetation zone	[56]
Squire et al	2018	Epidemiology	Coastal savannah zone, Ghana	Gastrointestinal helminths	ruminants	Farmers	Possible zoonotic transmission of cryptosporidiosis from livestock	[10]
Turkson and Boadu	1992	Epidemiology	Coastal savannah zone, Ghana	Brucellosis	Cattle		Overall prevalence of 9.3% Significantly higher infections in older animals compared to younger ones	[41]

Dipylidium caninum and *Diphyllobothrium latum* are other parasites of zoonotic importance, with the latter being a fish tapeworm [31]. A case of human dipylidiasis has been reported in Ghana [31], with infections of this zoonotic parasite rarely encountered worldwide. Dogs have also been implicated in the possible transfer of myiasis to humans, with two species of insects (*Cordylobia anthropohaga,* and *Dermatobia hominis*) identified as causative agents of the disease in dogs in the Greater Accra Region of Ghana [13]. Canine transmission of *Babesia* is also possible as dogs living in proximity to humans have been found to be positive for the pathogen [32]. Dogs may also aid in the transmission of *Ascaris lumbricoides* as they have been found to harbor viable eggs of the parasite elsewhere [33], though this is yet to be reported in Ghana. Dogs as companion animals, share closer bonds with humans compared to other domestic animals. Therefore, strict confinement and regular treatment/vaccination of these animals form a vital part of the management of zoonotic diseases in Ghana. Like dogs, cats are closely related to humans and have been implicated in the transmission of rabies, toxocariasis, and toxoplasmosis. However, there is no study on feline infections nor the role they play in zoonotic transmissions in Ghana.

3.2 Zoonotic Transmissions from Ruminants

Ruminants are another class of domestic animals kept by Ghanaians. Goats, sheep, and cattle are the main ruminants kept, providing income, employment, and a major source of animal protein [34]. To date, animal protein remains the largest source of protein in Ghana [35]. With Ghana's domestic production falling below FAO recommended levels, it is imperative to bolster meat production. However, a myriad of problems faced by farmers/animal owners hampers the realization of this objective. Financial constraints are the major challenges faced by farmers, as they cannot afford the high cost of drugs, feedstuffs, and adequate shelter for their animals [36]. In addition, diseases (including helminthiasis) and theft also account for a significant amount of animal losses. To avert economic losses resulting from theft [36], animal owners keep their livestock in proximity to their residence to ensure effective monitoring [37], a condition that may aid zoonotic transmissions. In Ghana, management practices and productivity of ruminants vary from place to place. However, an extensive system where animals are allowed free movements in search of food and water is the most practiced [35], creating ideal conditions for human-animal contact and allowing for the transfer of infections.

The strongylids (*Trichostrongylus* and *Haemonchus*) and *Fasciola* are among the zoonotic parasites that have been recovered from ruminants in Ghana [38], with a higher prevalence of nematode infections compared to trematode infections. A recent molecular characterization of *Trichostrongylus* infections in ruminants suggested zoonotic transmission of these parasites to humans [10]. In the absence of molecular diagnosis, these infections could easily have been diagnosed as hookworm infections, considering the similarity between ova of these parasites and the fact that human trichostrongyliasis is rarely reported.

Bovine brucellosis and tuberculosis are two of the world's major zoonotic diseases [39]. *Brucella* spp and *Mycobacterium bovis* respectively are the causative agents primarily affecting cattle [40]. Brucellosis has been reported in both large [41] and small ruminants [42,43] in Ghana. The free movement of ruminants increases the chances of infections. In Ghana, ruminant diseases remain a public health concern with close contact with infected animals being the major risk factor [44]. Their occurrence not only raise public health concerns but also have a serious economic impact on producers, regional and national economies through decreased productivity and trade loss [45]. The low endemicity of these diseases [46] does not translate to their absence and hence policies that check the unrestricted movements of ruminants, continuous veterinary practices, and good husbandry practices are needful for preventing infections.

Bovine tuberculosis remains a major public health problem in many sub-Saharan African countries like Ghana. Currently, the National Tuberculosis Control Programme focuses on case management in human populations, excluding the animals [47]. The increase in the population of ruminants and the frequent movement of livestock of unknown health status across our borders may support the transmission of bovine tuberculosis in Ghana. The fact that "post-mortem inspection of carcasses for lesions" remains the most widely diagnostic procedure is also a means of transmission particularly in densely populated areas, where animal-human contact is more frequent [47]. Seropositivity in

cattle has been associated with kraal density [43].

