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Review

Review on common foodborne pathogens in Ethiopia

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Foodborne pathogens are among the common causes of illness and death as well as public health problem which result in the loss of labor force both in developed and developing countries. The World Health Organization estimated that in developed countries, up to 30% of the population suffers from foodborne diseases each year, whereas in developing countries up to 70% of cases of diarrheal disease are associated with the consumption of contaminated food per year. Animal products such as meats, fish and their products are generally regarded as high-risk commodity in respect of pathogen contents, natural toxins and other possible contaminants. In Ethiopia, the widespread habit of raw beef consumption is a potential cause for foodborne illnesses besides, the common factors such as overcrowding, poverty, inadequate sanitary conditions, and poor general hygiene. In Ethiopia, as in other developing countries, it is difficult to evaluate the burden of food borne pathogens because of the limited scope of studies and lack of coordinated epidemiological surveillance systems. In addition, under-reporting of cases and the presence of other diseases considered to be of high priority may have overshadowed the problem of foodborne pathogens. This review focused on published report of common food borne pathogen specifically *Salmonella* spp., *Escherichia coli*, *Listeria* spp., *Staphylococcus* spp. and *Campylobacter* spp. in different parts of Ethiopia.

Key words: *Campylobacter* spp., *Escherichia coli*, Ethiopia, foodborne pathogen, *Listeria* spp., *Salmonella* spp., *Staphylococcus* spp.

INTRODUCTION

Foodborne pathogens are one of the leading causes of illness and death in developing countries resulting in the loss of labor force which could have contributed in the economic growth (Fratamico et al., 2005).

Food borne diseases occur particularly in Africa 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). Of the foods intended for humans, those of animal origin tend to be most hazardous unless the principles of food hygiene are employed. Animal products such as meats, fish and their products are generally regarded as high-risk commodity in respect of pathogen contents, natural toxins and other possible contaminants is an unavoidable consequence of meat processing (Jones et al., 2008). Data regarding meat borne diseases in Ethiopia are not well documented among which studies conducted

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in different parts of the country have shown the public health importance of several bacterial pathogens associated with foods of animal origin (Bayleyegn et al., 2003; Ejeta et al., 2004; Adem et al., 2008; Kumar et al., 2009; Tefera et al., 2009).

In Ethiopia, like other developing countries, it is difficult to evaluate the burden of food borne pathogens because of the limited scope of studies and lack of coordinated epidemiological surveillance systems. In addition, under-reporting of cases and the presence of other diseases considered to be of high priority may have overshadowed the problem of foodborne pathogens (Oosterom, 1991).

The widespread habit of raw beef consumption is a potential cause for food borne illnesses in Ethiopia, besides the common factors such as overcrowding, poverty, inadequate sanitary conditions and poor general hygiene (Siddiqui et al., 2006).

In Ethiopia, there have been several studies conducted on foodborne pathogens among which are *Salmonella* spp., *Escherichia coli* O157:H7, *Listeria monocytogenes*, Staphylococcus *aureus* and *Campylobacter* spp. but there is no compiled document for easy access. Therefore, the objectives of this review paper are: To provide well organized data on available research works (published) on common foodborne pathogens in Ethiopia. And to show research gaps on foodborne pathogens in Ethiopia.

Salmonella spp.

Salmonella are the major food borne pathogenic bacteria in humans as well as in animals. *Salmonella* species are leading causes of acute gastroenteritis in several countries and salmonellosis remains an important public health problem worldwide, particularly in the developing countries (Rotimi et al., 2008). Salmonellosis is the most common food borne disease in both developing and developed countries, although incidence rates vary according to the country (Stevens et al., 2006). The fecal wastes from infected animals and humans are important sources of bacterial contamination of the environment and the food chain (Ponce et al., 2008).

Salmonella infection in meat animals, including cattle, swine and sheep, arises from intensive rearing practices and the use of contaminated feeds (D'Aoust, 1989). Cross-contamination of carcasses with *Salmonella* can also occur during slaughtering operations. Stress associated with transport of animals to abattoir augments shedding of *Salmonella* by carrier animals and this may contribute to the spread of the organism to other animals in the slaughter plant (Baird-Parker, 1990; Isaacson et al., 1999). Slaughtering procedures potentially involve many risks of both direct and cross-contamination of carcasses and meat surfaces. During slaughter, faecal contamination of edible organs with subsequent contamination of the carcass may occur. This can be carried through all slaughter procedures up to the processing of the raw products, which are important sources of *Salmonella* in the human food chain (Edwards et al., 1997).

