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Research Article

Prevalence of Coliform Bacteria in Bovine Mastitis in Africa: A Systematic Review

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Abstract: Mastitis which is the inflammation of the mammary gland of mammals with changes in milk due to chemical, physical and bacteriological injuries results in reduction in milk yield and composition. The aim of this study was to assess by a systematic review of published data the occurrence of coliform bacteria in bovine mastitis in Africa from 2000 to 2017 and to investigate the risk factors associated with coliform mastitisThe Preferred Reporting Items for Systematic and Meta-Analyses (PRISMA) procedure was used in the study. The Sample, Phenomenon of Interest, Design, Evaluation, Research type (SPIDER) tool was chosen and modified to establish the research question. Six databases were searched in this study viz., Science Direct, Cochrane Library-central, Medline, Google Scholar, PsycINFO and Open Grey (a grey literature). Studies were critically analyzed and assessed using the Crowe critical appraisal Tool (CCAT). The search strategy generated 121 articles out of which 14 were selected for quality assessment and data extraction. Major findings indicated that the prevalence of coliforms associated with bovine mastitis ranged from as low as 0.4% to as high as 87.5%. However, the most dominant pathogen associated with bovine mastitis was *Staphylococcus aureus* with a prevalence of ranging from 20.6 – 54.4%. Data generated from the reviewed articles showed age, parity number, lactation stage, and general management system of various farms as the most important factors that influence the development of bovine coliform mastitis in Africa.
Keywords: Coliforms, Bovine mastitis, Subclinical mastitis, Risk Factors, Bacteria, *E. coli*.

INTRODUCTION

Mastitis is an inflammation of the parenchyma tissue of the mammary gland. The inflammation usually results in physical, chemical and bacteriological changes in milk and pathological changes in the glandular tissue. Mastitis also results in reduced milk yield and alteration of milk composition (Blowey, R. W. 1999; Souto, L. I. *et al.*, 2010). It is the most widespread and costly disease in dairy cattle occurring throughout the world (Abebe, R *et al.*, 2016). It is a condition that affects the dairy industry globally and causes significant economic losses due to reduced milk yield, additional labor and expenses on treatment or control (Hogeveen, H., *et al.*, 2011). The resulting losses due to mastitis in the dairy industry is about 2 billion dollars annually in the United States (Hoblet, K. H., *et al.*, 1991). This loss is a culmination of reduced milk yield, milk quality, early culling of affected animals and huge amount of money spent in antibiotic treatment.

A wide range of microorganisms have been implicated in the development of mastitis viz., *Corynebacterium pyogenes*, *S. aureus*, *Pseudomonas spp*, *Corynebacterium bovis*, *Bacillus spp*, *Salmonella*, *Micrococcus spp.* Others include *Enterobacter*, *E. coli*, *Klebsiella*, *Proteus*, *Citrobacter*, which are called are coliforms, a broad class of enterobacteriaceae found in our environment, including feces of man and other warm blooded animals (Guentzel, M. N. 1996). These organisms cause mastitis by entering the teat canal from dirty environment.

The aim of this study was to assess by a systematic review of data the occurrence of coliform

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bacteria in bovine mastitis in Africa and to investigate the risk factors associated with coliform mastitis. Two objectives were developed to achieve this aim: 1) explore the prevalence of coliform bacterial bovine mastitis in Africa, and 2) investigate the impacts of risk factors associated with bovine mastitis in Africa.

METHODOLOGY

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) procedure as published by Moher (Moher, D., *et al.*, 2009) was used in carrying out the study. The PRISMA flowchart was used for the study selection as shown in Figure 2 according to Liberati *et al.*, (2009). PRISMA was adopted and modified as this study did not work on interventions but qualitative and observational studies.

SEARCH STRATEGY

The SPIDER tool (Sample, Phenomenon of Interest, Design, Evaluation, Research type) was chosen and modified to establish the research question (Table 1).