Free-roaming ruminants become exposed to numerous pathogenic agents through what they consume while on the move. Zoonoses such as Anthrax [48], Q fever (*Coxiella burnetii*, leptospirosis (*Leptospira* species), rickettsioses (*Rickettsia* species), bartonellosis (*Bartonella* species), plague (*Yersinia pestis*), rift valley fever and chikungunya (arboviruses) are other diseases they can transmit. Small ruminants have been linked with the outbreak of Q fever in the Volta region of Ghana [49]. Q fever, a zoonotic disease caused by *Coxiella burnetii,* which is able to cause abortions in livestock and febrile illness in humans [49]. Studies have shown that there is an exceptionally high concentration of pathogenic agents at the time of parturition [50,51], suggesting possible transmission during handling of newborns, placental tissues, and amniotic fluids. The closeness of these ruminants to human settlements increases the rate of infection to the disease. Reports of Q-fever in children suggests the possibility of overestimation of malaria cases in Ghana, considering similar clinical manifestations of the two disease and the low knowledge on Q-fever infections [52].

Another zoonotic parasite recovered from ruminants in Ghana is *Cryptosporidium parvum [53]*. This parasite is an enteric protozoan noted for causing diarrhoea. Apart from breastfeeding, infections are transmissible through food, water, or soil containing oocysts- the infective stage of the parasite [54]. Indiscriminate defecation or disposal of animal excreta into water bodies could also introduce infections into the food chain. Other risk factors of infection include lack of potable water and toilets, overcrowding (especially in slums), and animal contact [55]. A study on *Cryptosporidium* infections in cattle from Southern Ghana revealed an overall prevalence of 29.0%, with infection rates varying according to vegetation zones [56]. The study further highlighted the possibility of zoonotic transmissions between farmers and their livestock. The use of untreated animal excreta as manure on vegetable farms could also aid in the transmission of cryptosporidiosis.

Toxoplasmosis, caused by the protozoan parasite *T. gondii*, is an important zoonosis worldwide. In Ghana, there are numerous reports of human infections (including pregnant and HIV patients) [57,58], but very little information on animals. Human infections result from the ingestion of raw foods (meat, vegetables, and fruits) and soil containing sporulated oocysts. Transmission through organ transplantation, blood transfusion as well as congenital transmissions have also been reported. With varying prevalence reported globally, pet-keeping, contact with soil and consumption of unpasteurized dairy products, and unwashed fruits and vegetables have been identified as significant risk factors. So far, small ruminants [59,60] and pigs [61] are known reservoirs of the parasite in Ghana. Although cats have been implicated in the spread of the disease in Ghana [58], there is no available report on toxoplasmosis in these companion animals.

Most of these zoonoses from ruminants are known to pose considerable challenges in their diagnosis as they share common symptoms with many infectious diseases [62]. For this reason, many of these zoonoses of public health concern appear understated, thereby limiting awareness of clinicians and policymakers. Additionally, the lack of adequate laboratory facilities hampers management efforts. Best preventive measures which include good animal husbandry, veterinary routines, grazing management, and personal hygiene [63] are paramount in protecting both animal and public health.

3.3 Zoonotic Transmissions from Pigs

Pig production is gaining prominence in the livestock production industry owing to the high prolificacy rate, short generational time, and the relative ease of management of these animals [64]. Globally, meat production has more than quadrupled over the past six decades, with pork as the leading source of animal protein [65]. Ghana has also seen a proliferation of pig farms (both commercial and smallholder pig production) as a result of increasing demand for animal protein in the country. Though there are by-laws prohibiting the raising of pigs near human settlements, it is not uncommon to find pigs in homes or roaming about in some communities [4]. With these animals feeding off anything they come across, free-ranging pigs that come into contact with human excreta can aid in the transmission of zoonosis. A study on toxoplasmosis in Ghana identified pigs as possible biological transmitters of the disease [61]. The study reported a national prevalence of 39% in pigs, with age and breed of pigs, environmental conditions, and management practices as significant risk factors. The recovery of *Taeniasolium*, *Trichinella*, and Hepatitis E Virus (HEV) from pigs in Ghana suggests

possible zoonotic transmissions to humans through the ingestion of raw or undercooked pork. Pregnant women are particularly vulnerable with the risk of stillbirths from hepatitis E infections [66], or possible congenital transmission of toxoplasmosis to their children [57,58]. This calls for urgent attention and regulation by relevant stakeholders.

