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Literature Review

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Review on the major causes and associated risk factors of calf morbidity and mortality in dairy farms of Ethiopia

Abstract

Dairying is becoming one of the most important parts of livestock sector where calves are future herd of a dairy farm in Ethiopia. The health and management of replacement animals are important components of total herd profitability. However, calf morbidity and mortality is an important productivity and economic factor in the success of dairy production. Therefore this seminar was carried out to review major reported causes and associated risk factor of morbidity and mortality of dairy calves in dairy farm of the country from some published articles. As reviewed several researchers reported overall morbidity and mortality of calves in their study sites. Study reported only morbidity was less except some authors, who reported crude morbidity rate and difficult to make comparisons, unlike mortality. Therefore, based on this current review, mortality statistics mostly, ranges from 6.5 to 30.7% in pre-weaned calves. Different researchers have also investigated numerous determinant factors in calf morbidity and mortality in the country. Accordingly calf hood diseases and disease syndrome like calf diarrhea and calf pneumonia were the leading causes of calf morbidity and mortality. In addition to calf hood diseases, host factors (calf factors (age, sex, vigor or dam factors (health and nutrition, parity, birth type), poor managemental and environmental factors ((like calving, colostrum feeding time and amount, poor housing, herd size, production system) were also reported as determinants of calf morbidity and mortality. However, many studies on calf morbidity and mortality focus on risk factors on an individual (calf) level and also on herd-level risk factors for disease and little is established about management practices that affect morbidity and mortality in dairy calves. Moreover, there is paucity of information done on identification of specific agents involved in disease syndromes associated with morbidity and mortality. Most those recently available few studies were mostly concentrated on government ranches, research centers, and central part of country which are less relevant to the smallholder farming system. Therefore, further study based on investigation of specific etiologies and associated risk factors associated with calf diarrhea and pneumonia and its economic significance in different production system should be required.

Keywords: calf, dairying, morbidity, mortality

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Introduction

Livestock production is one of the most important means to achieve better living standards in many regions of the developing world. The national economies and the livelihood of rural communities in sub-Saharan African countries like Ethiopia are largely depended on livestock production. Ethiopia has the largest livestock population in Africa, with a total cattle population of 59.5 million. Out of this total cattle population, the female cattle constitute about 55.5% and the remaining 44.5% were male cattle. Out of the female cattle which constitute about 55.5%; 5.5% are female calf of age of up to one year. Dairying is becoming one of the most important parts of livestock sector where calves are future herd of a dairy farm in Ethiopia,[1,2] and currently the country has given the priority on the development of dairying at farmer level to increase the supply of milk from smallholder dairy farms.[3–5] However, dairying based on indigenous cattle alone would not be a quick and suitable option to meet the increasing demands for milk and milk products in Ethiopia, as the indigenous cattle in the tropics is limited by low milk yield, low lactation length and poor growth rates.[6,7] It is, therefore, essential to explore the existing livestock production in particular of dairy production environment, analyze constraints of dairy production, and devise pertinent and workable strategies for sustainable market-oriented dairy development in the country.[8] The most favored alternatives in this regard could be incorporating crossbreeding (Local with improved European dairy breeds) scheme and intensification of animal production[9] and shifting of subsistence livestock production systems towards large scale commercial production units.[10,11] The productivity or success of dairying operation depends largely on their reproductive performance and the survival of calves.[12–14] Calf loss rates are rising on modern dairy farms in many countries internationally.[15] A range of 15 to 25% pre-weaning calf mortality is typical on many tropical dairy farms. It is often as high as 50%, indicating very poor calf management.[16] Some tropical African countries also reported mortality rate ranges. For instance in Tanzania, calf mortality rates range from 9% to 45%,[17,18] and in Mali the range is 10% to 25%.[19] In Sudan, 4.9% mortality was reported in dairy farms in Khartoum.[20] In Ethiopia, calf morbidity and mortality were the second biggest problem next to mastitis for dairy production.[21] Pre-weaning calf mortality rate of 30% was reported in mixed crop-livestock production systems in Amhara Region[22] and an 18% mortality rate was found in market-oriented dairy farms in Central Ethiopia.[14] The average mortality rate from birth to age at first calving among the Holstein Friesian female calves born was found to be 23% at Holleta farm.[23] Calf mortality rate of 20% can reduce net profit by 38%.[24] Therefore in a profitable dairy farm, calf mortality rate should be less than 3 to