It is usually difficult to evaluate the situation of salmonellosis in developing countries because of the very limited scope of studies and lack of coordinated epidemiological surveillance systems (Oosterom, 1991; Ache and Szyfres, 2001). In addition, under reporting of cases and presence of other diseases considered to be of high priority may have overshadowed the problem of salmonellosis in some developing countries including Ethiopia. The increased global population coupled with mass production of animal and animal food and the rapid international trade in agriculture, aquaculture and food products could worsen the problem (D'Aoust, 1994).

A periodic surveillance of the level of *Salmonella* contamination in the different food animals, food products and environment is necessary to control the spread of the pathogen and infection of man (Dawson, 1992). Therefore, the different studies conducted on food borne salmonellosis in different parts of Ethiopia by different researcher are systematically summarized and presented in Table 1.

From 2000-2013 almost 15 different studies were published on foodborne Salmonellosis which are concentrated in some parts of Ethiopia especially in Addis Ababa and Debre Zeit with 8 studies in Addis Ababa, 6 in Debre Zeit. There might be unpublished studies done in other place which helps to provide holistic figure of the overall foodborne Salmonellosis patterns in Ethiopia. As a recommendation, it is better to do region wide research to provide a representative estimate of foodborne Salmonellosis in Ethiopia.

Escherichia coli

Infection with *E. coli*O157:H7 is a major food borne and zoonotic pathogen responsible for hemorrhagic colitis and hemolytic uremic syndromes in humans. Transmission to human occurs through consumption of undercooked meat, unpasteurized dairy products, and vegetables or water contaminated by feces of carrier animals (Songer and Post, 2005).

Meats are a common source of *E. coli* contamination, which may be acquired during slaughter through fecal contact. *E. coli* outbreaks have been associated with meat (especially ground beef), dairy products, mayonnaise, apple cider, sprouts (radish), lettuce and spinach. *E. coli* outbreaks have also been associated with swimming pools and nursing schools (Arun, 2008).

Verocytotoxigenic *E. coli* (VTEC) (also referred to as Shiga toxin-producing *E. coli*), including serotype O157:H7, are one of such group, causing severe, chronic, and potentially fatal illness such as hemorrhagic colitis, hemolytic uremic syndrome, thrombotic thrombocytopenic purpura and, in severe cases, death, related

Table 1. Systematic summary of publications on foodborne Salmonellosis in Ethiopia.

Location	Sample/source	Prevalence (%)	Serotypes	Antimicrobial susceptibility profile	References
D/Zeit	Feces MLN Abdo.muscle Diaph.muscle	2/323(0.6) 4/323(1.2) 9/323(2.8) 10/323(3.1)	*S.* Mishmarhaemek *S.* Typhimurium *S.* Enteritidis *S.* Guildford *S.* Dublin	Resistant to AMP, CEP, SMX, TIC, TET	Alemayehu et al. (2003)
A/A D/Zeit Dire–dawa Jigijiga	**Slaughtered cattle** feces MLNs Muscle **Slaughtered Camel** Feces MLNs Liver Spleen Muscle **Slaughter house personnel** Human stool **Supermarket** Minced beef **Chicken meat and giblet** Meat Liver Gizzard Heart	 7/370(1.9) 9/370(2.4) 63/1116(5.6) 18/119(15.1) 19/119(15.9) 14/119(11.8) 17/119(14.3) 48/238(16.2) 18/300(6) 46/380(12.1) 54/452(8.3) 33/111(29.7) 48/116(41.4) 18/85(21.2)	*S.* Braenderup *S.* Dublin *S.* Saintpaul *S.* Typhimurium *S.* Typhimurium var. Copenhagen *S.* Anatum		Bayleyegn et al. (2003)
A/A D/Zeit	Chicken meat Skin Liver Gizzard Heart	16/104(15.4) 8/104(7.7) 19/55(34.5) 23/56(41.1) 14/59(23.7)	*S.* Braendrup, Typhimuriumvar Copenhagen, Anatum, Kottbus, Typhimurium	Resistance to CEX	Molla and Mesfin (2003)

Table 1. Contd.

