

Antimicrobial Resistance Of Foodborne Zoonotic Bacteria Its Contributing Factors And Status In Ethiopia.

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Abstract: Food-borne diseases encompass a wide spectrum of illnesses and that are common in developing countries including Ethiopia. Their occurrence is mainly because of the prevailing poor food handling and sanitation practices, inadequate food safety laws, weak regulatory systems, lack of financial resources to invest in safer equipment and lack of education for food-handlers. In Ethiopia, the cases of food-borne illnesses are rarely investigated in detail and under reported. Therefore, the objective of this paper was to review food-borne Zoonotic microbial commonly bacteria and their status of resistance of drug, illness reported so far in Ethiopia and forward recommendations that addresses the weak sides. Based on literatures assessed, food-borne bacterial diseases reported in Ethiopia were mainly caused by Salmonella spp, Campylobacter, Listeria, E.coli and Mycobacterium, staphylococcus aureus and Listeriosis. These food-borne bacterial diseases were reported from different parts of Ethiopia though it does not seem to cover wider geographic areas. Similarly, antimicrobial resistance has been reported against sulfisoxazole, ampicillin, streptomycin, cephalothin, cotrimoxazole, trimethoprim, cephalothin, tetracycline, methicillin, vancomycin and, clindamicin. The main risk factor for the increase in the antibiotic resistance has been suggested to be an extensive use of antibiotics in human health, Veterinary Medicine and agriculture which lead to the emergence and dissemination of resistant bacteria and resistant genes in animals and humans. Therefore, coordinated surveillance and monitoring system for food-borne pathogens must be designed and community awareness for improvement of management and hygienic practices as well as professionals working in the area of food animals must get refreshment courses in order to deal with the changing pattern of food-borne pathogens epidemiology.

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1. Introduction

Foodborne diseases are among the most widespread global public health problems of recent times, and their implication for health and economy is increasingly recognized (WHO, 2004). According to reports, every year, a huge number of people suffer from foodborne diseases worldwide due to contaminated food and water consumption (Buzby and Roberts, 2009). A wide range of pathogens play a role in foodborne disease, most of which have a zoonotic origin and have carriers in healthy food animals from which they spread to an increasing variety of foods of animal origin and are considered as major vehicles of foodborne infections (F.M.S'anchez-Vargas, et al. 2011). Among the pathogens, Salmonella is considered the most prevalent foodborne pathogen worldwide (Carrasco, 2012) and has long been recognized as an important zoonotic microorganism of economic significance in animals and humans (Carrasco, 2012), predominantly in the developing countries.

Consumption of raw or unsafe food, cross-contamination, improper food storage, poor personal hygiene practices, inadequate cooling and reheating of food items, and a prolonged time lapse between preparing and consuming food items were mentioned as contributing factors to an outbreak of salmonellosis in humans (K'ferstein, 2003), (E. Carrasco, et al. 2012).

Food-borne diseases encompass a wide spectrum of illnesses and are a growing public health problem worldwide. They are the result of ingesting contaminated foodstuffs and range from diseases caused by a multitude of microorganisms to those caused by chemical hazards. The global burden of food-borne diseases and its impact on development and trade is currently unknown in both industrialized and developing countries. However, developing countries tend to suffer from the largest share of the burden of food-borne diseases (WHO, 2012).

The World health organization (WHO) estimated that in developed countries, up to 30% of the population suffers from food-borne diseases each year,

whereas in developing countries up to 2 million deaths are estimated per year (WHO., 2007). Food-borne diseases are common in developing countries including Ethiopia because of the prevailing poor food handling and sanitation practices, inadequate food safety laws, weak regulatory systems, lack of financial resources to invest in safer equipment and lack of education for food-handlers (WHO, 2004).

National Hygiene and Sanitation Strategy program (WHO, 2005) reported that about 60% of the disease burden is related to poor hygiene and sanitation in Ethiopia. Unsafe sources, contaminated raw food items, improper food storage, poor personal hygiene during food- preparation, inadequate cooling and reheating of food items and a prolonged time lapse between preparing and consuming food items were mentioned as contributing factors for outbreak of food borne diseases. Studies conducted in different parts of the country showed the poor sanitary conditions of catering establishments and presence of pathogenic organisms like campylobacter, Salmonella, staphylococcus aureus, Bacillus cereus and Escherichia coli (Knife, 2007) -(Abera, et al. 2006).

The epidemiology of food-borne diseases is changing now days. New pathogens have emerged and some have spread worldwide (Mekonen, et al. 2011). The threats of new food-borne diseases are occurring for a number of reasons, through the globalization of the food supply, the inadvertent introduction of pathogens into new geographic areas, through travelers, refugees and immigrants exposed to unfamiliar food-borne hazards while abroad, through changes in micro-organisms, through changes in the human population (the number of highly susceptible persons is expanding worldwide because of ageing, malnutrition, HIV infections and other underlying medical conditions) and changes in lifestyle. It is well documented that raw or under-processed seafood provides important epidemiological pathways for food-borne disease transmission (WHO, 2002).

N. B:- In Ethiopia, the cases of food-borne illnesses are rarely investigated in detail and under reported even if diagnosed in the form of outbreak or individual illness of human beings and animals. Moreover, research in the area of identifying the causative agent and food incriminated is also at its infant and calf or kid stage because of lack of well-developed laboratory system of human animal's i.e. like one-health collaborations, consumables and reagents for isolation identification and lack of coordinated epidemiological surveillance systems of human animals. Therefore, the objective of this paper was to review zoonotic food-borne bacterial illness reported and antimicrobial resistance, so far in Ethiopia and forward recommendations that addresses the weak sides.

1.1. Objective:-

The objective of this review was:-To isolate and identify Zoonotic food borne diseases like Salmonella spp, staphylococcus aureus, Tuberculosis spp, Bacillus Cereus and E. coli O157:H7 from carcass, poorly hygienic prepared food, un-proper cooked food, raw meat and milk consumptions and environment of municipal abattoir, market sold food problems and their fate of drug resistances.

2. Antimicrobial Resistance Of Foodborne Zoonotic Bacteria Its Contributing Factors And Status In Ethiopia.

2.1. Zoonotic Disease Selection

In order to evaluate constraints to identification of solutions for zoonotic diseases that affect the developing world, we had first to select a set of diseases for examination. It was not possible to include in our all potential zoonotic diseases affecting the developing world. Therefore, a set of some diseases were selected that (Bean, et al. 1990) includes the most important zoonotic diseases of development, in addition to currently relevant diseases, includes those likely to become more important due to socio-economic and other changes in low and middle income countries like ours Ethiopia, and (Ashenafi, et al. 2006), reflects the diversity of zoonotic diseases, so that our general conclusions about technical gaps and research opportunities might apply to diseases not analyzed. Below we explain these selection criteria in more detail (Linscott, 2011) .