5% which set as a minimum, the standard of the western production system ANS01-202D.[25] Several factors affect the health and vigor of the calves immediately after birth.[26] Calf diseases that cause morbidity and mortality are the results of complex interaction of the management and environment practices, infectious agents, the dam, and the calf itself.[27,28] Proper nutrition is fundamental for calf growth, for the general profitability of calf rearing enterprise and minimizing stress and disease. Livestock housing conditions greatly affects health and productivity.[14,29] The poor immune system and lack of previous exposure to infection make new born calves susceptible to infectious diseases.[28,30] Passive immunity can be achieved through ingestion of an adequate volume of colostrum feds for calves.[31] Other environmental and managemental risk factors known to affect calf health and survival include level of herd production, practice of prophylactic antibiotics, weaning age, separation or mixing of the calves.[22,32,33] Therefore, with this background information, the objective of this seminar paper is to review the existing data on the major causes and associated risk factors of calf morbidity and mortality of dairy farm in Ethiopia

Literature review

The calf and peculiar features of its body and immune system

Calf refers to the age group of young cattle from birth to six month of age or young bovine up to one year of age.[34] Calves have some special features in their body system that have relevance in disease occurrence and accordingly require special attention in management. Those that have particular importance are the poorly developed defense mechanism and a dynamic digestive system that has to evolve from milk digestion to a solid feed digestion. As soon as birth, a calf's gastrointestinal tract is designed to temporarily allow the absorption of large molecules including antibodies ("immunoglobulin's") from the small intestine.[14,35] Pre-weaned calves have physiologically monogastric type stomach.[36–38] The newborn calf's immune system is functional but immature.[39] Immune system development is a graded response and a calf that is deprived of colostrum not be able to mount a strong immune response when it presented to an overwhelming disease challenge, because the calf's immune system has not reached the level of maturity it needs to prevent infections.[40]

The colostrum and its role to newborn calves

At birth, a calf has little or no immunity to disease. The calf gets this immunity from absorbing immunoglobulin (antibodies) found in the colostrum (ANS01-202D). Colostrum is the first lacteal secretion of the mammary gland prior to and after parturition. Important constituents of colostrum include Ig, maternal leukocytes, growth factors, hormones, cytokines, nonspecific antimicrobial factors, and nutrients.[41,42] Maternal colostrum contains several different types of immunoglobulin's including IgG, IgA and IgM. However, IgG accounts for roughly 85% of the total immunoglobulins in cow colostrum and it is absorbed in the largest amount by the gut of the calf.[40] Concentrations of many of these components are greatest in the first secretions harvested after calving (first milking colostrum), then decline steadily over the next milking.[41] Therefore, the calf is born completely dependent on the absorption of maternal antibodies from colostrum after birth.[39,40] Calves with inadequate immunoglobulin concentrations have reduced growth rates and feed efficiency, increased risk of disease and death, increased risk of being culled, and decreased milk production in their first lactation.[40,43,44] Failure of passive transfer may be attributed to colostrum containing inadequate mass of IgG, poor colostrum feeding methods, and poor efficiency of IgG absorption in calves.[40]

Calf morbidity and mortality in dairy farms of Ethiopia

Healthy calves form the basis of any successful cattle production system (calves for replacement or sale) from both an economic and an animal welfare point of view.[15,45,46] However, neonatal animal disease, morbidity and early mortality in the first days and/or weeks post-partum affect the health and survival of calves for the future replacement (McGuirek, 2014). Morbidity refers to the state of being diseased or unhealthy within a population and Mortality rate is defined as the number of dead calves divided by the number of individual time at-risk in a defined group or population.[47] According to Heinrichs et al.,[25] calf mortality can be divided into the following 4 groups based on age at time of death: abortions or prenatal deaths (stillborn from 40 to 270 day of gestation), perinatal mortality (stillborn after 270day of gestation or until 24hour after birth), neonatal mortality (death between 1 and 28 day of age), and older calf mortality (death between 1 and 6 months of age). In Ethiopia the overall morbidity and mortality recorded were reported by different authors from different parts of the country. The overall calf morbidity and mortality reported by Assefa et al.,[48] in dairy farm of Wolaita sodo town were 66.7% and 20%, respectively. There is also very close findings of Wudu et al.,[14] where the crude dairy calf morbidity was 62.0% and mortality 22.0% reported in smallholder dairy in Ada'a Liben district of Oromia. The overall morbidity and mortality reported by Bekele et al.,[49] in dairy farms of Hawassa town were 29.3% and 9.3%, respectively. The overall morbidity and mortality reported by Yeshwas et al.,[22] in dairy farms of Gozamen and Bahir Dar zuria, were 58.4% and 30.7%, respectively. The same author but one year later,[35] reported the overall morbidity and mortality in Bahir Dar milk shed were 47.3% and 17.9%, respectively. Based on reviewed study reports, it is tried to assess only morbidity and mortality reports to make comparison. But, study reported on only morbidity was less except who reported crude morbidity rate together with mortality rate as described above. From a few reports, 29.3% of morbidity in Sidamma zone and 35% of morbidity in Gedio zone Southern Ethiopia was reported by Yibrah et al.,[50] on the study of the calf health and management problems on small scale dairy farms. Therefore, most other available reports have covered both morbidities and mortalities as a result of this it is difficult to make comparisons about morbidity, unlike mortality. As in general, most recent studies on dairy calves reviewed for this paper reported only mortalities. Those available mortality reports also may varies with age of calves they took for studies. The mean annual calf mortality rate reported by Awol et al.,[51] in cross breed small holder dairy farm of Dessie town was 10.2%. According to[23] the average mortality rate from birth to age at first calving among the Holstein Friesian female calves born was found to be 23% at Holleta farm. In mixed crop-livestock and pastoral production systems, mean annual calf mortality (birth-to-weaning) were reported in the range of 9.2–14% and 26-29.2% respectively in calves as reported by Tsegawi. However, few authors also reported mortality rates over the above range. For instance, Mortality rate of 53% and 67% reported by Hassen et al.,[52] and Gryeels et al.,[53] respectively in calf age of up to 2 years. Therefore mortality statistics mostly, ranges from 6.5 to 30.7% in pre-weaned calves as shown in the Table 1 below. Almost all reasoned out on their findings and reported rate of mortality could be related to health problems and inadequate feeding management of calves.[23,35] In general when compared to other countries, information on calve morbidity and mortality is scarce in Ethiopia. Even those

