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Food-Borne Bacterial Diseases 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 bacterial 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. 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 vancomycinand 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 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.

Key words: Antimicrobial Resistance · Bacteria · Ethiopia · Food-Borne

INTRODUCTION

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 [1].

The World health organization (WHO) estimated that in developed countries, up to 30% of the population suffer from food-borne diseases each year, whereas in developing countries up to 2 million deaths are estimated per year [2]. 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 [3].

National Hygiene and Sanitation Strategy program [4] reported that bout 60% of the disease burden is related to poor hygiene and sanitation in Ethiopia. Unsafe sources,

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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, *taphylococcus aureus, Bacillus cereus and Escherichia coli,* [5-9].

The epidemiology of food-borne diseases is changing now days. New pathogens have emerged and some have spread worldwide. 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 [10].

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. Moreover, research in the area of identifying the causative agent and food incriminated is also at its infant stage because of lack of well developed laboratory system, consumables and reagents for isolation identification and lack of coordinated epidemiological surveillance systems. Therefore, the objective of this paper was to review food-borne bacterial illness reported so far in Ethiopia and forward recommendations that addresses the weak sides.

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., *taphylococcus aureus* and *Bacillus cereus*. Food-borne diseases result from ingestion of a wide variety of foods contaminated with pathogenic microorganisms, microbial toxins, or chemicals [11], 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. 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.

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 [12]. According to Linscott [13] more than 250 different food-borne illnesses are caused by various pathogens or by toxins and World Health Organization [14] 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, Molla [15] reported 5.1% prevalence of *Listeria from* retail meat and milk products. The *listeria* spps 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. It was isolated mainly from ice cream (19.6%) and pork samples (7.5%) followed by minced beef (1.6%), fish (2.3%) and chicken samples (1.9%). 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%).

In recent year the report of Garedew [16] indicated that the overall prevalence of *L. monocytogenes* and other *Listeria* species from foods of animal origin isolated from cake, raw meat, ice cream, minced beef, fish, unpasteurized milk and pizza in Gonder Were 6.25%.

According to report of Firehiwot [17] the overall prevalence of Listeri in retail meat and dairy products in Addis Ababa and its surrounding towns were *27.5%.* From this the prevalence rate of *L. monocytogenes* reported was 5.4%.

Roman Yilma [18] studied the occurrence of Llisteria pecies in retailed meat and milk products in Addis Ababa. According to the report, the overall prevalence of Listerian different food sample (chicken, cottage cheese, fish, ice cream, minced beef and pork) obtained from the super market in Addis Ababa were 32.6%.Out of this the prevalence in pork, minced beef, ice cream, fish, chiken and cottage cheese recorded was 69.8%, 47.5%, 43.5%, 18.6%, 15.5% and 1.6%, respectively. Listeria species isolated were *L.innacua* (21.1%), *L.monocytogen* (5.1%) *and L.seeligeri* (2.8%) *and L. welshimeri* (2.2%), *L.nurray* (0.6%) *L.ivanovi* (0.3%) and *L.grayi* (0.3%).

In another study, the overall prevalence *of Listeria monocytogenes* and other Listeri pecies in ready-to-eat food items (pasteurized milk, cheese, ice cream and cakes) and raw meat products (minced beef, pork and chicken carcasses) from supermarkets and pastry shops in Addis Ababa were reported to be 26.6 % [19]. *L. monocytogenes* isolated were 4.8% and pork was found to be the most contaminated with Listeri pecies (62.5%) followed by minced beef (47.7%), ice cream (42.7%), soft cheese (16.8%), chicken carcasses (16.0%) and cakes (12.1%). All pasteurized milk and cottage cheese samples examined were *Listeria* negative.

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 [20, 21]. Abattoir inspection [22]. 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 tuberculous lesions at slaughter [23, 24]. This may limit the sensitivity of this detection technique at abattoirs, although detection of tuberculous lesions through abattoir inspection is so far the common procedure in Ethiopia. Bovine Tuberculosis (BTB) s one of the endemic infectious diseases that have long been recorded in Ethiopia [25] and the infection has been detected in cattle in Ethiopia and rarely in other species of domestic animals [26]The fact that eating raw or undercooked meat is one way of contracting BTB [27] 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 [28] 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 [28].