Table 1: SPIDER Research Question Formulation

Sample	**Africa**
Phenomenon of interest	2000-2017 coliform isolates in bovine mastitis and risk factors
Design	Cross sectional studies, prevalence studies
Evaluation	Prevalence study
Research type	Qualitative and quantitative studies

The study involved coliform isolates and risk factors of bovine mastitis in Africa between 2000 and 2017. Only primary bovine mastitis articles published in English and carried out in Africa were included. The study selection criteria shown in Table 2 were used to screen articles identified with the search strategy for eligibility.

Table 2. Study selection criteria

Inclusion criteria	**Exclusion criteria**
Prevalence from 2000-2017	Prevalence before 2000
Africa	Other continents
Articles published in English	Non-English articles
Articles on the prevalence of coliform isolate in bovine mastitis	Reports, commentaries
Review articles	Newspaper commentaries
Cows	Humans, and other animals
Titles/abstracts in line with study aim	Titles/abstracts not in line with study aim
Free articles	**Articles that are not free**

Six databases were searched in this study viz., Science Direct, Cochrane Library-central, Medline, Google Scholar, PsycINFO; a grey literature search was also carried out using the Open Grey. Table 3 is a detail of the construction of the search strategy including the subject heading (MeSH) terms used in the study.

Table 3. Constructing a search strategy

Selection of databases	The Cochrane library-central, Medline, science direct, CINAHL, PsycINFO, SIGLE GREY Literatures
Dates	2000-2018
Identifying subject headings MeSH terms	Mastitis Clinical mastitis Subclinical Coliforms Bovine mastitis Africa Escherichia coli Klebsiella E. coli disease inflammation of the udder milk cow milk lactating cow raw milk West Africa Prevalence Disease prevalence
Removal of duplicates	Manually and electronically

DATA EXTRACTION AND QUALITY ASSESSMENT

Data was extracted into a MS Excel spread sheet based on the research questions formulated by the

use of the SPIDER tool. Extracted data from eligible studies included author, title of study, objectives, research design, study area and year, risk factor, prevalence, and major findings. Studies were critically analyzed and assessed using the Crowe Critical Appraisal Tool (CCAT) according to Crowe & Sheppard (2011) . The CCAT has 8 main sections with scores ranging from 0 to 5 giving it a total score of 40 per study (Crowe, M., & Sheppard, L. 2011). CCAT was used because of its validity and reliability to all research designs (Crowe, M., & Sheppard, L. 2011) .

RESULTS AND DISCUSSION

The initial searches of Science Direct, Cochrane Library-central, Medline, Google Scholar, PsycINFO and Open Grey resulted in a total of 121 articles. After subjecting the articles to our criteria, 30 articles not conducted in Africa, 30 that have titles not corresponding to our criteria, 30 that are not-free, 10 with contrary abstract and 6 duplicates were removed. On studying the fourteen articles met the inclusion/exclusion criteria; one more article was removed, leaving 14 articles for quality assessment and data extraction. See Figure 1.

