# EPIDEMIOLOGICAL DETERMINANTS AND MAGNITUDE OF CALF MORBIDITY AND MORTALITY IN BAHIR DAR MILK-SHED, NORTH WEST ETHIOPIA

MSc Thesis



By

Yeshwas Ferede Alemu

Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Clinical studies

June, 2015

Bishoftu, Ethiopia

EPIDEMIOLOGICAL DETERMINANTS AND MAGNITUDE OF CALF MORBIDITY AND MORTALITY IN BAHIR DAR MILK-SHED, NORTH WEST ETHIOPIA

A Thesis submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University in Partial Fulfillment of the Requirements for the degree of Master of Science in Tropical Veterinary Epidemiology

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Yeshwas Ferede Alemu

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As members of the Examining Board of the final MSc open defense, we certify that we have read and evaluated the Thesis prepared by: Yeshwas Ferede, titled **Epidemiological Determinants and Magnitude of Calf Morbidity and Mortality in Bahir Dar milk-shed, North West Ethiopia** and recommend that it be accepted as fulfilling the thesis requirement for the degree of: Masters of Science in Tropical Veterinary Epidemiology

Dr. Fekadu Regasa (DVM, MSc, PhD, Assoc. Prof.)    _____   _____

Chairman                                   Signature        Date

Dr. Ayele Gizachew (DVM, MSc, Assist. Prof.)     _____   _____

External Examiner                         Signature        Date

Dr. Yasmin Jibril (DVM, MSc, Assist. Prof.)      _____   _____

Internal Examiner                         Signature        Date

1. Dr. Reta Duguma (DVM, MSc, Assoc. Prof.)     _____   _____

Major Advisor                             Signature        Date

2. Dr. Zeleke Mekuriaw (PhD, Assoc. Prof.)      _____   _____

Co- Advisor                               Signature        Date

3. Dr. Wudu Temesgen (DVM, MSc, Assoc. Prof.)    _____   _____

Co- Advisor                               Signature        Date

4. Dr. Fufa Abunna (DVM, MSc, Assoc. Prof.)     _____   _____

Department chairperson                     Signature        Date

# DEDICATION

This MSc thesis work is dedicated to the memory of my beloved and kind grandmother, *Tateku Asfaw*, whom I lost at my 12. I grew up under her realm with her motherly love and care, as first son of my family. It is always surprising to me that her belief about education was so excited, though she did not receive any formal education. She allowed me to have a new life led by education. More importantly, her far sighted vision, dignified and disciplined personality, enhanced social relationship, positive attitude and hardworking spirit had shaped me and paved the way to my present situation. I wish if she could see my present situation. May GOD rest her soul in heaven!

# STATEMENT OF AUTHOR

First, I declare that this thesis is my *bona fide* work and that all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an advanced (MSc) degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University/College library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.


Name: Yeshwas Ferede                    Signature:_____

College of Veterinary Medicine and Agriculture, Bishoftu

Date of Submission:_____

*'Surly, as I have planned, so it will be, and as I have purposed, so it will stand (Isaiah 14:24)'*

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ADG | Average daily gain |
| BCoV | Bovine Corona Virus |
| BnoV | Bovine Noro Virus |
| BRV-A | Bovine Rota Virus |
| BtoV | Bovine Toro Virus |
| BVDV | Bovine Viral Diarrhea |
| *C.parvum* | *Cryptosporidium Parvum* |
| E.coli K99 | Escherichia coli K99 antigen |
| ECF | East Coast Fever |
| ELISA | Enzyme Linked Immunosorbent Assay |
| FAO | Food and Agriculture Organization for United Nations |
| FPT | Failure of passive transfer |
| HR | Hazard Ratio |
| IBR | Infectious Bovine Rhinotracheitis |
| Ig | Immunoglobulin |
| ILCA | International Livestock Center for Africa |
| ILRI | International Livestock Research Institute |
| IR | Incidence Rate |
| LIVES | Livestock and Irrigation Value chains for Ethiopian smallholders |
| LSD | Lumpy Skin Disease |
| *M. bovis* | *Mycobacterium bovis* |
| RID | Radial immune diffusion |
| SPSS | Statistical Package for Social Science |
| STP | Serum Total Protein |
| TIA | Turbidimetric immunoassay |
| TLU | Tropical Livestock Unit |
| ZnSo4.7H20 | Zinc Sulfate Hepta hydrate |

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EPIDEMIOLOGICAL DETERMINANTS AND MAGNITUDE OF CALF MORBIDITY AND MORTALITY IN BAHIR DAR MILK-SHED, NORTH WEST ETHIOPIA

## ABSTRACT

*Herd level cross-sectional and calf level longitudinal observational study was conducted between November 2014 to April 2015 in peri-urban and urban dairy farms of Bahir Dar milk-shed, Ethiopia. The aims of this study were therefore, to determine the incidence rate of calf morbidity and mortality, investigating potential determinant factors of calf morbidity and mortality and to determine the passive transfer of immunity in some selected dairy calves. Both concurrent and prospective cohorts were employed to recruit calves aged below 6 month in the study herds. A total of 440 calves, a random sample of 322 calves from small-holder and 118 from five large dairy farms located in Bahir Dar milk-shed were included in the study. Each study calf was individually ear-tagged and regularly monitored in monthly basis for clinical health problems up to an age of six months. Information on different potential risk factors was collected by using herd and calf level recording sheets and personal observations. Serum samples were taken from some study calves to determine their level of passive transfer and it was conducted in Bahir Dar Animal Health Diagnostic and Investigation Laboratory.*

*The overall incidences of crude morbidity and crude mortality rates found in this study were 47.3% and 17.9%, respectively. Calf diarrhea, pneumonia, navel ill, septicemic conditions, Lumpy Skin Disease, rabies, congenital problems and other miscellaneous cases were encountered during this study. The most frequent disease condition was calf diarrhea with the incidence rate of 25.2% followed by pneumonia (8.6 %). The incidence of crude mortality was apparently higher in large sized dairy farms than smallholder farms. However, calf diarrhea and crude morbidity rates were higher in the latter. About six, 6, 4 and 2 explanatory variables were found significantly associated with crude mortality, crude morbidity, diarrhea and pneumonia respectively by multivariate Cox-regression at P<0.05. Older calves above three months age were at lower risk (HR=0.03, P=0.000) of mortality than younger calves of below three month. The relative hazard (HR=0.15, P=0.000) of mortality in good vigored calves was lower than that of calves*

*with poor vigor at birth. Those calves fed complete colostrum were found at lower risk (HR=4.64, P=0.000) of mortality than those fed partial colostrum. Birth type (twin vs. single), method of colostrum feeding and farming system were also the other risk factors determining calf mortality. Likewise, older calves were found at lower risk of crude morbidity (H=0.45, P=0.000) than younger calves. The hazard of morbidity in those good vigored calves at birth was lower (HR=0.26, P=0.000) than calves with history of poor vigor. Furthermore, dam age, dam birth related disorders and study location were also found additional risk factors of crude calf morbidity. The relative hazard of diarrhea in crossbred calves (HR=2.63, P=0.016) was higher than that of local counter parts. Those good vigored calves at birth were also found at lower risk (HR=0.24, P=0.000) of diarrhea than that of poor vigored counter parts. Furthermore, calf age and study location were found to be additional risk factors of calf diarrhea. Those calves with previous treatment history were at greater risk (HR=0.076, P=0.000) for pneumonia than calves which did not receive any previous medical treatment. Moreover, vigor status at birth (HR=0.24, P=0.000) was found significantly associated with calf pneumonia.*

*Out of 46 calves examined by Zinc sulfate (ZnSo4.7H20) turbidity test, about 8.7% of them were found with no detectable colostral Ig (FPT), the remaining 34.8% and 56.5% were found with adequate and partial protection levels, respectively. Generally, 65.2% of calves were found immunologically unprotected in the study herds. In conclusion, the incidence of calf morbidity and mortality found in this study were high and above economically tolerable level. This record therefore, could affect the productivity of the dairy farms through mainly decreasing the availability of replacement stock. Among the significant risk factors investigated, calf vigor, age, breed, dam age and amount of colostrum ingestion were found very important determinant factors of calf mortality and morbidity under the context of small-holder farming system in Bahir Dar milk-shed. A sound dairy calf management practice, is therefore needs understanding and manipulating of the above mentioned calf health determinant factors with subsequent application of tailor-made interventions.*

***Keywords****: Bahir Dar, Calf, Diarrhea, Incidence rate, Longitudinal study, Morbidity, Mortality, Passive transfer, Pneumonia, Risk factor*

# 1. INTRODUCTION

Sub-Saharan Africa is approaching a demographic inflection point as the numbers of new urban residents are projected to rise sharply by over 300 million between 2000 and 2030 which is more than twice the rural population increment (World Bank, 2005). It is also true in the present Ethiopia, where population growth and urbanisations are running rampant than ever before. The country has an estimated human population of 77 million and is projected to increase to 140 million in the coming 25 years. Similarly, the current urban population of 6 million is projected to reach 36 million by 2025, an increase of 350% (Tegegne *et al*., 2007). This demands a parallel increase in food production, of which animal products such as milk, meat and egg are very important (Wudu, 2004; Adebabay, 2008).

In this regard, the current per capita milk consumption in Ethiopia is 25.6 kg/year (Yitaye, 2008), this low milk production lead an increasing trend in import of milk and dairy products (Getachew, 2003). When compared to other countries, it is still lower than the average of sub-Saharan (29.5 kg/year) and much far below than the average of developed countries (195.7 kg/year) and FAO's recommendation of 200 liter per head per year (Kyomo, 1997).

It is, therefore, essential to explore the existing dairy production environment, analyse constraints of dairy production, and devise pertinent and workable strategies for sustainable market-oriented dairy development in the country (Tegegne and Gebrewold, 1998). 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 (Azage *et al*., 1994; Tewodros, 2008). The most favored alternatives in this regard could be incorporating crossbreeding (Local with improved European dairy breeds) scheme and intensification of animal production (Auamuta *et al*., 2006) and shifting of subsistence livestock production systems towards large scale commercial production units (Azage *et al*., 2001). Among other alternatives, commercial and market oriented smallholder urban and peri-urban dairy production systems which keep high-grade cows, have tremendous potential in mitigating the acute shortage of dairy products in major urban centers in Ethiopia.

However, for these systems to develop and flourish and to ensure their sustainability, the constraints with the systems need to be addressed (Wudu, 2004). Animal diseases are therefore, among the technical and technological constraints for the peri-urban and urban dairy production systems (Tegegne and Gebrewold, 1998; Belihu, 2002).

Urban and peri-urban dairies which keep high grade- cows are intensive production systems, which are usually associated with reproductive inefficiency, poor survival rate, high calf morbidity and mortality, increased susceptibility to disease like mastitis, lameness, pneumonia and ketosis (ILCA, 1994; Eneyew *et al.*, 2000). About 70% of cumulative survival rate for calves was reported in intensive commercial dairy farms in and around Addis Ababa (Asseged and Birhanu 2004), this report emphasized that calf survival is a matter of serious concern in these types of dairy farms.

The health of replacement calves is an important component of total dairy operation profitability (Razzaque *et al.*, 2009), as the dairy heifer calf is the foundation of the future milking herd (Fox, 2007). Furthermore, high incidence of calf morbidity and mortality incurs great economic loss to dairy producers associated with death loss, treatment cost, decreased lifetime productivity and survivorship (Waltner-Toews *et al.*, 1986a) and limit dairy herd expansion and genetic selection (Mellado *et al.*, 2014).

In the past, many epidemiological studies have been conducted worldwide to document the magnitude of calf morbidity and mortality with causes and associated risk factors. The problem is more acute in developing countries; calf mortality rates 0-1 year can go as high as 50 % in the tropics due to bad management, poor adaptation of exotic breeds to the prevailing tropical environment and endemic diseases (Radostitis *et al.*, 1994). In general, calf mortality in Ethiopia is range from 7 to 30.7% (Amoki, 2001; Lemma *et al.*, 2001; Shiferaw *et al.,* 2002; Amuamuta *et al.*, 2006; Wudu *et al.*, 2008; Bekele *et al.,* 2009; Yeshwas *et al.*, 2014).

Calf diseases that cause morbidity and mortality are the results of complex interaction of the management practices and environment, infectious agents and the calf itself (Wudu, 2004; Klein-Jöbstl *et al*, 2014). Diarrhea in neonatal period and pneumonia in older calves are known to be responsible for most of calfhood morbidity and mortality (Agerholm *et al.*, 1993; Olsson *et al.*, 1993; Sivula *et al.*, 1996b; Svensson *et al.*, 2006).

Similar findings were reported from Ethiopia (Hussen, 1998; Amoki, 2001; Lemma *et al.*, 2001; Shiferaw *et al.*, 2002; Wudu *et al.*, 2008; Yeshwas *et al.*, 2014). Different researchers have investigated numerous determinant factors in calf morbidity and mortality (Svensson *et al.*, 2006; Lombard *et al.*, 2007; Wudu *et al.*, 2008; Gulliksen *et al.*, 2009; Azizzadeh *et al*, 2012; Barrier *et al.*, 2013a b; Windeyer *et al.*, 2014). By far, the greatest factor contributing to mortality of pre-weaned calves is failure of passive transfer (FTP), associated with 39 to 50% of pre-weaned calf mortality (Margerison and Downey, 2005).

There is an established fact that calf health and performance improvements in small-holder peri-urban and urban dairies can be achieved through development and application of sound dairy calf health and management practices. However, in developing and applying such intervention techniques, knowledge of descriptive epidemiology, risk factors associated with calf morbidity and mortality are required (Sivula *et al.,* 1996; Radostitis, 2001). In this regard, there are few published reports available in Ethiopia. Except few reports (Bekele *et al.,* 2009; Wudu *et al.*, 2008), those few studies were mostly done on government ranches and research centers, which are less relevant to the smallholder farming system, though this production system is the predominant one in the country.

Except one study done based on herd level cross-sectional questionnaire in Gozamen and Bahir Dar Zuria districts (Yeshwas *et al.*, 2014), so far, no reliable estimates found on the incidence of calf morbidity and mortality with detailed epidemiological analysis of risk factors in urban and peri-urban dairy production systems of Amhara Region in general and Bahir Dar Milk-shed in particular. Thus, there is a need to conduct exhaustive study in order to devise tailored recommendations to improve calf health and production performances in the study areas. Therefore, having all the above background, this longitudinal prospective study is conducted in Bahir Dar milk-shed with the following objectives;

- To determine the incidence rate of calf morbidity and mortality in pre-weaned dairy calves
- To investigate the potential risk factors of calf morbidity and mortality
- To determine passive transfer of immunity in some selected dairy calves

# 2. LITRATURE REVIEW

## 2.1. Overview of the Ethiopian Dairy Production System

As documented by Yitaye (2008), based on climate, land holdings and integration with crop production as criterion, three major dairy production systems are recognized in Ethiopia (Gebrewold and Alemu, 1998; Eneyew *et al.*, 2000; Sintayehu *et al.*, 2008). The first one is the urban dairy production system involving from smallholder to highly specialized dairy farms, found in major cities, including regional and district towns. These dairy farmers have no access to grazing land and hence, feeding is mainly depending on industrial bi-products. The second one is the peri-urban dairy production system which is found the outskirts of the capital city, regional cities, zonal and district towns. It includes commercial to smallholder dairy farms holding crossbred animals ranging from F1 (50 %) up to animals with a higher blood level of exotic breeds (mainly Holstein Friesian). The third one is the rural dairy production system which is part of the subsistence farming, and includes pastoralists, agro-pastoralists, and mixed crop–livestock producers.

## 2.2. The Calf and Peculiar Features of its Body and Immune System

As quoted from Wudu (2004), calf refers to the age group of young cattle from birth to six or nine month of age (West, 1995). Elsewhere it was defined as cattle up to six month of age after which in natural circumstances, it might be expected to be self-sufficient (Webster, 1984). The term calf, in less intensive system of production, may generally include cattle older than the age indicated in the above definitions. The proportion of calves weaned before six months of age increases from less intensive to more intensive systems of production (ILRI, 1996).

### 2.2.1. Features of the calf's body system

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 (Wudu, 2004).

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As soon as birth, a calf's gastrointestinal tract is designed to temporarily allow the absorption of large molecules including antibodies ("immunoglobulins") from the small intestine (Arnold, 2014).

Pre-weaned calves have physiologically monogastric type stomach. For the newborn calves, the presence of milk in the rumen and reticulum is considered to be abnormal and is undesirable from a physiological and nutritional standpoint. Hence, it is most important that esophageal groove closure occur prior to liquid feeding. As a result, the liquid feed (milk and milk replacer) flows through the closed esophageal groove bypassing the fore-stomach and flow directly into the abomasum for digestion (Blowey, 1990; Costello, 2010). There are also certain alterations in the digestive system of newborn calves. There is delay in acid secretion from stomach and in the development of pancreatic function; thus acid and trypsin digestion of protein is not started. For instance, calves less than one month of age lack sufficient post-ruminal digestive enzymes to break down most sugars and are limited in their ability to utilize starch, maltose, sucrose, or dextran (Heinrichs *et al*., 2007).

### 2.2.2. The calf immune system

The newborn calf's immune system is functional but immature (Gorden and Plummer, 2010). The complement level is about one-third of normal, B-cells are not yet at an adult level, and neutrophil function and its ability to phagocytize are not complete. Immune system development is a graded response that starts in the first trimester then begins to flatten out around puberty. 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 (Arnold, 2014).

## 2.3. The Colostrum and its Role to Newborn Calves

### 2.3.1. Colostrogenesis and colostrum composition

Colostrum is the first lacteal secretion of the mammary gland prior to and after parturition. Bovine colostrum consists of a mixture of lacteal secretions and constituents of blood serum, most notably Ig and other serum proteins, which accumulate in the mammary gland during the

prepartum dry period (Foley and Otterby, 1978). Important constituents of colostrum include Ig, maternal leukocytes, growth factors, hormones, cytokines, nonspecific antimicrobial factors, and nutrients (Godden, 2008). Maternal colostrum contains several different types of immunoglobulins 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 (Arnold, 2014). Concentrations of many of these components are greatest in the first secretions harvested after calving (first milking colostrum), then decline steadily over the next six milking (transition milk) (Foley and Otterby, 1978).