Among the undertaken abattoir studies, prevalence rates of 5.2% [29], 4.5% [24] and 3.5% [28] 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 ecorded as having a low prevalence of the infection. This difference is most probably linked to the type of the production system (most notably in extensive/pastoral), which is unlikely to favor he spread of the disease in contrast to intensive dairy farms [30, 28].

Despite the irregularities of the abattoirs meat inspection in Ethiopia due to the limitation of other diagnostic methods, detection of BTB continues to depend on slaughter surveillance as the most economically efficient method for the detection of infected cattle with *M. bovis.* Thus, meat inspection at abattoirs is still considered as a pivotal and the utmost obligatory method for the detection of BTB or other mycobacterial infections. However, because of inadequate comprehensive abattoir surveillance throughout the country, BTB prevalence data from abattoir meat inspections are still scarce [30].

Data from 1971 for the condemnation rate of cattle with BTB originating from the Dire-Dawa (Eastern Ethiopia) slaughter hous ranged between 1% and 1.5% that was 1.45% out of 6 940 animals slaughtered within 17 months [31]. Subsequently, summarized ata from abattoirs on the number of cases with tuberculous lesions ranging from 0.02% to1.8% in different parts of the country has been reported [25, 23]. According to Gezahegne [32], a report from eight export abattoirs showed a prevalence of 0.8% of 144 487 slaughtered animals, in which the whole carcass of 978 animals were condemned. Furthermore, based on meat inspection data [28] ndicated that BTB with a prevalence of 0.052% of 1 336 266 cattle, 0.001% of 534 436 sheep, 0.001% of 573 767 goats and 0.009% of 10 820 pigs slaughtered in Addis Ababa and Debre-Zeit abattoirs in the years 1996–2005.

Table 1: Summery of Prevalence rates of bovine tuberculosis detected by abattoir meat inspection in cattle in different city abattoirs from 1973-2006

	No. of cattle			
City abattoirs	Examined	Positive	%	Reference
Addis Ababa	81 944	123	0.15	[25]
Addis Ababa	1 350	20	1.48	[23]
Addis Ababa	984	34	3.46	[28]
Debre-Zeit	3 934	7	0.18	[25]
Dire-Dawa	7 453	4	0.05	[25]
Gonder	12 525	3	0.02	[25]
Hossana	751	34	4.53	[24]
Kombolcha	57 965	265	0.46	[33]
Makele	39 875	730	1.83	[25]
Nazareth	1 125	58	5.16	[29]
Wolaita-Sodo	402	32	7.96	[34]
Wondo-Genet	38 303	207	0.54	[25]
Total	246 611	1 517	0.62	

In other study [35] reported that the prevalence of tuberculosi (TB) in randomly selected male goats slaughtered at Modjo Modern Export Abattoir were 4.2% tuberculous lesions. Carcasses and organs of all the study animals were first examined by routine meat inspection followed by detailed meat inspection. Samples from tuberculous lesions were cultured for mycobacterial isolation and identification. From these, 30.8% samples were confirmed to be mycobacterium positive on culture, out of which 18 were *Mycobacterium bovis* and two were *Mycobacterium tuberculosis.*

Molecular characterization of BTB using the spoiling typing technique as also conducted by Biffa [36]. According to their study, carcasses of 3322 cattle of different age groups, sex, breeds and classes/types (bull, cow, calf or steer) were subjected to detailed necropsy examinations for the detection of gross lesions compatible with BTB at five abattoirs including four Municipal (Addis Ababa, Adama, Hawassa and Yabello) and one export (Melge-Wondo) abattoirs. Forty-five *M. bovis* isolates were obtained from 406 pathologic tissue specimens collected from 337 carcasses with lesions compatible with BTB. Twelve spoligotypes were identified from 34 distinct strains; with SB1176 as a dominant spoligotype (41.2% of the isolates) followed by SB0133 (14.7%). The majority of strains were obtained from cattle slaughtered at Addis Ababa abattoir. On the basis of the Spoligotype Evolutionary Index, SEI (a numeric expression approach to make standardized comparison of spoligotype evolution), *M. bovis* isolates from Ethiopia were reported to be relatively more heterogeneous (SEI=3.2) compared to isolates from other countries.