available are mostly from research and institutional herds, which do not properly represent the predominant smallholder production system existing in the country.[14,23,31,35]

The major reported causes of calf morbidity and mortality in Ethiopia

Several studies have been conducted in the country from different study sites and documented data sources to major causes of calf morbidity, mortality and associated risk factors using of different study methodology like cross sectional, retrospective and prospective data sources. Calf diseases and disease syndromes were the leading causes of calf morbidity and mortality as reported in the country and among other disease syndromes, calf diarrhea and pneumonia were most frequently reported.[31,54–56]

Table 1 Calf morbidity and mortality rates compiled from different studies in Ethiopia

Study areas	Age of calf	Morbidity rate	Mortality rate (%)	References/author
Gonder town	Up to 6 months	-	4.68	Muluken et al., (2017)
Andassa ranch	Pre-weaning	-	6.5	Amuamuta et al., (2006)
Holleta	Preweaning	-	7	Shiferaw et al., (2002)
Hawassa town	-	29.3	9.3	Bekele et al., (2009)
Bishoftu town	Preweaning	-	11.6	Gebremedhin , 2014
Amhara region	Up to 1 year	-	11.9	Tsegawi, (2016)
Around Holleta	Preweaning	-	14.2	Amoki (2001)
Ethiopia	Preweaning	-	15	ILRI (1996)
Abernosa ranch	Pre-weaning	-	17.3	Ababu et al., (2006)
Adami tulu	Upto 6 months	-	17.5	Hussien (1998)
Bahir Dar milk shed	Up to 6 months	47.3	17.9	Yeshwas (2015)
Wolaita soddo town	Up to 6 months	66.7	20	Assefa and Ashenafi (2016)
Gonder town	Up to 6 months	-	20.45	Esubalew and Debebe (2017)
Oromia region	Up to 1 year	-	20.9	Tsegawi, (2016)
Ada'a Liben district	Up to 6 month	62	22	Wudu et al., (2008)
Gozamen & B. Zuria	Pre-weaning	58.4	30.7	Yeshwas et al., (2014)

Calf diarrhea

Like others documented elsewhere.[13,19,29,57,58] calf diarrhea was the most frequently reported causes of dairy calf morbidity and mortality in Ethiopia.[14,31–35,59] For instance, the study in small-holder dairy farms in Ada'a Liben district of Oromia, carried out by Wudu,[28] revealed the most frequent disease syndrome was calf diarrhea with the incidence rate of 42.9 % followed by pneumonia. Shiferaw et al.,[55] reported a 6-month cumulative incidence of calf diarrhea was 42%. Awol et al.,[51] reported the calf mortality risk recorded due to only diarrhea was (44%). In his single visit survey study by Tsegawi young stock mortality in major livestock production systems of Ethiopia also reported calf diarrhea (48.7%) was the most causes of calf mortality in Oromia region. According to Gebremedhin, among the causes of death recorded, calf diarrhea was the leading cause of calf mortality with case specific mortality rate of 5.8% in intensive dairy farms of Bishoftu town. Yeshwas et al.,[22] reported calf diarrhea (21.4%) was the leading cause of morbidity and mortality of pre-weaned crossbred calves in Bahir Dar Zuria and Gozamen districts. Minda et al.,[60] in Holleta Agricultural Research Center Dairy Farm, Holleta, Ethiopia, reported the predominant calf health problem, with incidence rate of 12.5% was calf diarrhea followed by pneumonia 11.5% and pink eye 5.2%. In Ethiopia, in addition to reporting high prevalence of calf diarrhea, there are also some studies done on identification of specific agents involved in diarrheic calves.[50,61–63] For instance, Abraham et al.,[61] tried to identify specific infectious agents associated with neonatal diarrhea in dairy calves and found bovine enteric corona virus, group A, rotavirus and K99 Enterotoxigenic *E. coli* independently or in combination in diarrheic calves. Moreover, *Escherichia coli* (26.3%), *Salmonella* (10.5 %) and 10.5% of concurrent infection with two microorganisms (*E.coli+Salmonella*) and 52.6% of Cryptosporidium were identified by Assefa et al.,[48] from diarrheic calves; and overall 76.9% diarrheic calves were found to be affected by different parasites independently and concurrently.[48] Therefore, calf diarrhea is a complex multi factorial disease syndrome in which numerous infectious and non infectious factors are involved. Diarrhea or scouring is the commonest disease syndrome and the greatest single cause of neonatal mortality during the first week of life and this risk decreases with age[14,64] and result great economic loss with high morbidity and mortality in the cattle industry worldwide.[27,65]