*2.3.2. The role of colostrum to newborn calves*

During gestation, in humans antibodies can pass from the maternal side to the fetus, but the placenta of the cow effectively separates the blood of the fetus from that of the dam and prevents any transfer of protective immunity while in the uterus. As a result, calves are born with no circulating antibodies to combat infection (Bath *et al.,* 1985). Therefore, the calf is born completely dependent on the absorption of maternal antibodies from colostrum after birth (Gorden and Plummer, 2010; Arnold, 2014). 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 (Trotz-Williams and Leslie, 2008; Arnold, 2014; Windeyer *et al.*, 2014). Therefore, early and adequate consumption of high quality colostrum during the first 24 hours after birth is considered the single most important management factor in determining health and survival of the neonatal calf.

2.3.2.1. Failure of passive transfer of immunity (FPT)

Failure of passive transfer of immunity in calves is defined as a blood IgG level of less than 10 mg/mL at 24 hours after birth (Godden, 2008; Jones and Heinrichs, 2011; Arnold, 2014) or serum protein levels less than 5.2 to 5.5 g/dL (Naylor and Kronfeld, 1977). 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 (Arnold, 2014). The major factor affecting the absorption of Ig molecules into circulation is the quickness after birth, with which the first colostrum feeding is provided (Godden, 2008).

Birth weight, sex, seasonal influence, stress and use of colostral supplements also affect passive transfer of colostral immunity from dam to the neonatal calf (Sangwan *et al.,* 1985; Aldridge *et al.,* 1992).

Survival of calves with inadequate serum immunoglobulin concentrations is reduced, compared with calves having acceptable levels of immunity (Lang, 2008) (Fig. 1).
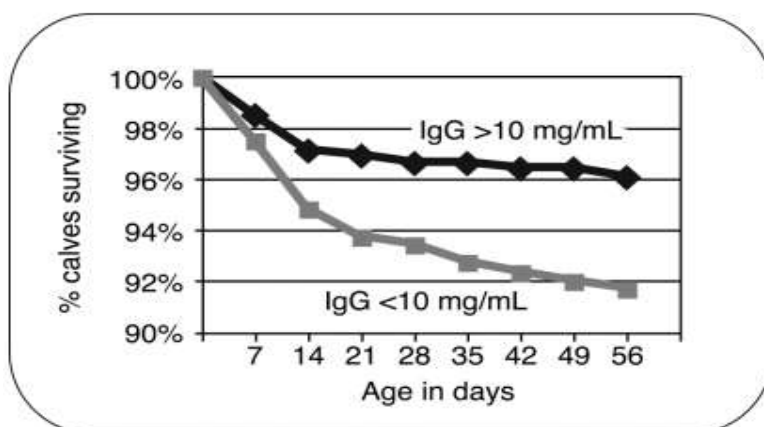


Figure 1. Survival of calves associated with serum immunoglobulin concentrations

2.3.2.2. Methods of serum IgG concentration measurement

Failure of passive transfer of immunity can be diagnosed with a blood sample drawn between 24 and 48 hours of age. The presence of FTP in calves is usually determined directly by measuring the concentration of IgG in the calf's serum using either an ELISA test or radial immunodiffusion (RID), or indirectly by measuring serum total protein (STP) by refractometer (Wallace *et al*., 2006; Trotz-Williams *et al*., 2008; Doepel and Bartier, 2014). Turbidimetric immunoassay (TIA) by using Sodium sulfite or Zinc sulfate turbidity has been found to be an accurate method of analyzing IgG in serum (Quigley *et al*., 2013).

## 2.4. Morbidity and Mortality in Dairy Calves

### 2.4.1. Economic significance of calf morbidity and mortality

Healthy calves form the basis of any successful cattle production system, from both an economic and an animal welfare point of view (Gulliksen *et al*, 2009).

More importantly, rearing of dairy or beef calves for replacement or sale is an important source of income for dairy herd manager (Azizzadeh *et al*., 2012). Furthermore, milk production depends on calf survival, as local Zebu (*Bos taurus indicus*) and N'Dama (*Bos taurus taurus*) cows often need the stimulus of their suckling calf for milk letdown (Wymann *et al*., 2006). Even the risk of mastitis is lower in suckled cows than not suckled (Alvarez *et al*., 1980). In spite of fact that, the most significant loss in the dairy or beef enterprises is calf mortality. High incidence of calf morbidity and mortality incurs great economic loss to dairy producers. This arises from death loss, treatment cost, limits genetic selection, decreased lifetime productivity and survivorship (Waltner-Toews *et al*., 1986b; Mellado *et al*., 2014).

As described by Ortiz-Pelaez *et al*. (2008), according to the UK Department of Environment, Food and Rural Affairs, it is estimated that up to 6% of the calves born in the UK die before they reach 6 months of age, at a cost to the industry of about £60 million per annum. The annual costs of gastrointestinal problems and respiratory disease were estimated to be $33.46 and $14.71 per pre-weaned calf at risk of disease (Windeyer *et al*., 2014). Calf mortality rate of 20% can reduce net profit by 38%. Therefore in a profitable dairy farm, calf mortality rate should be kept below 5% (Alemu and Teshome, 1987; Kifaro and Timba, 1990).

### 2.4.2. Major causes of calf morbidity and mortality

Several studies have been conducted in the past from many parts of the world using both retrospective and prospective data sources to document major causes of calf mortality (Gitau *et al*., 1994; Gitau *et al*., 1999; Wymann *et al*., 2006; Wudu *et al*., 2008; George *et al*., 2010). The above studies have reported the major causes of calf mortality and the associated risk factors. The leading causes of calf morbidity and mortality reported worldwide are diarrhea (scours) and respiratory diseases (Waltner-Toews *et al*., 1986a,b; Gitau *et al*., 1994; Mulei *et al*., 1995; Gitau *et al*., 1999; Wymann *et al*., 2006; Wudu *et al*., 2008; George *et al*., 2010; Hussain, 2011).

### 2.4.2.1. Calf Diarrhea

Diarrhea is a complex multifactorial disease in which numerous infectious and noninfectious factors are involved. Diarrhea or scouring is the commonest disease and the greatest single cause of neonatal mortality during the first week of life and this risk decreases with age (Waltner-Toews *et al.*, 1986a; Sivula *et al.*, 1996a; Wudu *et al.*, 2008) and result great economic loss with high morbidity and mortality in the cattle industry worldwide (Torsein *et al.*, 2011; Cho *et al.,* 2013; Klein-Jöbstl *et al,* 2014). Calf diarrhea accounts for approximately 75% of the mortality of dairy calves aged below three weeks of age (Blowey, 1990). The incidence risks of diarrhoea in calves < 30 days old vary between 15 and 20% (Lorino *et al.*, 2005) and the mortality risk of diarrhea was between 1.5–8% (Quigley *et al.*, 1995).

As documented by Cho *et al.* (2013), calf diarrhea has been commonly attributed to bovine rotavirus group A (BRV-A), bovine coronavirus (BCoV), bovine viral diarrhea virus (BVDV), *Salmonella spp*. *Escherichia coli* (E. *coli*) K99, *Clostridium perfringens type C* and Cryptosporidium parvum (*C. parvum*). However, various authors indicated that bovine rotavirus group A (BRV-A), bovine coronavirus (BCoV), Salmonella spp. Escherichia coli (*E. coli*) K99 and *Cryptosporidium parvum* were the most commonly reported causes of neonatal calf diarrhea (Reynolds *et al*, 1986; Snodgrass *et al.*, 1986; Abraham *et al.*, 1992; Hussain, 2011). These organisms are responsible for the vast majority (75-95%) of enteric infections in neonatal calves worldwide (Tzipori, 1985). Nevertheless, recently, bovine norovirus (BNoV), Nebovirus, bovine enterovirus (BEV) and bovine torovirus (BToV) have been identified as emerging causes of calf diarrhea (Cho *et al.*, 2013).

Because of the large number of etiological agents involved, the prevention of neonatal diarrhea in calves is difficult. However, prevention approaches should be centered on management factors (Lorino *et al.*, 2005).

### 2.4.2.2. Calf Pneumonia (Enzootic Pneumonia)

Enzootic pneumonia of calves refers to infectious respiratory disease in calves. It is primarily a problem in calves <6 month old with peak occurrence from 2–10 wk, but it may be seen in calves up to 1 yr of age (Campbell, 2012). Nevertheless, Heinrichs and Radostits, (2001), 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 more common in dairy than in beef calves and is a common problem in veal calves (Campbell, 2012).

A multitude of environmental and management factors and their interactions are responsible for the occurrence of calf pneumonia (AHI, 2012). It is caused by one or more of a whole range of organisms, including bacteria (like *Pasteurella multocida*, *Manhaemia haemolytica*, *Hemophilus somnus*, *Actinomyces pyogenes*), virus (like Respiratory syncytial virus, Para infulenza virus type 3 and infectious bovine rhinotracheitis virus (IBR) and bovine corona virus (BCV)) and *Mycoplasma* (*M. bovis*, *M. dispar*) (Sivula *et al*., 1996b; Smith, 2005; Autio *et al*., 2007; Hussain, 2011; AHI, 2012; Campbell, 2012). Partial or complete failure of passive transfer of maternal antibodies is an important host factor related to development of pneumonia in young calves (Campbell, 2012; Windeyer *et al*., 2014).

The main environmental factor predisposing calves to respiratory disease is poor ventilation in calf housing (Hussain, 2011). It is also more common in housed dairy calves than in those raised outside in hutches (Campbell, 2012). Furthermore, cold, humid conditions, sudden changes in air temperature, stress due to different causes from environmental and management factors, overcrowding, and nutritional factors such as poor quality milk replacers predisposed calves to respiratory diseases (Hussain, 2011; Campbell, 2012). Calves that have suffered from scour (diarrhea) are more likely to develop pneumonia later in life (AHI, 2012).

2.4.2.3. Navel Ill (Omphalitis)

Navel infection (Omphalitis) is an inflammation of the umbilicus. Omphalophlebitis, omphaloarthritis, and urachitis are terms used further describe the extension of inflammation or infection from the external umbilicus to the intra-abdominal segment of the umbilical vein, umbilical arteries, and urachus respectively (Kasari, 1993). Survey on the incidence of umbilical infection showed that the age of calves for its occurrence is usually in the first week of life (Virtala *et al*., 1996),  2-5 days after the birth of calf (Ganga *et al*., 2011) and can often become a chronic debilitating problem in newborn calves.

In omphalophelebitis and omphaloarteritis, the clinical findings are enlarged umbilicus with purulent material, chronic toxemia, unthriftiness (Ganga *et al*., 2011). The most frequently isolated pathogen from navel ill is *Actinomyces pyogens* in mixed infection with other bacteria usually *E .coli* (Kasari, 1993) and others include *Streptococcus sp*, *Pasturella sp* and Chlamydia. Infectious agents can enter the body through the umbilicus, after contact with dirt and infected material (Ganga *et al.,* 2011). Unhygienic conditions at birth and after birth and bruising around the naval are predisposing factors for naval ill (Cattle health fact sheet, 2013).

### 2.4.2.4. Septicemia

Septicemia is also known as bacteremia or blood poisoning. It occurs when a pathogen or its toxins are present in the calf's blood. It is another possible sequella to failure of passive transfer and remains a major cause of mortality in calves less than 14 days of age (Smith, 2005; Hussain, 2011). Initial clinical signs can include progressive lethargy, depression and in appetence (Smith, 2005). 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 (Hussain, 2011).

### 2.4.2.5. Vector-borne diseases and Helminths

Some authors have been reported the importance vector borne diseases and Helminths associated with calf morbidity and mortality in Africa. For instance, East Coast fever (ECF), Trypanosomosis, Anaplasmosis and Babesiosis were the major reported causes of calf morbidity and mortality in Kenya, Mali and Tanazania (Muraguri *et al*., 2005; Wymann *et al*., 2006). In Kenya, the incidences of East Coast fever (ECF) (23.1%) and trypanosomosis (29.1%) were the highest among the vector-borne diseases. The corresponding mortality incidence rates of ECF and trypanosomosis were 10.9 and 3.6%, respectively (Muraguri *et al*., 2005)**.**

In Tanzania, of the total deaths, 56% were attributed to Tick Born Diseases (37.5% by East Coast fever (ECF) and 18% by anaplasmosis) (Wymann *et al*., 2006). Furthermore, calf helminthosis and coccidiosis were reported from Ethiopia as causes of morbidity in grazing calves (Bekele *et al*., 2009; Darsema, 2009; Yeshwas, 2013).

2.4.2.6. Other miscellaneous causes

Other some diseases of calves include arthritis, bloat, arthropod parasites and nutritional diseases (like inadequate intake of energy, protein, vitamins, and mineral) and immunodeficiency (Heinrichs and Radostits, 2001; George *et al*., 2010). Tympani and milk indigestion also play an active role in the neonatal calf mortality (Khan and Khan, 1991).

*2.4.3. Reported causes of calf morbidity and mortality in Ethiopia*

Most frequently reported causes of dairy calf morbidity and mortality in Ethiopia include calf diarrhea, calf pneumonia, omphalaitis, septicemic condition, gastrointestinal parasites, joint ill, skin disease (Gryseels and de Boodet, 1986; Hassen and Brannag, 1996; Amoki, 2001; Lemma *et al*., 2001; Shiferaw *et al.,* 2002; Wudu *et al*., 2008; Yeshwas *et al*., 2014). Most of these studies showed calf diarrhea and calf pneumonia were the leading causes in younger calves and gastrointestinal parasites in older calves.

However, there is paucity of information done on identification of specific agents involved in disease syndromes associated with morbidity and mortality. The reason why scarce information in this regard could be due to logistical difficulties, as the process of identifying specific disease etiologies require intensive monitoring of study animals, timely submission of samples, laboratory facility, and all these activities are expensive. In this respect, among very few studies conducted, Abraham *et al*. (1992), tried to identify specific infectious agents associated with neonatal diarrhea in Ethiopian dairy calves. They found bovine enteric corona virus, group A rotavirus and K99 Enterotoxogenic *E. coli* independently or in combination in diarrheic calves. Bovine enteric coronavirus was the most frequently detected pathogen followed by rotavirus.

Salmonella was detected in diarrheic calves and was responsible for the death of calves in different parts of the country (Pergram *et al*., 1981). Hussien (1998) and Simachew (1998) have also isolated *E. coli* from diarrheic calves, but as explained by Wudu (2004), this study did tell little about the significance of the isolated bacteria to the causation of the disease. This is because most *E. coli* strains are normal flora of gastrointestinal tract of mammals and the strain causing with ability of causing disease should be identified before incriminating them as the causes.

## 2.5. Epidemiology of Calf Morbidity and Mortality in Dairy Calves

### 2.5.1. Global picture of calf morbidity and mortality

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 (Dohoo *et al*., 2003). According to Heinrichs and Radostitis (2001), calf mortality can be divided into the following 4 groups according to age at time of death: abortions or prenatal deaths (stillborn from 40 to 270 d of gestation), perinatal mortality (stillborn after 270 d of gestation or until 24 h after birth), neonatal mortality (death between 1 and 28 d of age), and older calf mortality (death between 1 and 6 months of age).

Most of the time, morbidity statistics of dairy calf are not available, when available are not as reliable as those in mortality because they depend on the producers' diagnosis, amount of time spent observing the animal, degree of illness expressed by the animal, and tendency of producers not to record every illness event (Bruning-Fann and Keneene, 1992 ). Nevertheless, some authors reported crude and specific morbidities (Waltner-Toews *et al*., 1986a; Debnath *et al*., 1990; Razzique *et al*., 2001; Svensson *et al*., 2006; Wudu *et al*., 2008 ; Gulliksen *et al*., 2009; Yeshwas *et al*., 2014) from different areas.

Generally, the magnitude of calf hood morbidities and mortalities are variable from year to year and location to location. Differences in reported morbidity and mortality rate may be influenced by many calf and herd-level risk factors, as well as case definition, age of the calves, study design and agro-ecology (Windeyer *et al*., 2014). Despite considerable variation, mortality rate in well managed dairy calves in temperate climates usually ranges from 8% to 12% (Svensson *et al*., 2006; Lombard *et al*., 2007; Magalhaes *et al*., 2008; Torsein *et al*., 2011). As documented by Azizzadeh *et al* (2012), relatively lower calf mortality rates have been reported, 3% in Sweden (Svensson *et al*., 2006), 5% in Norway (Gulliksen *et al*., 2009) and 2–6% in Britain (Ortiz-Pelaez *et al*., 2008), 6.3% in USA (Wells *et al*., 1996), 4.6% in the Netherlands (Perez *et al*., 1990), 2.8% in New York (Curtis *et al*., 1988), and 3.8% from Ontario (Waltner-Toews *et al*.,1986a). However, higher estimates of calf mortality have been reported, for instance, 14% of overall mortality was reported from a hot-arid environment of northern Mexico (Mellado *et al*., 2014), 34% from birth to 1 year of age among Jersey calves

in India (Raina *et al*., 2001). As described by Razzaque *et al* (2001), in Kuwait, much higher mortality rate, as high as 90% (mean 43%) was recorded.

### 2.5.2. Calf morbidity and mortality in Africa

From African continent, wide range (6-47%) of calf mortality rates (0−12 months) has been reported by several researchers (Table 1).

Table 1. Calf mortality rates (0-12 months) compiled from different parts of Africa

| Country | Management type | Mortality rate (%) | References |
| --- | --- | --- | --- |
| Ethiopia | Smallholder/intensive | 22 | Wudu *et al.* (2008) |
| Mali | Traditional and modern | 17 | Wymann *et al.* (2006) |
| Tanzania | Smallholder | 12 | Swai *et al.* (2009) |
| Kenya | Smallholder | 15.8 | Muraguri *et al.* (2005) |
| Burkina Faso | Traditional/village | 6 | Ganaba *et al.* (2002) |
| Zimbabwe | Smallholder | 35 | French *et al.* (2001) |
| Côte d' Ivoire | Traditional | 19 | Knopf *et al.* (2000) |
| Mali | Traditional/nomadic | 19-47 | Wagenaar *et al.* (1986) |
| Mali | Traditional/village | 13 | Traoré & Wilson (1988) |
| Nigeria | Traditional/village | 46 | Kudi *et al.* (1998) |
| Senegal | Traditional/Village | 12 | Fall *et al.* (1999) |
| Gambia | Tradational/Village | 8-21 | Zinsstag *et al.* (1997) |

Modified from Wymann *et al.*, (2005)

### 2.5.3. Calf morbidity and mortality in Ethiopia

When compared to other countries, information on calf morbidity and mortality is scarce in Ethiopia. This could be due to unavailability and unreliability of farm records on illnesses. In Ethiopia most studies on calves reported mortalities. Except some authors, Wudu *et al.* (2008), 62% crude morbidity rate, Bekele *et al.* (2009), 29.3% crude morbidity rate and Yeshwas *et al.* (2014), 58.4% crude calf morbidity, most other reports have covered specific morbidities. For instance, Shiferaw *et al.* (2002), reported a 6-month cumulative incidence of scour (42%) and respiratory disease (38%).