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 [37, 38]. Consumption of raw or undercooked foods, especially undercooked minced beef has been found to be the most common means of transmission [37]. Little is known about the prevalence of this serogroup and associated genes in humans, animals or in foods of animal origin in Ethiopia [39].

In Modjo town export abattoir [32] 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 [39] 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, [40] 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.

Campylobacter: Campylobacter are small gram-negative, non-spore forming helical bacteria with a distinctive `darting' motility and are catalase and oxidase positive.

Campylobacter spp. can be found in the reproductive organs, intestinal tracts and oral cavity of animals and humans. They are the leading cause of bacterial diarrheal disease worldwide, resulting mainly from the contamination of poultry or other meats, raw milk, other milk products and surface water [41].

In Debre-Zeit private export abattoir, [8]. reported 10.1% thermophilic *Campylobacter* spp. isolated from sheep and goat carcasses. From this thermophilic campylobacter *C. jejuni* and *C. coli* accounted for 72.5% and 27.5%, respectively and indicated that raw meat from food animals could serve as potential source of campylobacter, indicating possible risks of infection to people through the consumption of raw/under-cooked meat.

Another study was conducted by Lemma & Daniel [42]. in Addis Ababa and Debre Zeit. The overall prevalence of Campylobacter spp. isolated from meat samples were 9.3%. The highest prevalence (21.7%) was recorded in chicken meat, followed by sheep meat (10.5%), pork meat (8.5%), goat meat (7.6%) and beef (6.2%). Among the isolates, 78% were identified to be *C. jejuni*, 18% were *C. coli* and 4% were *C. lari*.

According to the report of Tesfaye [43] the overall prevalence of thermotolerant Campylobacter spp. in various food Animals (cattle, poultry, pigs and sheep) in Jimma zone were 39.6%. The highest isolation rate were recorded among chickens (68.1%), followed by pigs (50.0%), sheep (38.0%) and cattle (12.7%). Among the thermophilic campylobacters isolated, 70.3% were identified to be *C. jejuni*, 26.6% were *C. coli* and 3.1% were *C. lari*. *C. jejuni* was the most prevalent species in chickens (80.8%), followed by sheep (59.3%) and cattle (53.8%). All isolates found in pigs were identified to be *C. coli* (100%). They concluded that thermophilic campylobacters are very frequent among various food animals in Ethiopia, suggesting possible risks of infection to people through the consumption of contaminated animal products or through contact with infected animals.

In Bahir Dar, the study conducted by Desalegne & Adane [44]. revealed the Prevalence of thermophilic campylobacters reported were 8% and 72.7% in humans and chickens, respectively. In humans, 94.1% of the isolates were *C. jejuni* and 5.9% were *C. coli*. *C. jejuni* was a predominant species of thermophilic campylobacters in all categories of patients. In chicken, 92.5% of thermophilic campylobacters isolated were *C. jejuni* and 7.5% were *C. coli*.

Foods of animal origin are considered to be the major sources of food-borne salmonellosis.

According to the study of Gebretsadik [16]. in Addis Ababa, the overall prevalence of Salmonella isolated from minced meat beef, mutton and pork from retail supermarkets were 14.7%. *Salmonella* was detected in 14.4% minced beef, 14.1% mutton and 16.4% pork samples subjected to isolation and identification.

Addis [45]. report that the prevalence of salmonella in Addis Ababa by collecting milk and faecal samples from lactating cows and stool samples from humans working in dairy farms were 10.7% of cow and 13.6% of the human. The 10.7% of prevalence of salmonella in cow were either from milk or faeces. Of these cows, 71.4% (15/21) were positive from faecal sample and 28.6% (6/21) were positive from milk sample.

The prevalence of Salmonella recorded in eggs from Kombolcha poultry multiplication and breeding farm and market were 11.5%, from which (6.3%) and (6.8%) were found from egg shell and egg content, respectively. The prevalence of Salmonella in egg content of the poultry farm (10.5%) was reported to be significantly higher than the prevalence of Salmonella n egg content of open market (3.0%) [46].