Zoonotic diseases affect the poor in two important ways (Molyneux, et al. 2011). Firstly, like all animal diseases, they have a socio-economic effect by reducing the productivity (World Health Organization, 2011) and income of poor households that depend on animals for their livelihoods, or by affecting income at a national level through impacts on food value chains, markets and trade (Shaw, A., 2009). Secondly, because these diseases affect humans, they reduce health, contributing to morbidity, mortality and, where the ability to work is affected, they reduce income and livelihoods, with possible consequences for health (Meslin, F. 2006). There is an additional effect of zoonotic diseases that relates particularly to households or local communities that are dependent on producing their own animal-based foods for consumption (Perry, B. & Grace, D., 2009) . For these groups, animal diseases limit access to and consumption of important nutrients associated with these foods, particularly micronutrients, with particular implications for child health (Murphy, S. P & Allen, L. H, 2003). Rural farming communities, which comprise the majority of households living in poverty, are particularly affected in this way

(Thornton, P. K., et al. 2002). In our prioritization, we include this as an additional socio-economic effect.

It is these potential effects that make the evaluation of zoonotic diseases and their impacts complex. While there is strong evidence for independent socio-economic or health effects of zoonotic diseases, there has been little examination of their combined effects; this has been limited particularly by a lack of common metrics for agriculture and health outcomes (Shaw, A. 2009). However, the potential additive nature of the agricultural and health effects of zoonosis is highlighted by a well-known cost-benefit analysis of brucellosis control in Ethiopia like that of the Central Asia which showed the cost of control to be economical relative to the combined effects of the disease on human health and livestock productivity (Roth, F. et al. 2003).

2.2. Landscape For Zoonotic Diseases Of The Poor

Recent changes in low and middle income countries (LMICs) with respect to human and animal populations will affect the nature and importance of zoonosis (Cascio, A., et al. 2011). Population and economic growth in these countries is leading to an extension of agriculture and human populations into natural ecosystems, creating greater contact between people, livestock and wildlife, which will facilitate movement of zoonotic diseases (Wilcox, B. A & Guble, D. J. 2005).

At the same time, demand for animal-based foods, associated with growing incomes in LMICs, is stimulating intensification of livestock production and the emergence of more complex food chains linking production with consumers (Delgado, C. et al. 1999). New production systems and food value chains may lead to a change in the importance of zoonotic diseases, as exemplified by a growing importance of food-borne diseases, relative to diseases associated with direct animal-human contact (Slingenbergh, J. et al. 2004). These changes will affect zoonotic risks to the poor in rural settings, but will have a particular effect on growing urban and pre-urban poor populations, with their increasing livestock production, where consumers sit at the end of increasingly long food chains (Schelling, E., et al. 2007).

Another anticipated trend is the emergence of entirely new zoonotic diseases in LMICs (Jones et al, 2008). Studies of the emergence of new zoonotic diseases suggest that this is associated with the overlap of dense human populations with areas of high mammalian biodiversity ('hot spots'), which are particularly associated with LMICs (Kleczkowski, A. et al 2012). While much research has focused on emerging zoonotic diseases as global threats, and their

potential impact on global economies and high income countries, it is likely that poor populations in their countries of origin will be particularly affected due to a lower capacity to manage zoonotic diseases generally (Jones, K. E., et al, 2008).

2.3. Methods for Disease Prioritization

Disease prioritization was undertaken by a team comprising experts in both animal and human disease in LMICs, selected particularly for their experience in the development and use of diagnostics, medicines, vaccines and management practices. The team drew upon their own expertise and a set of recent publications on the distribution of animal, zoonotic and human diseases of the poor.

A long-list of 61 zoonotic diseases was selected, based on (Taylor, L. H., et al, 2001). The team was asked to consider these diseases and any others that they felt should be included, guided by the need to reflect currently important diseases and those that might arise through the trends described above. They were then asked to score these diseases in terms of a range of characteristics that reflected: socio-economic impact on poor populations, health impact on poor populations. The listed diseases were then ranked according to the cumulative scores given by team members. The team then examined the list to confirm the significance of these diseases relative to the criteria. Particular attention was paid to diseases with similar rankings around the cut-off point of 20, and a reserve list of 10 was made for further consideration. The entire list was then checked to ensure that it had a representation of zoonotic disease diversity that would well capture a broad range of potential interventions for analysis as described above (Perry B. D., et al, 2002).

According to WHO and Developed countries criteria's were listed:- The list of selected diseases is presented in the Framework (Supplementary document 1). Several lists of priority zoonotic diseases have been made in recent years. Differences in selection criteria make direct comparison of these lists difficult, but we note that our top list of 20 includes: 8 priority zoonotic diseases identified for action by the WHO/FAO/IOE Interagency Meeting on Planning the Prevention and Control of Neglected Zoonotic Diseases (2011); 10 of the top 15 zoonotic diseases rated by the International Livestock Research Institute (ILRI) on the basis of their importance in pro-poor development (Sekar, N. et al. 2011). 11 priority zoonotic diseases identified by the Roadmap to Combat Zoonosis in India Initiative (WHO, 2009); 10 of the 11 zoonotic diseases targeted by the WHO-UNDP-World Bank Special Program's Disease Reference Group on Zoonotic Diseases and Other Marginalized Infections of Poverty (World Bank., 2010).

Finally, we note that in table 1. below the inclusion of veterinary and medical experts in our team broadened the selection of diseases, with veterinary specialists ensuring inclusion of diseases

with socio-economic impact, and medical specialists ensuring inclusion of some diseases with little economic impact but potentially high health impact.

Table 1. Highlights the key characteristics across the list of 20 zoonosis analyzed

Characteristics Viruses Bacteria Parasites	Viruses	Bacteria	Parasite
% Representation in list of 20 zoonosis	35%	30%	35%(15% protozoa & 20% helminths)
% Representation in total list of 868 known zoonoses (Taylor et al, 2001- 13% Fungi)	19%	31% (bacteria or rickettsia)	37% (5% protozoa & 32% helminths)
Biological classification & evolutionary characteristics	All are RNA viruses- mixture of single-stranded +ve/-ve and segmented/non-segmented High nucleotide substitution rate and reduced error-proofing capabilities- increased plasticity & ability to infect new hosts (Taylor et al, 2001; Woolhouse et al, 2005; Cleaveland et al, 2001)	Wide range of bacterial species responsible for zoonoses (Meslin et al, 2005)	Mixture of protozoan and helminthic zoonoses
Disease patterns	Feature prominently among emerging zoonoses (e.g. ebola, lassa fever, RVF) (Jones et al, 2008)	More stable, endemic zoonoses transmission dynamics (Bovine Tb & brucellosis) Drug resistant bacteria responsible for proportion of emerging zoonoses (food-chain related)- Jones et al, 2008	Protozoan zoonoses more likely to be linked emerging infections (Taylor et al, 2001)- e.g. cryptosporidiosis
Transmission & life cycle characteristics	Predominant mixture of vector-borne and direct transmission pathways	Food chain - increasing use of industrialised livestock systems to feed slum populations in developing countries with poor management practices (salmonella and campylobacter spp.) consequently environment contamination important	Representative across vector borne, human exposure through environmental contamination and food-borne zoonoses Complex lifecycles involving intermediate hosts (e.g. snail-fascioliasis, schistosomiasis) Environment contamination importance
Reservoir hosts	Wildlife non-pathogen reservoir component important (JE virus, H5/H7 influenza subtypes, lassa fever, ebola)	Livestock central to bacterial zoonoses: often livelihood related (changing dynamics between human-livestock and livestock-livestock) populations (e.g. bovine tb/brucellosis)	Production and companion animals important