In small-holder dairy farms in Ada 'a Liben district of Oromia, the most frequent disease syndrome was calf diarrhea with the incidence rate of 42.9 % followed by pneumonia (4.9%) (Wudu, 2004). Diarrhea (21.4%), pneumonia (18.6%), septicemic conditions (12.4%) and navel ill (8.1%) were reported in pre-weaned crossbred calves in Bahir Dar Zuria and Gozamen Districts (Yeshwas *et al*., 2014). Calf scour (19.0%) and enzootic pneumonia (9.2%) were the main causes of calf mortality followed by infections associated with navel ill (8.3 %) at Andassa ranch (Amuamuta, 2006). The most frequent disease syndrome was diarrhea with incidence rates of 10% followed by septicemia (6.4%) (Bekele *et al*., 2009).

Mortality statistics in Ethiopia mostly, ranges from 7 to 30.7% in pre-weaned calves (Sisay and Ebro, 1998; Shiferaw *et al*., 2002; Wudu *et al*., 2008; Bekele *et al*., 2009; Yeshwas *et al.,* 2014). However, few authors reported mortality rates over the above range (Hassen and Brannag, 1996; Gryseals and de Boodet, 1986). Mortality rates and proportions reported from different parts of Ethiopia are summarized in Table 2.

Table 2. Calf mortality rates compiled from different studies in Ethiopia

| Study area | Age of the calf | Mortality rate (%) | References |
|---|---|---|---|
| Andassa ranch | Pre-weaning | 6.5 | Amuamuta *et al*. (2006) |
| Holleta | Pre-weaning | 7 | Shiferaw *et al*. (2002) |
| Around Holetta | Pre-weaning | 14.2 | Amoki (2001) |
| - | Pre-weaning | 25 | Sisay and Ebro (1998) |
| - | Pre-weaning | 15 | ILRI (1996) |
| Ada Berga farm | - | 53 | Hassen and Brannang (1996) |
| Adamitulu | Up to 6 months | 17.5 | Hussien (1998) |
| Debre Zeit area | 2 years | 67 | Gryseels and deBoodet (1986) |
| Ada'a Liben district | Up to 6 month | 22 | Wudu *et al* (2008) |
| Gozamen & B. Zuria | Pre-weaning | 30.7* | Yeshwas *et al*. (2014) |
| Abernosa ranch | Pre-weaning | 17.3* | Ababu *et al*.(2006) |
| Hawassa town | - | 9.3* | Bekele *et al*. (2009) |
| Highland of Arsi | - | 11.5-16.7* | Bulale (2000) |

*=mortality proportion

*2.5.4. Determinants of calf morbidity and mortality*

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

2.5.4.1. Calf associated risk factors

Age of the Calf

The age of the calf is the most important determinant factor affecting calf morbidity and mortality (Waltner-Toews *et al.*, 1986b; Virtala *et al.*, 1996; Wudu *et al.*, 2008). A high proportion of calf death occur in the first week of life (Svensson *et al.*, 2006; Gulliksen *et al.*, 2009). Approximately 60-75% of the mortality in calves occurs in the first month of their life in dairy animals (Waltner-Toews *et al.*, 1986a; Heinrichs and Radostits, 2001). Analysis of survival times to death indicated that calves < 6 months of age had higher death rates than older calves (Swai *et al.*, 2009). 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 3 month of life (Gryseels and de Boodet, 1986).

Breed and exotic 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 (Wudu, 2004). Higher calf mortality in exotic breeds than locals has been reported (Hailemariam *et al.*1993a) and dairy breeds had higher perinatal mortality rates than beef breeds (Bleul, 2011).

High exotic blood level was found to have a significant effect on increased calf mortality rate (Gryseels and de Boodet, 1986; Debnath *et al.*, 1990; Ababu *et al.*, 2006; Swai *et al.*, 2010; Yeshwas *et al.*, 2014). This might be due to the susceptibility of B. taurus breeds to climatic and disease stress in tropical environments (Debnath *et al.*, 1990; Wudu *et al.*, 2008; Swai *et al.*, 2010). Hence keeping crossbred dairy cows of the intermediate exotic blood (62.5% -75%, Friesian inheritance) is suggested for better health and production (Yahya *et al.*, 2011) and

further grading up above 75% towards the Bos taurus breed has given variable and often disappointing results (Ababu *et al.,* 2006).

Sex of the calf

Several researchers have reported that mortality rate is differed between sexes of calf. The mortality rate was significantly higher in male than female calves (Sangwan *et al*., 1985; Debnath et *al*., 1990; Khan and Kahan, 1991; Perez*et al*., 1990; Amuamuta *et al*., 2006; Silva del Rio *et al*., 2007; Lombard *et al*., 2007; Bleul, 2011; Mellado *et al*., 2014). Incidence of dystocia and still birth also are higher in male calving (Patterson *et al*., 1987; Bleul, 2011). Moreover, male calves had greater odds of poor vigor (score based on capacity to nurse) than female calves (Riley *et al*., 2004). Reasons for this higher mortality in male calves might be due to less colostral immunoglobulin absorbed in male than female during neonatal life (Sangwan *et al*., 1985). 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 (Mellado *et al*., 2014).

Birth weight

The most common cause of dystocia is excessively large calf birth weight (Lombard *et al.,* 2007). The threshold for calf bodyweight in Holsteins lies between 42 and 45 kg. If calf weight increases above 45 kg, the rate of dystocia increases significantly (Johanson and Berger, 2003). Calves which survive dystocia experience lower passive immunity transfer, reduced protection against neonatal diseases and higher mortality and physiological stress (Vermorel *et al*., 1989; Hussain, 2011; Barrier *et al*., 2013b). However, a contradict report has been found (Amuamuta *et al*., 2006), birth weight is negatively correlated with cumulative mortality rate and calves with lower birth weights have also poor vitality and survival ability (Debnath *et al*., 1990; Lopez, 1985).

Calf's vigor and health

The cow's pre-calving energy and protein levels affect calf vigor and survival (Wren, 1996). A calf's voluntary intake of colostrum is mainly predictable by birth weight and the calf's vigor (Vasseur *et al.,* 2009).

Prolonged parturition affects the calf's health and vigor (Sivula *et al.*, 1996b). Thus, vigor and health of the calf at birth is highly correlated to morbidity and mortality (Heinrichs and Radostits, 2001; Vasseur *et al.*, 2009). Poor vigor at birth increases odds of death and delayed suckling or lower colostrum intake (Vasseur *et al.*, 2009). Severely acidotic calves as a result of difficult labor had a 52% decrease in colostrum intake (Besser *et al.*, 1990). Calves that needed assistance during delivery developed enteritis at an earlier age than those born without assistance (Sivula *et al.*,1996a).

2.5.4.2. Dam associated factors

Parity and age of calving

Incidence of dystocia and still birth are higher in primiparous dams than multiparous dams (Khan and Khan., 1991; Gulliksen *et al.*, 2009). Furthermore, immune status is better in calves from multiparous than primiparous dams; this could be due to insufficient or lower concentration of colostrum from first lactating heifers (Tayler *et al.*, 1999; Lundborg *et al.*, 2003). The risk of developing calf diarrhea is higher in calves of first calving cows (Perez *et al.*, 1990).

Age of the dam was also identified as a risk factor for calf mortality (Bleul, 2011; Steinbock *et al.*, 2003), calves born to young heifers had a significantly higher perinatal mortality rate than calves born to older cows. 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 (Bleul, 2011). Older cows tend to have more IgGs than first calf heifers, as they have been exposed to a greater number of pathogens during their lifetimes (Arnold, 2014).

Breed and dry period

Breed of the dam also affects the quality and concentration of colostrum. For example, beef cattle breeds have higher immunoglobulin concentration than Holsteins and among dairy breeds; it is higher in Holstein than in Guerency (Tyler *et al.*, 1999). Length of the dry period was risk factor for respiratory disease in the calves (Lundborg *et al.*, 2003). The relative risk of respiratory disease was higher in calves born to cows with a short dry period than in calves born to cows with an average or long dry period, perhaps because of lower concentrations of

IgG in the colostrum (Logan *et al*., 1981). A minimum of 40 days and a maximum of 90 dry days resulted in best quality colostrum (Besser *et al.,* 1991).

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 (Wudu, 2004). Mastitis during dry period of cows decreases the concentration of IgG, particularly IgG1 in the colostrum of the next lactation. Dam diseases in the period 50-280 days before calving, retained placenta, and mastitis were risk factors for respiratory disease in the calves, emphasizing the importance of the dam health on calf morbidity (Lundborg *et al*., 2003). 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. Despite the mechanism is unclear, a protective effect against calf death was seen for those calves whose dams were injected with vitamin A-D-E during pregnancy (Sivula *et al*.,1996a).

Mothering instinct and presence of the dam

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 (Hussain, 2011). Poor mothering ability combined with reduced calf vigor could decrease the effectiveness of passive transfer (Sivula *et al*., 1996a). Grooming the calf by the cow may reduce stress and blood serum corticosteroid concentration and there by improve absorption (Husband *et al*., 1973). It has also been reported that efficiency of Ig absorption was improved when calves were housed with the dam. However, this practice may increase the calf's risk for exposure to pathogens from the dam or her environment (Godden, 2008).

The length of time for which calves remained with their dams after birth was significantly associated with diarrhea. For instance, a study on dairy farms in Ontario reported, the odds of diarrhea in calves remaining with their mothers for more than 1 h were 39% higher than the odds of diarrhea in those separated from the dam within an hour of birth (Trotz-Williams *et al*., 2007).

As a result, it is currently recommended that the calf be removed from the dam within 1 to 2 hours of birth and then hand fed a known volume of colostrum (McGuirk and Collins, 2004).

Twins birth

Twinning is undesirable in dairy cattle production because of increased calf mortality rates during the first month of life (Gulliksen *et al*., 2009). The risk of perinatal mortality increased significantly in twins compared with singletons (Mee *et al*., 2008 a,b). Calf mortality rate from twin births was five percentage points higher than single birth calves (Mellado *et al*., 2014). Twin births have also been associated with decreased gestation length, increased abortion, increased dystocia, retained placenta, metritis and decreased perinatal viability (Silva del Río *et al*., 2007; Gulliksen *et al*., 2009).

### 2.5.4.3. Managerial risk factors

Managerial risk factors are considered as major determinants of calf morbidity and mortality (Bruning-Fann and Kaneene, 1992; Lance *et al.,* 1992).

Calving management at birth

Calving management has an important effect on calf performance and health (Klein-Jöbstl *et al.,* 2014). The process of assisted calving can be a traumatic and hazardous event in the life of a calf (Leslie, 2012). Ninety per cent of calves that die perinatally are alive at the commencement of the calving process, emphasizing the critical nature of the course and management of the birth process (Mee, 2008b; Barrier *et al.,* 2013a).

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 (Lombard *et al*., 2007; Leslie, 2012). A large number of stillbirth deaths are also attributed to trauma, suggesting either inappropriate timing of assistance or excessive force during delivery (Mee, 2008b; Leslie, 2012). When excessive force is applied during the delivery process, trauma inflicted can affect several body systems including haemorrhages, injuries to the central nervous system, fractures of rib, limb, jaw and pelvic fractures in dams (Leslie, 2012; Barrier *et al*., 2013a). It has been shown that consumption of colostrum in calves with fetal distress is reduced by up to 74% during the first 12 hours after birth (Vermorel *et al*., 1989).

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 (Leslie, 2012).

Colostrum feeding management

The importance of colostrum feeding in relation to neonatal calf morbidity and mortality has been elucidated elsewhere (Waltner-Toews *et al*., 1986a; le Rousie *et al.,*2000; Godden, 2008; Trotz-Williams *et al*., 2008; Wudu *et al*., 2008; Furman-Fratczak *et al*., 2011; Arnold, 2014). There are five major components to colostrum and its management that are key to a calf achieving adequate immunity: time of feeding, quantity, quality, cleanliness and method of feeding (Doepel and Bartier., 2014).

- Time to first colostrum ingestion

The most important factor affecting Ig absorption efficiency is the age of the calf (Godden, 2008). Time between birth and the first feeding is the prime factor for the failure of passive transfer of colostral immunity. The efficiency of Ig transfer across the gut epithelium is optimal in the first 4 hours postpartum, but after 6 hours there is a progressive decline in the efficiency of Ig absorption over time (Michanek *et al*., 1989). Delaying the first colostrum feeding can only slightly postpone gut closure (36 hours). Producers should aim to feed all calves within 1 to 2 hours after birth and by 6 hours at a maximum (Godden, 2008).
Studies showed that calf mortality is significantly higher in calves that got colostrum late after birth than those that got colostrum soon after birth (Bruning-Fann and Kaneene, 1992; Wells *et al*., 1996). Each hour of delay within the range of 1 to 12 hours after birth increased the risk of illness by 10% (Olsson *et al.,* 1993).

- Quantity

Ingestion and absorption of enough quantity (10% to 12% of their body weight) of colostrum during the period shortly after birth is vital to the calf's health and survival (Fallon *et al*., 1989; Werem *et al.*, 2001; Wudu *et al*., 2008; Arnold, 2014).

Therefore, for typical Holstein calves (38.5-40 kg), 4 quarts (3.78 L) of colostrum and for smaller calves such as Jerseys 3 quarts (2.83 L) of colostrum should be fed as soon as possible after birth (Gorden and Plummer, 2010).

- Quality

Colostrum quality is considered to be high if the IgG level is greater than 50 g/L (McGuirk and Collins, 2004; Godden *et al*., 2009; Arnold, 2014). Unfortunately, up to 35% of colostrum contains IgG below this value (Quigley *et al*., 2013), which makes measuring the quality of colostrum before feeding it absolutely essential to ensure calves receive an adequate amount of IgG (Doepel and Bartier., 2014). Many methods have been used to assess the Ig concentration of colostrum (Bielmann *et al*., 2010). Hydrometers often called a colostrometer ® and refractometers (optical or digital brix) can be used on the farm to estimate colostrum IgG, separates high quality colostrum from low quality colostrum (Lang, 2008; Quigley *et al*., 2013; Doepel and Bartier., 2014).

- Method 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 Ig absorption (Godden, 2008). Method of colostrum feeding is also more important factor for failure of passive immunity in calves (Besser *et al*., 1991; Gorden and Plummer, 2010). Colostrum delivered by a nurse bottle or esophageal feeder will result in adequate passive transfer and provides assurance that the calf has consumed an adequate volume (Gorden and Plummer, 2010).

Failure to passive transfer immunity was less frequent in dairies that used artificial feeding either nipple bottle or tube feeding, than in dairies that allow calves to suckle (Besser *et al*., 1991). This is suggested to be due to inability of calves to ingest enough volume of colostrum by suckling, the reason could be due to delay in suckling. Recent studies have found 46-61% of calves fail to suckle in the first 6 hours 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 (Arnold, 2014). As a result, suckling calves had an increased risk of death during the first week of life (Quigley *et al*., 1995).

However, passive transfer can be improved better when suckling supplemented with bottle feeding (Bringole and Stott, 1980).

Feeding after colostrum

To ensure that calves grow well and are not marginally malnourished, they should get a daily amount of at least 13-15% of their birth weight in whole milk or a good quality milk replacer, mixed at 125 g/L water (AHI, 2012). A transition from liquid pre-weaned feed to solid weaned calf feed is also a critical time in feeding calves. If this is not done carefully, the calf will get dietary stress (Blowey, 1990) and has a negative effect on the immune system of the calf leads to a greater risk of developing pneumonia and to other different diseases (AHI, 2012). One study in France reported that calves from herds with no concentrate feeding were at higher hazard of diarrhea (Lorino *et al*., 2005).

Watering

Providing good quality water to calves is crucial, not only for maintaining hydration status but also for adequate rumen development. Research has demonstrated that free-choice water vs. no water available promoted better starter intake, improved ADG, and reduced the incidence of scours (Kertz *et al*., 1984). Partial water deprivation could lead to reduced feed intake, behavioral problems, physiological changes, and an increased concentration of urine and feces (Igbokwe, 1997; Kamphues, 2000). The calf's water requirement might be enhanced by the provision of solid feed in addition to the liquid diet (Gottardo *et al*., 2002).

2.5.4.4. Environmental risk factors

Housing

Different calf housing types have been associated with different rates of calf morbidity and mortality. Naturally ventilated calf housing in all weather conditions, especially during winter, had a positive impact on feed intake and growth rate of young calves (Hill *et al.,* 2007). As documented by Lundborg *et al*. (2003), calves in group pens had a lower average daily weight gain than calves in individual hutches. Group housing increases risk of calf mortality (Waltner-Toews *et al*., 1986b; Olsson *et al*., 1993).

Calves being housed in group pens were associated with an increased risk of respiratory disease, lower age of onset of diarrhea, and more severe cases of diarrhea compared with calves housed in individual pens (Olsson *et al.* 1993; Svensson *et al*., 2006; AHI, 2012).

A study conducted in Kuwait had shown lower mean risk rates of mortality in hutch (open type) housing compared to conventional (closed type) housing (Razzaque *et al*., 2009). In general, morbidity and mortality rates are usually higher in calves housed indoors than outdoors. The increased illness and mortality in calves that are reared indoors is often attributed to a combination of inadequate control of thermal environment, poor air quality, undesirable relative humidity, inadequate exchange of air and poor sanitation (Blowey, 1990 and Wudu, 2004).