Molla, Mohammed & Salah [15]. reported that the prevalence of salmonella from apparently health slaughtered camels in Eastern Ethiopia was 16.2%. The different serotypes were identified of which *Salmonella saintpaul* (38.8%) and *S. braenderup* (22.4%) were the most prevalent followed by *S. muenchen* (8.6%), *S. kottbus* (6.0%) and *S. havana* (5.2%). Other serotypes, including *S. typhimurium*, *S. heidelberg* and *S. enteritidis* were also detected from Ethiopian camels.

In Addis Ababa [47] investigated the prevalence of salmonella in market food items (consisting of chicken carcass, pork, mutton, minced beef, cottage cheese, *Tilapia* fish meat and ice cream) and apparently healthy supermarket butchery. Out of the food items, 7.8% were positive for Salmonella and of sixty-eight stool samples five gave positive result (7.4%). About 14% of chicken carcass, 11.3% of pork, 10.8% of mutton, 8.5% of minced beef, 2.1% of cottage cheese, 2.3% of fish and none of the ice cream yielded Salmonella.

Molla [48]. studied the prevalence of Salmonella erovars in apparently healthy slaughtered sheep and goats in central Ethiopia. They isolated Salmonella from samples of faeces, mesenteric lymph nodes, liver, spleen and abdominal and diaphragmatic muscle and the prevalence were 11.5% in sheep and 3% in goats. Of the samples examined from sheep and goats, 2.9% and 0.7%, respectively were Salmonella positive.

According to Sefinew & Bayleyegn [49]. the prevalence of Salmonella in apparently healthy slaughtered cattle (Liver, mesenteric lymph nodes, intestinal content and carcass swab) at Bahir Dar abattoir, the overall prevalence of Salmonella at animal level were 7%. At sample level, the prevalence of Salmonella detected from liver, mesenteric lymph nodes, carcass swab and intestinal content samples were 1.1%, 3.2%, 4.8% and 5.9%, respectively. Twenty-eight isolates consisting of *Salmonella Typhimurium*, *Salmonella Newport*, *Salmonella* haifa, *Salmonella Heidelberg*, *Salmonella Infantis* and *Salmonella Mishmarhaemek* were identified. *Salmonella Typhimurium* and *Salmonella Newport w*ere the most frequently isolated while *Salmonella heidelberg* and *Salmonella mishmarhaemek* were isolated least. *Salmonella typhimurium* and *Salmonella newport* were isolated at the highest frequency; *Salmonella Heidelberg* and *Salmonella mishmarhaemek* were isolated at frequency of 7.1% (2 of 28) of the total isolates.

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 [50]. However the sources of food contamination are diverse. It may be contaminated by polluted water, flies, animals and pets, unclean utensils and pots, dust and dirt. Unhygienic food handlers can also inoculate the food with infected excreta, pus, respiratory drippings' or other infectious discharges [51].

Studies conducted in different parts of the country showed the poor sanitary conditions of catering establishments and presence of pathogenic organisms like campylobacter, Salmonella, *taphylococcus aureus, Bacillus cereus and Escherichia coli* [52, 8, 9].

In Ethiopia, data on sanitation conditions and ensuing effects on health are very limited. Few studies conducted in Addis Ababa, Awassa and 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 [53, 54].

Various factors such as the general sanitary standards of the house, the proper use of sanitation facilities like latrines, hand-washing lavatories, refuse management systems and dishwashing facilities affect food safety in food establishments. Food handling, preparation and servicing practices are other important factors in determining the safety of food. Conditions of cooking utensils, food storage systems (time and temperature), as well as food handlers' knowledge and practices similarly affect food safety directly or indirectly [55].

Microorganisms, particularly bacteria, can be found almost everywhere. They are present in the air, water and soil; they can grow wherever higher organisms can grow and can be found on the surfaces of plants and animals as well as in the mouth, nose and intestines of animals, including humans. They also occur in places that are far too inhospitable for higher life forms, such as in hot sulfur springs. As a result, foods are hardly ever sterile, that is to say completely free from viable microorganisms. Foods carry a mixed population of microorganisms derived from the natural microflora of the original plant or animal, those picked up from its environment and those introduced during harvest/slaughter and subsequent handling, processing and storage. The common factors such as overcrowding, poverty, inadequate sanitary conditions and poor general hygiene [56].