Segregating the list into viruses, bacteria and parasites as it would be indicated on figure 1. And 2 below, gave a clear set of categories across the list, and mirrored the classification of main biological groups of zoonosis from Taylor et al.- wherever the

literature on the characteristics of the wider zoonosis list shared characteristics with our list, references have been indicated.

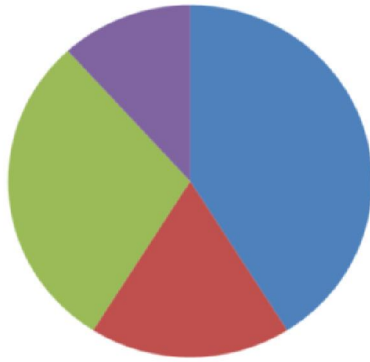


Figure 1. Main Source of Zoonotic Infections for human (Taylor et al, 2001).

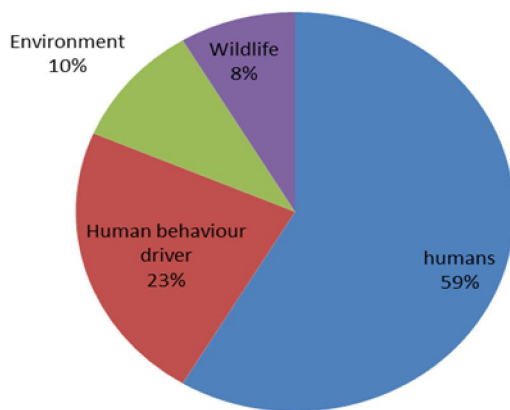


Figure 2. Relative importance of different hosts/factors in the epidemiology of selected zoonosis (Taylor et al, 2001).

2.4. Socioeconomics of Zoonosis

The World Bank estimates that zoonotic diseases have cost over \$20 billion to global economies in direct costs over the past decade, with a further \$200 billion in indirect costs (Knobel, D.L. et al, 2005) . Quantifying impacts of zoonosis requires assessing the disease costs across multiple sectors, including human health, livestock production, as well as tourism and other sectors.

The complex relationship between zoonotic disease and poverty is illustrated in Figure 3. This illustrates that, as diseases of livestock, zoonosis affect production and reduce market access. Interventions against these diseases, whether they are aimed at reducing losses or reducing human health effects, may be expensive to producers. All of these may contribute to maintaining producer communities in poverty. Moving to the right of this diagram, animal diseases may also affect health, by reducing the nutritional benefits of animal products, whose micronutrients are particularly important in child development, and by causing disease in humans, with its consequences of morbidity and mortality, reduced labor and income, and the costs of treating these diseases(Kock, R., Alders, R., Wallen, R. 2012). Both agricultural effects and health effects therefore may contribute to the persistence of poverty in poor populations associated with animal production. These effects are considered in more detail below. The burden of disease in humans includes morbidity and mortality, (commonly measured as Disability Adjusted Life Years (DALYs)), as well as monetary losses due to income reduction and the costs of treatment and prevention. Determining accurate human health costs, particularly in poor settings, is complicated by the frequent under-reporting and misdiagnosis of zoonotic diseases (Coker, R. et al, 2011).

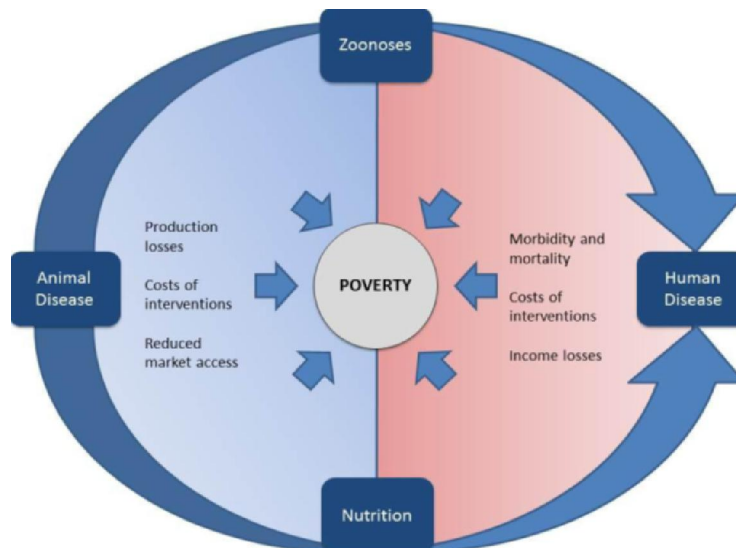


Figure 3. Impacts of animal disease on human health (Wallen, R. 2012)

2.5. Factors Influencing Zoonotic Disease Management In The Developing World

Social, economic, cultural and biological factors must be understood before effective control technologies and practices can be developed and implemented (Coker, R. et al, 2011). Factors contributing to zoonotic disease emergence can be broadly human-related, pathogen-related, or climate/environment-related (adapted). Human-related factors include: living conditions, such as lack of infrastructure (housing, sanitation and water provision) (Ehrenberg, J. P. & Ault, S. K, 2005) and occupation, where there is greater direct dependency on wild and domestic animals for food, transport and draft. These occupations increase exposure to pathogens through direct contact. Exposure is also affected by poor capacity for adequate food preparation, transport and preservation, due in part to poor access to energy.

Pathogen-related factors include: ecosystem change and biodiversity loss, favoring expansion of disease hosts or vectors, pressure for virulence/resistance selection, and genomic homogeneity in domestic animals (Breithaupt, H. 2003). Intensification of production systems and genetic homogeneity has improved supply of animal-based foods but also created more favorable environments for pathogen emergence (Slingenbergh, J. et al. 2004), including new channels for RNA virus recombination and re-assortment with ready amplification in domestic animal populations)- (FAO, 2007); (Springbett, A. K., et al, 2003).

Climate/environment-related factors include: changing rainfall patterns and global warming. These affect host-vector life cycles through various means, including drought and/or flooding, which force animal and human populations closer together as they search for food, facilitating cross infection through breeches in the species barrier (Mills, J. N, Cage, K. L, & Khan, A. S, 2010); (Singh, B. B. et al, 2011).