Herd Size

A marked increase in population density commonly results in an increase in the incidence of infectious diseases and mortality (Wudu, 2004; Mellado *et al*., 2014). Calf mortality rate was significantly higher in larger herd sizes (Silva del Rio *et al*., 2007; Torsein *et al*., 2011; Mellado *et al*., 2014). The incidence risk of diarrhea was lower with the smallest herd size (Wells *et al*., 1996).

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 (Wudu, 2004).

Season of calving

Season has a significant effect on the calf mortality as well as on the absorption of immunoglobulins in neonatal calves (Khan and Khan, 1991; Wells *et al*., 1996). Calves were suffered with morbidity and mortality and show less performance during winter than other seasons (Bruning-Fann and Keneene, 1992). In temperate climates the mean serum IgG1 concentrations were lowest in winter born calves and increased during the spring and early summer.

Moreover, absorption of Ig may be impaired when newborn calves are exposed to extreme cold, possibly because of direct effects on intestinal absorption and transport and indirect effects on the calf's ability to stand and nurse (Olson et al., 1981). In tropical areas high mortality was reported in hot dry season (Hailemariam *et al*., 1993b) which could arise from shortage of feed in dry season.

Farm ownership and personnel

Personal closeness between the owner and the animal may play an important role for the animal's welfare and health (Wymann *et al*., 2006; Wudu, 2004). Fewer death losses were observed on farms where the owner managed the calves than on farms where employees or hired labor performed the duties (Jenney *et al*., 1981; Britney *et al*., 1984). Low calf mortality was seen in herds owned by older and more experienced managers (Heinrichs and Radostits, 2001). This suggests that owners might be motivated sufficiently to provide the care necessary to insure high survival (Wymann *et al*., 2006).

2.5.4.5. Other risk factors

In calf houses; poor ventilation, poor barn cleanness and bedding management, humidity, dampness, overcrowding, no regular cleaning and disinfection create conditions conducive to a high number of aerosolized organisms, noxious gases and other contaminants that may compromise calf health, leading to high calf mortality (Khan and Khan, 1991; McGuirk, 2003; Wudu *et al*., 2008).

Other managemental and environmental risk factors suspected to affect calf morbidity and mortality include: dam preventive practices by vaccination, the sanitation of calving area, perinatal care, grazing level (whether zero grazing, partial grazing or total grazing), level of herd production, practice of prophylactic antibiotics, weaning age, separation or mixing of calves (Brunning- and Kanene, 1992; Lance *et al*., 1992; Olsson *et al.,* 1993).

## 2.5.5. Risk Factors assessed in Ethiopia

Different researchers in Ethiopia have tried to assess and evaluate different risk factors for calf morbidity and mortality. Among calf related factors, young age and exotic genetic influence (Gryseels and de Boodet, 1986; Hialemariam *et al*., 1993a; Shiferaw *et al*., 2002; Wudu *et al*., 2008), low calf birth weight (Amuamuta *et al*., 2006) and sex (Bekele *et al*., 2009) were found to be associated with higher calf mortality. Among dam factors, parity was found significantly affect calf mortality (Ababu *et al*., 2006).

Different managerial and environmental factors were also reported associated with calf morbidity and mortality. These include: colostral feeding and age at first colostrum feeding, housing, calving assistance, production system, herd size, hygiene of micro-environment, season and geographical location (ILRI, 1996; Simachew, 1998; Amoki, 2001; Shiferaw *et al*., 2002; Ababu *et al*., 2006; Wudu *et al*., 2008; Bekele *et al*., 2009; Yeshwas *et al*., 2014). Cleanness of the calf house was found significantly associated with calf morbidity and diarrhea (Wudu, 2004).

# 3. MATERRIALS AND METHODS

## 3.1. Study Area Description

This study was conducted in urban and peri-urban dairy farms of Bahir Dar Milk-shed, West Gojjam Zone. It includes a total of four administrative districts (Bahir Dar special Zone, Bahir Dar Zuria, Mecha and Yilmana Densa districts) (Fig. 2). In these areas, about half a million smallholder farming households produce milk mostly from indigenous cattle breeds. Average milk production per cow in the Zone is about one liter per day, resulting in an estimated milk production of 46,710,335 liters per lactation form all lactating cows (Assaminew, 2007). The predominant production system in the areas is mixed crop-livestock farming and cattle are the most important livestock species reared in these areas. According to the 2005 report of Department of Agriculture of West Gojam Zone, 1,399,491 cattle, 554,677 shoat and 176,338 equines exist in the zone.

These study sites are areas where crossbred dairying is being promoted by the Regional government through distribution of pregnant crossbred heifers and use of Artificial Insemination (AI) due to the high milk demand and supply variation in the nearby urban and peri-urban centers. Peri-urban and urban commercial and small-holders which keep crossbred dairy cows are flourishing around regional (Bahir Dar), Zonal and District towns

Bahir Dar special Zone

Bahir Dar is the capital city of Amhara National Regional State. It is situated on the southern shore of Lake Tana. The city is located approximately 565 km north-northwest of Addis Ababa, having a latitude and longitude of 11°36′ N 37°23′ E coordinates, and an elevation of 1840m above sea level. Its temperature ranges from 10 to $38^0$ C. The area receives mean annual rainfall of 750mm (DOA, 2000a).

Bahir Dar Zuria District

This district located in the vicinity of Bahir Dar city, situated at an altitude ranging from 1700-2300 meters above sea level. The temperature of the district ranges from 10 to $38^0$C along the year with annual rain fall of 800-1,250mm.

The District has a total population of 182,730, of whom 93,642 are men and 89,088 women. The district has an area of 1,443.37 square kilometers. The livelihood of major section of the population in the area depends on crop- livestock mixed farming. The district comprises 121,528 Cattle, 2,346 Shoats, 37,839 Equine and 62,012 Poultry (Bahir Dar zuria BoA report, 2014).

Mecha District

The area is located about 524 km north-west of Addis Ababa and about 40 km south of Bahir Dar town. The area lies on an elevated plateau ranging from 1800-2500 meters above sea level and has area coverage of 159,898 ha. The area receives an average annual rainfall that ranges from about 820 to 1250 mm. The minimum and maximum daily temperatures of the area are 17 and 30$^{\circ}$C, respectively. The major crops gr own in the area are wheat, barley, millet, teff and maize (DOA, 2000b).

Yilmana Densa District

 It is located at about 40 km in south-east of Bahir Dar 11°10′–11°15′ N and 37°30′–37°40′ E at an altitude range between 1500 to 3000m above sea level. The area receives a mean annual rainfall of about 1270 mm (1051 to 1488mm) which occurs from May to October (ENMA, unpublished).

Generally, study calves in Bahir Dar milk-shed were distributed within the range of 1642 m.a.s.l (Tis Abay) to 2360 m.a.s.l (Adet). The study areas have mean temperature value of 18.6$^{\circ}$c, ranging from 11.54$^{\circ}$c to 32.3$^{\circ}$c and mean humidity of 53% ranging from 35.2% to 74.5% during September, 2014 to April, 2015 (Bahir Dar Metrology office report, 2015).
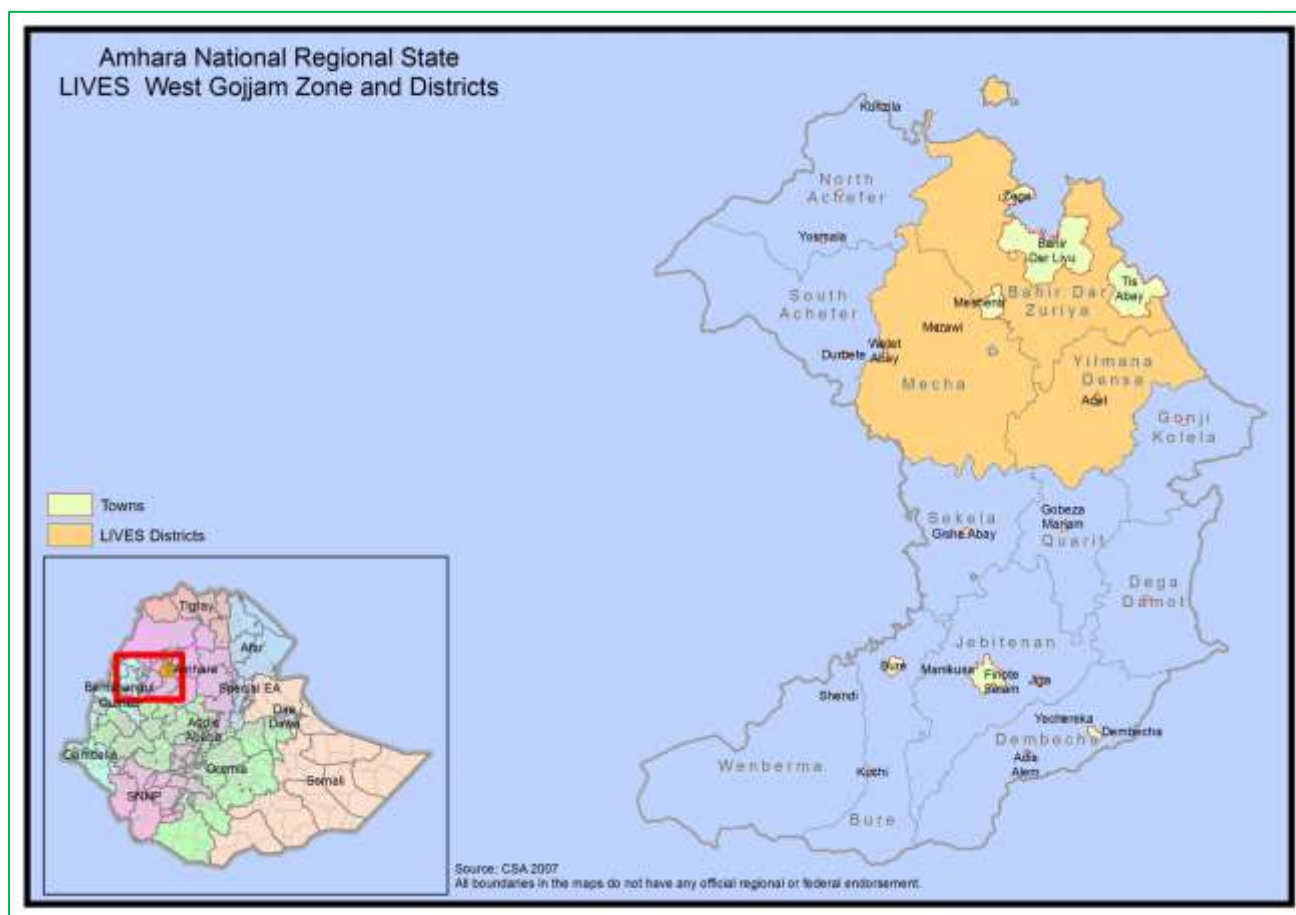
Figure 2. Location map of the study areas

### 3.2. Study Farms

For this study purpose, dairy production systems in the milk-shed were classified as urban and peri-urban. This classification was made based on location, spatial land use and integration with crop production (Tegegne and Gebrewold, 1998; Sintayehu *et al*., 2008; Yitaye, 2008). Dairy farms located in regional city (Bahir Dar), District towns (Adet and Merawi) were considered as urban dairy farms, which encompass from smallholder to highly specialized dairy farms, and are engaged in market oriented dairy production. On the other hand, dairy farms located in the outskirts of the respective city and towns were considered as peri-urban dairy farms. Most of these farms were integrated both crop and livestock. Both local and improved dairy cattle were owned by peri-urban farmers.

Accordingly, a total of 174 study farms, peri-urban (108) and urban (66) were used for this study. Of which, 257 and 183 calves were recruited respectively for the study cohort.

In this study, according to Muraguri *et al*., (2005), a smallholder dairy farm was defined as one with at least 1 and at most 20 cattle of all ages and sexes. Dairy producers who had more than 20 dairy cattle during sampling were categorized as large sized dairy farms. Thus, 169 small-holders and 5 relatively large dairy farms were considered during this study.

## 3.3. Study Population

Both local Zebu and crossbred (Zebu X Holstein Frisian) dairy calves of both sexes reared under small-holder and commercial dairy farms aged between birth to 6 months were the study animals. All calves from dairy farms surrounding the Bahir Dar milk-shed constituted as the study population.

## 3.4. Sampling Technique and Sample Size Determination

Before the commencement of the actual study, preliminary data were sourced from the respective District Agricultural Office and dairy cooperatives to document the lists of small-holder and commercial dairy producers and to estimate the size of study population. Study sites were selected purposively based on their dairy potential. All calves from the five large sized dairy farms namely; Andassa Livestock Research Center, Avallo dairy farm, Bahir Dar University dairy farm, Kobel and Balew dairy farms, and a representative random sample of calves from 169 small-holders were selected for the study. The sampling units were both local and crossbred dairy calves aged between birth and 6 month.

Considering individual members of dairy cooperatives in each study location as a cluster, cluster sampling method was used to select calves from small-holder dairy producers. In this study, sampling frame for study herds was taken from the four dairy cooperatives located in Bahir Dar Zuria district (Tis Abay dairy cooperative, Tikur Abay dairy cooperative and Andinet primary dairy cooperative) and Bahir Dar city (Bahir Dar milk and milk product marketing cooperative). A total of 166 small-holder dairy producers were registered in the four dairy cooperatives.

Accordingly, 83 small-holders were sampled by using systematic random sampling technique (every $2^{nd}$ small-holder) from the documented sampling frame. When a selected small-holder farmer did not have calf or no pregnant cows with due calving date in the six month cohort period, it was then replaced by another dairy farmer mostly from the nearby area.

However, as there was no dairy cooperatives found in Mecha and Yilmana Densa districts, list of small-holders engaged in urban and peri-urban dairying was taken from the respective District Agricultural Office and hence, study herds were sampled randomly by lottery system until the required sample size was fulfilled. Thus, 51 and 35 herds were sampled from Mecha and Yilmana Densa districts, respectively. Sample size for cluster sampling was determined by adjusting the sample size calculated for simple random sampling. The adjustment is the function of average cluster size and intraculster correlation, and mathematically expressed as follows;

$$n' = n[(1 + ((m-1)*\rho)]$$

where;

n' = sample size for cluster sampling

n = sample size calculated for simple random sampling

m = average cluster size

$\rho$ = intracluster correlation

However, in the present study the average herd (cluster) size (calves per each dairy farm) was 1.6. As clustering was found small, the effect of intracluster correlation would be small and n' would approximate n. So the sample size calculated for random sampling was taken directly to be the sample size for this study. To estimate the magnitude of calf mortality and specific morbidities, sample size was determined by using simple random sampling method (Martin *et al.*, 1987; Thrusfield, 2007).

$$n = \frac{(Z\alpha/2)^2 \ (P(1-P)^2)}{\Delta^2}$$

Where;  n = sample size

Z$\alpha$/2 = the value of the required confidence interval (1.96)

P = expected prevalence (50%)

$\Delta$ = precision level (5%).

Using expected calf mortality prevalence (30.7%) in Bahir Dar Zuria and Gozamen districts (Yehswas *et al*., 2014), confidence level of 95% and required absolute precision of 5%; a total of 322 sample size was determined for smallholder dairy farmers in urban and peri-urban dairy farms of Bahir Dar milk-shed. However, a total of 440 calves were enrolled during the 6month/180 days of follow up period to enhance precision and to compare mortality and morbidity magnitude across different herd sizes. Of which, 322 calves were from 169 small-holders and 118 calves from 5 large dairy farms.

## 3.5. Study Design

### 3.5.1. Cross-sectional study

A cross-sectional interview questionnaire was administered to small-holder and commercial dairy producers found in Bahir Dar Milk-shed at the beginning of the study. Herd-level data was taken by in-person interview aimed at soliciting information pertaining on farm characteristics, pre-weaning dairy calf management practices (colostrum management, feeding, housing and health management) and pre-parturient cows management practices. The sample questionnaire format is attached in Annex I.

### 3.5.2. Longitudinal study

Causal relationship is better explained by longitudinal prospective observations than cross sectional studies. Having this background, the present study has employed this longitudinal observational study between November/2014 to April/2015 to determine the incidence rate of calf morbidity and mortality and to investigate determinant factors of calf morbidity and mortality. The sampling units (calves) were identified individually and monitored throughout the study period.

*Calf recruitment criteria*: A total of 440 new born calves from sampled small-holders and commercial dairy farms were enrolled and followed for approximately 6 months/180 days. Calves of less than 3 months of age at the initial visit and whose disease history and date of birth known were recruited retrospectively (concurrent cohort) and allowed to join into the prospective cohort.

Other calves were recruited progressively as they were born within the selected farms during the study period. Purchased or entrusted calves were not included in this study. The recruited calves and those born after the initial visit were ear-tagged at the earliest farm visit. All selected calves were regularly visited in monthly basis by the investigator as well as by assigned enumerator until the calves reached 6 months of age. Calves were withdrawn from the follow up when they completed their 6 months of age. When calf loss happened during the follow up period, date and reason of loss was recorded. Individual-calf risk factors were identified by means of check-off forms provided by the investigator at the beginning of the study. Calf level recording off sheet is attached (Annex II).

### 3.6. Laboratory Methods

#### 3.6.1. Determination of passive transfer of immunity in dairy calves

To determine passive transfer of immunity in some selected dairy calves, Zinc Sulfate Hepta-hydrate Turbidity test (Chemical composition; $ZnSo4.7H20$, mol wt=287.55, England) was employed as per the procedures of Morrill (2011) and Fecteau et al. (2013). About 5 ml of blood samples were collected from 46 calves aged between 24-48hr of birth, by using non-heparinized vacutainer tubes. The collected blood was kept horizontally overnight and the serum was obtained by centrifugation at 2000-3000 rpm for 10-15 minutes. Then the separated serum was labeled and kept under refrigeration ($-20^{o}c$) until serum analysis was conducted.

*Laboratory procedure*: Serum samples were assayed for total immunoglobulin (Ig) levels by the Zinc sulfate turbidity test. About 208 mg $ZnSo4.7H20$ was weighed by sensitive balance and then mixed with 1 liter of distilled water. Then one hundred microliters (0.1ml) of each serum samples were mixed with 6ml of $ZnSO4$ solution in 10 ml plain vaccutainer tubes. After gentle mixing, the tubes were incubated for 1h at room temperature. The turbidity of the solution was then semi-quantitatively and subjectively rated (total failure (score 0), partial failure (score 1-2), or adequate protection (score 3)) by visual examination. Result category was made based on the degree of precipitation formed between serum Ig and $ZnSo4$ (Fig 11).