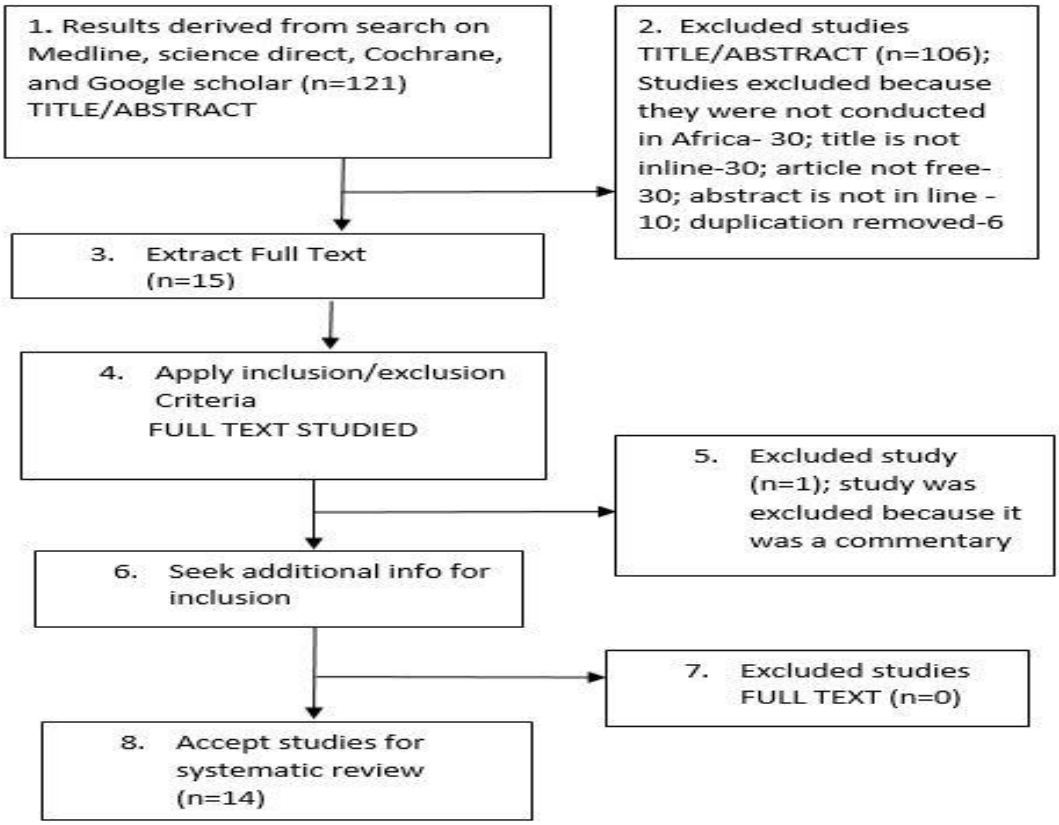

FIGURE 1. PRISMA PROTOCOL

On Medline data base search 8 articles were obtained (Table 4) but at the end of the inclusion and exclusion criteria, only 1 had its data extracted and analyzed.

Table 4. Medline data base search

S/No	Search Items	Result
#3	Search mastitis bovine	5007
#4	Search "clinical mastitis"	147939
#5	Search "subclinical mastitis"	360160
#6	Search "inflammation of the udder"	361791
#7	Search "dairy cows"	4511
#8	Search "dairy cattle"	30926
#9	Search "lactating cattle"	14042
#10	Search "mastitis"	111
#11	Search (((((((mastitis bovine) OR "clinical mastitis") OR "subclinical mastitis") OR "inflammation of the udder") OR "dairy cows") OR "dairy cattle") OR "lactating cattle") OR "mastitis"	7728
#12	Search coliforms	12616