Calf pneumonia

Calf pneumonia refers to infectious respiratory disease in calves. It is primarily a problem in calves less than 6 month old with peak occurrence from 2–10 week, but it may be seen in calves up to 1 year of age.[66] In Ethiopia, calf pneumonia was the second most frequently reported disease syndrome that causes of calf morbidity and mortality next to calf diarrhea.[9,22,28,51–60] For instance, Calf pneumonia with incidence of 28%, 18.6%, 11.5%, 9.2% and 4.9% were reported by Wudu,[28] Yeshwas et al.,[22] Minda et al.,[60] Amuamuta et al.,[9] and Awol et al.,[51] respectively in their site of study. Heinrichs et al.,[25] explained that although it can affect pre-weaned calves, calf pneumonia is the most common of all the diseases of the weaned calves and causes

the highest loss in this age group, both in terms of mortality and reduced growth rates and accounts for about 15% of calf mortality from birth to 6 month of age. It is caused by one or more of a whole range of organisms, including bacteria (like *Pasteurella multocida*, *Hemophilus somnus*) virus (like, Para infulenza virus type 3) and parasites.[66–68] A multitude of environmental and management factors and their interactions are also responsible for the occurrence of calf pneumonia.[35,49,67]

Septicemic condition

Septicemia is also known as bacteremia or any condition characterized by depression, anorexia and fever without any distinct involvement of specific body system as described by Yeshwas,[35] for case definition of septicemic condition. This disease syndrome is also one of causes of calf morbidity and mortality in Ethiopia.[22,49,50] According to the findings of Yibrah et al.,[50] septicemia and diarrhea (43.7%) was found to be the most frequently observed disease syndrome followed by internal parasite (31.2%), and external parasite (16.7%) in small scale dairy farms of Sidamma and Gedio Zones. Septicemic conditions (12.4%) followed by navel ill (8.1%) were reported in pre-weaned crossbred calves in Bahir Dar Zuria and Gozamen districts.[22] In the study of Bekele et al.,[49] the most frequent disease syndrome next to diarrhea was septicemia with incidence rates of septicemia (21%). Septicemia occurs when a pathogen or its toxins are present in the calf's blood and remains a major cause of mortality in calves less than 14days of age.[58,68] Septicemia often results when the calf is still in the mothers' uterus, or during or immediately after birth. Blood from its' sick mother or infected placenta, the calf's navel, umbilicus, mouth, nose, or wound are usually the source of infection.[58]

Navel Ill (Omphalitis)

Navel infection (Omphalitis) is an inflammation of the umbilicus.[69] Navel infection is one of the disease conditions which have serious impact on the survival of calves as reported by Wudu et al.[14] Navel ill with incidence rate of 8.1% by Yeshwas et al.,[22] 8.3% by Amuamuta et al.,[9] and Awol et al.,[51] and 7.7% by Tsegawi, were reported as cause of calf morbidity and mortality in their study areas of the country. Moreover Assefa al.,[48] found that calf morbidity was high in calves where navel was untreated than treated one. As they described the increased morbidity of navel of untreated calves might be attributable to the entrance of pathogens from the contaminated calves' environment through the umbilicus. The same reason to the above is that infectious agents can enter the body through the umbilicus, after contact with dirt and infected material;[70] and unhygienic conditions at birth and after birth and bruising around the navel are the predisposing factors for naval ill.[71]

Helminthes and Vector-borne diseases

Some authors have been reported the importance vector borne diseases and helminthes associated with calf morbidity and mortality in Ethiopia. Calf helminthosis, babesiosis and coccidiosis were reported from Ethiopia as causes of morbidity in calves.[48–50,59,72–74] For instance next to diarrhea and septicemic conditions, helminthosis was the common problem in dairy calves as reported by Yibrah et al.[50] Out of total calves sampled, 55.5% calves were found to be positive for helminth parasites as reported by Yeshwas.[74] A Coproscopical examination employed by Minda et al.,[60] for identification of ova/oocyst indicated that cumulative incidence of endo-parasites was 60.4% in the study dairy farm calves.