### 3.7. Data Collection

Data was collected on hypothesized risk factors and laboratory results that were presumed to be associated with dairy calf health and survival. Risk factors were grouped into farm and calf-level factors. Data on farm-level factors include farm description, calf colostrum management, calf housing, health and overall feeding management. Calf-level factors include recording of genealogy of the calf, place of birth, calving events, colostrum administration, initial housing, routine management practices applied to the calf and health problem incidents that were observed during the monitoring period. Furthermore, calf birth weight was recorded by using a salter balance. Records of mortality, specific disease events and treatments were maintained by the investigator by using standardized case definitions. Standardized case definitions are shown in Annex III.

The main activities that have been accomplished during the regular visits were;

- Asking calf attendants about the occurrence of calf health problem incidents between the visits and recording of the history of the calf health problem.
- Clinical examination of calves for any health problem. This involved physical examination of calves and taking normal body parameters like body temperature, respiratory rate and pulse rate when abnormalities are suspected
- Observation on cleanness of the calf house and assessment of the condition of the barn floor (housing type, ventilation, drainage system) and general hygiene in calf house and its surroundings.
- Observation of calf feeding practices and type of feeds given (concentrate, hay or straw /crop residue).
- In addition to regular visits, emergency visits were paid in response to calls from dairy farm owners for calf health problems.

### 3.8. Data Management and Statistical Analysis

#### 3.8.1. Estimation of Morbidity and Mortality Rates

Morbidity and mortality are the outcome measures of interest in this study. Morbidity is defined as any sickness with recognizable clinical signs which ultimately ended in death or warranted therapeutic intervention during the course of follow up period. Whereas, mortality is defined as any observed death irrespective of cause. As animals in this longitudinal study were recruited at different times and were followed for different periods of time, and thus incident density (true rate) was used in describing diseases occurrences. The speed at which an event occurs per unit time at risk (true rate) was calculated to define the risk of morbidity, mortality and other specific disease conditions (Muraguri *et al*., 2005). Therefore, the incidence rates (IR) or cause specific rates (CSR) were estimated by the following formula:

$$IR(x) = \frac{\text{number of events occured during observation period}}{\text{Total calf days at risk}}$$

The numerator is the number of occurrences of the outcome of interest, whereas the denominator is the number of calf-days at risk for the given period. Number of calf days at risk was calculated by adding the number of days at risk of obtaining a new case in each calf from birth up to 6 month of age or the time of removal from the herd. In the calculation to describe crude morbidity rate, a calf recovered from an illness was considered to be at risk for another illness. Similarly, two or more cases of the same disease condition was considered as different cases in calculating the incidence of that disease condition as far as the second occurred after the disappearance of the clinical sign of the first (Wudu, 2004). For this study purpose, total calf days at risk were converted to calf months at risk, as the age of calf is defined up to six month. Moreover, to facilitate result comparisons with other findings and because of directly taking true rate results tend to overestimate calf morbidity and mortality rates (Gitau *et al*., 1994), true rates calculated for mortality, morbidity and other specific disease conditions were derived into risk rates based on the formula ($RR= 1^{-e^{-\text{True Rate}}}$ ) (Martin *et al*.,1987).

To describe congenital health problems encountered in this study, prevalence rate was calculated instead of incidence rate, since these problems were time independent for individual calves and recorded only in the first visit of individual calves.

### 3.8.2. Investigation of Risk Factors for Morbidity and Mortality

Generally 50 hypothesized explanatory variables for calf mortality and morbidity, 35 and 22 for diarrhea and pneumonia respectively, were initially considered for analysis. However, only 28 potential risk variables were recruited associated with crude morbidity, crude mortality, diarrhea and pneumonia. Of which, six, 5, 7, 5, 5 were calf, dam, management, farm attributes and environmental risk factors respectively (Annex IV). The responses (outcome) of all variables were dichotomised to facilitate analysis and interpretation of results. As the incidence of specific diseases other than calf diarrhoea and pneumonia were small, statistical computing was not made for risk factors.

### 3.8.3. Survival analysis and Modeling

SPSS statistical software version 20 was used to run *Kaplan–Meier* and Cox regression. First, *Kaplan–Meier* method was employed to estimate hazard function of observed hazard differences for different explanatory variables with crude morbidity and crude mortality. The probability of obtaining the observed hazard curves were evaluated by Log rank test at $P<0.05$. Furthermore, to evaluate and quantify the association between explanatory variables (herd and calf-level variables) and survival up to 180 days of age, Cox's proportional hazard model was used. Initially, the association of individual risk factor with an outcome variable was screened by univariate Cox-regression. Those variables significantly associated with the outcome variable at 5% significance level in the univariate analysis were recruited for multivariate analysis using multiple Cox-regression to see their independent effect. In the multivariate analysis a model was fitted for each outcome variable by stepwise backward elimination of insignificant variables ($P>0.05$).

# 4. RESULTS

## 4.1. Herd Level Study Based on Interview Questionnaire

### *4.1.1. Household, livestock and land demography*

Among total dairy producers interviewed in Bahir Dar milk-shed, 60.9% of dairy producers were from urban dairy and 39.1% from peri-urban. Among interviewed dairy owners, 90.2% and 9.8% were male and female households, respectively. The average family size, age of respondents and land holding characteristics per small-holders and large sized farms is shown in Table 3. As to the respondent's literacy rate, 23.6% of dairy farm owners were illiterates, read and write (33.3%), elementary education (22.4%), high school completed (12.1%) and the remaining (8.6%) were professionals, of which only 2.9% were found related to animal production and animal health.

Table 3. Household, livestock and land holding characteristics

| Variables | N | Minimum | Maximum | Mean ± SD |
|---|---|---|---|---|
| Total family size | 174 | 1 | 11 | 5.7 ±2.1 |
| Age of house hold/respondent | 174 | 20 | 77 | 44.3 ±11.2 |
| Birth weight for local calves | 80[a] | 16 | 29 | 22.8±2.7 |
| Birth weight for crossbred calves | 57[b] | 21 | 41 | 29.1±4.6 |
| *Smallholder farms* | | | | |
| Land holding (ha) | 169 | 0.025 | 5.25 | 0.9 ±1.1 |
| Total livestock holding | 169 | 2 | 19 | 7.1 ±4.1 |
| Number of lactating cows (TLU) | 169 | 1 | 8 | 1.8±1.4 |
| Pre-weaned calves (<6m) | 169 | 1 | 5 | 1.6± 0.9 |
| *Large dairy farms* | | | | |
| Land holding (ha) | 5 | 0.5 | 325[c] | 37.2± 101.6 |
| Total livestock holding | 5 | 20 | 439 | 75.6±128.4 |
| Pre-weaned calves (<6m) | 5 | 3 | 62 | 12.4±17.8 |
| Number of lactating cows (TLU) | 5 | 3 | 54 | 14.3± 14.3 |

N=number of respondents        a =number of local calves        b=number of crossbred calves

C=Maximum land holding was recorded from Andassa Livestock Research Center

*4.1.2. Farm characteristics and dairy calf management practices*

About 68.4% of respondents had knowledge of the advantage of feeding colostrum to calves over ordinary milk and fed colostrum with in six hour of birth. But the remaining 31.6% respondents did not have the knowledge of the advantage of early colostrum feeding and hence new born calves were enforced to suckle partial residual colostrum (they discard first colostrum) and are allowed to suckle colostrum lately, after the retained placenta is expelled out. Because, as per their perception, they believed that complete feeding of colostrum as soon as birth causes the calf to gastric disorder and retention of fetal membrane. Method of colostrum feeding was suckling (96%) and hand feeding (4%). Only 19% of dairy farm owners separate calves from their dams after first nursing, while others (80.5%) separate calves one or three days later. Only 29.9% dairy producers provide separate calf pen, others 42.6% and 27.6% keep their calves in cow shed and their own house hold home, respectively. Modes of calf feeding were stall feeding (64.4%) and grazing with supplement (35.6%).

About 96 % of dairy farms fed whole residual milk for calves two times daily. No special starter feed was used in any of the farms rather the same feed given to cows was used for calves. These include straw, crop residue (mainly maize, millet and teff) and concentrate mixture (wheat bran and Nug cake (*Guizoitia abyssinica*). Other non-conventional feeds like local beer by-products (*atela* and *brint*) were also used as animal feeds specially in Yimana Densa and Mecha Districts.

Age to introduce non-milk feed and weaning age varied from farms to farms. In most urban dairy farms, average weaning age was (6.8 month) in cross bred calves, while relatively extended weaning age (8 month) was recorded in peri-urban dairy farms. Average weaning age for local calves was more than 1 year (13 month). Among interviewed small-holder and large dairy farms, about 20% mentioned calf mortality and morbidity as one of the health problems in their farms. In urban dairy farms calf mortality and mastitis were the primary animal health concerns next to feed shortage. The association of herd level factors with proportion of calf morbidity and mortality are described (Table 4).

Table 4. Distribution of calf morbidity and mortality proportion across herd level management factors in Bahir Dar milk-shed

| Herd level Variables | Categories | N | Morbidity | | Mortality | |
|---|---|---|---|---|---|---|
| | | | Sick | % | Dead | % |
| Dairying experience | < 5year | 67 | 27 | 40.3 | 11 | 16.4 |
| | >5 year | 373 | 114 | 30.6 | 43 | 11.5 |
| Dairying serve as income | Primary | 252 | 98 | 38.9 | 38 | 15.1 |
| | Secondary | 188 | 43 | 22.9 | 16 | 8.5 |
| Colostrum feeding | Complete feeding | 370 | 41 | 11.1 | 39 | 10.5 |
| | Partial feeding | 70 | 30 | 42.9 | 15 | 21.4 |
| Method of colostrum feeding | Suckling | 387 | 117 | 30.2 | 34 | 8.8 |
| | Hand/bucket | 53 | 24 | 45.3 | 20 | 37.7 |
| Breeding method | AI | 147 | 52 | 35.4 | 31 | 21.1 |
| | Natural Mating | 293 | 89 | 30.4 | 23 | 7.8 |
| Who raises calves | Owner | 217 | 80 | 36.9 | 18 | 8.3 |
| | Hired | 223 | 61 | 27.4 | 36 | 16.1 |
| Where calved | Indoor | 336 | 114 | 33.9 | 46 | 13.7 |
| | Outdoor | 104 | 27 | 25.9 | 8 | 7.7 |
| Calf pen location | Cow shed | 183 | 69 | 37.7 | 25 | 13.7 |
| | Separate pen | 219 | 55 | 25.1 | 24 | 10.9 |
| | Household home | 38 | 17 | 44.7 | 5 | 13.2 |
| When the calf separated from dam postpartum (h) | After first nursing (<6hr) | 111 | 49 | 44.1 | 18 | 16.2 |
| | One day later (>24h) | 329 | 92 | 27.9 | 36 | 10.9 |
| Type of floor in calf house | Concrete | 258 | 87 | 33.7 | 43 | 16.7 |
| | Dirt | 182 | 54 | 29.7 | 11 | 6 |
| Bedding | Yes | 34 | 12 | 35.3 | 10 | 29 |
| | No | 406 | 129 | 31.8 | 44 | 10.8 |
| Mode of feeding | Partial grazing | 215 | 51 | 23.7 | 24 | 11.2 |
| | Stall feeding | 225 | 90 | 40 | 30 | 13.3 |
| Improved forage feeding | Yes | 156 | 40 | 25.6 | 14 | 9 |
| | No | 284 | 101 | 35.6 | 40 | 14.1 |
| Concentrate feeding | Yes | 386 | 127 | 32.9 | 52 | 13.5 |
| | No | 54 | 14 | 25.9 | 2 | 3.7 |
| Watering access | Free | 137 | 55 | 40.1 | 19 | 13.8 |
| | Limited | 303 | 86 | 28.4 | 35 | 11.6 |

N=number of observation in each category

## 4.2. Calf-level study/longitudinal observation

### 4.2.1. Distribution and dynamics of the cohort

A total of 440 calves (299 cross and 141 local) calves were recruited from 174 selected dairy farms in urban and peri-urban dairy farms of Bahir Dar milk-shed. At the start of the study, about 123 (28%) of calves with birth and disease history records were recruited concurrently. Almost all calf entries resulted mainly from births within the study farms. Purchased or entrusted calves during the study period were not included in this study due to lack complete calf information. Female and male calves contributed 233 (53%) and 207(47%) of the entries over the observation period, respectively. They contributed a total of 49,237 calf days at risk, which is also equivalent to 274 calf six months at risk.

The dynamics of the study cohort is shown here under in Table 5. A total of 61 calves out of 440, which contributed to the follow ups exited due to deaths and sales from the study before the termination of the cohort period. The total exit rate was 13.9% of which 32 (7.3%) and 29 (6.6%) were females and males, respectively.

Table 5. Number of calves monitored and reasons of withdrawals from the longitudinal cohort

| Visit number (Monthly basis) | Number of calves born | Withdrawals | | |
|---|---|---|---|---|
| | | Deaths | Sales | Total |
| First Visit | 123[a] | 16 | NK | 16 |
| 1 (November) | 45 | 5 | 0 | 5 |
| 2 (December) | 54 | 4 | 1 | 5 |
| 3 (January) | 59 | 7 | 0 | 7 |
| 4 (February) | 57 | 8 | 2 | 10 |
| 5 (March) | 47 | 3 | 3 | 6 |
| 6 (April) | 55 | 11 | 1 | 12 |
| Total | 440 | 54 | 7 | 61 |

a=dead calves born in September and October     NK= not known

modified from Muraguri *et a*. (2005)

### 4.2.2. Morbidity and Mortality

The present 6 month longitudinal prospective study revealed that the incidence of crude morbidity and crude mortality risk rates were 47.3% and 17.9%, respectively. From disease conditions encountered during the follow up period, calf diarrhea was the leading cause of calf morbidity with incidence rate of 25.2%, followed by pneumonia (8.6%), septicemic conditions (5.8%) and naval ill (5.8%). The incidences of other calf hood diseases were relatively low (Table 6). Furthermore, incidence risk rate of crude morbidity, crude mortality, diarrhea and pneumonia are computed across study districts, farming system and type of dairy production (Table 6).

Table 6. Incidence (true rate and risk rate) of crude morbidity, crude mortality and specific disease conditions in urban and peri-urban dairy farms at Bahir Dar Milk-shed

| Disease condition | N | Calf days at risk | Calf six months at risk | Incidence Rate (IR) | |
|---|---|---|---|---|---|
| | | | | True rate/6Calf months at risk | Risk rate (%)[a] |
| Crude morbidity rate | 141 | 39844 | 221 | 0.64 | 47.3 |
| Crude mortality rate | 54 | 49237 | 274 | 0.19 | 17.9 |
| Diarrhea | 71 | 43942 | 244 | 0.29 | 25.2 |
| Pneumonia | 25 | 47615 | 265 | 0.09 | 8.6 |
| Naval ill (Omphalitis) | 16 | 47459 | 264 | 0.06 | 5.8 |
| Septicemic conditions | 15 | 48917 | 272 | 0.06 | 5.8 |
| LSD | 13 | 48725 | 271 | 0.05 | 4.9 |
| Rabies | 2 | 49172 | 273 | 0.01 | 1 |
| Miscellaneous cases | 30 | 46871 | 260 | 0.12 | 11.3 |
| Congenital disorder | 5 | 440[b] | - | - | 1.14[c] |

N= number of cases    b = number of calves,    c = prevalence    LSD=Lumpy Skin Disease
a =Risk rates estimated from true rates using the formula, Risk rate = $1-e^{-true\ rate}$ (Martin *et al.*, 1987)

Lumpy Skin Disease (LSD) outbreak occurred in some urban and peri-urban dairy farms with incidence risk of 4.9%. Moreover, a clinical syndrome of alopecia (loss of hair), unthriftness, ring worm infection, external parasite infestation, traumatic injury and others were grouped into the miscellaneous category.

About 1.14 % prevalence of congenital disorders was recorded in this study, of which 2 of the 5 cases were congenital loss of sight. The remaining 3 were congenital loss of tail, congenital deformed lumbar vertebrae and triple navel flap.

In this study, the principal cause of death in most neonatal calves (below 3 month of age) was diarrhea (either watery or bloody), which is evidenced by 20 death records among overall 54 dead calves. It has also been observed that, calves with history of previous diarrhea were unthrifty and vulnerable to other diseases. Two calves died of rabies and the other 10 and 8 calves were died in association with LSD infection and poor vigor, respectively. Other suggested causes of calf death were miscellaneous which includes sudden death (10), natural accident/light-struck (1), unthriftness (4), and heart water (1) and carbohydrate engorgement (1).

The average age for the occurrence of crude morbidity, crude mortality, diarrhea and pneumonia were seven, six, five and six weeks, respectively. Of the total cases recorded, relatively the highest crude morbidity (52%), mortality (53%) and diarrhea (63%) incidents occurred in the first month of age. Proportionally, highest death record was observed in younger calves aged below 3 months (67.9%), others were older calves aged above 3 months (16.1%) and perinatal mortality (death within 24 hr of birth) (12.5%). Out of 16 Omphalitis cases, 62.5% was recorded in the first weeks of life. About 17.4% of pneumonia cases were diagnosed in older (>3 month of age) calves. When calf health problems were compared by herd size, the incidence of crude mortality was apparently higher in large sized farms than in small-holders (Table 7). But crude morbidity and other specific disease conditions were apparently higher in the later. Furthermore, crude mortality, crude morbidity and other calf diseases were apparently higher in urban than pei-urban dairy farms (Table 7).