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) 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 [57, 58].

The presence of even small numbers of pathogens in carcass meat and edible offal may lead to heavy contamination of minced meat when it is cut into pieces; as more microorganisms are added to the surfaces of exposed tissue. Previous studies conducted in Addis Ababa indicated the occurrence of pathogens including Salmonella in different food animals, meat and meat products. In addition, outbreaks of infections somehow related with poor hygiene and consumption of contaminated food were reported in Ethiopia and some were caused by Salmonella and Shigella [57, 59].

According to Gebretsadik [16] 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 their study were limited to one abattoir, sheep and goats can be potential sources of *E. coli* O157:H7 for human infection in the country.

[12] reported the role of cockroaches as potential vectors of food-borne bacterial pathogens in four hospitals and four food catering centres in Addis Ababa. Culturing external surface wash and gut homogenates by pooling cockroaches in batches resulted in the isolation of 12 *Salmonella* spp., two *Shigella flexneri*, two *Escherichia coli* O157:H7, 17 *Staphylococcus aureus* and 25 *Bacillus cereus*. They suggested that *Battella germanica* is a possible reservoir and potential vector of some food-borne pathogens and may spread multiple drug resistance in hospitals and food catering establishments.

During food preparation pathogenic organisms may be transferred to food items by the handler both directly or by cross contamination through hands, surfaces, utensils and equipment that have been inadequately clean and disinfected between the preparations of different types of food [60]. Contamination of raw milk by pathogenic bacteria from source external to the udder may be caused by salmonellae strains, which produce many outbreaks of enteritis [58].

According to Haileselassie, Habtamu & Kelali [61] observations in Mekelle city most of the establishments of the kitchen were found to be congested, dirty and also used as storage. As the result, space of the kitchen was compromised and cockroaches were also prevalent in some of the inspected kitchens. Most of the establishments had two compartments of glass and dish washing devices, which used "bowl and/or bucket" system as a surrogate to sink or vat washing devices which predispose food to be contaminated. Regarding latrine facility most of the establishments had private or used communal latrine together with neighbors and had not enough water, as the result flies infested it.

Food is an important vehicle for spread infectious agents causing disease resulting appreciable morbidity and mortality. Food handlers play an important role in ensuring food safety. However, in developing countries like Ethiopia the proportion of certified food handlers and their carrier status is not well studied. For example *Salmonellosis* is one of such diseases that can be transmitted from chronic asymptomatic *salmonella* carriers especially the food handlers [62].

Food contamination can not only happen as a result of the poor facilities, but is also strongly associated with the personnel engaged in the food handling process until consumption. The existing poor personal hygiene and improper outer working clothing in most establishments and the presence of obvious infections (just the iceberg) among the observed food handlers are strong grounds for the favorable chain of transmission for food borne communicable diseases [62].

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 [63], 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 [64].

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 [65].

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 [66]. A major concern is that the high levels of antibiotic resistance are a result of the use of antibiotics in food animals. In developing countries, household subsistence farming is common, which means that a large proportion of the population has close contact with food animals; therefore, if resistant organisms are common in animals, the chance that they will be transmitted to human beings is more likely [67].

The increased occurrence of drug-resistant pathogens in food of animal origin emphasizes the general need for cooking such foods thoroughly prior to consumption. Education of food handlers in the principle of safe food handling is an essential step towards reducing the incidence of food-borne diseases resulting from cross-contamination during processing and preparation of foods [4].

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 [68].

In Ethiopia [69] reported resistance pattern of *Salmonella* isolates from chickens indicated large proportions of strains resistant to a variety of drugs. From his study conducted on *Salmonella* strains isolated from chicken carcass and giblets (liver, gizzard and heart) obtained from processing plants at Debre Zeit and supermarkets in Addis Ababa 63.7% of the 80 *Salmonella* strains were resistant to one or more antimicrobials of which 52.5% displayed multiple-drug resistance. Among the strains, 51.2% were resistant to sulfisoxazole, 46.2% to spectinomycin, 45% to amoxicillin-clavulanic acid and ampicillin, 41.2% to tetracycline and 30% to chloramphenicol. Less than 27.5% of the strains showed resistance to florfenicol, streptomycin, cotrimoxazole and to trimethoprim. *S. typhimurium* var. Copenhagen (100%), *S. anatum* (62.5%), *S. typhimurium* (33.3%) and *S. braenderup* (34.3%) showed multiple antimicrobial resistance to up to eight antimicrobials. They indicated that chickens as source of multiple antimicrobial-resistant *Salmonella* for human infections.