#13	Search Escherichia	657
#14	Search Escherichia coli	971
#15	Search "E. coli"	1563
#16	Search "citrobacter"	8127
#17	Search "citrobacter species"	162
#18	Search "klebsiella species"	768
#19	Search "enterobacter species"	523
#20	Search "enterobacter"	13615
#21	Search "klebsiella"	33178
#22	Search "lactose fermenters"	28
#23	Search "enterobacteriaceae"	31753
#24	Search "enterobacteria"	4433
#25	Search "hafnia"	678
#26	Search "hafnia species"	5
#27	Search "cow milk"	1946
#28	Search "milk"	127063
#29	Search (((((("Africa") OR "west Africa") OR "east Africa") OR "central Africa") OR "north Africa") OR "southern Africa"	181331
#30	Search "southern Africa"	6429
#31	Search "north Africa"	2854
#32	Search "central Africa"	3781
#33	Search "east Africa"	3738
#34	Search "west Africa"	8337
#35	Search "Africa"	181329
#36	Search ((((((((((((coliforms) OR escherichia) OR escherichia coli) OR "E. coli") OR "citrobacter") OR "citrobacter species") OR "klebsiella species") OR "klebsiella") OR "enterobacter") OR "enterobacter species") OR "hafnia species") OR "hafnia") OR "enterobacteria") OR "enterobacteriaceae") OR "lactose fermenters"	426605
#37	Search (prevalence) OR disease prevalence	2409420
#38	Search disease prevalence	823133
#39	Search prevalence	2409420
#40	Search (((((("milk") OR "cow milk") OR cow's milk) OR "raw cow's milk") OR "raw cow milk") OR "cattle milk"	127063
#41	Search "cattle milk"	61
#42	Search "raw cow milk"	76
#43	Search "raw cow's milk"	119
#44	Search cow's milk	6081
#45	Search ((((((((((((mastitis bovine) OR "clinical mastitis") OR "subclinical mastitis") OR "inflammation of the udder") OR "dairy cows") OR "dairy cattle") OR "lactating cattle") OR "mastitis")) AND ((((((((((((((coliforms) OR escherichia) OR escherichia coli) OR "E. coli") OR "citrobacter") OR "citrobacter species") OR "klebsiella species") OR "klebsiella") OR "enterobacter") OR "enterobacter species") OR "hafnia species") OR "hafnia") OR "enterobacteria") OR "enterobacteriaceae") OR "lactose fermenters")) AND ((((((("Africa") OR "west Africa") OR "east Africa") OR "central Africa") OR "north Africa") OR "southern Africa")) AND ((((((("milk") OR "cow milk") OR cow's milk) OR "raw cow's milk") OR "raw cow milk") OR "cattle milk")) AND ((prevalence) OR disease prevalence)	8
TOTAL		8

Twelve of the 14 articles that met the final criteria were from Google Scholar. See Table 5.

Table 5. Database search result

Name of database	**Number of articles found**		
	Studies	**Report**	**Total**
Medline	8	0	8
Cochrane	12	0	12
Google Scholar	99	0	99
PsycINFO	0	0	0
Open grey	0	0	0
Science direct	2	0	2
Total	120	0	121