Other miscellaneous causes

Other some diseases and disease syndromes reported with less frequently on calves include arthritis, skin disease, Foot and mouth disease, Lumpy skin disease, congenital disorder, accidents, bloat and Poor nutrition.35,[51,75] For example, next to diarrhea and pneumonia, bloat with cause specific mortality rate of 8% was the main cause of cross-breed calf mortality in dairy farms of Dessie town and its environ as reported by Awol et al.[51] All studies reviewed in this paper, reported calf diarrhea was the leading causes of calf morbidity and mortality followed by calf pneumonia and this is true as described in the above Figure 1.

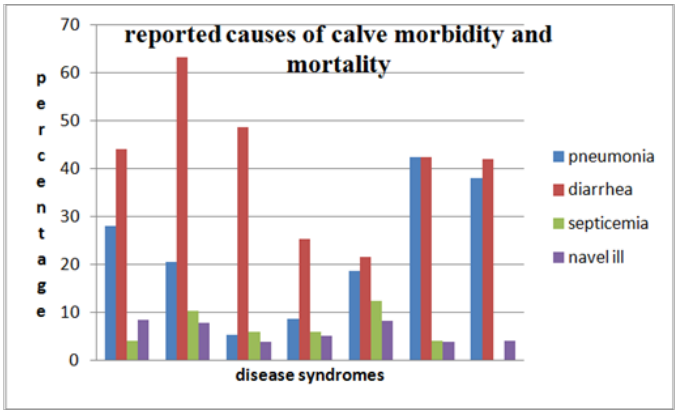

Figure 1 Major reported causes of calf morbidity and mortality in dairy farm of Ethiopia.

The major reported risk factors of calf morbidity and mortality in Ethiopia

Morbidity and mortality in dairy calves have multi-factorial etiology, resulting from interactions between the calf, dam, infectious agent, management and environmental factors.[28,47–51]

Calf associated risk factors

Age of the calf

Many researchers in their articles indicated the age of the calf is the most important determinant factor affecting calf morbidity and mortality.[48,60,76] Analysis of survival times to death carried out by Assegid et al.,[77] indicated that calves less than 6months of age had higher death rates than older calves. According to the findings of Yeshwas,[35] 67.9% of mortality rate was reported in the first three months as compared to 16.1% mortality rate above three months. There were also lower rate of reports. In a study on smallholder dairying in Debre Zeit, 15% of the mortality rate was reported in the first month as compared to 8% mortality rate in 1 to 3month of life and 39.3% of the mortality rate upto 3month as compared to 3-6 months (30.3%) also reported in Bahir Dar district.[22] Moreover approximately 60-75% of the mortality in calves occurs in the first month of their life in dairy.[25] The susceptibility of calf to diseases also observed among different age groups. Both diarrhea and pneumonia were significantly highest in calf of age 0-3months than 4-6months.[60] In the assessing of age as risk factor for the morbidity of the diarrheic dairy calves, the highest incidence of diarrhea 68.4% among the diarrheic dairy calves were occurred at the age of less than two months, followed by 26.3% at the age of 2–4months, and 5.3% at the age of 4–6months as reported by Assefa et al.[48] As compiled the data from Yeshwas et al.,[22]

Yeshwas,[35] and Assefa et al.,[48] in the Figure 2 above indicates as the age of calf increases, both morbidity and mortality rate will decreases and vice versa**.**

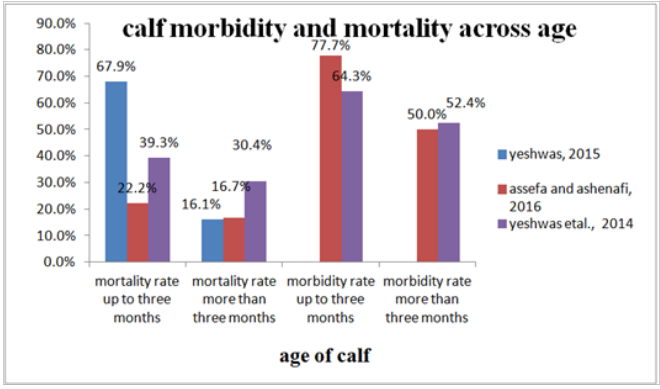

Figure 2 Age of calf as risk factor for both morbidity and mortality.