Addis [45] documented resistant *Salmonella* in Addis Ababa which were isolated from milk and faecal samples of from lactating cows and stool from humans working in dairy farms .All the twenty four isolates of Salmonella, from cows and humans, were subjected to a panel of ten antimicrobials. The antimicrobial susceptibility pattern of the isolates indicated that all isolates were 100%, 66.7% and 58.3% resistant to ampicillin, streptomycin and nitrofurantoine, respectively. On the other hand the isolates were, 91.7%, 87.5% and 75% sensitive to ciproflocacillin and cotrimoxazole, chloramphenicol and ceftriaxone, respectively. About 83.3% of both human and cow isolates showed resistance for two or more of the antimicrobials tested. Form these resistance isolates, most of them (20%) showed resistance to ampicillin and streptomycin followed by resistance to gentamycin, ampicillin, streptomycin, kanamycin and nitrofurantoine (15%) and to ampicillin, streptomycin and nitrofurantoine (10%). One milk isolate and one faecal isolate of cow showed multiple antimicrobial resistances to 60% of the antimicrobials tested.

In Jimma [40] conducted resistance test and from the two Salmonella isolates one was reported to be susceptible against all 12 tested antimicrobials, while the other to all the 11 except cephalexin. *Shigella dysentery* was resistant only to co-trimoxazole and tetracycline. Out of the 20 S. aureus isolates, 90% showed resistance to oxacillin, 85% to ampicillin, 65% to erythromycin, 60% to amoxicillin, 35% to streptomycin and 20% to vancomycin and all isolates were sensitive to co-trimoxazole (100%). In this study, 90% (18/20) of the *S. aureus* isolates were methicillin Resistant *Staphylococcus aureus*. In this study high percentage of indicator organisms as well as food borne pathogens were identified, which shows unhygienic condition of handling and processing in the food establishments.

According to Firehiwot [17] the antimicrobial profile of *L. monocytogenes* was assesed and it was found that *L. monocytogenes* was sensitive to most drugs except clindamycin which showed the highest resistance rate (100%) and also to certain extent to chloramphenicol (53.9%), tetracycline (31.8%) penicillin (23.1%) and rifampicin (15.4%).

According to Sefinew & Bayleyegn [49] out of twenty-eight salmonella spps. Isolated. Eleven of them (39.3%) were resistant to one or more of the antimicrobials tested. In their study resistance was shown to ampicillin, chloramphenicol, gentamycin, norfloxacin, polymyxin-B, streptomycin, tetracycline and trimethoprim. Four of 11 (36.4%) were multiple antimicrobial resistant. All the isolates tested were susceptible to the antimicrobial effects of gentamycin, norfloxacin and trimethoprim. All isolates of *Salmonella Infantis*, *Salmonella Typhimurium* (except one) and *Salmonella Mishmarhaemek* were susceptible to the tested antimicrobials. One *Typhimurium* isolate was resistant to chloramphenicol, streptomycin and tetracycline. Salmonella Haifa was multiply antimicrobial resistant to ampicillin, tetracycline and streptomycin. All isolates of Salmonella Heidelberg were resistant to streptomycin.

Molla [48] investigated antimicrobial resistance pattern of *Salmonella* serovars and reported 31.8% multidrug-resistant Salmonella serovars to various antimicrobials. All Salmonella isolates were susceptible to the antimicrobial effects of amikacin, apramycin, carbadox, ceftriaxone, ceftiofur, cefoxitin, ciprofloxacin, florfenicol, gentamicin, kanamycin, nalidix acid, neomycin, nitrofurantoin and tobramycin. Resistance to the remaining 10 antimicrobials varied between 4.6% and