A/A	Minced beef	23/160(14.4)	*S.* Infantis, Braenderup, dublin, Saintpaul, Bovismorbificans, Anatum, vojle*, S.*I:8, 20		Ejeta et al. (2004)
	Mutton	12/85(14.1)	*S.* Infantis, Braenderup, Anatum, Bovismorbificans & *S.* I:47, z4, z23		
	Pork	9/55(16.4)	*S.* Infantis, Braenderup & Vejle		
D/Zeit	Feces	5/107(4.7)	*S.* Infantis, Butantan		Woldemariam et al. (2005)
	MLN	3/107(2.8)	*S.* Infantis, Anatum, Zanzibar, Butantan, Typhimurium & Kingabowa		
	Liver	2/107(1.9)	*S.* Infantis, Butantan, Braenderup & Kottbus		
	Spleen	7/107(6.5)	*S.* Infantis & Butantan		
	Diagh.muscle	9/107(8.4)	*S.* Infantis & Butantan & Gingabwa		
	Abdo.muscle	7/107(6.5)	*S.* Infantis, Braenderup & Butantan		
D/Zeit	Pork	94/501(18.8)	*S.* Anatum, Newport, Enteritidis, Hadar, Uganda, Eastnourne & Kentucky	Multidrug resistant (*S.hadar* highest).	Molla et al. (2006a)
A/A Modjo	Feces MLN Liver Spleen Abdo. Muscle Diagh. Muscle	7/204(3.4) 10/204(4.9) 2/204(0.9) 1/204(0.5) 2/204(0.9) 0/204	*S.* Typhimurium, Give, Herdelberg, Reading, Poona & Enteritidis	*S.typhimurium* (STR, sulfisoxazole, TET, TMP) *S. reading* (STR, SUL, TET).	Molla et al. (2006b)

Table 1. Contd.

A/A	cecal content MLN Carcass swab	63/278(23) 99/278(36) 11/278(4)	*S.* Hadar, Eastnourne, Saintpaul, Typhimurium, & Var. Copenhagen, Enteritidis, Newport & Anatum.	Substantially multidrug resistant	Aragaw et al. (2007)
A/A	Chicken meat	29/208(13.9)	*S.* Braenderup, Hadar, Newport, Kentucky, Typhimurium , Bovismorbificans & Anatum.	*S. braenderup*(AMP, SPT, STR, SUL, SXT, TMP)	Zewdu and Cornelius (2009)
	Pork	22/194(11.3)	*S.* Newport, Haifa, Dublin , Infantis & Kottbus.	*S. kentucky* (AMP, AMC, CEF, CIP, GEN, NAL, SPT, STR, SUL, TTC)	
	Minced beef	12/142(8.5)	*S.* Newport, Dublin, Anatum, Infantis, Typhimurium, Kentucky & Saintpaul		
	Mutton	23/212(10.8)	*S.* Newport, Hadar, Typhimurium, Dublin, Bovismorbificans, Infantis & Zanzibar	*S. Dublin* (CRB, TTC)	
	Cottage cheese	4/190(2.1)	S.Newport & Haifa		
	Fish	3/128(2.3)	*S.* Newport & Zanzibar		
	Ice cream	0/126			
	Stool sample	5/68(7.4)	*S.* Newport		
A/A	Lettuce Green paper	8/40(20) 4/40(10)	*Salmonella* spp.	All *salmonella* isolates resistant (PEN and AMC)	Biniam and Mogessie (2010)

Table 1. Contd.

