Chapter

Bovine Mastitis in Ethiopia

Tadele Tolosa Fulasa and Feyissa Begna Deressa

Abstract

Ethiopia is located in tropical region and livestock production represents a major national resource and forms an integral part of the Agricultural production system and livelihood of the society. Dairy farming being one of the agricultural production in Ethiopia, is practiced mainly as an extensive type of management system, which involves smallholder farmers in rural areas and semi-intensive and intensive managements in per urban and urban areas. Despite a large number of milking cows, there is low milk production because of many factors, including low genetic potential of indigenous breeds, extensive and poor husbandry practices, and widespread livestock diseases. Among the dairy cows' diseases, mastitis is prevalent in the dairy production system incurring high economic losses and social burden. Several reports on mastitis in Ethiopia are present but are scattered. We focused on reviewing articles published in indexed journals reporting bovine mastitis to summarize its common etiologies, prevalence, and risk factors in Ethiopia. The common pathogens reported from different parts of Ethiopia are *Staphylococcus aureus (Staph. aureus)*, non-aureus staphylococci, *Streptococcus* spp. (*Strep. agalactiae*, *Strep. dysgalactiae*, *Strep. uberis*), coliforms (*E. coli, Klebsiella pneumonae*), *Trueperella pyogenes* and *Mannheimia haemolytica (M. haemolytica), Pseudomonas aeruginosa (P. aeroginosa)*, *Enterobater aerogenes*, *Bacillus* species, *Micrococcus* species. *Staphylococcus aureus* and *E. coli* are the most common isolates from clinical mastitis (CM). *Staphylococcus aureus* is also the most frequently isolated pathogen from sub-clinical mastitis (SCM). Sub-clinical mastitis which usually ranges from 25.4% to 73.3%, is highly prevalent than the clinical cases of mastitis which ranges from 3.2% to 26.5%. Several mastitis risk factors were reported. These were breed of animals, parity number, stage of lactation, presence of teat/udder lesion and hygiene measure of the farms. Thus, it is essential to plan and implement control measures including maintenance of good dairy farm environment, udder and milking hygiene at farm level; regular monitoring of udder health with special attention to exotic, crossbred and lactating cows and culling of older cows. Isolation, characterization and conducting antibacterial sensitivity test should be integral part of mastitis control strategy for effective control of the mastitis causing pathogens.

Keywords: Bovine mastitis, Ethiopia, prevalence, risk factor

1. Introduction

The Ethiopian economy is highly dependent on agriculture, which involves crop and livestock production in the highland areas and mainly livestock production in the lowland areas. The livestock subsector plays a vital role as source of food, income, services and foreign exchange to the Ethiopian economy, and contributes 16.5% and 45% of the total and agricultural GDP, respectively [1, 2]. It also accounts for 12–15% of the total export earnings, second in order of importance [3]. Despite the huge number of livestock in the country, the performance of the sector is poor considering its potential. Dairy farming is an important sub-sector of livestock production, and serves as a source of food and income to many resource poor communities in the country.

In Ethiopia, dairy farming is mainly under the extensive type of management system, which involves smallholder farmers in rural areas. Currently, there are also emerging semi-intensive and intensive dairy production systems, practiced by farmers who have good access to the markets. However, the dairy production is being challenged by major constraints such as low genetic potential of indigenous cattle breed, diseases, inadequate feed and water and poor advancement in dairy development technologies. The problem of diseases is becoming very important with the importation of exotic breeds into the country for improved genetics and milk production. Among the diseases, mastitis is known to be prevalent in different dairy production systems in the country, incurring high economic losses.

Mastitis, an inflammation of the mammary gland, is usually a consequence of a bacterial intramammary infection (IMI) [4, 5]. Its can be presented with visible or invisible inflammatory responses of the udder. Mastitis with visible symptoms is called clinical mastitis, whereas mastitis without visible symptoms is called subclinical mastitis (SCM) [6].