2.6. Reports of Food-Borne Bacterial Pathogens in Ethiopia:

Food consumers in developing countries including Ethiopia suffer from food-borne bacterial illnesses, especially from those of *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus* and *Bacillus cereus*. Food-borne diseases result from ingestion of a wide variety of foods contaminated with pathogenic microorganisms, microbial toxins, or chemicals (Bean, 1990), found that over 90 percent of confirmed food-borne human illness cases and deaths reported to the Centers for Disease Control and Prevention (CDC) are attributed to bacteria but now a day there is no clean information that has been reported. Bacteria are

commonly found in soil, water, plants and animals (including humans). People can also be exposed to some bacteria through inhalation, contaminated drinking water and contact with infected pets, farm animals and humans. Here, “food sources” is broadly defined to include all sources of exposure to pathogens in the food chain, between exposures at the farm or production level to exposure at the food consumption level.

Salmonellosis:- is considered as one of the most widespread food borne zoonosis associated with food of animal origin in industrialized as well as developing countries even though the incidence seems to vary between countries (Acha PN. and Szyfres B., 2001) and (CLIS, 2012) reports that, *Salmonella* covers 88% of the food borne infections. In many registers non-typhoidal *Salmonella* species are documented as one of the leading causes of bacterial diseases. Food borne *Salmonella* typically causes acute gastroenteritis and may cause a more Septicemic disease usually in very young, the elderly and immune compromised subject (Teklu, A. 2008).

Unhygienic food handling results in food contaminated by pathogens. One possible source of food contaminations could be dissemination of the pathogens to foods and/or utensils of catering centers through small animals such as cockroaches that live closely with humans in urban environments (Ashenafi, M, E. Tachbele, W. Erku & Gebire-Michael, 2006). According to Linscott (Linscott, A. J. 2011) more than 250 different food-borne illnesses are caused by various pathogens or by toxins and World Health Organization (World Health Organization, 2011) stated that food-borne illnesses result from consumption of food containing pathogens such as bacteria, viruses, parasites or the food contaminated by poisonous chemicals or bio-toxins. In Ethiopia, as in other developing countries, there are no well-organized epidemiological surveillance systems and few studies available so far are summarized below.

Listeriosis: In Addis Ababa, as Dr. Molla (Molla, B. 2004) reported 5.1% prevalence of *Listeria* from retail meat and milk products. The *Listeria* spp were detected in 69.8%, 47.5%, 43.5%, 18.6%, 15.4% and 1.6% of the pork, minced beef, ice cream, fish, chicken and cottage cheese samples respectively. The prevalence of *Listeria monocytogenes* were 5.1% from the samples they were used. In addition to *Listeria monocytogenes*, other *Listeria* species identified were *Listeria (L). innocua* (65%), *L. seeligeri* (8.7%), *L. welshimeri* (6.8), *L. murrayi* (*L. ivanovii* and *L. grayi* (each 0.9%).

Tuberculosis: Bovine tuberculosis is an endemic disease of cattle in Ethiopia. It has been reported from

different regions of the country on the basis of the tuberculin test (Ameni, G. 1999), (Asseged, B. et al., 2000). Abattoir inspection. However, the prevalence of the disease has not been well established because of inadequate disease surveillance and lack of better diagnostic facilities. The very few studies in Ethiopia have indicated that not all cattle infected with *Mycobacterium bovis* have visible tuberculosis lesions at slaughter (Asseged, B. et al., 2004), (Teklu, A. et al., 2008). This may limit the sensitivity of this detection technique at abattoirs, although detection of tuberculosis lesions through abattoir inspection is so far the common procedure in Ethiopia. Bovine Tuberculosis (BTB) is one of the endemic infectious diseases that have long been recorded in Ethiopia and the infection has been detected in cattle in Ethiopia and rarely in other species of domestic animals. The fact that eating raw or undercooked meat is one way of contracting BTB (Etter, E. et al., 2006) has great implications for importance of BTB as a zoonotic disease in Ethiopia, since raw meat consumption is local cultural habit and because BTB is highly

prevalent in the cattle population and control measures are not implemented.

According to the studies of (Shitaye, J. E., et al, 2006) indicated the prevalence rate of BTB with a range of 3.4% (in small holder production system) to 50% (in intensive dairy productions) and a range of 3.5% to 5.2% in slaughterhouses in various places of the country. BTB in cattle remains to be a great concern due to the susceptibility of humans to the disease. The infections mainly take place by drinking raw milk and occur in the extra-pulmonary form, in the cervical lymphadenitis form in particular (Shitaye, J. E, et al., 2006).

Among the undertaken abattoir studies, prevalence rates of 5.2% (Ameni, G & Wudie, A. 2003), 4.5% and 3.5% (Shitaye, J. E, et al., 2006) have been reported in different abattoirs in the country. The infection rate in cattle has been found to differ greatly from place to place, especially in slaughter houses recorded as having a low prevalence of the infection. Number of cattle that has been sampled for tuberculosis analysis.

Table 2. Summary of Prevalence rates of bovine tuberculosis detected by abattoir meat inspection in cattle in different city abattoirs from (1973-2006)

City abattoirs	Examined	Positive	%	Reference
Addis Ababa	81 944	123	0.15	(Hailemariam, S., 1975)
Addis Ababa	1 350	20	1.48	(Asseged, B,2004)
Addis Ababa	984	34	3.46	(Shitaye, J. E., et al,2006)
Debre-Zeit	3 934	7	0.18	(Hailemariam, S., 1975)
Dire-Dawa	7 453	4	0.05	(Hailemariam, S., 1975)
Gonder	12 525	3	0.02	(Hailemariam, S., 1975)
Hossana	751	34	4.53	(Tekilu, A.,2004)
Kombolcha	57 965	265	0.46	(MoA, 1973.)
Makele	39 875	730	1.83	(Hailemariam, S., 1975)
Nazareth	1 125	58	5.16	(Ameni, G. and A. Wudie, 2003.)
Wolaita-Sodo	402	32	7.96	(Regassa, A., 1999)
Wondo-Genet	38 303	207	0.54	(Hailemariam, S., 1975)
Total	246 611	1 517	0.62	

Escherichia coli: Cattle are the major reservoirs of *E. coli* O157: H7 followed by sheep and goats. The pathogen is carried in the intestinal tract and excreted in faeces (Chapman P., et al., 2001),(Battisti, P. et al, 2006). Consumption of raw or undercooked foods, especially undercooked minced beef has been found to be the most Common means of transmission (Chapman P., et al, 2001) . Little is known about the prevalence of this sero-group and associated genes in humans, animals or in foods of animal origin in Ethiopia (Hiko, A., Daniel, A. & Girma, Z., 2008). In Modjo town export abattoir studied the occurrence and

proportion of *Escherichia coli* O157: H7 in faeces, skin swabs and carcasses before and after washing, from sheep and goats.