D/Zeit	Hide swab	31/100(31)	*S.* Anatum	(STR, TTC)	Sibhat et al. (2011)
	Hand swab(at fly	7/100(7)	*S.* Newport	(TTC, STR, SUL)	
	Hand swab (at evisceration)	2/100(2)	*S.* Eastbourne	(TTC)	
	Carcass	2/100(2)	*S.* Uganda	-	
B/Dar	Liver	2/186(1.1)	*S.* Typhimurium *S.* Infantis	Multidrug resistant	Alemu and Zewde (2012)
	MLN	6/186(3.2)	*S.* Newport		
	Carcass swab	9/186(4.8)	*S.* Hidelberg *S.* Mishmarhaemak		
	Intestinal content sample	11/186(5.9)	*S.* Haifa		
Mekelle	Margarine	0/10	*Salmonella* spp.		Mekonnen et al. (2012a)
	Mayonnaise	2/10(20)			
	Sardine	2/10(20)			
	"wot"	13/30(43.3)			
	Macaroni	2/10(20)			
	"fata"	0/30			
	"zahla"	4/10(40)			
	Mango juice	7/15(45)			
	Avocado juice	4/17(23.5)			
	Fruit mix	2/8(25)			
	Table scraping	11/110(10)			
B/Dar	Ready to eat white lupine	23/40(57.5)	*Salmonella* spp.	Highest resistance to ERY (86.9%)	Mulgeta and Million (2013)
A/A	Whole egg	18/384(4.6	*S.* Enteritidis	-	Zinabu et al. (2013)

A/A: Addis Ababa B/Dar: Bahir Dar D/Zeit: Debre Zeit (current name Bishoftu).

to their ability to produce one or more toxins known as verotoxin or Shiga toxin (Tarr, 1995). Consumption of raw or undercooked foods of bovine origin has been the most common means of transmitting VTEC organisms in sporadic cases and in outbreaks of VTEC infection (Uhitil et al., 2005).

Outbreaks of *E. coli*O157 have been reported in different parts of the world and antibiotic use is controversial because of the potential to increase production and secretion of Shiga toxins. Increase in antibiotic resistance has been noted over the last 20 years (Adem et al., 2008). Differentiation of pathogenic strains from the normal flora depends on the identification of virulence characteristics (OIE, 2008).

In Ethiopia, there were studies conducted by few researchers (Adem et al., 2008; Mersha et al., 2009; Taye et al., 2013) to determine the occurrence and proportion of *E. coli* O157:H7 in faeces, skin swabs and carcasses of sheep, goat and cattle in Debre Zeit, Modjo and Haramaya University. Even though little is known about the prevalence and antimicrobial susceptibility pattern of this bacterium in Ethiopia either in humans or animal population or foods, there is no information in eastern Ethiopia generally and in Haramaya

University and its surrounding specifically, where large populations of cattle are reared for slaughter Taye et al., 2013).

Studies done on foodborne *E. coli* infection are few in number and little is known about the public health effect of foodborne *E. coli* due to lack of well documentation system and integrated surveillance system in Ethiopia. This review will provide a systematic summary of those studies conducted by few researchers on foodborne *E. coli* infection (Table 2).

Different researches were conducted on foodborne *E. coli* based on abattoir sample, butcher shop, dairy milk and different food which are ready to eat from 2008-2014 only in limited parts of Ethiopia. Out of seventeen research, six specially emphasized on *E. coli* O157:H7 serogroups.

As a remark since *E. coli* O157:H7 is an emerging foodborne and zoonotic pathogen, researchers should emphasis on the public health significance of this pathogen to assess the overall prevalence and public health importance of food borne *E. coli* O157:H7 in Ethiopia.

Listeria monocytogenes

Listeriosis is one of the important emerging bacterial zoonotic diseases that occur in a variety of animals and humans. It arises mainly from the consumption of contaminated food products (Acha and Szyfres, 2001; Malik et al., 2002). Reports indicate that listeriosis has emerged to be more important in developed countries but is reported less frequently in developing countries (Todar, 2003). This could be associated with lack of awareness of laboratory technicians or lack of diagnostic facilities and limited resources together with the presence of other disease epidemics that claim more priority than listeriosis in developing countries including Ethiopia.

A number of food borne outbreaks caused by *L. monocytogenes*, have so far been reported, which were known to cause serial deaths in a number of individuals and in different regions, especially in Europe and the USA (Todar, 2003). However, in most African countries, there are a few reports on *Listeria* and listeriosis, as compared to the Europe and USA (Molla et al., 2004). This is because; the organism has not been given much attention, and may be due to lack of adequate facility, life style differences and RTE foods are more common in USA and Europe than in Africa regardless of the habit of consumption of raw milk and milk product as well as raw meat. Published information on the status of food borne listeriosis is very limited both in the veterinary and public health sectors in Ethiopia and those studies which are published are presented in well summarized manner (Table 3).