Table 7. Incidence risk rate of crude mortality, morbidity and diarrhea across study localities and dairy production system

| Variables | Crude mortality | | | | | Crude morbidity | | | | Diarrhea | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Study Districts* | N | n | CMR | TR | RR (%)[a] | N | CMR | TR | RR (%)[a] | n | CMR | TR | RR (%)[a] |
| Bahir Dar town | 173 | 28 | 95 | 0.29 | 25 | 71 | 67 | 1.05 | 65 | 45 | 76 | 0.61 | 46 |
| Bahir Dar Zuria | 157 | 23 | 104 | 0.22 | 20 | 45 | 92 | 0.49 | 38.7 | 13 | 100 | 0.13 | 12.2 |
| Mecha | 73 | 2 | 25 | 0.08 | 7.7 | 20 | 42 | 0.48 | 38.1 | 10 | 45 | 0.22 | 19.7 |
| Yilmana Densa | 37 | 1 | 49 | 0.02 | 1.9 | 6 | 21 | 0.29 | 25.2 | 3 | 24 | 0.13 | 12 |
| *Dairy Production* | | | | | | | | | | | | | |
| Urban | 183 | 29 | 105 | 0.28 | 24.4 | 78 | 75 | 1.04 | 64.7 | 48 | 85 | 0.56 | 42.9 |
| Peri-urban | 257 | 25 | 168 | 0.15 | 14 | 63 | 147 | 0.43 | 34.9 | 23 | 159 | 0.15 | 13.9 |
| *Farming system* | | | | | | | | | | | | | |
| Mixed crop-livestock | 157 | 11 | 109 | 0.1 | 9.5 | 47 | 89 | 0.52 | 40.5 | 22 | 98 | 0.22 | 19.7 |
| Livestock | 283 | 43 | 165 | 0.26 | 22.9 | 94 | 132 | 0.71 | 50.8 | 94 | 146 | 0.64 | 47.3 |
| *Dairy farm size* | | | | | | | | | | | | | |
| Small-holder | 265 | 25 | 176 | 0.14 | 13.1 | 93 | 134 | 0.69 | 49.8 | 47 | 153 | 0.31 | 26.7 |
| Large dairy farms | 175 | 29 | 97 | 0.29 | 25.2 | 48 | 87 | 0.55 | 42.3 | 24 | 91 | 0.26 | 22.9 |

N=Total number of calves followed    n=number of cases    CMR=total calf months at risk    TR=true rate    RR=Incidence risk

a= Risk rates estimated from true rates using the formula, Risk rate = $1-e^{-\text{true rate}}$ (Martin *et al*., 1987)

*4.2.3. Association of explanatory variables with Morbidity and Mortality*

### 4.2.3.1. Risk factors of crude mortality

A total of 21 explanatory variables significantly (P<0.05) associated with mortality were recruited by univariate Cox-regression modelling (Table 8).

Table 8. Explanatory variables significantly associated with the incidence of crude mortality based on univariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Age | >3m vs.<3m | 0.03 | 0.012-0.083 | 0.000 |
| Breed | Cross vs. Local | 1.78 | 1.209-2.564 | 0.03 |
| Ease of birth | Dystocia vs. Normal | 2.11 | 1.128-3.932 | 0.019 |
| Vigor | Good Vs. Poor | 0.25 | 0.188-0.347 | 0.000 |
| Dam age | >=5yr vs. <5yr | 0.87 | 0.788-0.957 | 0.005 |
| Birth type | Twin Vs. Single | 10.7 | 4.519-25.468 | 0.000 |
| Birth related disorders | No vs. Yes | 0.67 | 0.493-0.905 | 0.009 |
| Mastitis (early lactation) | No vs. Yes | 0.71 | 0.514-0.997 | 0.048 |
| Breeding method | AI vs. NM | 1.72 | 1.315-2.256 | 0.000 |
| Colostrum feeding | Complete vs. Partial | 0.46 | 0.255-0.804 | 0.011 |
| Age at 1st colostrum ingestion | <6hr vs.>6hr | 0.46 | 0.253-0.816 | 0.008 |
| Method of colostrum feeding | Bucket vs. Suckling | 4.63 | 2.663-8.050 | 0.000 |
| Farm ownership | Hired vs. Owner | 1.43 | 1.083-1.908 | 0.012 |
| Sex of calf care taker | Male vs. Female | 0.66 | 0.466-0.944 | 0.023 |
| Calf care taker experience | <5yr vs.>5yr | 1.94 | 1.081-3.485 | 0.026 |
| Dairy as source of income | Yes vs. No | 2.07 | 1.153-3.714 | 0.015 |
| Herd size | Small vs. Large | 1.8 | 1.056-3.080 | 0.031 |
| Dairy production system | Per-urban vs. Urban | 0.5 | 0.293-0.856 | 0.011 |
| Farming system | Mixed vs. Livestock | 0.41 | 0.211-0.795 | 0.008 |
| Elevation (Altitude m.a.s.l) | >2000 vs.<2000 | 0.24 | 0.076-0.778 | 0.017 |
| Study location/District | BD[a] vs. YD[b] | 8.007 | 1.809-58.872 | 0.041 |

* Hazard ratio (which has similar meaning to relative risk)    a=Bahir Dar special Zone    b=Yilmana Densa

When all the above significant variables re-offered to multivariate Cox-regression, only calf age, vigor status at birth, birth type, degree of colostrum feeding, method of colostrum feeding and farm type were significantly associated (P<0.05) with crude mortality (Table 9).

Age (HR=0.03, P=0.000) and vigor status at birth (HR=0.15, P=0.000) were found the most determinant factors of calf mortality. The median age for mortality was 30 days (Fig 3). According to the model, keeping the effect of other variables constant, the hazard of mortality was 4.64 fold higher for calves, which ingested partial colostrum than those fed adequate colostrum. The association of colostrum feeding with mortality is clearly demonstrated in the hazard function curve (Fig 4).

Table 9. Potential risk factors significantly associated with the incidence of crude mortality based on multivariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Age | Old vs. Young | 0.03 | 0.010-0.0081 | 0.000 |
| Vigor | Good vs. Poor | 0.15 | 0.074-0.318 | 0.000 |
| Birth type | Twin vs. Single | 2.21 | 1.272-3.793 | 0.005 |
| Colostrum feeding | Partial vs. Complete | 4.64 | 2.200-9.784 | 0.000 |
| MCF** | Bucket vs. Suckling | 4.13 | 1.81-9.417 | 0.001 |
| Farming system | Livestock vs. Mixed | 2.77 | 1.346-5.699 | 0.006 |

* Hazard ratio (which has similar meaning to relative risk)    **= Method of colostrum feeding
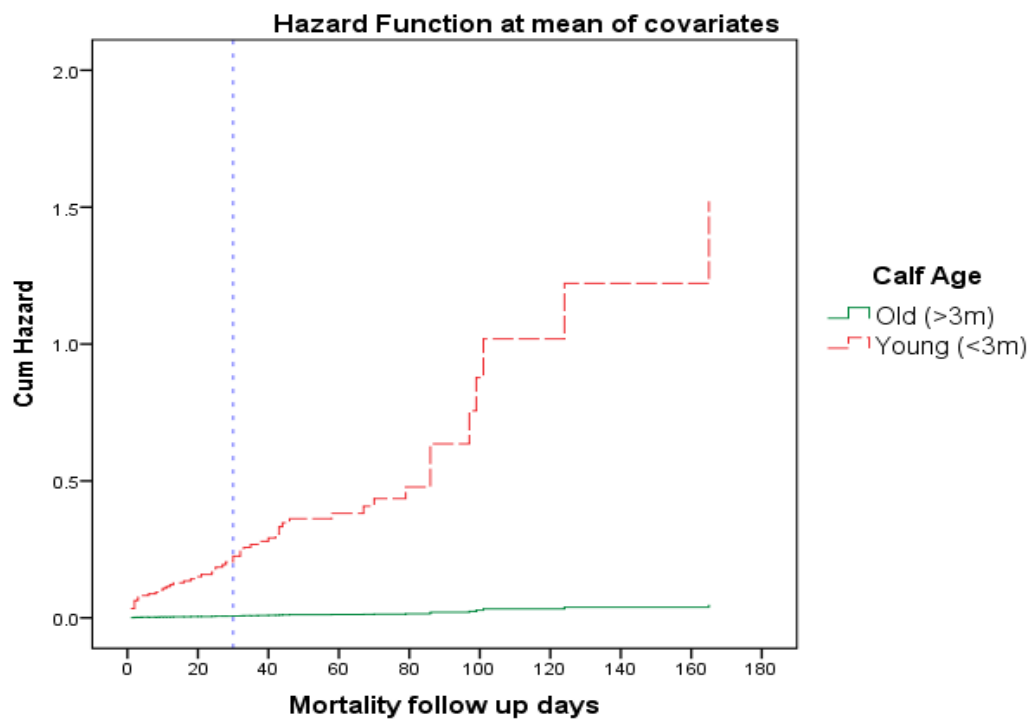
Figure 3. The hazard for crude calf mortality compared by age of calves
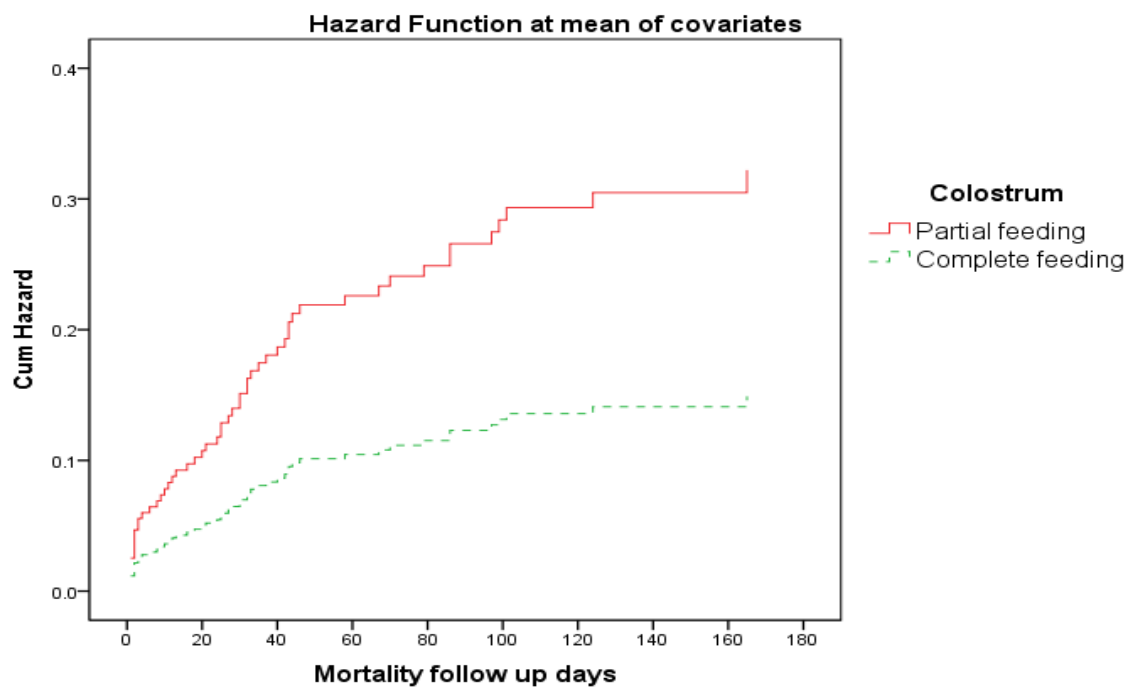


Figure 4. The hazard for crude calf mortality compared by degree of colostrum feeding

Among disease conditions examined by multivariate Cox regression, diarrhea, pneumonia and LSD were significantly associated as causes of calf mortality (Table 10). According to the model, holding the effect of other variables constant, the risk of mortality was 2.78 times higher in diarrheic calves than that of normal calves. Moreover, the relative hazard of mortality in those calves with no history of previous treatment was 26% lower than that of previously treated calves. Pneumonia and LSD were also additional risk factors for mortality (Table 10). As these explanatory variables were interdependent on crude morbidity, the effect of crude morbidity on crude mortality was not evaluated in the above multivariate model. However, it was found a significant risk factor for crude mortality in univariate analysis (HR=12, P=0.000).

Table 10. Association of calf hood diseases and previous treatment history with calf mortality based on multivariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Diarrhea | Yes vs. No | 2.78 | 1.240-6.189 | 0.001 |
| Pneumonia | Yes vs.no | 3.23 | 1.231-8.454 | 0.017 |
| LSD | Yes vs.no | 5.52 | 2.035-15.015 | 0.003 |
| Previous treatment | No vs. Yes | 0.26 | 0.121-0.576 | 0.001 |

* Hazard ratio (which has similar meaning to relative risk)

4.2.3.2. Risk factors of crude morbidity

About 16 risk factors were found significantly associated (P<0.05) with calf morbidity by univariate Cox-regression (Table 11).

Table 11. Potential risk variables significantly associated with the incidence of crude morbidity based on univariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Breed | Cross vs. Local | 2.51 | 1.637-3.851 | 0.000 |
| Calf age | Old vs. Young | 0.45 | 0.312-0.666 | 0.000 |
| Birth type | Twin vs. Single | 3.59 | 1.460-8.838 | 0.051 |
| Vigor | Good vs. Poor | 0.14 | 0.089-0.235 | 0.000 |
| Colostrum feeding | Partial vs. Complete | 1.52 | 1.017-2.282 | 0.041 |
| Age at 1st colostrum ingestion | <6hr vs.>6hr | 0.58 | 0.397-0.853 | 0.006 |
| Ease of birth | Dystocia vs. Normal | 1.51 | 0.977-2.325 | 0.053 |
| Dam age | <5yr vs. >5yr | 1.76 | 1.261-2.453 | 0.001 |
| Birth related disorders | No vs. Yes | 0.47 | 0.322-0.698 | 0.000 |
| Herd size | Small vs. Large | 0.80 | 0.647-0.994 | 0.044 |
| Dairy production | Peri-urban vs. Urban | 0.45 | 0.325-0.634 | 0.000 |
| Dairy as source of income | No vs. Yes | 0.48 | 0.339-0.696 | 0.000 |
| Mode of feeding | Grazing vs. Stall feeding | 0.52 | 0.367-0.732 | 0.000 |
| Study location/Districts | BD[a] vs.YD[b] | 3.04 | 1.397-6.608 | 0.005 |
| Method of colostrum feeding | Bucket vs. Suckling | 1.27 | 1.024-1.590 | 0.030 |
| Dam vaccination | No vs. Yes | 1.25 | 1.045-1.505 | 0.015 |

* Hazard ratio (which has similar meaning to relative risk)     a=Bahir Dar special Zone     b=Yilmana Densa

However, after multivariate modelling at P<0.05, only calf age, vigor status at birth, colostrum feeding, dam age, study location and birth related disorders were found significantly associated with crude morbidity (Table 12). According to the model, holding the effect of other variables constant, the relative hazard of morbidity in those calves located in Bahir Dar town was 2.61 fold higher than that of calves located in Yimana Densa district (Fig 5). Significant variation was not observed in other study districts. The association between dam age and crude morbidity is explained in the hazard function curve (Fig.6). Calf vigor status at birth, colostrum feeding and birth related disorders were also found additional risk factors of calf morbidity (Table 12).

Table 12. Potential risk variables significantly associated with the incidence of crude morbidity based on multivariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Calf Age | Old vs. Young | 0.45 | 0.302-0.685 | 0.000 |
| Calf Vigor | Good vs. Poor | 0.26 | 0.147-0.460 | 0.000 |
| Dam age | <=5yr vs.>5yr | 1.45 | 1.018-2.056 | 0.040 |
| Colostrum feeding | Partial vs. Complete | 1.86 | 1.186-2.965 | 0.007 |
| Study location | BD vs. YD | 2.61 | 1.082-6.981 | 0.033 |
| Birth related disorders | No vs. Yes | 0.603 | 0.371-0.981 | 0.031 |

* Hazard ratio (which has similar meaning to relative risk)     BD=Bahir Dar     YD=Yilmana Densa
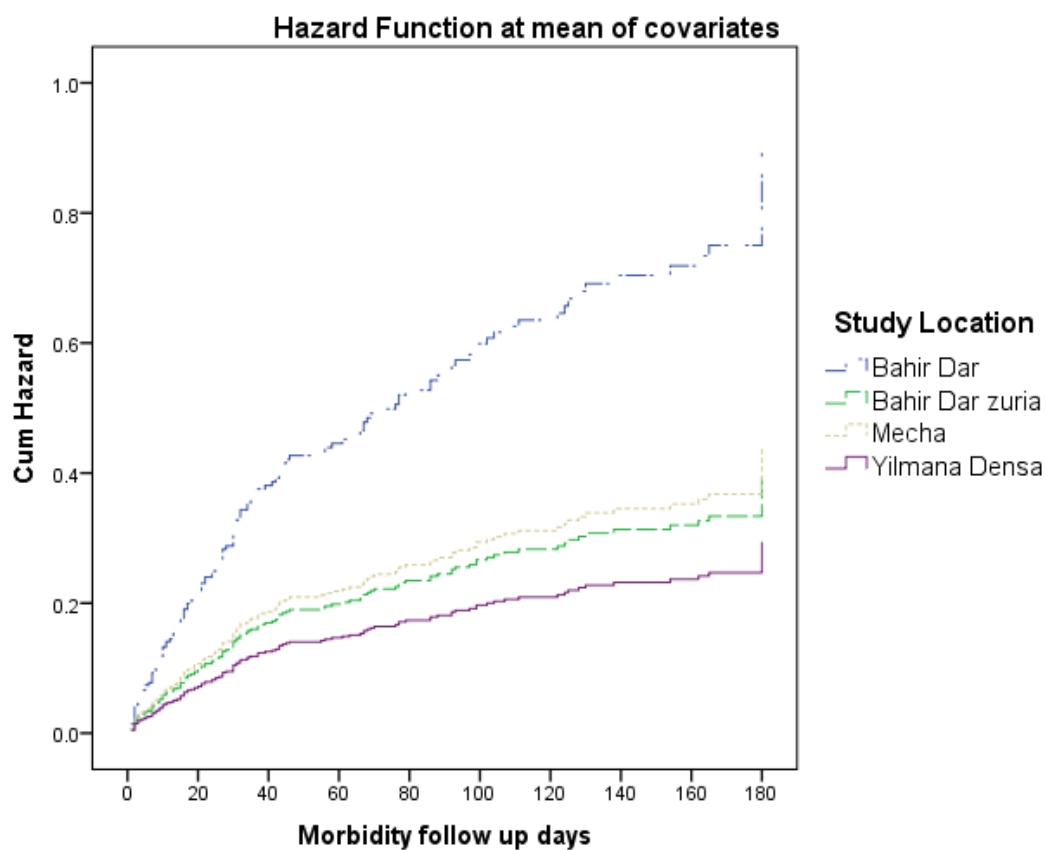