Breed and genetic influence

A difference in susceptibility of calves to diseases is often observed among different breeds, Taurine breeds and their crosses are generally more susceptible to diseases in tropical climates.[14] Higher calf mortality in exotic breeds than locals has been reported and dairy breeds had higher perinatal mortality rates than beef breeds.[9,78–81] High exotic blood level was found to have a significant effect on increased calf mortality rate.[22,76,82] For instance as reported by Esubalew et al.,[79] the extent of calf mortality (37.5%) was high in exotic breeds than cross (21.51%) and local (9.18%) breeds. Both morbidity and mortality rate across breeds was reported. For instance Yeshwas et al.,[22] reported morbidity of 47.1%, and mortality rate of 18.8% in exotic blood level of up to 25%; Morbidity of 55.5% and mortality of 25.2% in exotic blood level of 25-50%; Morbidity of 61.1% and mortality of 34.7% in exotic blood level of 50-75% and Morbidity of 78.6% and mortality of 52.3% in exotic blood level of above 75% respectively. In general as the blood level of calf increases, the susceptibility to disease also increases. This might be due to the susceptibility of *B. Taurus* breeds to climatic and disease stress in tropical environments.[83] Hence keeping crossbred dairy cows of the intermediate exotic blood (62.5%–75%, Friesian inheritance) is suggested for better health and production[22] and further grading up above 75% towards the *Bos taurus* breed has given variable and often disappointing results.[82]

Sex of the calf

Several researchers have reported that morbidity and mortality rate were differed between sexes of calf. Significantly higher mortality rate was reported in male than female calves.[9,75,78,84] In support of the above findings, Assefa et al.,[48] reported that morbidity of female calf due to diarrhea was lower than male and high percentage of male calves died (22.2%) than female calves (19%). Reasons for this higher mortality in male calves might be due to less colostral immunoglobulin absorbed in male than female during neonatal life. It is also worth mentioning that male calves are not as valuable to the dairy operation as females and therefore may not receive the attention the heifers do, possibly accounting for the higher mortality in males.[75,84] Moreover, male calves had greater odds of poor vigor (score based on capacity to nurse) than female calves.[85]

Calf's vigor and health

A calf's voluntary intake of colostrum is mainly predictable by birth weight and the calf's vigor. The cow's pre-calving energy and protein levels affect calf vigor and survival. Poor vigor at birth increases odds of death and delayed suckling or lower colostrum intake.[9,31,86] Among other causes, animals born weak at birth and small in size were also the causes with considerable contribution to calf mortality.[87] Yeshwas,[35] reported in his epidemiological investigation study of calf morbidity and mortality, the relative hazard of mortality in good vigored calves was lower than that of calves with poor vigor at birth. Thus, vigor and health of the calf at birth is highly correlated to morbidity and mortality.[25,35,86]

Dam associated risk factors

Parity and age at calving

Parity of the dam was also identified as a risk factor for calf mortality, and calves born to young heifers had a significantly higher perinatal mortality rate than calves born to older cows.[78,79] For instance, calves born to cows younger than 2 years of age had a perinatal mortality rate of 5.88%, which was significantly greater than that of calves born to cows older than 2 years.[79] Assefa et al.,[48] also reported morbidity of dairy calves was highest in primiparous than multiparous dam. Incidence of dystocia and still birth are higher in primiparous than multiparous dams.[82] About 27.7% of the cows calved abnormally during their first calving and proportion decreases as parity increases.[23] This might be associated to the calving difficulty young cows as a result of undeveloped reproductive systems and to some genetic inheritance. On the review of the genetic and biology of reproduction of cattle carried out by Fries et al.,[88] showed that incidence of dystocia is three to four times as frequent in females calving for the first time compared to females in the second parity and the same was attributed to lighter body weight of first calves because of the lesser skeletal development relative to mature female cow, and sex of the calf.[23,88] Mebrahtu et al.,[63] find that parity of the dam contributes to the occurrence of septicemic *E. coli* and they showed a significance association between the dam parity and prevalence of *E. coli*., and stated that colostrum of heifer is lower in immunoglobulin (Ig) content than older cows and colostrum deprived calves are highly susceptible for colisepticemia. Furthermore older cows tend to have more IgG than first calf heifers, as they have been exposed to a greater number of pathogens during their lifetimes.[40]

Dam health and nutrition status

Dam health and nutrition status also affects calf survival. Calves born from dams with inadequate nutrition at late pregnancy or affected with prolonged anorexia, fever, or septicemia may be weak.[28] The amount of weight body lost between calving and conception affect the rate of loss of resultant offspring.[23] According to Assefa et al.,[48] dam disease and poor body condition of the dam was significantly linked to high morbidity (83.3%) and mortality (22.2%) in dairy calves. Mastitis during dry period of cows decreases the concentration of IgG, particularly IgG1 in the colostrum of the next lactation. In this similar study, the size of the calf at birth was smaller if the dam had clinical mastitis during the 49-day period prior to calving.[89]

Birth type (twinning)