Few researches were done on foodborne *L. monocytogenes* and other *Listeria* spp. in Ethiopia from 2000- 2014 and all studies were done in Addis Ababa.

There may be unpublished study output which is kept on shelf only, so this will not represent the overall status of foodborne *L. monocytogenes* in Ethiopia. This is a wide research area for researchers with emphases given on public health significance, prevalence and antimicrobial susceptibility profile of *L. monocytogenes* since little is known about the burden of *L. monocytogenes* in food specifically in raw milk and meat product and habit of consuming raw milk and meat in Ethiopia.

Staphylococcus aureus

S. aureus is one of the most common causes of food borne intoxication in most countries of the world. *S. aureus* is a facultative anaerobic Gram-positive coccus, nonmotile, catalase and coagulase positive of the micrococcaceae family (Bhatia and Zahoor, 2007).

Convenience food offers a suitable growth environment for toxin-producing bacteria such as *S. aureus*, which is able to grow and express virulence in a wide variety of foods such as milk products, mixed foods, meat and meat products, egg and egg products, cakes and ice cream (Silva et al., 2001).

Various fatal diseases caused by street food intoxications have been lately reported (Sina et al., 2011). In reported street food epidemiology studies, *S. aureus* is the most predominant virulent bacteria responsible for a wide range of human diseases. It represents the major causal agent of food intoxication through its enterotoxin products (Le Loir et al., 2003). Several studies have been conducted in Ethiopia but there is no properly documented file so this review provides a published research output in summarized manner in Table 4.

Various researches has been done on foodborne *S. aureus* intoxication in certain parts of Ethiopia but little is known about the status of *S. aureus* due to less priority given by researchers and public health professionals both in human and veterinary medicine in Ethiopia at large. From 2000-2014 only nineteen published studies were done among which are 2 in Jimma, 2 in D/Zeit, 1 in Jigjiga, 3 in Mekelle, 2 in B/dar, 1 in Adami-Tulu, 1 in Adama, 1 in Shashemene, 1 in Gondar, 1 in Hawassa, 1 in Yabello, 1 in Humera and Abergelle and 2 in A/A. Since *S. aureus* is a highly zoonotic foodborne pathogen, due emphases should be given to assess and determine the overall prevalence, public health significant and antimicrobial susceptibility profile of foodborne *S. aureus* in Ethiopia.

Campylobacter spp.

Campylobacteriosis is historically a zoonotic disease found among cats, goats, poultry, calves, lambs and dogs. Although uncommon, human-to-human spread is also possible through faecal-oral route. The cross-contamination of foods during preparation is also likely to

Table 2. Systematic summary of publications on foodborne *E. coli* including *E. coli* O157:H7 in Ethiopia.

Location	Sample/source	Prevalence (%)	*E. coli* Serotype	Antimicrobial susceptibility profile	Reference
D/Zeit Modjo	Meat Beef Mutton Goat meat	20/250(8) 6/243(2.5) 5/245(2)	*E. coli* O157:H7	(KAN, STR, AMP, CEP, TTC, TRIM)	Hiko et al. (2008)
Modjo	Feces Skin swab Carcass before wash Carcass after wash Water	8/172(4.7) 15/172(8.7) 14/172(8.1) 15/172(8.7) 1/23(4.3)	*E. coli* O157:H7	-	Mersha et al. (2009)
Jimma	'Kitifo' Surface swab Carcass swab	120 12 33 44/165(26.6)	Thermo tolerant *E. coli* (84%)	-	Haimanot et al. (2010)
Jimma	Cow milk	164/218(75.22)	*E. coli* (9.17%) isolates	-	Tariku et al. (2011)
Gondar	Cow milk	164/322(50.9)	*E. coli* (4.3%)	ERY, AMP, TTC	Nibret et al. (2011)
B/dar	Cow milk	99/139(71.2)	*E. coli* (2.5%)	-	Molalign et al. (2011)
Shashemene	Cow milk	217/364(59.6)	*E. coli* (10.6%)	-	Desie et al. (2011)
Yabello	Cow milk	81/712(11.37)	*E. coli*	-	Adane et al. (2012)
Humera&Abergelle	Sheep milk Goat milk	135 255 84/390(21.5)	*E. coli* (17%)	-	G/Wahid et al. (2012)
Mekele	Margarine mayonnaise sardine "wot" Macaroni "fata" "Zahla" Mango juice Avocado juice Fruit mix Table scraping	4/10(40) 2/10(20) 0/10 4/30(13.4) 0/10 10/30(33.4) 2/10(20) 3/15(20) 7/17(41.1) 1/8(12.5) 32/110(29)	*E. coli*	-	Mekonnenet al. (2012a)

Table 2. Contd.