Figure 5. The hazard for crude calf morbidity compared by study locations/Districts
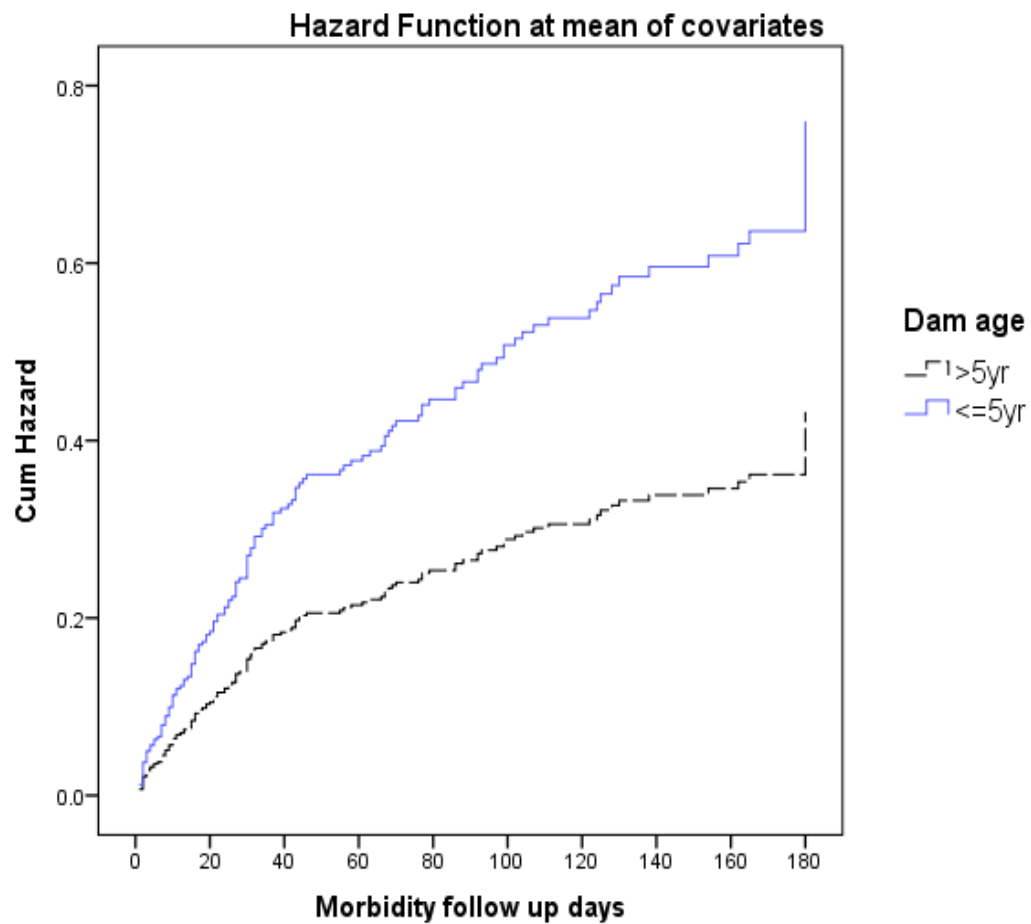
Figure 6. The hazard for crude calf morbidity compared by dam age factor

### 4.2.3.3. Risk factors of diarrhea

Eleven explanatory variables for diarrhea were recruited by using a univariate Cox regression analysis at P<0.05 (Table 13).

Table 13. Potential risk variables significantly associated with the incidence of calf diarrhea based on univariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Breed | Cross vs. Local | 1.93 | 1.362-2.744 | 0.000 |
| Age | Old vs. Young | 0.75 | 0.578-0.976 | 0.032 |
| Birth type | Twin vs. Single | 5.54 | 1.999-15.402 | 0.001 |
| Vigor | Good vs. Poor | 0.38 | 0.269-0.533 | 0.000 |
| MCF** | Bucket vs. Suckling | 1.41 | 1.054-1.84 | 0.021 |
| Birth related disorders | No vs. Yes | 0.69 | 0.524-0.0905 | 0.007 |
| Dairy production | Peri-urban vs. Urban | 0.53 | 0.409-0.674 | 0.000 |
| Dairy as source of income | No vs. Yes | 0.58 | 0.435-0.761 | 0.000 |
| Barn cleanness | Clean vs. Unclean | 0.77 | 0.604-0.989 | 0.041 |
| Calving site | Barn vs. Outdoor | 2.02 | 1.381-2.966 | 0.000 |
| Study location/Districts | BD[a] vs. YD[b] | 6.64 | 1.609-27.363 | 0.009 |

* Hazard ratio (which has similar meaning to relative risk)     a=Bahir Dar special Zone  b=Yilmana Densa

**=method of colostrum feeding

When fitting these all variables in to a multivariate Cox regression model, only age, vigor, breed, and study location were made significant (P<0.05) contribution to the final model (Table 14). According to the model, holding the effect of other risk factors constant, the hazard of diarrhea was 2.63 times higher in cross bred calves than that of local calves. The association between calf breed and age with diarrhea is clearly indicated in the hazard function curve (Fig 7 and 8). Vigor status at birth and study districts was also found additional risk factor for calf diarrhea (Table 14).

Table 14. Potential risk variables significantly associated with the incidence of calf diarrhea based on multivariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Age | Old vs. Young | 0.53 | 0.3000-0.929 | 0.027 |
| Vigor | Good vs. Poor | 0.24 | 0.112-0.524 | 0.000 |
| Breed | Cross vs. Local | 2.63 | 1.199-5.779 | 0.016 |
| Study location/Districts | BD vs. YD | 5.42 | 1.266-23.213 | 0.023 |

 * Hazard ratio (which has similar meaning to relative risk)      BD=Bahir Dar          YD=Yilmana Densa
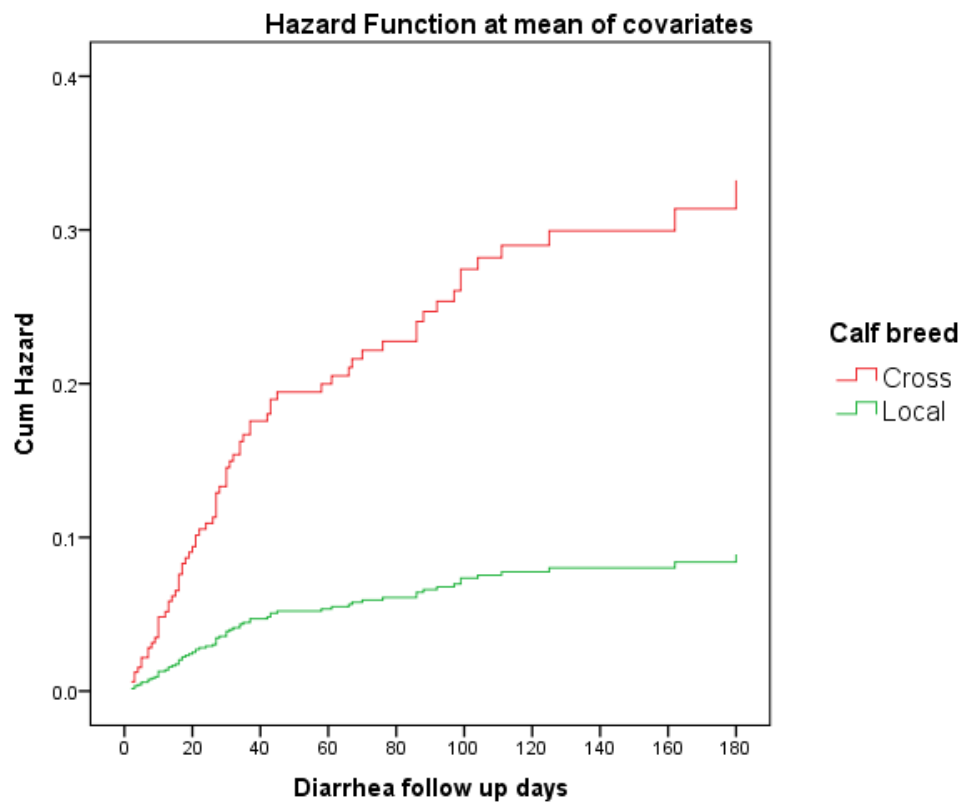
Figure 7. The hazard for diarrhea compared by breed of calves
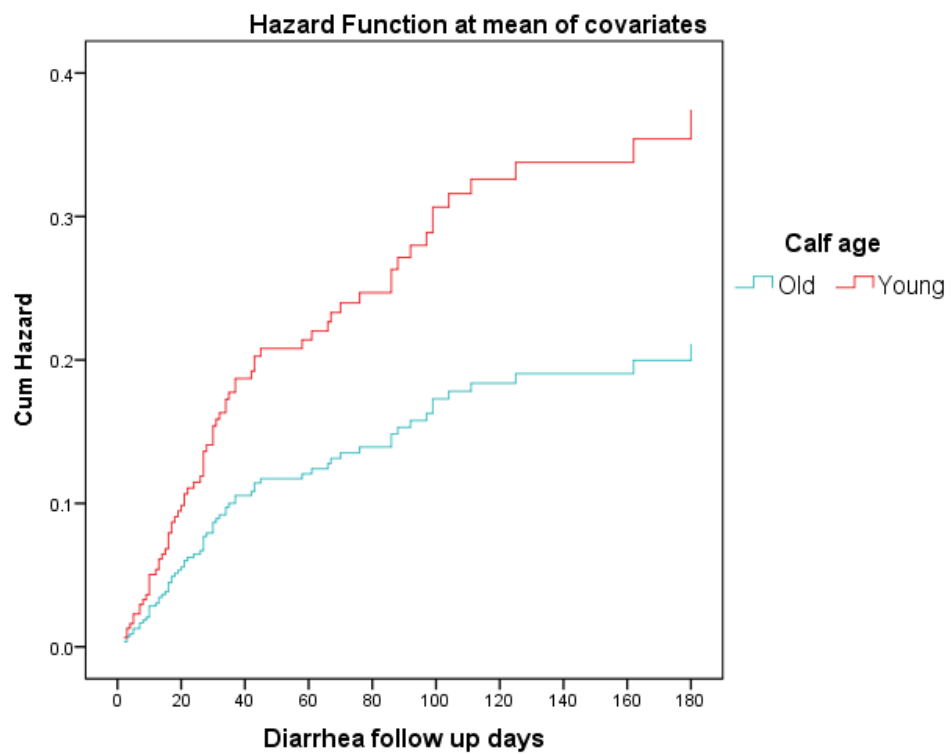


Figure 8. The hazard for diarrhea compared by age group of calves

4.2.3.4. Risk factors of pneumonia

About 6 risk factors of pneumonia were selected by using a univariate Cox regression analysis at P<0.05 (Table 15).

Table 15. Potential risk variables significantly associated with the incidence of calf pneumonia based on univariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Age | Old vs. Young | 0.37 | 0.146-0.947 | 0.038 |
| Vigor | Good vs. Poor | 0.08 | 0.032-0.225 | 0.000 |
| Previous treatment | No vs.Yes | 0.06 | 0.026-0.170 | 0.000 |
| Dairy production | Peri-urban vs. Urban | 0.44 | 0.192-1.003 | 0.051 |
| Mode of feeding | Grazing vs Stall feeding | 0.05 | 0.168-0.995 | 0.049 |
| Calf housing | Cow barn vs. Separate calf pen | 2.81 | 1.107-7.120 | 0.030 |

* Hazard ratio (which has similar meaning to relative risk)

When these all variables are evaluated in multivariate Cox regression model, only history of previous medical treatment and vigor status at birth were found significantly associated with pneumonia (Table 16). The risk of pneumonia was 7.6 % lower in previously untreated calves than those with history of previous medical treatment. The association between previous medical treatment and calf pneumonia is clearly demonstrated in the hazard function curve (Fig. 9).

Table 16. Potential risk variables significantly associated with the incidence of calf pneumonia based on multivariate analysis using Cox regression

| Variables | Categories | HR* | 95% CI for HR | P value |
|---|---|---|---|---|
| Previous treatment | No vs. Yes | 0.076 | 0.028-0.210 | 0.000 |
| Vigor | Good vs. Poor | 0.23 | 0.081-0.650 | 0.000 |

* = Hazard ratio (which has similar meaning to relative risk )
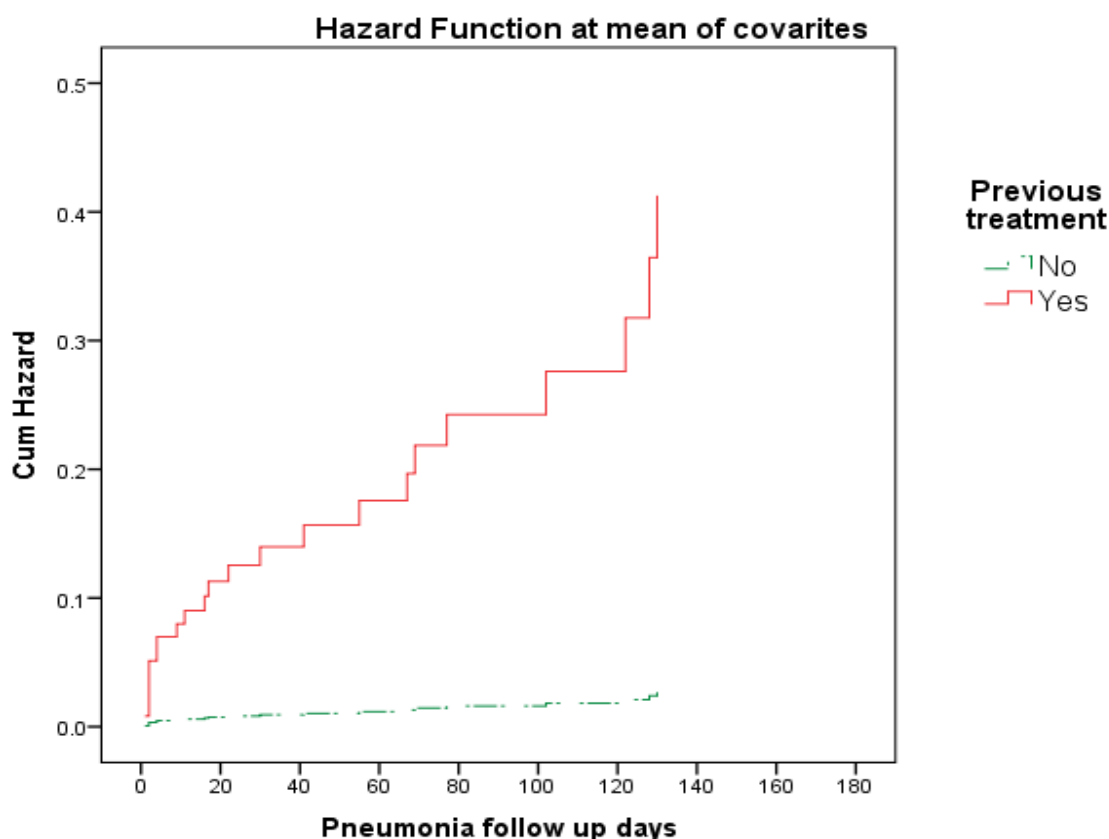
Figure 9. The hazard of pneumonia compared by history of treatment record

*4.2.4. Status of passive transfer of immunity in dairy calves*

Passive immunity determination based on Zinc sulfate (ZnSo4.7H20) turbidity was carried out in some selected farms of Bahir Dar milk shed. Of total 46 calves considered, 29 (63%) were from peri-urban and 17(37%) from urban dairy farms. Test result revealed that the prevalence of failure of passive transfer (FPT) was 8.7% (4/46). About 16 (34.8%) and 26 (56.5%) of calves were found to be adequately adequately and partially protected, respectively.