Birth type was also found as determinant factor of mortality as indicated. Co-twin calves were found at higher hazard of mortality than that of singleton.[23,35] Yeshwas,[35] found that among 8co-twin calves born during his follow up period, 6(75%) were died before

they reached their three months of age. This his finding was found consistent with Mellado et al.,[84] that calf mortality rate from twin births was higher than single birth calves. Moreover the risk of perinatal mortality increased significantly in twins compared with singletons.[15] Twin births have also been associated with increased dystocia, metritis and decreased perinatal viability.[23,46,90]

Mothering ability and presence of the dam with calf

Increased survivability of calves is very much dependent on mothering instincts of dam which is characterized by stimulating the calf to stand and stimulate suckling behavior. This is mainly true for local breeds.[14,28,58] According to Batiley,[31] high statistical association was observed between mothering instincts and failure of passive transfer of immunity. He concludes that mothering instinct problem is observed more in heifers than cows and, cows have better maternal instincts than heifers. Mothered calves absorb 70percent or more immunoglobulin than non-mothered calves. Poor mothering ability combined with reduced calve vigour could decrease the effectiveness of passive transfer in calves.[77] Batiley, 2018 also gave some possible explanations for his study, and state that calves that suckle colostrum from cow with poor mothering instinct are likely to ingest less colostrum than the recommended amount during the first feeding. Furthermore, the ability of calves to absorb IgG decreases with time, and some calves do not suckle quickly enough because of dam's poor mothering instinct.[58]

Management and environmental risk factors

Calving management at birth

Calving management has an important effect on calf performance and health. The process of assisted calving can be a traumatic and hazardous event in the life of a calf.[22,31,35,91] Calves that have experienced trauma from a difficult calving often have reduced newborn viability, resulting in an increased risk of having health problems and death.[75,92,93] A large number of stillbirth deaths are also attributed to trauma, suggesting either inappropriate timing of assistance or excessive force during delivery.[15,92] When excessive force is applied during the delivery process, trauma inflicted can affect several body systems including hemorrhages, injuries to the central nervous system, fractures of rib, limb, jaw and pelvic fractures in dams[15,51] Therefore, dairy producers can make meaningful improvements in calf health and performance by focusing on management interventions to reduce the frequency of difficult calving, and by appropriate assistance at the calving event.[49,92]

Time to first colostrum ingestion

Time between birth and the first feeding is the prime factor for the failure of passive transfer of colostral immunity.[31,35] Studies in Ethiopia showed that calf morbidity and mortality is significantly higher in calves that got colostrum late after birth than those that got colostrum soon after birth. Yibrah et al.,[50] and Admasu et al.,[59] found that the majority calf health problems were less in those fed colostrum immediately after birth from 1-6hours than those from 6-24hours. Therefore producers should aim to feed all calves within 1 to 2hours after birth and by 6 hours at a maximum because the efficiency of Ig transfer across the gut epithelium is optimal in the first 4hours postpartum, but after 6hours there is a progressive decline in the efficiency of Ig absorption over time.[41,42] and each hour of delay within the range of 1 to 12hours after birth increased the risk of illness by 10%.[33]

Method and amount of colostrum feeding

The method of feeding colostrum is worth considering because this can influence the time to first feeding, the volume consumed, and the efficiency of passive Ig absorption.[31,35,41] According to studies, amount of colostrum and its method of provision were found significantly associated with calf mortality and morbidity and those calves with history of partial colostrum feeding were at higher risk of mortality and morbidity than those calves with complete colostrum feeding. They also suggested that hand feeding was better than suckling.[14,76,79,80] Moreover in addition to their suggestion or findings ingestion and absorption of enough quality and quantity of colostrum is a critical determinant for the health and survival of neonatal calves. Leaving the newborn dairy calf with the cow is no guarantee that the calf will obtain sufficient colostrum and a high proportion fail either to suck early or to absorb sufficient immunoglobulins from ingested colostrum. This problem can be alleviated to some extent by assisted natural sucking but this can fail because not all calves requiring assistance are detected. An alternate approach is to milk 2L of colostrum from the dam, bottle feed each calf as soon after birth as possible, then leave the calf with the cow for 24 hours and allow it to suck voluntarily.[51] Recent studies have found 46-61% of calves fail to suckle in the first 6hours after birth. Reasons for this delay include a low, pendulous udder, large teats, poor mothering ability or calves born in very cold weather or those experiencing difficult birth.[40,22,35]