	Meat				
Mekele	Butcher shop Abattoir Street meat sales	2/30(6.7) 2/5(40) 3/5(60)	*E. coli* *E. coli*32 (91.4%) *E. coli* O15:H7 3 (2.6%)	AMP, ERY, CL, NA, CHL, TRIM-SUL	Mekonnen et al. (2012b)
Mekele	Cow milk	128/174(73.56)	*E. coli* (27.3%)	*E.coli* (TTC (48.57%), C (28.86%), KEN (8.86%), SPT (5.7%), AMP (65.7%) AMC (66.67%))	Haftu et al. (2012)
Haramaya university	Carcass swab	35/113(30.97)	*E. coli*	*E.coli* O157:H7 (TTC (33.33%), AMP (100%), AMC (100%).	Taye et al. (2013)
B/dar	Ready to eat white lupin	29/40(72.5)	*E. coli*	Resistant to TTC	Mulugeta and Million (2013)
Holeta	Cow milk	183/224(81.7)	*E. coli* (11.6%)		Ayano et al. (2013)
A/A	Cow milk	80/118(67.8)	*E. coli* O157:H7 (6.9%) *E. coli* (18.7%)	- -	Zeryehun et al. (2013)
Jigjiga	Camel carcass PES Meat	2/70(2.86) 6/90(6.67) 4/70(5.71)	*E. coli* O157:H7	-	Henok (2014)

Table 3. Systematic summary of study done on foodborne *L .monocytogene* in Ethiopia

Location	Sample/source	Prevalence (%)	*Listeria* spp.	Antimicrobial susceptibility profile	References
A/A	Minced beef Pork Chicken Fish Cottage cheese Ice cream	29/61(47.5) 37/53(69.8) 8/52(15.4) 8/43(18.6) 1/61(1.6) 20/46(43.5)	*L. monocytogene* (5.1%) *L. innocua* (21.2%) *L. seeligeri* *L. welshimeri* *L. murrayi* *L. grayi*	-	Molla et al., 2004

Table 3. Contd.

A/A	Raw meat Raw milk Cottage cheese Cream cake	41/60(68.34) 6/60(10) 6/60(10) 13/60(21.67)	*L. monocytogene* (19.7%) *L. innocua* (39.4%) *L. seeligeri*(4.5%) *L. welshimeri* (12.12%) *L. murrayi* (13.6%) *L. grayi* (1.5%)	Firehiwot (2007)
A/A	Pasteurized milk Cheese Ice cream Cake Minced beef Pork Chicken carcass	0/101 0/102 43/101(42.7) 12/101(12.1) 48/102(47.7) 63/102(62.5) 16/102(16.67)	*L. monocytogene* (4.8%) *Listeria* spp. (21.8%)	Desalegn et al. (2009)
A/A	Liquid whole egg Raw beef Raw milk Cottage cheese	37/115(32.2) 39/76(51.3) 22/100(22) 4/100(4)	*L. monocytogene* (5.4%) *L. innocua* (15.9%) *L. seeligeri* (1%) *L. welshimeri* (1.8%) *L. murrayi* (0.8%) *L. grayi* (0.8%) *L. ivanovii* (0.5%)	Gebretsadik et al. (2011)
Jigjiga	Camel carcass PES Meat	0/70 0/90 1/70(1.43)	*L. monocytogenes*	Henok (2014)

Table 4. Systematic summary of studies conducted on foodborne *S. aureus* in Ethiopia