Their study revealed *Escherichia coli* O157: H7 from faeces 4.7%, skin swabs 8.7%, carcasses before washing 8.1% and after washing 8.7% and on water samples 4.2%. In their report, the proportion of carcasses contaminated with *E. coli* O157: H7 was strongly associated with those recovered from faecal and skin samples. Even though the numbers of samples examined in this study were limited to one abattoir. Sheep and goats can be potential sources of

E. coli O157: H7 for human infection in the country. Control measures to reduce the public health risks arising from *E. coli* O157: H7 in reservoir animals need to be addressed at abattoir levels by reducing skin and faecal sources and carcass contaminations at different stages of slaughter operations.

In another study conducted in Debre Zeit and Modjo area by Hiko, Daniel & Girma (HikoA., Daniel, A., Girma, Z., 2008) 4.2% *E. coli* O157: H7 was isolated from meat samples collected from raw meat samples of bovines, sheep and goat. Among meat samples examined, the highest prevalence (8%) was recorded in beef, followed by lamb and mutton (2.5%) and goat meat (2%). The results of their study also revealed the presence of *E. coli* O157:H7 in retail raw meats reaching consumers, indicating possible risks of infection to people through the consumption of raw/under-cooked meat or cross-contamination of other food products.

In Jimma, (Haimanot, T. et al, 2010) reported 26.6% *E. coli* in raw beef (meat) collected from common retail shops, restaurants and abattoir. They indicated that the widespread habit of raw beef consumption is potential cause for food borne illnesses.

2.7. Antimicrobial Resistance In Food-Borne Pathogens:-

Over the years, bacterial pathogens have developed resistance to various antibiotics. The main risk factor for the increase in the antibiotic resistance is an extensive use of antibiotics in human health and agriculture (Lukasova, J. & Sustackova, A. 2003), which lead to the emergence and dissemination of resistant bacteria and resistant genes in animals and humans. The veterinary use of antibiotics includes therapy, prophylaxis and growth promotion. Some antibiotic are used both in veterinary and human medicine. The antimicrobial agents used in animal care are important, not only in increasing the resistance in animal pathogens, but also in bacteria transmitted from animals to humans (Aarestrup, F. M., Wegener, H. C. & Collignon, P. 2008).

The frequently exposed microbes during the use of antibiotics for these purposes are the gut flora and, hence, there is a possible development of resistance in

the pathogenic and commensal bacteria. The commensal bacteria constitute a reservoir of resistant genes for possible transfer to pathogenic bacteria. Their level of resistance is considered as a good indicator of the selection pressure of antibiotic use and for resistance problem to be expected in pathogens (Bonomo, R. A., & Rossolini, G. M., 2008).

Drug resistance in food-borne bacterial enteric pathogens is an almost inevitable consequence of the use of antimicrobial drugs in food-producing animals and specifically in the developing countries including Ethiopia by use of medicines in humans (Mather et al, 2011). Antimicrobial resistance is one of the biggest challenges facing global public health. Although antimicrobial drugs have saved many lives and eased the suffering of many millions, poverty, ignorance, poor sanitation, hunger and malnutrition, inadequate access to drugs, poor and inadequate health care systems, civil conflicts and bad governance (Mather et al, 2011). The body of literature is overwhelming that supports the theory that resistant bacteria arising in animal populations can transfer to and colonize humans, and that genetic material from bacteria present in farm animals can transfer to bacteria normally present in humans (Mather et al, 2011).

In Table 3. there is increasing evidence that the use of antimicrobials in animal health contributes to increasing levels of antimicrobial resistance in pathogens in humans. This can be through the development of resistance in animals followed by spread of the resistant pathogen to humans or by spread of genetic material through horizontal transfer. Naturally, it is difficult to detect such events, but the problem of resistance in human and animal health is clear and there is a growing list of examples where the probable origin of resistance in pathogens in humans can be attributed to antimicrobial treatment in animals. Antibiotic use on farms only contributes to a limited range of resistance problems in humans. However, evidence is building that for some infections the development of antibiotic resistance on farms is a significant part of the problem which makes it more difficult to treat affected patients, with potentially fatal delays in identifying an effective antibiotic when needed (Nunan and Young 2012).

Table 3. Summary of the bacterial species and their drug resistance according to status of Ethiopia (Addis, Z. et al.,2011).

Bacterial Spps	Resisted Drugs	In %	Reference
S. typhimurium var	Copenhagen	100	(Molla, B.,et al.2003)
S. anatum	Copenhagen	62.5	(Molla, B.,et al.2003)
S. typhimurium	Copenhagen	33.3	(Molla, B.,et al.2003)
S. braenderup	Copenhagen	34.3	(Molla, B.,et al.2003)
Salmonella from milk	ampicillin,	100	(Addis, Z. et al.,2011)
Salmonella from milk	streptomycin	66.7	(Addis, Z. et al.,2011)
Salmonella from milk	nitrofurantoin	58.3	(Addis, Z. et al.,2011)
Shigella dysentery	co-trimoxazole	No,	(Haimanot, T.,et al., 2012)
Shigella dysentery	tetracycline	No,	(Haimanot, T.,et al., 2012)
S. aureus	oxacillin	90	(Haimanot, T.,et al., 2012)
S. aureus	ampicillin	85	(Haimanot, T.,et al., 2012)
S. aureus	erythromycin	65	(Haimanot, T.,et al., 2012)
S. aureus	amoxicillin	60	(Haimanot, T.,et al., 2012)
S. aureus	streptomycin	35	(Haimanot, T.,et al., 2012)
S. aureus	vancomycin	20	(Haimanot, T.,et al., 2012)
L. monocytogenes	clindamycin	100	(Firehiwot, A., 2012)
L. monocytogenes	chloramphenicol	53.9	(Firehiwot, A., 2012)
L. monocytogenes	tetracycline	31.8	(Firehiwot, A., 2012)
L. monocytogenes	penicillin	23.1	(Firehiwot, A., 2012)

2.8. Sources of Infection:-

Food can be contaminated by physical, chemical and microbiological agents. The microbial agents responsible for food borne diseases are bacteria, viruses, parasites and fungi. However the sources of food contamination are diverse. It may be contaminated by polluted water, flies, animals and pets, unclean utensils and pots, dust, chef, shop and dirt environmental sources of food items. Unhygienic food handlers can also inoculate the food with infected excreta, pus, respiratory drippings' or other infectious discharges (Dugassa, G. 2007). Studies conducted in different parts of the country showed the poor sanitary conditions of catering establishments and presence of pathogenic organisms like campylobacter, Salmonella, staphylococcus aureus, Bacillus cereus, Tuberculosis and Escherichia coli (Kinfé, Z. 2007).