Table 6: Data extractions from 14 articles

3	Author	Title	Objectives	Research design	Country & year	Prevalence	Risk factor	Major findings
1.	Zeryehun & Abera (2017)	Prevalence and Bacterial Isolates of Mastitis in Dairy Farms in Selected Districts of Eastern Harrarghe Zone, Eastern Ethiopia	To estimate the prevalence of mastitis in lactating dairy cows; to assess the associated risk factors, and to isolate and identify the major bacterial pathogens	Cross-sectional	Ethiopia 2015-2016	64.3%	Age, lactation stage, parity, & breed	a) Prevalence of subclinical mastitis was higher (51.8%) than clinical mastitis (12.5%). b) Coagulase negative Staphylococci was the most frequently isolated; coliforms were not isolated.
2.	Mpatswenumugabo *et al.,* (2017)	Prevalence of Subclinical Mastitis and Distribution of Pathogens in Dairy Farms of Rubavu and Nyabihu districts, Rwanda	To determine the prevalence of SCM as well as isolate and identify the bacterial agents associated with SCM in lactating cows; and to assess possible association with SCM	Cross sectional	Rwanda 2016-2017	50.4%	Environment, milking technique	a) Milking practices and procedures are inadequate in the study area; poor management and udder health practices b) Coagulase negative Staphylococci was the most frequently isolated; only coliform isolated was *E. coli* and was the least frequently isolated with 1.5% prevalence.
3.	Belayneh *et al.,* (2013)	Dairy cows mastitis survey in Adama Town, Ethiopia	To determine the prevalence of mastitis, to isolate and identify major mastitis pathogens, to perform *in vitro* antimicrobial susceptibility test and to assess risk factors.	Cross sectional	Ethiopia. 2008-2009	73.4%	Parity, herd size, stage of lactation, teat lesion, housing, hygiene	a) Prevalence of Subclinical mastitis (at herd level) was higher (57.8%) than that of clinical mastitis (15.6%). b) It is necessary to set up permanent resistance surveillance programs in the country. c) *S. aureus* was the most frequently isolated; coliforms included *E. coli* (8.1, 8.7%), *Enterobacter* (2.2%), & *Klebsiella* (3.3%) & found only in the SCM.
4.	Mekonnin *et al.,* (2016)	A Study on the Prevalence of Bovine Mastitis and Associated Risk Factors in and the Surrounding areas of Sodo Town, Wolaita Zone, Ethiopia	To determine the prevalence of bovine subclinical mastitis; to identify the major bacteria that cause subclinical mastitis; to determine its various associated risk factors	Cross sectional	Ethiopia 2016	32.92%	Age, parity, stage of lactation, frequency of milking, and hygiene	a) Good herd management; improving hygiene and/or providing a physical barrier at the teat end b) *S. aureus* was the most frequently isolated; the only coliform isolated was *E. coli* with 14.29% prevalence.
5.	Iraguha *et al.,* (2015)	Bovine mastitis prevalence and associated risk factors in dairy cows in Nyagatare District, Rwanda	This study indicate the need to dip the teats of cows in sanitizers improve cow hygiene, and introduce mastitis prevention and control programmes	Cross sectional	Rwanda 2015	51.8%	Teat-end, lactation stage, breed, Parity, age and cow dirtiness.	a) General management was obviously paramount - dipping the teats of cows in sanitizers, improve cow hygiene, and introduce mastitis prevention & control. b) Coliforms were the highest occurring bacteria with 87.5% prevalence while *S. aureus* had 6.25%.

6.	Adane *et al., (2012)*	Study on prevalence & risk Factors of Bovine Mastitis in Borana Pastoral & Agro-Pastoral Settings of Yabello District, Borana Zone, Ethiopia	To determine the prevalence rate of mastitis; Isolate Mastitis causing bacteria; to determine predisposing risk factors for the disease	Cross-Sectional	Ethiopia 2010-2011	59.1%	Age, lactation stage, parity, & management	a) Prevalence of subclinical mastitis was higher (38%) than clinical mastitis (21.1%). b) Better management practices in milking. c) *S. aureus* was the most frequently isolated; the only coliform isolated was *E. coli* with 11.4% prevalence.
7.	Tekle & Berihe (2016)	Bovine mastitis: prevalence, risk factors and major pathogens in the Sidamo zone SNNPRS, Ethiopia.	To determine the prevalence of bovine mastitis, assess the potential risk factors & isolate the pathogens in smallholder lactating dairy cows.	Cross sectional	Ethiopia. 2010-2011	42.71%	Age, breed, lactating stage; parity, previous history of mastitis, housing, hygiene	a) Prevalence of subclinical mastitis was higher (42.7%) than clinical mastitis (2.08%). b) General hygienic – milking practice, proper manure removal; good housing and management. c) *S. aureus* was the most frequently isolated; coliforms included *E. coli* (3.8%), *Klebsiella* (13.5%), and *Enterobacter*(3.8%)
8.	Yohannis & Molla (2013)	Prevalence, risk factors and major bacterial causes of bovine mastitis in and around Wolaita Sodo, Southern Ethiopia	Determining the prevalence of bovine mastitis at Wolaita Sodo and its surroundings, assessing the associated risk factors and isolating the frequent bacterial causes.	Cross-sectional	Ethiopia 2011-2012	29.5%	Breed, age, milking hygiene, parity, lactation stage	a) Prevalence of subclinical mastitis was higher (26.9%) than clinical mastitis (2.6%). b) Appropriate control measures targeting the specific causative agents should be in place to reduce the impact of the disease. c) *S. aureus* was the most frequently isolated; the only coliform isolated was *E. coli* with 17.8% prevalence.
.	Belina *et al.*, (2016)	Prevalence, Isolation of bacteria & Risk Factors of Mastitis of Dairy Cattle in Selected Zones of Oromia Regional States, Ethiopia	To determine the prevalence and major risk factors associated with clinical and subclinical mastitis at herd, cow and quarter level in smallholder and pastoral area dairy cattle.	Cross sectional	Ethiopia 2012-2014	50.3%	Parity, lactation stage, husbandry type, housing system, milking practice & hygiene.	a) Prevalence of subclinical mastitis was higher (40.7%) than clinical mastitis (9.5%). b) Farmers don't have enough understanding about effect of sanitation on the occurrence of the disease. c) *S. aureus* was the most frequently isolated; the only coliform isolated was *E. coli* with 5.7% prevalence.
10.	Salihu *et al.*, (2011)	Prevalence of mastitis in lactating cows in some selected Commercial dairy farms in Sokoto Metropolis	To determine the prevalence of the disease in lactating cows	Cross sectional	Nigeria 2011	52%	Hygiene practice	a) Dairy farmers to be educated on the implications of irrational & unhygienic method of milking cows; the lack of surveillance programme for mastitis b) *S. aureus* was the most frequently isolated; coliforms included *E. coli* (9.78%), *Klebsiella* (4.35%), and *Enterobacter*(1.09%)
11.	Seid *et al.*, (2010)	Prevalence, Risk Factors and Major Bacterial Causes of Bovine Mastitis in West Arsi Zone of Oromia	To estimate the prevalence of bovine mastitis, assess major risk factors and isolate etiology	Cross-sectional	Ethiopia 2014-2015	38%	Breed, age, parity, tick infestation of udder, sequence of milking, floor, husbandry	a) Prevalence of subclinical mastitis was higher (30.7%) than clinical mastitis (7.3%). b) All quarters of the udder of each cow should be periodically checked