Location	Sample/source	Prevalence (%)	*Staphylococcus* spp.	Antimicrobial susceptibility profile	References (*=unpublished)
B/dar	Cow milk	147/1347(10.9)	*CNS* (49.6%) *S. aureus* (17.8%) *S. intermidius* (5.2%)	TTC, ERY, OXA, CHL, CL, S	Alemaw (2004)*
D/Zeit	Pasteurized milk Milk from Udder Bucket milk Stored milk	94/100(94) 70/77(91) 77/77(100) 12/12(100)	*S. aureus,* *S. intermidus,* *S. hyicus* *S. epidermidus*	-	Wubete (2004)
Adami- tulu	Goat milk	374/680(55)	*S. aureus* (12.8%) *CNS* (9.6%)	CLO, METH ,OTTC, ERY, CHL	Wakwoya et al. (2006)
D/Zeit	Cottage cheese Bucket milk Tank milk	48/200(24) 33/100(33) 46/100(46)	*S. aureus* (7%) *S. intermidius* (7%) *S. hyicus* (5%) *CNS* (12.8%)	-	Mekonnen (2009)

Table 4. Contd.

B/dar	Cow milk	99/139(71.2)	*S. aureus* (20.3%) *CNS* (51.9%)	-	Molalign et al. (2010)
Adama	Cow milk	59/140(42.14)	*S.aureus*	AMP (36.1%), STR (5.6%), PEN (94.4%), TMP-SULFA (58.3%)	Abera et al. (2010)
Jimma Shashemene	Kitifo Surface swab Carcass swab Cow milk	120 12 33 20/165(12.1) 217/364(59.6)	*S. aureus* (28.1%) Other *Staph* (22.1%)	(AMP, STR, AMC, ERY, OXA, VAN)	Haimanot et al. (2010) Desie et al. (2011)
Gondar	Cow milk	164/322(50.9)	*S.aureus* (16.5%) *CNS* (31.1%)	TTC,CAF, KAN, OXA, AMP, SU, S, ERY, CL	Nibret et al. (2011)
Jimma	Cow milk	164/218(75.22)	*S.aureus* (39.44) *CNS* (18.8%)	PEN-G, VAN, CHL,CAF, NAL, AMP	Tariku et al. (2011)
Yabello	Cow milk	577/712(81)	*S.aureus* (29.2%)	-	Adane et al. (2012)
Hawassa	Cow milk	78/160(48.75)	*S.aureus*	AMP, PEN-G, OXA	Dakaet al. (2012)
Humera & Abergelle	Goat milk Sheep milk	255 135 84/390(21.5)	*S.aureus* (27.7%) *CNS* (44.7%)	-	Gebrewahid et al. (2012)
Mekelle	Cow milk	128/174(73.56)	*S. aureus* (36%)	CHL, AMP, ERY, Trim-sulfa	Haftu et al. (2012)
Mekelle	Margarine Mayonnaise Sardine "wot" Macaroni "Feta " "zahla" Mango juice Avocado Fruit mix Table scraping	2/10(20) 0/10 0/10 1/30(3.34) 1/10(10) 5/30(16.7) 2/10(20) 5/15(33.3) 2/17(13) 0/8 55/110(50)	*S. aureus*	-	Mekonnen et al. (2012a)
Mekelle	Meat Bucher shop Abattoir Street meat sale	 2/30(6.7) 2/5(40) 3/5(60)	*S. aureus*	-	Mekonnen et al. (2012b)

Table 4. Contd.

A/A	Cow milk	71/146(64.54)	*S. aureus*(21.13%) *S. agalactiae* (18.3%) *CNS* (11.2%)	-	Abunna et al. (2013)
A/A	Cow milk	80/118(67.8)	*S. aureus*(28.7%)	-	Zeryehun et al. (2013)
Jigjiga	Camel carcass PES Meat	6/70(8.57) 29/90(32.22) 11/70(15.7)	*S. aureus*	-	Henok (2014)

Pen-G-penicillin G, S-streptomycin, CAF-chloramphenicol, tmp-sulfa-trimethoprim-sulfaoxizine, CL-clindamycine, Sul-sulfioxazole.

Table 5. Systematic summary on foodborne Campylobacteriosis in Ethiopia.