In Ethiopia, data on sanitation conditions and ensuing effects on health are very limited. Few studies conducted in Addis Ababa, Awassa, Jimma, Mekele, Gonder, Bishoftu, Modjo and Batu (Zeway) indicate the prevailing poor sanitary conditions in mass catering establishments. Lack of cleanliness, inadequate sanitary facilities and improper waste management were common features of catering establishments in these locales. These establishments commonly did not have adequate facilities for washing utensils nor for clients to wash their hands (Kumie, A. et al, 2002), (T/Mariam, S. et al, 2000).

In Ethiopia, the widespread habit of raw beef consumption is a potential cause for food borne illnesses besides, raw meat is available in open-air

local retail shops without appropriate temperature control and this is purchased by households and also minced meat (Kitfo), Lablab and others which facilitate more appropriate for bacterial well growth is served at restaurants as raw, slightly-cooked or well-cooked. Meat processing at retail level is likely to contribute for the higher levels of contamination in minced beef as compared to carcasses (Tegegne, M & Ashenafi, M. 1998).

2.9. Control and Prevention of Food-borne Pathogens in Ethiopia:

Fermentation technology is one of the oldest known methods of food preservation. Fermentation processes promote the development of essential and safe micro flora, which play a vital role in preventing the outgrowth of spoilage bacteria and food borne pathogens (Gibbs, P. A., 1987). Lactic acid bacteria (LAB) are important in much fermentation and the antagonistic effects of LAB are attributed to some of their biochemical features. They can utilize carbohydrates and produce organic acids as lactic acid or acetic acid. The majority of foods borne contaminants, either pathogenic or nonpathogenic, are sensitive to these acids and the resulting low pH. They also produce antibacterial substances such as bactericides, hydrogen peroxide, diacetyl and CO which may also play part in the antagonism of LAB on other microorganisms. LAB also produces different types of compounds that offer fermented foods their characteristic flavor, color, aroma and test (Rodriguez, E. et al, 2005).

Prevention and control of food-borne diseases, regardless of the specific cause, are based on the same principles. These principles are; avoidance of food contamination, destruction or prevention of contaminants, prevention of further spread or multiplication of contaminants, Appropriate handling and well cooking methods. Specific modes of intervention vary from area to area depending on environmental, economic, political, technology and socio cultural factors. The preventive and control strategies may be approached based on the major site in the cycle of transmission or acquisition where they are implemented. These involve the following activities performed at the source of infection, environment and host (Negga, B. et al, 2005) .

The contamination of food is influenced by multiple factors and may occur anywhere in the food production process (Newell, D. J., et al, 2010) . However, most of the food-borne illnesses can be traced back to infected food handlers. Therefore, it is important that strict personal hygiene measures should be adopted during food preparation. To prevent food-borne infections in children, educational measures are needed for parents and care-takers. The interventions should focus on avoiding exposure to infectious agents and on preventing cross-contamination (Marcus, R. 2008) .

3. Conclusions And Recommendations

Currently there are limited opportunities for drug interventions in the control of zoonotic infections although there are clear possibilities for drug use that would improve both prevention and treatment. The limitations (potency, toxicity and resistance) associated with the available drugs is a key reason why this intervention is not exploited more effectively. There has also been an absence of strategy to demonstrate the potential of more rigorous drug trials in animal populations, to explore therapeutic switching of drugs registered for other indications, and to implement studies to identify appropriate drug combinations or novel formulations. Therefore, there are select, but significant, opportunities to improve interventions through drug use, as well as clear strategies that could be deployed to limit antimicrobial resistance. The following Recommendations are forwarded by me:-Coordinated surveillance and monitoring system for food-borne pathogens must be in place to design effective and efficient control and prevention protocols for food-borne diseases in general. In most parts of Ethiopia, animals are kept near dwellings and maintained under very poor management and hygienic status, thus increasing the risk of acquiring infection for animals and humans as well. Therefore, creating awareness among the people, to meet the standard hygienic requirement and to

improve husbandry practices is of paramount importance. The human-animal mutual life is common in rural areas and small scale poultry farming is too in urban areas of our country and then as much as possible separation of those animals from that of human living house is mandatory and villagers training concerning of human-animal linked diseases are the one what our forgotten works and we have to preceding on it as it will mine work. Professionals working in the area of food animals must be given trainings and refreshment courses in order to deal with the changing pattern of food-borne pathogens epidemiology, and clean handling of food and cooking place with together of hygienic wearing during food preparation is the most zoonotic disease minimization techniques.

References

1. Aarestrup, F. M., Wegener, H. C. & Collignon, P. 2008 Resistance in bacteria of the food chain: epidemiology and control strategies. *expert. Rev. Anti. Infect. Ther.*, 6: 733-750.
2. Abera, K., M. Ashebir, A. Aderajew, T. Ayalew and B. Bedasa, 2006. The sanitary condition of food and drink establishments in Awash-Sebat Kilo town, Afar Region, *Ethiopian J. Health Dev.*, 20(3): 201-203.
3. Acha PN. and Szyfres B. (2001). *Zoonoses and Communicable Diseases Common to Man and Animals*. Third Edition, Washington DC: Pan American Health Organization., 233-246.
4. Ameni, G., H. Miorner, F. Roger and M. Tibbo 1999. Comparison between comparative tuberculin and g-interferon tests for the diagnosis of bovine TB in Ethiopia. *Tropical Animal Health and Production*, 32: 267-276.
5. Ameni, G and Wudie, A., 2003. Preliminary study on bovine tuberculosis in Nazareth municipality abattoir of central Ethiopia. *Bulletin of Animal Health and Production in Africa*, 51: 125-132.
6. Ashenafi, M., E. Tachbele, W. Erku and Gebre-Michael, 2006. Cockroach-associated food-borne bacterial pathogens from some hospitals and restaurants in Addis Ababa, Ethiopia: Distribution and antibiograms *Journal of Rural and Tropical Public Health*, 5: 34-41.
7. Asseged, B., A. Lubke-Becker, E. Lemma, K. Taddele and S. Britton, 2000. Bovine TB: a cross-sectional and epidemiological study in and around Addis Ababa. *Bulletin of Animal Health and Production in Africa*, 48: 71-80.
8. Asseged, B., Z. Woldesenbet, E. Yimer and E. Lemma, 2004. Evaluation of abattoir inspection for the diagnosis of *Mycobacterium bovis* infection in cattle at Addis Ababa abattoir.