Clinical mastitis is recognized by the presence of abnormal milk or udder characterized by discoloration, clots or swelling of the infected quarter [7, 8]. Cows with acute clinical mastitis may show generalized symptoms such as fever, loss of appetite, reduced mobility due to pain in the swollen udder, and systemic shock. Mastitis also threatens animal welfare [9, 10] due to pain, higher mean rectal temperature, increased heart rate, and respiratory rate caused by clinical mastitis. Severe cases of mastitis can even result in the death of the infected animal [9]. Furthermore, discarding milk from lactating animal suffering from mastitis results in substantial food losses, which causes nutritional shortage to the children and nursing women resulting in nutritional deficiency diseases.

Subclinical mastitis refers to inflammation of the mammary gland in the absence of visible symptoms, which can develop into clinical mastitis and vice versa. This type of mastitis causes an invisible reduction in milk production [11, 12], changes in milk quality [13], and composition [12]. Severe or chronic inflammation can result in loss of quarter (s) or teats. Cows with blind quarters produce less [14] and are more likely to be prematurely culled than healthy herd mates [14]. In Ethiopia, different reports showed that the prevalence of mastitis is different in different parts of the country and different breeds [15–18]. These reports also indicated that a number of factors influences bovine mastitis at individual animal and farm level. Therefore, this book chapter aims to provide summarized information on the etiology, prevalence, associated risk factors, and control measures for bovine mastitis in Ethiopia.

2. Etiology

A variety of microorganisms have been isolated from the milk of a cow with mastitis [5]. Mastitis-causing pathogens can be grouped into Gram-positive or Gram-negative based on their Gram-staining characteristics or major or minor pathogens based on potential damage they cause to the host or contagious or environmental based on their mode of transmission [19].

Contagious mastitis pathogens are in the infected mammary gland of the host, and mainly spread from infected to uninfected udders during milking [19]. The cow's environment is the main source of infection for environmental mastitis causing pathogens. Their number can be high in soil, manure, bedding, or contaminated water [19].

Staphylococci, Streptococci and coliforms are the most common causes of bovine mastitis [3]. *Staphylococci* are Gram-positive, catalase-positive cocci and are categorized into *Staph. aureus* and non-aureus staphylococci. *Streptococcus agalactiae*, *Strep. dysgalactiae* and *Strep. uberis* are the most common streptococcal species that cause bovine mastitis [5]. All the three are Gram-positive and catalase-negative major pathogens causing mastitis. *Streptococcus agalactiae* and *Strep. uberis* are known as a typical contagious and environmental mastitis pathogen, respectively, whereas *Strep. dysgalactiae* is likely to spread from cow to cow than from the environment to the cow.

Escherichia coli and *Klebsiella* spp. belong to the coliform group and are the most common Gram-negative pathogens that cause bovine mastitis. Both are major environmental mastitis causing pathogens.

The pathogens distribution of clinical and subclinical mastitis has been studied in several countries. For example, *Strep. uberis* was the most frequently isolated pathogen from clinical mastitis cases of British and Flemish herds of Belgium [20, 21], whereas *Staph. aureus* was the most frequently isolated pathogen causing clinical mastitis in Canada and Ireland [22, 23]. Non-aureus staphylococci (*Staph. chromogenes*, *Staph. epidermidis*, *Staph. haemolyticus*, *Staph. simulans*, and *Staph. xylosus*) were the most common cause of subclinical mastitis cases in the UK and Flanders part of Belgium [20, 24, 25]. Non-aureus staphylococci were also reported to be the most common isolates from subclinical cases of mastitis in Uganda [26].