Housing

Dairy housing conditions greatly affect health and productivity. Cleanliness of the barn influences calf health, as calves housed in unclean barns are at higher risk of diseases than calves housed in clean barns.[14] Cleanness of the calf house was found significantly associated with calf morbidity and diarrhea.[28] Admasu et al.,[59] found that hygiene (cleanness of the calf house) was significantly associated with the health of the calves. The higher risk of morbidity was associated with the dirtiness of calf house. This his finding is in agreement with the results of Shiferaw et al.,[55] who reported the effect of the micro environment of calves in the occurrence of calf mortality and morbidity in Holleta Ethiopia. Moreover calves kept together with cows have higher incidence of diseases than those raised in individual calf pen.[14,54,75] The main environmental factor predisposing calves to respiratory disease is poor ventilation in calf housing.[58] Calf health problem is also more common in housed dairy calves than in those raised outside in hutches.[66] Moreover the most important risk factors associated with calf morbidity and mortality were use of bedding materials and floor types, and both morbidity and mortality records were higher in those calf houses with bedding than non bedding, in soily floor than concreted respectively.[49]

Herd size

A marked increase in population density commonly results in an increase in the incidence of infectious diseases and mortality and herd size is the most important risk factor for calf morbidity and mortality.[28,49,84] Calf mortality rate was significantly higher in larger herd sizes than small size. The incidence risk of diarrhea and pneumonia was higher with the larger herd size.[48–50,79,80] Herd size by itself has not a biological effect on the calf health; rather, it may be a measurement of other factors like time available to observe and care for calves. Other possible reason for the apparent association between herd size and calf mortality could be that in case of small herd sizes enough time may elapse between successive births, which

will reduce the concentration of infectious agents in the calf-rearing environment.[28]

Production and farming system

Calf health problems in the farms may varies with regard to farming system as reported by different authors.[59,75,76] The morbidity and mortality rate reported varies across the farming system. With this regards Konjit et al.,[75] found that respiratory problems including others was highest prevalence in intensive farming system than semi intensive. About 70% of cumulative survival rate for calves was reported in intensive commercial dairy farms in and around Addis Ababa and their report emphasized that calf survival is a matter of serious concern in these types of dairy farms.[77] Studies carried out on different livestock production system also reported calf morbidity and mortality rate varies with the type of production system. In mixed crop-livestock production systems, mean annual mortality (birth-to-weaning) was reported in the range of 9.2–14% in calves. The annual calf mortality in the urban and peri-urban dairy production system was reported in the range of 15.3–25%. In the pastoral production system, the annual birth-to-weaning mortality of young cattle was reported in the range of 26–29.2% in cattle (Tsegawi, 2016).

Other risk factors

Other managemental and environmental risk factors suspected to affect calf morbidity and mortality include: frequency of milk feeding, dam health preventive practices, the sanitation of calving area, perinatal care, grazing level (whether zero grazing, partial grazing or total grazing), teat size and distance from the ground, weaning age, congenital disorders, season of birth, birth weight, water provisions, quality and quantity of colostrum, separation or mixing of calves.[14,32,33,94,95]

Conclusion and recommendations

In Ethiopia, dairying is becoming one of the most important parts of livestock sector where calves are future herd of a dairy farm. The health and management of replacement animals are important components of total herd profitability. Several factors affect the health of the calves immediately after birth.[96] The poor immune system and lack of previous exposure to infection make new born calves susceptible to infectious diseases. According to this review, calf morbidity and mortality were an important productivity and economic factor in the success of dairy production.[97] As reviewed several researchers reported overall morbidity and mortality of calves in their study sites. Study reported only morbidity was less except some authors, who reported crude morbidity rate together with mortality and therefore difficult to make comparisons of morbidity, unlike mortality. Therefore, based on this current review, mortality statistics mostly, ranges from 6.5 to 30.7% in pre-weaned calves. Different researchers have investigated numerous determinant factors in calf morbidity and mortality in the country.[98–100] Accordingly calf diarrhea followed by calf pneumonia was the most frequently reported leading causes of calf morbidity and mortality. In addition to calf hood diseases;[101–103] host (calf and dam) factors and poor management practices appeared to be the most important causes of calf morbidity and mortality across the species and the production systems they studied. However, many available studies on calf morbidity and mortality focus on risk factors on an individual (calf) level and also on herd-level risk factors for disease only and little is established about management practices that affect morbidity and mortality in dairy calves. Moreover there is paucity of information done on identification of specific agents involved in disease syndromes associated with morbidity and mortality; and also except those few reports, those recently reviewed few studies were mostly concentrated on government ranches, research centers, and central part of country (state farms) which are less relevant to the smallholder farming system, though this production system is the predominant one in the country. Therefore based on this conclusion, the following recommendations are forwarded:

i. There should be the development and application of sound dairy calf health and management practices for the improvements of calf health and performance in all dairy production system.

ii. These may includes proper housing and hygiene, provision of adequate feed, and adequate provision of high quality colostrum during the first 6hours, close attention to animals to minimize transfer of diseases, disease prevention and control measures such as regular vaccinations, chemotherapeutic measures, awareness creation on good recording keeping and animal health practices.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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