		Region, Southern Ethiopia	of mastitis in the selected districts of west Arsi zone				system, lactation stage & hygiene	for the timely treatment and Prevention. c) *S. aureus* was the most frequently isolated; coliforms included *E. coli* (4.8%), *Klebsiella* (3.6%)
12.	Mekonnen & Tesfaye (2010)	Prevalence and etiology of mastitis & related management factors in market oriented smallholder dairy farms in Adama, Ethiopia	To determine the prevalence and causative agents of mastitis and associated Risk factors in smallholder dairies in Adam district.	Cross sectional	Ethiopia 2010	48%	Husbandry practice, previous history of mastitis	a) The prevalence of sub-clinical mastitis was higher than clinical mastitis by 4.5, 6.6 and 9.3 folds, respectively, at herd, cow and quarter levels. b) Contagious mastitis prevalence is considerably influenced by the milking procedures c) *S. agalactiae* was the most frequently isolated; the only coliform isolated was *E. coli* with 7.5% prevalence.
13.	Michael *et al.*, (2013)	Study on prevalence of bovine mastitis in lactating cows and associated risk factors in and around Areka town, Southern of Ethiopia.	To isolate the major causative agent and to assess the major risk factors responsible for mastitis in the study area.	Cross-sectional	Ethiopia 2011-2012	52.9%	Age, parity, lactation stage, housing condition and previous history of mastitis	a) Prevalence of subclinical mastitis was higher (43.5%) than clinical mastitis (9.4%). b) General hygiene is necessary in lowering the prevalence of mastitis in this region. c) *S. aureus* was the most frequently isolated; coliform had 0.25% prevalence.
14.	Mbuk *et al.*, (2016)	Coliform organisms associated with milk of cows with mastitis and their sensitivity to commonly available antibiotics in Kaduna State, Nigeria	Not stated	Cross-sectional	Nigeria 2016	10.3%	Age, parity, stage of lactation, management system, hygiene of milking process, lesion on udder/teat	a) All the risk factors examined were found to significantly associated with mastitis. An overall prevalence of 10.3% was found for coliforms isolates which included *Enterobacter, Citrobacter, Klebsiella, Serratia, Proteus*