Numerous organisms have been reported associated with mastitis in Ethiopia. These include *Staphylococcus* spp. (*Staph. aureus*, *non-aureus* staphylococci), *Streptococcus* spp. (*Strep. agalactiae, Strep. dysgalactiae, Strep. uberis*), Coliforms (*E. coli, Klebsiella pneumonae and other Klebsiella species)*, *Trueperella* and *M. haemolytica*, *P. aeruginosa*, *Enterobater aerogenes*, *Bacillus* species, *Micrococcus* species and others (**Table 1**). Among all the pathogens of bovine mastitis, *Staph. aureus* is recognized as the most common causative agent of bovine mastitis in Ethiopia [18, 27–36]. The authors also reported that the most common contagious pathogens are *Staph. aureus* and *Strep. agalactiae* indicating that their presence in high prevalence could be due to lack of effective udder hygiene and poor milkers' hygiene practice during

Isolates	Study areas						
	Addis Ababa[a]		Selale[b]	Asella[c]		Mekele[d]	
	CM	SCM	SCM	CM	SCM	CM	SCM
Staphylococcus aureus	21	50	43	29	20	11	43
Non-aureus staphylococci	10	20	24	8	24	4	10
Streptococcus agalactiae	18	2	13	15	11	11	6
Streptococcus dysgalactiae	3	5	2	7	7	11	1
Streptococcus uberis	5	5	10	3	4	0	3
Escherichia coli	23	0	1	14	3	57	19
Klebsiella spp.	0	2	0	0	0	7	9
Others	21	16	7	24	31	0	9

a= Addis Ababa capital city of Ethiopia.
b= Capital town of North Shewa zone Oromia state.
c= Capital town of Easter Arsi Zone of Oromia state.
d= Capital city of Tigray state.

Table 1.
Pathogen distribution (in %) of clinical mastitis (CM) and subclinical mastitis (SCM) samples collected from different Ethiopian regions.

Figure 1.
Map showing study areas conducted on bovine mastitis in Ethiopia.

milking. The most common environmental mastitis pathogens were coliform bacteria [37]. Transmission of environmental mastitis pathogens may occur at any time including during milking and between milkings since they are in the environments of dairy cows. e.g., *Trueperella pyogenes* [38] and *Bacillus* species as summarized under the heading of others **Table 1** were also isolated [18].

The pathogen distribution of clinical mastitis (CM) and subclinical mastitis (SCM) has also been studied in different Regions of Ethiopian (**Table 1**; **Figure 1**). *Escherichia coli* was the most common pathogen causing CM in farms in and around Addis Ababa [39] and Mekele [37] whereas *Staph. aureus* was the most common pathogen causing CM in farms in and around Addis Ababa and Asella [18]. *Staphylococcus aureus* was the most frequently isolated pathogen from SCM samples in farms in and around Addis Ababa [39], Selale [17] and Mekele [37]. *Non*-aureus staphylococci species were more prevalent in the SCM samples in farms in and around Asella and Selale compared to the prevalence of *non*-aureus staphylococci species in the other regions (**Table 1**) [18].

3. Prevalence of mastitis in Ethiopia

Dairy farms in Ethiopia are not registered, and therefore, information on the exact number and distribution of dairy farms is lacking. However, reports indicated that the number of farms are increasing yearly although it does not commensurate with human population growth in the country [40]. The number of herds, which are indicated below, is retrieved from prevalence studies carried out in different Regions. Most studied farms are similar in average herd size, milk production and farming practices. In addition, most farms are hand-milked, and cows are managed under zero-grazing conditions. However, the differences observed in prevalence of mastitis between studies might be explained by the differences between individual farm management, environment, and breed of the animals.