- Tropical Animal Health and Production, 36: 537-546.
9. Battisti, A., S. Lovari, A. Franco, A. Diegido, Tozzoli, R. Caprioli and S. Morabito, 2006. Prevalence of *Escherichia coli* O157 in lambs at slaughter in Rome, central Italy. *Epidemiol Infect*, 134: 415-419.
 10. Bean, N. H., P. M. Griffin, J. S. Goulding and C. B. Ivey, 1990. Food-borne Disease Outbreaks, 5 Year Summary, 1983-1987, " CDC Surveill. Summ. *Morb. Mort. Weekly Rep. (MMWR)* 39: SS-1, 15-59 and *J. Food Prot*, 53: 711.
 11. Breithaupt H. Fierce creatures. *EMBO Rep* 2003; 4: 921-924.
 12. Bonomo, R. A. and G. M. Rossolini, 2008. Importance of antibiotic resistance and resistance mechanisms. *Expert Rev Antiinfect Ther*, 6: 549-550.
 13. Buzby, J., Roberts, T., 2009. "The Economics of Enteric Infections: human food borne disease costs. *Gastroenterology*, 136 (6): 1851-62. *Vet World* 6: pp. 291-294.
 14. Cascio, A, Bosilkovski, M., Rodriguez-Morales, A J., & Pappas, G. (2011). The socio-ecology of zoonotic infections. *Clinical microbiology and infection: the official publication of the European Society of Clinical Microbiology and Infectious Diseases*, 17(3), 336-42.
 15. Chapman P., Cerdaçn, A. Malo, M. Ellin, R. Ashton and M. Harkin, 2001. *Escherichia coli* O157 in cattle and sheep at slaughter, on beef and lamb carcasses and in raw beef and lamb products in south Yorkshire. *Int J. Food Microbiol.*, 64: 139-150.
 16. CLIS (2012): Performance standards for antimicrobial susceptibility testing; twenty second informational supplements. CLIS document M100-S22 Wayne PA.
 17. Coker, R., Rushton, J., Mounier-Jack, S., Karimuribo, E., Lutumba, P., Kambarage, D., Pfeiffer, D. U., et al. (2011). Towards a conceptual framework to support one-health research for policy on emerging zoonoses. *The Lancet infectious diseases*, 11(4), 326-31.
 18. Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. & Courbois, C. 1999 *Livestock to 2020: the next food revolution*. Washington, Rome and Nairobi: IFPRI, FAO and ILRI.
 19. Dugasa, G. 2007. *Sanitary Survey of Food and Drinking Establishments in Ambo Town West Showa Zone Oromia Region*, [Msc Thesis] Addis Ababa University, Ethiopia.
 20. E. Carrasco, A. Morales-Rueda, and R. M. Garc'ia-Gimeno, "Cross-contamination and recontamination by *Salmonella* in foods: a review," *Food Research International*, vol. 45, no. 2, pp. 545-556, 2012.
 21. Ehrenberg, J. P., & Ault, S. K. (2005). Neglected diseases of neglected populations: thinking to reshape the determinants of health in Latin America and the Caribbean. *BMC public health*, 5, 119. doi:10.1186/1471-2458-5-119.
 22. Etter, E., P. Donado, F. Jori, A. Caron, F. Goutard and F. Roger, 2006. Risk analysis and bovine tuberculosis, a re-emerging zoonosis. *Ann. NY. Acad. Sci.*, 1081: 61-73.
 23. FAO (2007) *The State of the World's Animal Genetic Resources for Food and Agriculture- in brief*. Commission on genetic resources for food and agriculture food and agriculture organization of the United Nations.
 24. Firehiwot, A., 2012. Prevalence and antimicrobial profile of *listeria monocytogenes* in retail meat and dairy products in Addis Ababa and its surrounding towns, Ethiopia: <http://hdl.handle.net/123456789/2286>
 25. F. M. S'anchez-Vargas, M. A. Abu-El-Haija, and O. G. G'omez- Duarte, "Salmonella infections: an update on epidemiology, management, and prevention," *Travel Medicine and Infectious Disease*, vol. 9, no. 6, pp. 263-277, 2011.
 26. Gibbs, P. A., 1987. Novel uses for lactic acid fermentation in food preservation. *Journal of Applied Bacteriology Symposium Supplement*, 16: 515-85.
 27. Haimanot, T., A. Alemseged, B. Getenet and Solomon 2010. Microbial flora and food borne pathogens on minced meat and their susceptibility to anti microbial agents. *Ethiop J. Health Sci.*, 20: 3.
 28. Hiko, A., A. Daniel and Z. Girma, 2008. Occurrence of *Escherichia coli* O157: H7 in retail raw meat products in Ethiopia. Department of Veterinary Microbiology and Public Health, Faculty of Veterinary Medicine, Addis Ababa University, Debre Zeit, Ethiopia. *J Infect Developing Countries*, 2(5): 389-393.
 29. Jones, K. E., Patel, N. G., Levy, M. a, Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. *Nature*, 451(7181), 990-3. doi:10.1038/nature06536.
 30. K'äferstein, F., 2003. "Foodborne diseases in developing countries: aetiology, epidemiology and strategies for prevention," *International Journal of Environmental Health Research*, vol. 13, no. 1, pp. S161-S168. U. K, Leicester.
 31. Kleczkowski, A., Breed, L Matthews, D. Thronicker, F., de Vries (2012). Characterising livestock system " zoonoses hotspots ". *DFID REPORT* 1-28.