Table 8: Crowe Critical Appraisal Tool On Included Studies

Study	Preliminaries	Introduction	Design	Sampling	Data collection	Ethical matters	Result	Discussion	Total	Percentage (%)
Zeryehun & Abera (2017)	3	4	3	4	5	0	5	5	29	72.5
Mpatswenumugabo *et al.*, (2011)	3	4	3	3	4	0	5	5	27	67.5
Belayneh *et al.*, (2013)	4	3	4	3	3	0	5	4	26	65
Mekonnin *et al.*, (2016)	0	4	4	5	5	0	5	4	27	67.5
Iraguha *et al.*, (2015)	3	4	4	4	3	0	4	4	26	67
Adane *et al.*, (2012)	5	4	4	4	3	0	5	4	29	72.5
Tekle & Berihe (2016)	4	4	3	4	4	0	5	4	28	70
Yohannis & Molla (2013)	5	4	4	3	4	0	5	5	30	75
elina *et al.*, (2016)	4	4	4	5	4	0	5	5	31	77.5
Salihu *et al.*, (2011)	4	2	2	3	2	0	4	4	21	52.5
Seid *et al.*, (2015)	4	5	4	5	4	0	5	5	32	80
Mekonnen & Tesfaye (2010)	4	2	3	5	4	0	5	4	27	67.5
Michael *et al.*, (2013)	4	3	3	4	3	0	5	4	26	65
Mbuk *et al.*, (2016)	4	2	3	3	4	0	4	5	25	62.5

This systematic review explored the prevalence of coliforms in cases of bovine mastitis in Africa. Majority of the published articles accessed and reviewed were on studies conducted in Ethiopia. According to FAO, Ethiopia has the largest population of cows in Africa with about 54 million cows; which explains the large number of research articles done in this sector (Food and Agricultural Organization (FAO). 2013).

In most of the articles studied, subclinical mastitis had higher prevalence than clinical with ranges of 26.9 – 57.8% and 2.08% - 21.1% respectively (Zeryehun, T., & Abera, G. 2017; Belayneh, R., *et al.*, 2013; Bedane, A.,*et al.*, 2012; Tekle, Y., & Berihe, T. 2016; Yohannis, M., & Molla, W. 2013; Belina, D., *et al.*, 2016; Seid, U., *et al.*, 2015; Mekonnen, H., & Tesfaye, A. 2010; Michael, L., *et al.*, 2013). This might mean that dairy farm managers are only concerned with clinical form of mastitis and often are unaware of the status of subclinical Infection in the herd because of its asymptomatic nature. As a result more attention are paid to treating clinical cases. Meanwhile, subclinical mastitis has as much economic implication as the clinical in milk production losses, discarded milk, veterinary services labor, product quality, materials and investments, diagnostics, and culling in accordance to Halasa (Radostits, O.M., *et al.*, 2000).

The articles studied identified the following risk factors associated with clinical and subclinical mastitis: Lack of proper attention to their health, breed, age, parity, and sequence of milking floor, inadequate sanitation of dairy environment, cow dirtiness, lactation stages, and husbandry type, lack of proper management of the udders and poor animal health services, lack of awareness of the impact of the disease. These risk factors could be as a result of low level of education of the herdsmen and herds owners. Most of the herds of cows in Africa are not managed in the intensive system but move from place to place as in the nomadic system.