3.1 Clinical mastitis

Clinical mastitis in cows has been reported with varying degree of occurrence in Ethiopia (**Table 2**) [17, 18, 37, 41–43]. In Ethiopia, the prevalence of clinical mastitis ranged from 3.2% to 26.5% at the cow level and from 0.9% to 14.9% at the quarter level

Region	Herd	Cows			Quarters			Reference (s)
	n	n	% CM	% SCM	n	% CM	% SCM	
Sodo and Awassa	20	307	15	25.4	1133	7.3	11.4	[15]
Addis Ababa	51	363	6.6	46.6	1452	2.7	26.7	[41]
Selale	109	500	3.2	29.4	2000	0.9	13.2	[17]
Asella	42	223	26.5	38.1	892	14.9	30.4	[18]
Adama	95	206	6.3	41.7	794	2.4	22.2	[42]
Mekelle	13	305	3.6	33.8	1220	14.3	11.9	[37]
Jimma	42	176	11.4	61.9	704	9.8	46.3	[43]
Assella		66	12.1	54.5		10	32	[44]
Holota		107	22.4	48.6		10	34.8	[45]
Bishoftu Town		262		40.1			16.1	[46]
Eastern Harrarghe Zone		384	12.5	51.8		10.7	46.4	[47]
Hawassa		201	5	25.4		2.1	8.2	[48]
Wolayita Sodo		349	2.6	26.9				[49]
Haramaya		384	6.77	56.25		6.38	22.66	[50]
Holleta		90	7.8	73.3		5.59	75.3	[51]
Ambo		302	9.9	32.8		9.3	32.8	[52]
Meta analysis		39	8.3	37				[53]

Table 2.
The prevalence of clinical mastitis (CM) and subclinical mastitis (SCM) from different studies conducted in Ethiopian.

(**Table 2**). The lowest prevalence of clinical mastitis was reported in farms in Selale [17] while the highest was in farms in and around Holota [45]. The variability in prevalence of clinical mastitis among different studies conducted at different areas of the country might be attributed to differences in management practices, environmental conditions in the study areas and other factors. Unlike other countries, no longitudinal studies have been performed on clinical mastitis in Ethiopia [21, 22, 54]. Consequently, the incidence and average duration of clinical mastitis cases are unknown.

3.2 Subclinical mastitis

Subclinical mastitis is considered as the most economically important type of mastitis because of long term effects of chronic infections. The prevalence of subclinical mastitis (SCM) ranged from 25.4% to 73.3% at the cow level and from 8.2% to 75.3% at the quarter level (**Table 2**). The lowest quarter level prevalence of SCM was observed in Southern Ethiopia (Awasa) [48] and the highest quarter level prevalence of SCM were observed in West Shewa of Ethiopia (Holota) [51]. The variation of findings among studies might be attributed to differences in management and environmental conditions in the different study areas as well as cow breed variations in susceptibility to mastitis. Nevertheless, it can be concluded that comparison to other countries, the prevalence of subclinical (or clinical or both) mastitis is high in Ethiopia (**Table 2**). Moreover, different scholars have reported varying ranges of clinical and subclinical cases of mastitis (**Table 2**; **Figure 1**) [27–36].

4. Risk factors

Mastitis is a multifactorial disease. Identification of risk factors and characteristics associated with the likelihood of the disease, can lead to better control of mastitis. Different herd, cow, and quarter characteristics associated with pathogen-specific IMI or subclinical mastitis has been identified [27–35, 54–56]. However, as management largely differs between regions, not all risk factors associations can be generalized, leaving the need for implementation of region- or even herd-specific control plans.

In Africa, researchers from Zimbabwe (pure breed Friesian, Jersey and Red Dane and their crosses compared with Mashona indigenous breed) and Rwanda (pure-breed Friesian, Jersey and their crosses and local breed Ankole and Sahiwal) reported that farms with pure and cross-breed herds had higher odds to mastitis compared with the indigenous breed [57, 58]. It is also reported that farms which use pre-milking teat dipping in antiseptic solution (0.5% iodine) had lower odds to mastitis compared with farms not using pre-milking teat dipping [57].