18.2%. Resistance to ampicillin, sulfisoxazole, streptomycin and cephalothin (each 18.2%) was common among the isolates, followed by tetracycline (13.6%). *Salmonella typhimurium* isolates showed resistance to ampicillin and cephalothin, sulfisoxazole, streptomycin, sulfamethoxazole-trimethoprim and trimethoprim, amoxicillin/clavulanic acid, chloramphenicol, spectinomycin and tetracycline. However, *S. reading* isolates showed resistance to streptomycin, sulfisoxazole and tetracycline only. All the resistant strains of *S. typhimurium* and *S. reading* showed a multidrug resistance pattern. *S. typhimurium* PT 193 demonstrated a multidrug resistance pattern to up to 9 different antimicrobials (AmpAmcCefChlSpt-StrSulSxtTmp).

Behailu & Mogessie [70] studied drug resistance among enterococci and Salmonella from poultry and cattle in Ethiopia. Among the enterococci, resistance to erythromycin (Ery), clindamicin (Cli), amoxicillin (Amo), ampicillin (Amp) and cephalothin (Cep) was high. Resistance to vancomycin (Van) was detected in all enterococcal species. Over 80% of the isolates showed multiple drug resistance. The most dominant patterns in poultry were Amo/Amp/Cep/Pen and Amo/Amp/Cep/Cli/Pen/Van. Among isolates from cattle, Amo/Amp/Cep/Cli/Ery/Pen/Van and Amo/Amp/Cli/Ery/Pen/Van constituted the most dominant multiple resistance patterns. A total of 51 *Salmonella* isolates were obtained from poultry (43/280) and cattle (8/450). About 70% of the isolates had varying resistance to the tested antibiotics. Multiple drug resistance was observed in over 30% of the Salmonella isolates. The most frequent resistance pattern was Amo/Amp/Cip/Gen/Str in cattle and Amo/Amp/ Cep/Cip/Gen/Kan/Str in poultry. Enteroccoccal and Salmonella isolates showed multiple resistance to those antibiotics used in human and veterinary medicine. The high frequency of isolation of resistant enterococci is indicative of the wide dissemination of antibiotic resistant bacteria in the farm environment. Enteroccoccal and Salmonella isolates showed multiple resistance to those antibiotics used in human and veterinary medicine. The high frequency of isolation of resistant enterococci was reported to be indicative of the wide dissemination of antibiotic resistant bacteria in the farm environment.

Control and Prevention of Food-borne Pathogens: Fermentation technology is one of the oldest known methods of food preservation. Fermentation processes promote the development of essential and safe microflora, which play a vital role in preventing the outgrowth of spoilage bacteria and food borne pathogens [71].

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 bacteriocines, hydrogen peroxide, diacetyl and CO_2 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 [72].

Ergo is a naturally processed indigenous Ethiopian fermented dairy product, which is commonly prepared at household level. The fermentation of this product is dominated by LAB [12].

Although fermented food products are usually considered safe because of the antagonistic effect of LAB, some food-borne pathogens have been reported to survive and grow in fermented milks [73, 74] indicated the involvement of milk and milk products in staphylococcal food poisoning [75, 76] indicated the survival of *L. monocytogenes,* Salmonella*spp*. *Staphylococcus aureus* and *Bacillus cereus* for 24-48 h during *ergo* fermentation. Since *ergo* is commonly consumed soon after 24 h of fermentation, the survival of pathogen beyond 24 h would be undesirable. Various workers reported the isolation of different strains of *E. coli* including pathogenic types from raw milk and fermented milk products like yoghurt and cheeses. The count of different strains of entero haemorrhagic *E. coli* during spontaneous fermentation of *ergo* decreased by 2 log units at 24 h of fermentation [77].

Anteneh [78] that selected mixed LAB cultures may be considered in *ergo* fermentation for a safer product both during fermentation and storage. The study also suggests that the isolates, especially in the form of mixed lactic cultures are possible candidates for the formulation of bioprotective starter cultures that can be employed for production of safe and potentially probiotic.

The study of Mogessie, Anteneh & Tetemke [79]. shown that selected mixed LAB cultures may be considered in *ergo* fermentation for a safer product both during fermentation and storage. The study also suggests that the isolates, especially in the form of mixed lactic cultures are possible candidates for the formulation of bioprotective starter cultures that can be employed for production of safe and potentially probiotic ergo.