This study also revealed that there is an association between bovine mastitis and teat-end condition, cow dirtiness, breed, production system and stage of lactation. According to Radostitis, mastitis is a complicated problem, associated with almost every conceivable factor of management and the environment (Radostits, O.M., *et al.*, 2000) Teat-end condition has also been mentioned by Biffa as a factor influencing mastitis prevalence (Biffa, D., *et al.*, 2005)

Cows with leaky sphincters may be more susceptible to infection (Katunguka-Rwakishaya, E., & Ndikuwera, J. 2008). On the other hand, non-use of teat dips and other mastitis control techniques due to lack of knowledge could greatly contribute to the high prevalence of SCM in the study area. It could also be due to traditional diary husbandry practices whereby calves are kept away from their dams over a long period of time and are only allowed to suckle for a short period as well as inadequate milk supply which leads to calves suckling vigorously thereby enlarging the udder and causing sores on the teats.

Prevalence of coliforms ranged from as low as 0.4% to as high as 87.5%, according to Mpatswenumugabo *et al.*,, Belayneh *et al.*,, Mekonnin *et al.*,, Iraguha *et al.*,, Adane *et al.*,, Tekle & Berihe, Yohannis & Molla, Belina *et al.*, , Salihu *et al.*,, Seid *et al.*,, Mekonnen & Tesfaye, Michael *et al.*,. *(2017;2013;2016;2015;2012;2016;2013;2016;2011;20 15*). *Escherichia coli* had between 0.7-35.7% (Belayneh, R.,*et al.*, 2013; Michael, L.,*et al.*, 2013), *Klebsiella* species had 3.6-13.5% (Mpatswenumugabo, J. P. *et al.*, 2017; Seid, U., *et al.*, 2015), Coliforms are environmental bacteria that could cause mastitis but are indicative of hygienic conditions of the farm. The cleaner the environment, the lower the prevalence.

The study also showed that numerous pathogenic bacteria were isolated. The most dominant pathogenic species incriminated to causing clinical and subclinical mastitis were *Staphylococcus aureus* with a prevalence ranging from 20.6 – 54.4%. According to Michael *et al.*, and Mpatswenumugabo *et al.*,, *S. aureus* prevalence rate could be associated with poor milking hygiene and lack of teat dipping (Mpatswenumugabo, J. P.,*et al.*, 2017; Michael, L., *et al.*, 2013. Other pathogens and their prevalence are *Streptococcus agalactiae* (18.1%), *Pseudomonas aeroginosa* (3.6%) according to Seid *et al.*, (2015); *Staphylococcus epidermidis* (10.9%), *Streptococcus spp.* (14.1%), *Corynebacterium spp (15.2%), Bacillus spp (7.6%)* according to Salihu *et al.*, (2017); *Streptococcus agalactiae* (17%), *Micrococcus* spp (6.4%), *Streptococcus uberis* (3.7%) according to Zeryehun and Abera (2017) . The reason for the higher isolation rate of these organisms is the wide ecological distribution inside the mammary gland and skin. *S.aureus* is adapted to survive in the udder and usually establishes mild sub clinical infection of long duration from which it is shaded through milk serving as sources of infection for

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other healthy cows and transmitted during the milking process (Radostits, O.M., *et al.*, 200). Hence, the organism has been assuming a position of major importance as a cause of bovine mastitis.

CONCLUSION

Environmental mastitis caused by coliforms isolated from milk of cows in the studies reviewed in this work might have been greatly influenced by risk factors observed such as age, parity number, lactation stage, and general management system of various farms studied. Of immense importance is the hygienic condition of the farms, milking styles, milking equipment containers and milkers. Therefore standard hygienic protocols, treating of clinically infected cows and dry period therapy, culling of infected cows could reduce coliform mastitis in Africa.

Moreover, use of antibiotics susceptibility testing before the administration of antibiotics for treatment of intra-mammary infections in cows with mastitis could reduce prevalence and incidences of resistant coliforms in cows. This will have public health significance as the transfer of zoonotic resistant coliforms to humans especially herdsmen would have been reduced.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest in publishing this manuscript.

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