Risk factors	Outcome	Level	Reference
Age (cow) ↑	CM↑	2 (Middle, old)	[41]
Age (cow) ↑	↓	2 (≤4 years, >4 years)	[59]
Parity↑	↑	3 (1, 2, 3)	[41]
Lactation stage ↑	↑	2 (Mid, late)	[41]
Body score↓	↑	3 (Good, fair, poor)	[41]
Leaking milk↑	↑	2 (Yes, no)	[41]
Previous udder problem	↑	2 (Yes, no)	[41]
Heifers purchased in the last year (herd) ↑	↓	2 (Yes, no)	[59]
Teat injury (quarter)	↑	2 (No, yes)	[59]
Age (cow) ↑	SCM↑	2 (Middle, old)	[41]
Parity↑	↑	3 (1, 2, 3)	[41]
Lactation stage↑	↑	2 (Mid, late)	[41]
Breed		2 (Cross, Zebu)	[16]
Lactation stage↑	↑	2(>210 DIM vs. <121 DIM)	[16]
Parity↑	↑	3 (1or2, 3–5, >5)	[16]
Lactation stage↑	↑	3 (Beginning, mid, end)	[17]
Breed		2 (Cross, Arsi)	[18]
Parity↑	↑	7 (1–7)	[18]
hygiene↓	↑	2 (poor Vs good)	[18]
Lactation stage↑	↑	3 (< 90 DIM, >90–180 DIM, >180 DIM)	[43]
Body score↓	↑	3 (Good, fair, poor)	[41]
Lesion on teat/udder	↑	2 (Yes, no)	[17]

Table 3.
Reports on association of different risk factors with the prevalence of mastitis (SCM, CM), data from different scholarly articles from Ethiopia.

In Ethiopia, several scholars have reported the significant association of breed, physiological state, parity, stage of lactation and presence of lesion on udder/teat skin with the prevalence of mastitis (**Table 3**).

Higher prevalence of the disease was reported on exotic or cross breed (Holstein-Friesian) than local indigenous zebu [15, 18]. This indicates higher yielding cows are more likely suffering from the disease. The findings reported from various parts of Ethiopia have also indicated parity of the dairy cows is a risk factor of mastitis. Increased prevalence of mastitis with increasing parity number was reported by many authors [15, 17, 18]. The significant difference in prevalence of mastitis at different lactation stages was also reported. Cows in early lactation stage are more likely affected with mastitis than mid lactation [15]. Difference in prevalence of mastitis was also observed among cows with different body conditions. Cows with poor body condition are more likely affected with mastitis than cows with good body condition [41, 43]. The presence of predisposing factors such as teat and/or udder lesions and tick bites have a significant influence on the prevalence of mastitis. Cows with teat and/or udder lesions and tick bites were more affected by mastitis than without these factors (**Table 3**) [15, 17, 18].

5. Diagnosis

Monitoring udder health performance is impossible without reliable and affordable diagnostic methods [60]. Diagnosing udder health problems needs to distinguish between Intramammary infections (IMI), clinical mastitis, and subclinical mastitis which requires laboratory facility [60].

The diagnosis starts with physical clinical examination which involves palpation of the mammary gland and visual inspection of milk. In CM cases, the infected quarter may manifest inflammatory changes such as hot, red, swollen and painful. Inflammatory changes in milk include change of color such as bloody or watery milk, change in consistency which can be viscous, watery and/or clots, and change in smell of the milk [18].

Since milk seems normal in SCM, diagnosis is based on additional testing of milk samples such as direct somatic cell count (SCC) or indirect estimation of somatic cells in milk by California Mastitis Test (CMT) or other quick cow side tests. The SCC can be measured at the quarter, cow and herd-level. The CMT qualitatively estimates the number of somatic cells in milk secretions and is performed by mixing 2 mL of milk sample with a 2 mL of the CMT detergent which dissolves cell walls and releases DNA. The more cells in milk the more DNA is released, the thicker the mixture would be indicating the presence of high SCC. Hence, SCC can be scored based on the degree of thickening or gel formation. The test is cheap, applicable on farm but comes with inter-operator variation and has a low sensitivity [60, 61]. According to European Union countries, bulk milk SCC gives an indication of the presence of SCM in the herd's when it counts above 400,000 cells/mL, >200,000 cells/mL SCC for individual cow of composite milk and individual quarter SCC (>50,000 cells/mL) [62].