Food items like minced beef should be cooked to specified temperatures to kill microorganisms associated with bacterial food-borne disease [80].

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. 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 [81].

The contamination of food is influenced by multiple factors and may occur anywhere in the food production process [82]. 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 [83].

The control strategies should be based on creating awareness among the consumers, farmers and those raising farm animals. The improvement of farming conditions, the development of more sensitive methods for detection of pathogens in slaughtered animals and in food products and proper sewage disposal are other intervention strategies [84]. Hygienic measures are required throughout the continuum from “farm to fork”. Further research is also required to explore pathways of the food-borne illness and to determine the vehicles of the greatest importance [85]

Proper processing of food is necessary to ensure the reduction or elimination of the growth of harmful microorganisms. Pasteurization of milk and dairy products and hygienic manufacturing processes for canned foods will help reduce the cases of food-borne illnesses. Food irradiation is a recent technology for prevention of food-borne illnesses. The food irradiation methods include Gamma irradiation, Electron beam irradiation and X-irradiation. Irradiation destroys the organism’s DNA and prevents DNA replication. Food irradiation could eliminate *E. coli* in ground beef, *Campylobacter* in poultry, *Listeria* in food and dairy products and *Toxoplasma gondii* in meat. However, all food products cannot be irradiated Linscott [13].

The consumers should also take precautions to prevent food-borne illnesses. These include cooking meat, poultry and eggs at appropriate temperatures; proper refrigeration and storage of foods at recommended temperatures; prevention of cross-contamination of food; use of clean slicing boards and utensils while cooking; and washing hands often while preparing food [13].

Good agriculture practice and good manufacturing practice should be adopted to prevent introduction of pathogens into food products. In order to control food-borne bacterial infections, it is important to increase awareness of food handlers regarding the presence and spread of these bacterial. In addition, standardized methods for the detection of food-borne bacteria should be utilized and laboratory-based surveillance should be established for early detection of the pathogen [86] and Dairy farmer should be informed about the hygienic method of handling food [87, 88, 89, 90, 91, 92].

To reduce significantly the risk of food-borne pathogens, the [93]. issued the following rules for safe food preparation: These rules are described as “The Ten Golden Rules” of WHO for Safe Food Preparation (10) Choose foods processed for safety, cook food thoroughly, eat cooked foods immediately, store cooked foods carefully, reheat cooked foods thoroughly, avoid contact between raw and cooked food, wash hands repeatedly, keep all kitchen surfaces meticulously clean, protect food from insects, rodents and other animals and use safe water.

CONCLUSION AND RECOMMENDATIONS

The population in developing countries is more prone to suffer from food-borne illnesses because of multiple reasons, including lack of access to clean preparation, inappropriate transportation and storage of foods and lack of awareness regarding safe and hygienic food practices. Moreover, majority of the developing countries including Ethiopia have limited capacity to implement rules and regulations regarding food safety. Also, there is lack of effective surveillance and monitoring systems for food-borne illness, inspection systems for food safety and educational programs regarding awareness of food hygiene given to them.

Microorganisms are everywhere& can cause illness, they can spoil food and some can ferment it into desired products. So proper hygiene is needed. Pathogenic microorganisms can be part of a food's natural microflora or may be contaminants. Contaminants can come from the normal environment, a polluted environment, pests and pets, the food handler and/or equipment. Bacteria and moulds are able to grow in foods, increasing the risks that they pose. The growth of bacteria and moulds can be extremely rapid. This growth is affected by the composition of the food and its storage environment. The possibilities of both growth and survival of bacteria must be considered when assessing safety. Heating is the most effective single method for improving food safety. Based on the above generalization, the following recommendations are forwarded:

- 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.
- Community awareness for improvement of management and hygienic practices by all food handlers and in food processing facilities must be given due attention. The awareness creation areas include:
- 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.
- Pasteurization of milk and milk products should be done as routine practice most notably in rural communities.
- Preparation of food several hours prior to consumption, combined with its storage at temperatures which favors the growth of pathogenic bacteria or the formation of toxins, insufficient cooking or reheating of food to reduce or eliminate pathogens, minimizing Cross-contamination.
- 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.

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