Location	Sample/source	Prevalence (%)	*Campylobacter* spp.	Antimicrobial susceptibility profile	References (*=unpublished)
A/A D/Zeit	Beef Sheep meat Goat meat Pork Chicken	14/227(6.2) 12/114(10.5) 7/92(7.6) 4/47(8.5) 13/60(21.7)	*C. jejuni* (78%) *C. coli* (18%) *C. lari* (4%)	-	Dadiand Asrat (2008)
D/Zeit	Sheep carcass	23/218(10.6)	*C. jejuni* (7.3%) *C. coli* (2.7%)	-	Woldemariam et al. (2009)
B/dar	Chicken	160/220(7.27)	*C. jejuni* (92.5%) *C. coli* (7.5%)	AMP, ERY, STR, TTC AMP, STR, TTC	Ewnetu and Mihret (2010)
Jigjiga	Camel carcass PES Meat	4/70(5.71) 3/90(3.33) 3/70(4.28)	*C. jejuni* (2.85%) *C. coli* (2.14%)		Henok (2014)

be important (Solomon and Hoover, 1999).

The pathogenesis of *C. gastroenteritis* is not fully characterized (Rollins and Joseph, 2001). A serious consequence of diarrheal diseases is the Guillain-Barrè syndrome (GBS) characterized by polyneuritis of the peripheral nerves, which may lead to either short-term or lengthy paralysis (Blaser et al., 1983).

In Ethiopia, few studies reported that *Campylobacter* species are common cause of childhood diarrhea and antimicrobial resistant strains were also reported (Beyene and Haile-Amlak, 2004). The absence of national surveillance program, limited routine culture availability for the isolation of *Campylobacter* species at clinical and research settings, the need for selective media and unique growth atmosphere; makes it difficult to give an accurate picture of the burden. This fact indicates that *Campylobacter* as a causative agent of diarrhea is not given appropriate weight and consideration in Ethiopia. Those studies which are done on foodborne Campylobacteriosis in different parts of Ethiopia are summarized in Table 5.

Very few published studies are found on foodborne campylobacteriosis in Ethiopia regardless of sever pathogenic cause of gastroenteritis in human. Studies from 2000-2014 show that only three published research were done in Addis Ababa and D/Zeit (Dadi and Asrat, 2008), D/Zeit (Woldemariam et al., 2009) and B/dar (Ewnetu and Mihretu, 2010) and one unpublished research done in Jigjiga (Henok, 2014). Since foodborne campylobactersis are the cause of diarrhea in human especially in children little emphases is given by human and veterinary medicine.

As a remark, researchers should give special attention to this area to assess and determine the prevalence; public health significance and antimicrobial susceptibility profile of foodborne campylobactersis with special emphases on *Campylobacter jejuni* and *Campylobacter coli* in Ethiopia since this species become an emerging antimicrobial resistant strain due to consumption of not thoroughly cooked food of animal product like poultry since sometimes while cooking doro-wote when the chickens are young, the meat is easily cooked with minimum heat in this case some of the bacteria may survive heating temperature and transfer the antimicrobial resistant gene to the normal intestinal flora of human by either plasmid, transposons or transfor-mation.

All the published studies on common food borne pathogens such as *Salmonella* spp., *Escherichia coli* spp., *Listeria* spp., *Staphylococcus* spp. and *Campylobacter* spp. conducted by different investigators in Ethiopia have shown the widespread distributions of foodborne pathogen isolates in the community. Several common foodborne pathogens with their antimicrobial resistance profiles have been investigated from the year 2000-2014.

Recommendations

1. The epidemiology of foodborne pathogen in Ethiopia has not been well investigated and it requires continuous integrated surveillance both nationally and regionally in order to establish holistic figure for foodborne pathogen in the country.
2. The national research institutes and government universities should be able to identify foodborne pathogen to the level of serovar and measure quantitatively antibiotic susceptibility pattern, so that comparison with serovars isolated from humans, animals and food products could be possible. Additionally if all these institutions are working in well-organized way, it will avoid repeated work on same area and same pathogen finally saving extra costs for surveillance.
3. To decrease the incidence of foodborne pathogen in Ethiopia, besides giving attention in identification, suscepti-bility testing and reporting during routine bacteriological analysis, public health measures such as improving personnel, food hygiene and intensive health education should be implemented.
4. Finally, according to "publish or perish" motto of the scientific community, it is recommended that everyone should publish the research outputs and make them available to the public.

Conflict of interest

The author(s) have not declared any conflict of interests.

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