32. Knife, Z. and K. Abera, 2007. Sanitary conditions of food establishments in Mekelle town, Tigray, North Ethiopia. *Ethiopian J. Health Dev.*, 21(1): 3-11.
33. Knobel, D. L., Cleaveland, S., Coleman, P. G., Fèvre, E. M., Meltzer, M. I., Miranda, M. E. G., Shaw, A., et al. (2005). Re-evaluating the burden of rabies in Africa and Asia. *Bulletin of the World Health Organization*, 83(5), 360-8.
34. Kock, R., Alders, R., Wallace R. (2012) Wildlife, wild food, food security and human society. In Press- Compendium of the OIE global conference (2011).
35. Kumie, A., K. Genete, H. Worku, E. Kebede, F. Ayele, and H. Mulugeta, 2002. The Sanitary Conditions of Public Food and Drink Establishments in the District town of Zeway, Southern Ethiopia. *Ethiop. J. Health Dev.*, 16(1): 95- 104.
36. Linscott, A. J., 2011. Food-Borne Illnesses. *Clinical Microbiology Newsletter*, 33(6): 41-45.
37. Lukasova, J. and A. Sustackova, 2003. Enterococci and antibiotic resistance. *Acta Vet. Brun.*, 72: 315-323.
38. Marcus, R., 2008. New information about pediatric food-borne infections: the view from Food Net. *Current Opinion in Pediatrics*, 20(1): 79-84.
39. Mekonnen, H., T. Habtamu, Kelali and K. Shewit, 2011. Study on food safety knowledge and practices of abattoir and butchery shops in Mekelle City, Ethiopia (un published).
40. Meslin, F. (2006). Impact of zoonoses on human health L ' impatto delle zoonosi sulla salute umana, 42(4), 369-379.
41. Mills, J. N., Gage, K. L., & Khan, A. S. (2010). Potential influence of climate change on vector-borne and zoonotic diseases: a review and proposed research plan. *Environmental health perspectives*, 118(11), 1507-14. doi:10.1289/ehp.0901389
42. Molyneux, D., Hallaj, Z., Keusch, G. T., McManus, D. P., Ngowi, H., Cleaveland, S., Ramos-Jimenez, P., et al. (2011). Zoonoses and marginalised infectious diseases of poverty: where do we stand? *Parasites & vectors*, 4(1), 106. BioMed Central Ltd.
43. Molla, B., A. Mesfin and D. Alemayehu, 2003 Multiple antimicrobial-resistant Salmonella serotypes isolated from chicken carcass and giblets in Debre Zeit and Addis Ababa, Ethiopia. *Ethiop. J. Health. Dev.*, 17(2): 131-149.
44. Murphy, S. P., & Allen, L. H. (2003). Animal Source Foods to Improve Micronutrient Nutrition and Human Function in Developing Countries Nutritional Importance of Animal Source Foods 1, 3932-3935.
45. Negga, B., W. Abera, A. Mussie, O. Lemessa, M. Habtamu, M. Seyoum and K. Fekade, 2005. Food-borne Diseases. For Health Officers, Nurses, Environmental health Officers and Medical Laboratory Technologists Module. Ethiopian Public Health Training Institute.
46. Newell, D. G., M. Koopmans, L. Verhoef, E. Duizer, A. Aidara-Kane, H. Sprong and Opsteegh, 2010. Food-borne diseases -- The challenges of 20 years ago still persist while new ones continue to emerge. *International Journal of Food Microbiology*, 139(1): S3-S15.
47. Perry, B., & Grace, D. (2009). The impacts of livestock diseases and their control on growth and development processes that are pro-poor. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 364(1530), 2643-5.
48. Perry B. D., Randolph T. F., McDermott J. J., Sones K. R. and Thornton P. K. 2002. Investing in animal health research to alleviate poverty. ILRI, Nairobi.
49. Roth, F., Zinsstag, J., Orkhon, D., Chimed-Ochir, G., Hutton, G., Cosivi, O., Carrin, G., et al. (2003). Human health benefits from livestock vaccination for brucellosis: case study. *Bulletin of the World Health Organization*, 81(12), 867-76.
50. Rodriguez, E., J. Arques, M. Nunez, P. Gaya and M. Medina 2005. Combined effect of high-pressure treatments and bacteriocin-producing lactic acid bacteria on inactivation of *Escherichia coli* O157: H7 in raw-milk cheese. *Applied and Environmental Microbiology*, 71: 3399-3404.
51. Sekar, N., Shah, N. K., Abbas, S. S., & Kakkar, M. (2011). Research options for controlling zoonotic disease in India, 2010-2015. *PLoS one*, 6(2), e17120.
52. Schelling, E., Grace, D., Willingham, A., L., & Randolph, T. (2007). Research approaches for improved pro-poor control of zoonoses. *Food and nutrition bulletin*, 28(2 Suppl), S345-56.
53. Shaw, A. (2009). The Economics of Zoonoses and Their Control. In: Rushton, J *The Economics of Animal Health and Production*. London: CABI. 161-167.
54. Shitaye, J. E., B. Getahun, T. Alemayehu, M. Skoric, F. Treml, P. Fictum, V. Vrbas and I. Pavlik, 2006. A prevalence study of bovine tuberculosis by using abattoir meat inspection and tuberculin skin testing data, histopathological and IS6110 PCR examination of tissues with tuberculous lesions in cattle in Ethiopia. *Veterinarni Medicina*, 51: 512-522.

55. Singh, B. B., Sharma, R., Gill, J. P. S., Aulakh, R. S., & Banga, H. S. (2011). Climate change, zoonoses and India Climate change in India, 30(3), 779-788.
56. Slingenbergh, J., Gilbert, M., Balogh, K. D., & Wint, W. (2004). Ecological sources of zoonotic diseases Factors affecting the emergence, 23(2), 467-484.
57. Springbett, A. J., Mackenzie, K., Woolliams, J. A., & Bishop, S. C. (2003). The Contribution of Genetic Diversity to the Spread of Infectious Diseases in Livestock Populations. 165 (3): 1465-1474.
58. Taylor, L. H., Latham, S. M., & Woolhouse, M. E. (2001). Risk factors for human disease emergence. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 356(1411), 983-9. doi:10.1098/rstb.2001.0888.
59. Tegegne, M. and M. Ashenafi, 1998. Microbial load and incidence of Salmonella species in,, kitfo?, traditional Ethiopian spiced, minced meat dish." Ethiop J. Health Dev., 12: 135-140.
60. Teklu, A. (2008): Prevalence and serotype distribution of Salmonella in slaughtered sheep and goat and abattoir environment in an export abattoir, Modjo, Ethiopia. MSc thesis, Addis Ababa University Faculty of Veterinary Medicine, Debrezeit, Ethiopia.
61. Teklu, A., B. Aseged, E. Yimer, M. Gebeyehu and Z. Woldesenbet, 2004. Tuberculous lesions not detected by routine abattoir inspection: the experience of the Hossana municipal abattoir, Southern Ethiopia. Review of Science and Technology, Office International des Epizooties, 23: 957-964.
62. Thornton, P. K., Kruska, R. L., Henninger, N., Kristjanson, P. M., Reid, R. S., Atieno, F., Odero, A. & Ndegwa, T. 2002 Mapping poverty and livestock. Nairobi, Kenya: ILRI.
63. WHO, 2004. Regional Office for Africa "Developing and Maintaining Food Safety Control Systems for Africa Current Status and Prospects for Change", Second FAO/WHO Global Forum of Food Safety Regulators, Bangkok, Thailand. pp. 12-14.
64. WHO, 2012. Initiative to estimate the Global Burden of Food-borne Diseases. <http://www.who.int/foodsafety/food-borne-disease/ferg/en/>.
65. WHO, 2007. Food Safety Food-borne Diseases and value chain management for food safety. "Forging links between Agriculture and Health" CGIAR on Agriculture and Health Meeting in WHO/HQ.
66. WHO, 2005. International health regulations. The fifty-eighth world health assembly. Geneva.
67. WHO (2009). Integrated control of neglected zoonotic diseases in Africa. Report of a Joint WHO/EU/ILRI/DBL/FAO/OIE/AU Meeting. 84 (17): 147-8.
68. Wilcox, B. A, & Gubler, D. J. (2005). Disease ecology and the global emergence of zoonotic pathogens. Environmental health and preventive medicine, 10(5), 263-72. doi:10.1007/BF02897701
69. World Health Organization, 2011. Initiative to estimate the Global Burden of Food-borne Diseases: Information and publications. Retrieved June http://www.who.int/foodsafety/food-borne_disease/ferg/en/index7.html.

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