3.4 Zoonotic Transmissions from Poultry

The poultry industry contributes substantially to animal protein worldwide, second only to pork as the leading source of animal protein. These birds are mainly kept for their eggs and/or meat, while their droppings may serve as sources of farm manure. Competitive pricing and the absence of cultural or religious prohibitions on consumption make chicken an attractive option to consumers as compared to other animals [67]. Attempts to increase productivity amidst the growing demand for animal protein is often met with constraints, including diseases. A number of zoonotic poultry diseases have been recorded in Ghana, including highly pathogenic avian influenza (HPAI) virus subtype H5N1, Newcastle disease, Salmonellosis, and Coccidiosis [68-71]. Poor on-farm attitudes and practices increase the risk of human infections with zoonotic poultry diseases [37].

3.5 Zoonotic Transmissions from Rabbits And Grass Cutters

In addition to the aforementioned animals, rabbits and grass cutters are also kept in some households, though on a small-scale. These animals are kept under strict confinement, limiting contact with their caregivers or owners. Several pathogens have been recovered from grasscutters, including *Trichomonas* spp, *Giardia* spp, *Eimeria* spp., *Ancylostoma* sp., and *Schistosoma haematobium*, with no available information on zoonosis [72,73]. Zoonotic infections from these animals may stem from improper cooking of meat or contact with their feces. Hunting for wild game and domestication of wild species of animals like grass cutters may be a source of zoonotic transmissions from the wild.

4. ROLE OF SLAUGHTERHOUSES, BUTCHERS, FOOD VENDORS AND NOMADIC HERDSMEN IN TRANSMISSION OF ZOONOSIS

Apart from keeping live animals close to human settlements, zoonotic diseases are also transmissible from meat products bought from food vendors, meat shops, and slaughterhouses. Slaughterhouses play a critical role in the food industry, contributing to the alleviation of protein malnutrition while providing employment for several others, including butchers. As such proper surveillance and surveys on slaughterhouse activities are needful to avert transmission of zoonotic diseases to the public through improvement in the detection and management of diseases. Rigorous ante- and post-mortem inspections are also vital in protecting the health of patrons. Reports of failure of butchers to adhere to safety protocols and precautionary measures as a result of ignorance, indifference, or religious beliefs are a source of concern [74]. It is therefore unsurprising that zoonotic infections such as brucellosis have been reported in slaughterhouse workers in Ghana [75]. Regular training and formulation of laws are needed to limit community-spread of zoonoses from slaughterhouses.

The activities of nomadic herdsmen who herd their flock (mainly cattle) close to human settlements may also be a source of zoonotic transmissions. Indiscriminate defecation as these animal graze tends to release enteric zoonotic agents into the environment. Like farmers, these herdsmen have regular, close contact with the animals, a risk factor for transmission of most zoonotic infections. Activities of chop bar operators and other intermediaries involved in the sale or processing of meat products should also be well regulated to avert transmission of infections along the food chain.

5. CONCLUSION

Ghana has seen an increased household-human-animal ratio over the past few decades. Lack of confinement of unvaccinated animals which are harboring zoonotic agents is ideal for the transmission of zoonoses to humans. Lack of adequate laboratory facilities and lack of coordination between health and veterinary services affects the timely diagnosis of infections. A One-Health approach is needed for effective control of zoonoses in Ghana.

6. RECOMMENDATIONS

Epidemiology data on populations of animals, management practices and zoonotic diseases nationwide to inform control strategies. Formulation and enforcement of policies and by-laws on pet keeping and livestock production,

particularly near human settlements are needed to prevent zoonotic transmissions. National Control Programmes for diseases like TB should include the management of disease in animal populations. Management of zoonosis should include well-coordinated efforts between health and veterinary services to ensure timely diagnosis and management of diseases.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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