Other tests which indicates the presence SCM in the milk are measuring N-acetyl-β-D glucosaminidase (NAGase), lactate dehydrogenase (LDH) and electric conductivity of milk but are less frequently used compared to SCC [63]. These tests indicate the association between the activities of NAGase and LDH and SCC with respect to udder health status. The stronger the relationship between NAGase and LDH activity and SCC indicates the presence of mastitis. On the other hand, in both SCM and CM, intramammary infections can be detected by bacteriological culture or PCR test on milk samples. Bacteriological culturing of milk can be done from bulk milk, individual quarter or cow. This gives a clue to evaluating udder health and mastitis control at the herd, cow or quarter level when it is performed combined with SCC.

6. Control measures

Mastitis control includes treatment of existing IMI and prevention of new IMI [64]. In the 1960s, the Five-Point Plan was initiated in the UK which includes (1) early detection and treatment of clinical cases, (2) blanket dry cow therapy, (3) post milking teat disinfection (4) identification and culling of chronically infected cows and (5) the routine maintenance of the milking machine [65–67]. In Ethiopia, early detection and treatment of clinical cases is most applicaple in majority of rural farms. In urban and periurban farms, application of the Five-Point control/prevention plan are possible. Yet, application of the other points in the rural farms are not possible. For example, tubes for dry cow therapy are not availability on the local markets and almost all farms in rural Ethiopia are not using milking machine.

Implementation of the five-point control/prevention plan was mainly successful in controlling contagious mastitis pathogens but less effective against environmental mastitis pathogens [20]. Therefore, an extended 10-point mastitis control plan was designed by the National Mastitis Council (NMC, a global organization for mastitis control and milk quality). This program includes preventive measure against environmental mastitis pathogens such as maintenance of a clean, dry, comfortable environment. Yet, not all 10-points mastitis control plan are applicable on rural farms in Ethiopia. Some of the 10-point mastitis control plan can be customized in Ethiopian by increasing the awareness of the farmers. For example, establishing goals for udder heath, maintaining a clean, dry, comfortable environment, good record keeping, management of clinical mastitis during lactation, and maintenance of biosecurity can be adopt and most big farms are applying them.

7. Conclusion

The prevalence of bovine clinical mastitis ranged from 3.2% to 26.5% at the cow level and from 0.9% to 14.9% at the quarter level while subclinical mastitis ranged from 25.4% to 73.3% at the cow level and from 8.2% to 75.3% at the quarter leve in Ethiopia. This indicates that the subclinical mastitis incurs more economic losses to the farmers and the nutritional supply of the community. Both contagious and environmental pathogens of mastitis are commonly isolated from dairy cows at different corners of the country. *Staph. aureus* and *Escherichia coli* are the most common isolates from clinical cases of mastitis, whereas *Staphylococcus aureus* is the most frequently isolated pathogen from Subclinical mastitis. Staphylococci other than *Staph. aureus* are also more prevalent in the SCM in some parts of the country. Several risk factor for mastitiss such as breed, parity number, stage of lactation, teat/udder lesion, tick infestation, and hygienic measures of the farms have been identified in Ethiopian dairy farms. Some of these factors such as hygiene, tick control are modifiable at farm level whereas most are beyond the control of the farmers. Example, the farmer does not have an influence on the parity or stage of lactation of his cows. To this end, there is a need to identify management practices that have an effect on mastitis and that are really relevant in the field by establishing national guideline in Ethiopia. The essential control plans can be adoppeted from mastitis control plans designed by the National Mastitis Council (NMC) and implement with local modifications. The most important control measures against bovine mastitis to be mentioned are good dairy environmental hygeign practice, udder, and milking hygiene at farm level; regular monitoring of udder health with special attention to exotic, crossbreed, and lactating cows.

Conflict of interest

The authors declare that they have no conflict of interest.

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