Total failure (65.2%) was calculated by summing together up the FPT and partial failure, as partially protected calves are considered unlikely to be protected (Fig 10). From immunology perspective, the precipitation formed between Zinc sulfate and serum Ig was subjectively scored between 0 and 3 (Fig 11).
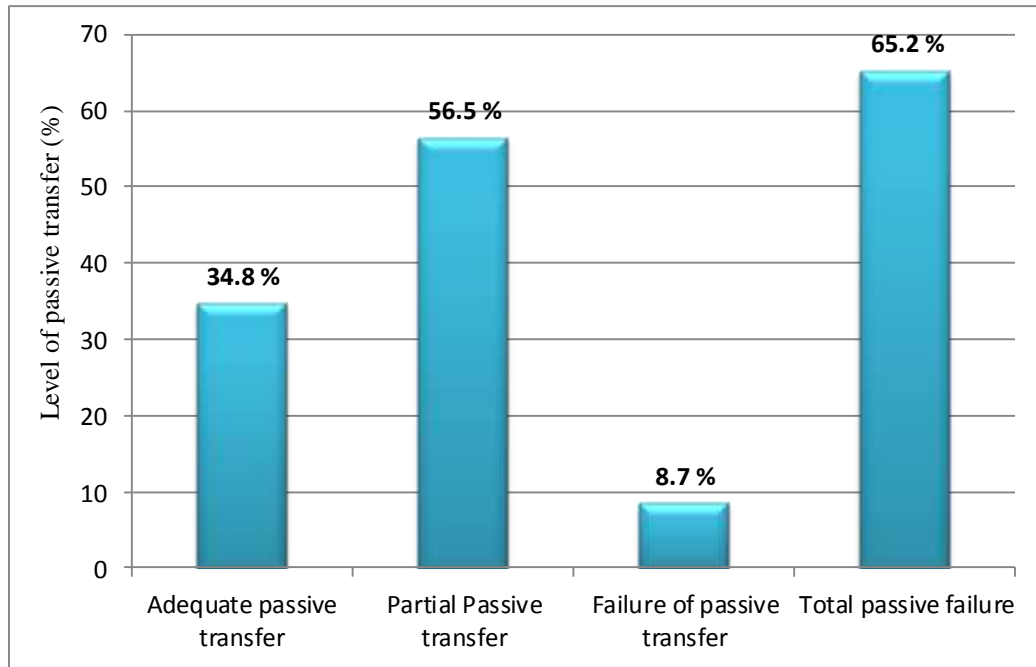
Figure 10. Level of passive transfer in dairy calves at Bahir Dar milk-shed
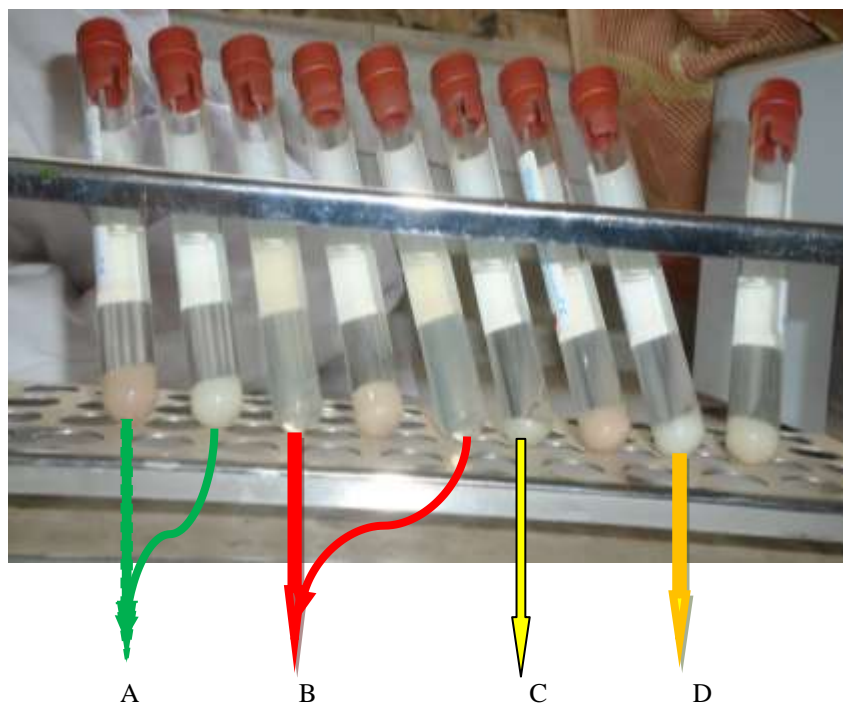


A=Score 3 (high serum Ig, adequate protection)

B=Score 0 (no serum Ig, failure of passive transfer)

C=Score 2 (low serum Ig, partial protection)

D =Score 1 (moderate serum Ig, partial protection)

Figure 11. Examination of passive transfer by Zinc Sulfate (ZnSo4.7H$_2$0) turbidity test

# 5. DISCUSSION

This study was conducted to determine the incidence of calf morbidity and mortality, to investigate the underlining risk factors and also to determine passive transfer of immunity in dairy calves in some selected dairy farms of Bahir Dar milk-shed. The study was designed to meet the intended objectives through herd level cross-sectional and calf level longitudinal observations. Thus, calf health problems and their determinant factors in urban and peri-urban dairy farms of Bahir Dar milk-shed have been addressed in a comprehensive way. Furthermore, this study tried to determine the level of passive transfer of immunity in some dairy calves, which could be the first report in the present study areas. However, the issue of specific etiological agents involved in each mortality and morbidity were not addressed due to logistical limitations.

As to the present information, except some studies like Wudu *et al.* (2008) and Bekele *et al.* (2009), many earlier calf health studies in Ethiopia were limited to state farms, ranches and research centers, in which case they could not clearly explore calf health and management problems under small-holder farming condition, though it is the dominant dairy production system in the country. It is therefore the present study is expected to contribute invaluable information in the area of dairy calf health management, and the associated determinant factors of calf morbidity and mortality in the rapidly expanding small-holder and commercial dairy farms located in Bahir Dar milk-shed, North West Ethiopia.

## 5.1. Mortality and Morbidity

In the present study, in urban and peri-urban dairy farms of Bahir Dar milk-shed, crude calf morbidity rate of 47.3% and crude calf mortality rate of 17.9% were recorded. This mortality and morbidity statistics can be considered among the highest reported results in the country and abroad so far. This mortality record is also above the economically tolerable level, which is much higher than the 3 to 5% calf mortality rate set as a minimum, the standard of the western production systems (Roy, 1990; Heinrichs and Radostits, 2000).

Generally when mortality and morbidity comparisons were made between the present and other previous reports, there was an inherent difficulty. Such kind of difficulties was also previously mentioned by Wudu (2004). As per this author, contributing factors for wide variation comparisons include the method used in measuring rates (Risk Rate, True rate) and the unit of the

study used (herd or calf). Variations in morbidity and mortality can be explained by many calf and herd-level risk factors, case definition, age of the calves, study design, sample size and agro-ecology (Windeyer *et al*., 2014).

The magnitude of calf mortality rate found in this study has considerably congruent with other findings reported in different parts of Ethiopia (ILRI, 1996; Hussien, 1998; Amoki, 2001; Wudu *et al*., 2008). This mortality rate finding was also comparable with other similar studies from different parts of Africa (Knopf *et al.,* 2000; Muraguri *et al*. 2005; Wymann *et al*., 2006). Conversely, the present mortality finding was relatively higher when compared to some reports in Ethiopia (Shiferaw *et al*., 2002; Amuamuta *et al*., 2006) and in Africa (Ganaba *et al*., 2002; Swai *et al*., 2009). This report was also found relatively lower than that of some earlier reports in Ethiopia (Hassen and Brannang, 1996; Sisay and Ebro, 1998; Yeshwas *et al.*, 2014), including some reports from Africa (Kudi *et al*., 1998; French *et al*., 2001). However, when comparisons were made between the present and studies conducted in western countries, lower mortality rate in the later was observed (Svensson *et al*., 2006; Lombard *et al*., 2007; Magalhaes *et al*., 2008; Torsein *et al*., 2011). Even an economically acceptable level of mortality was also set like, 3% in Sweden (Svensson *et al*., 2006), 5% in Norway (Gulliksen *et al*., 2009) and 2−6% in Britain (Ortiz-Pelaez *et al*., 2008).

The discrepancy between the present and previous reports in Ethiopia and other parts of the world, might be attributed to variations in many calf and herd-level risk factors, management practices, age of the calf considered, breed of study calves, agro-ecology and the method they used to measure mortality (incidence rate/risk or prevalence). For instance, most previous reports from Ethiopia were based on studies in research stations and government ranches with large herd sizes and usually owning high exotic blood level animals; apparently these are associated with increased risk of calf disease occurrence (Wudu, 2004). However the present study was conducted in small-holder dairy farmers holding small number of calves per farm (average 1.6) and thus farmers can easily monitor calves and take measures to avoid calf health problems.

This could be one of the reasons for lower mortality rate in small sized farms than in large herd sized farms mentioned above. For instance, the lower mortality rate in many developed countries might be influenced by better management practices, whereas the tropical environment for which temperate breeds are not well adapted might have been an additional stress to increase the risks of health problems (Wudu, 2004).

In general, most of the times, morbidity statistics is unavailable in many farms and difficult to make comparisons, unlike mortality. If available, variations are wide; this might be partly due to lack of reliable morbidity records by dairy producers (Bruning-Fann and Keneene, 1992) and the different methods used in diagnosis. For instance, some authors report calf morbidity based on producer diagnosis and treatments, while others depended on veterinarian diagnosis (Wudu, 2004). Considering the above facts, some authors have reported crude morbidity (Waltner-Toews *et al.*, 1986a; Debnath *et al.*, 1990; Razzique *et al.*, 2001; Svensson *et al.*, 2006; Wudu *et al.*, 2008 ; Gulliksen *et al.*, 2009; Yeshwas *et al.*, 2014) from different parts of the world. The present morbidity finding was slightly congruent with Virtala *et al.* (1996) and Debnath *et al.* (1990), who reported 52% morbidity rate in dairy calves. However, except, Bekele *et al.* (2009), who reported 29.3%, other reports like 62% (Wudu *et al.*, 2008) and 58.4% (Yeshwas *et al,* 2014) were higher than the present value.

## 5.2. Relative morbidities

In this study, calf diarrhea was found to be the predominant calf health problem with incidence rate of 25.2% followed by pneumonia (8.6%). Diarrhea was also the principal cause of death in most neonatal calves aged below 3 month. This finding has also been supported by other studies (Waltner-Toews *et al.*, 1986a; Sivula *et al.*, 1996a; Wells *et al.,* 1996; Wudu, 2004), who explained that diarrhea is the commonest disease and the greatest single cause of neonatal mortality during the first week of life. Calf diarrhea accounts for approximately 75% of the mortality of dairy calves aged below three weeks of age (Blowey, 1990). Furthermore, these findings are consistent with the reports of Lemma *et al.* (2001) and Hussein (1998) in Ethiopia and many other studies elsewhere, which reported diarrhea and pneumonia as the first and second important disease complexes that affect calf health (Olsson *et al.*, 1993; Debanth *et al.*, 1995; Sivula *et al.*, 1996a).

However, there are also some contradictory reports that details pneumonia is the leading cause of calf mortality (Shiferaw *et al.*, 2002). The reason why diarrhea is the predominant cause of calf mortality might be due to poor hygienic handling of feeding utensils, calving area, calf pen and fail to provide adequate colostrum on time. All these managerial factors might be incriminated in the high incidence of calf diarrhea reported by the present study and in many previous reports. The relatively lower incidence of pneumonia in this study might be due to the small-herd size of farms.

Except five large sized farms, the average total herd size of 164 small-holders in this study was about 7 animals per farm. Large herd size has strong correlation with environmental stress that exposes calves to respiratory problems (Wudu, 2004); it was observed that a 50% decrease in stocking density was increasing the ventilation rate by 20 times there by decreasing the risk of pneumonia (Blowey, 1990).

Of total Omphalitis cases, 62.5% was recorded in the first weeks of life. This finding is consistent with Virtala *et al.* (1996) and Ganga *et al.* (2011), who reported the incidence of umbilical infection is usually common in the first week of life and within 2-5 days after the birth of calf, respectively.

The incidence rates of other calf health problems were found lower as compared to diarrhea and pneumonia. Navel Ill (5.8%), septicemic condition (5.8%), Lumpy Skin Disease (4.9%), rabies (1%), miscellaneous causes (11.3%) and congenital defects (1.1%) were recorded in this study. Except LSD and rabies, this finding was slightly congruent with various earlier reports from different parts of the world (Britney *et al.*, 1984; Olsson *et al.*, 1993; Virtala *et al.*, 1996; Shiferaw *et al.*, 2002, Wudu *et al.*, 2008).

LSD outbreak occurred in some urban and peri-urban dairy farms since August 2014 with 4.9% incidence rate. Although the disease was known in its severe morbidity and minimal mortality, neonatal calves and adult crossbred animals were died of LSD due to secondary complications in the present study areas. As per the farmers view, animals with LSD infection were not allowed to visit Veterinarians, since they perceived that medical treatment make the disease worsen. They also explained that lack of LSD vaccine allowed the disease to be maintained and occurred in a cyclical pattern. Such farmers traditional practice coupled with lack of its vaccine might be associated with the increased mortality and morbidity records by LSD.

About 1% incidence rate of rabies was also reported in this study. Two rabies cases were recorded in Bahir Dar town and Bahir Dar Zuria due to sudden bite with rabid dog. Many owned and stray dogs were observed in urban dairy farms especially in Bahir Dar town, dogs were served as a farm guard. Although rabies vaccine has become accessible via mobile clinics, many small-holders failed to vaccinate their dogs on a regular basis. The frequent contact of animals with unvaccinated dogs might precipitate further rabies infection. Therefore as rabies is a fatal disease, caution should be taken in managing dogs and calves shall be kept away from in contact with dogs.

The 1.1% (5/440) prevalence of congenital disorders was recorded in this study, of which two were congenital loss of sight and the others were complete loss of tail, triple naval flap and congenital deformed lumbar vertebrae. Although the figure is differed, similar finding was reported by Wudu *et al* (2008), reported 5% prevalence of congenital problems.

However, it is difficult to reason out these congenital problems. Some toxins and infection like bovine virus diarrhea (BVD) virus can cause congenital cataract with consequences of blindness (Blowey, 1990).

## 5.3. Determinants of calf morbidity and mortality/risk factor investigation

Generally about 50 hypothesized explanatory variables were tested for their association with crude mortality and morbidity in small-holder and commercial dairy farms located in Bahir Dar milk-shed. However, procedurally these variables were examined stringently through univariate and multivariate analysis by using Cox-regression. In the final model (multivariate Cox-regression), age, vigor status at birth, birth type (single/twin), colostrum feeding, method of colostrum feeding and farming system were investigated as risk factors of calf mortality. Calf age, vigor, colostrum feeding, dam age, study location and birth related disorders were also the proven determinant factors of calf morbidity.

Age (except for pneumonia) and vigor status at birth has taken a lion share in determining all cases encountered in this study (mortality, morbidity, diarrhea and pneumonia). In all cases, younger calves aged below three month were at higher risk as compared to their older counter parts. It has been shown that the average age for the occurrence of crude morbidity, crude mortality, diarrhea and pneumonia were seven, 6, 5 and 6 weeks, respectively. Of total cases recorded, relatively highest crude morbidity (52%), mortality (53%) and diarrhea (63%) incidents occurred in the first month of age. This finding is also supported by various authors. Olsson *et al.* (1993) reported that 65% and 75% of morbidity and mortality in three months of life occurred in the first month of age. Approximately 60-75% of the mortality in calves occurs in the first month of their life (Waltner-Toews *et al*., 1986a; Heinrichs and Radostits, 2001; Svensson *et al*., 2006; Wudu *et al*., 2008; Gulliksen *et al*., 2009). However, there is also one study which reported higher mortality in older calves than younger calves (Gitau *et al*., 1994). This implies that besides the undeveloped inherent immunity in very young calves, other factors like malnutrition in older calves were important in calf health management (Wudu, 2004).

Generally, the relatively higher risk of mortality and morbidity in young calves observed in many earlier and the present findings proved how young age is a critical determinant factor of calf health. Thus dairy producers need to give proper managerial attention to younger calves as compared to older ones.

Vigor status at birth was found significantly associated with calf mortality in all observed cases (mortality, morbidity, diarrhea and pneumonia). Poor vigored calves were at higher risk for mortality and morbidity than that of good vigored calves. The present finding is found congruent with earlier reports, vigor and health of the calf at birth is highly correlated to morbidity and mortality (Heinrichs and Radostits, 2001; Vasseur *et al*., 2009). Poor vigor at birth increases odds of death and delayed suckling or lower colostrum intake (Vasseur *et al*., 2009). Prolonged parturition affects the calf's health and vigor (Sivula *et al*., 1996b), and decrease their colostrum intake by 52% (Besser *et al*.,1990). Thus, dairy producers can make meaningful improvements in calf health and vigor by focusing on management interventions, like providing timely birth assistances during difficult calving and better feeding and health management during pregnancy.

Birth type was also found as determinant factor of mortality in this study. Co-twin calves were found at higher hazard of mortality than that of singletons. Among 8 co-twin calves born during the follow up period, 6 (75%) were died before they reached their three months of age. This finding was found consistent with Mellado *et al*. (2014), that calf mortality rate from twin births was five percentage points higher than single birth calves. The risk of perinatal mortality increased significantly in twins compared with singletons (Mee *et al*., 2008 a,b). Twin births have also been associated with decreased gestation length, increased abortion, increased dystocia, retained placenta, metritis and decreased perinatal viability (Silva del Río *et al*., 2007; Gulliksen *et al*., 2009). Thus, all the above findings concluded that twining in dairy cattle is undesirable trait because of increased calf mortality rates during the first month of life.

Degree of colostrum feeding and its method of provision were found significantly associated with calf mortality and morbidity. Those calves with history of partial colostrum feeding were at higher risk of mortality and morbidity than those calves with complete colostrum feeding. In this regard, many published papers has been explained the ultra-significance of adequate and optimal time of colostrum feeding vis-a-vis mortality and morbidity. For instance, ingestion and absorption of enough quantity (10% to 12% of their body weight) of colostrum during the period shortly after birth is vital to the calf's health and survival (Fallon *et al*., 1989; Werem *et al*., 2001;

Wudu *et al*., 2008; Arnold, 2014). But in this study, it has been observed that many small-holder farmers (31.6%) were not aware of the importance of complete colostrum feeding due to various unproved cultural taboos. They believed that the calf should not access complete colostrum as it is the cause of diarrhea and alopecia (neonatal hair loses). Thus, dairy calves especially owned in these small-holder groups are not getting the required amount of colostrum and are remaining at higher hazard for mortality and morbidity.

Method of colostrum provision was significantly associated with calf mortality, but not for morbidity. Hand/bucket feeding increases the hazard rate of mortality than suckling. However, many reports have been detailed the advantage of hand feeding (esophageal or nipple bottle) over the natural method, suckling. Failure to passive transfer immunity was less frequent in dairies that used artificial feeding either nipple bottle or tube feeding, than in dairies that allow calves to suckle (Besser *et al*., 1991). Colostrum delivered by a nurse bottle or esophageal feeder will result in adequate passive transfer and provides assurance that the calf has consumed an adequate volume (Gorden and Plummer, 2010). Suckling calves had an increased risk of death during the first week of life (Quigley *et al*., 1995). Others also suggested that passive transfer can be improved better when suckling supplemented with bottle feeding (Bringole and Stott, 1980; Fallon *et al*., 1989). The question why hand/bucket feeding is the risk of mortality in the present study is difficult to justify. This might be partly associated with the sanitary condition of feeding utensils (bucket). Otherwise, the contradict report provided by the present study needs further investigation and verification under the existing small-holder farming condition.

Another differed finding encountered in the present study, was significantly association between farming system and study location/district with calf mortality and morbidity, respectively. The hazard for mortality was lower in small-holder farms that undergo mixed crop-livestock farming than that of specialized livestock farms. This finding could not be computed with other findings because of lack published materials in this regard. Though it could be uncertain, it can be speculated that this phenomena might be associated with nutrition. For instance, during the six month observation period and interview finding, feed shortage (in terms of scarcity and increased cost) was stand as major dairy production constraint in most urban dairy farms. Whereas many farms located in peri-urban-rural areas have better access to year round animal feed resources mainly derived from crop residue (maize), irrigated crop by-products and even to other non-conventional feed staffs/local beer byproducts (*atela* ad *brint*).

Furthermore, despite herd density in this study lack association with mortality, the relatively lower herd size coupled with good nutrition status in crop mixed livestock farms might have a protective effect in calf health and survival.

Calves located in Bahir Dar town were significantly at higher risk of morbidity than that of calves located in Yilmana Densa district. Of course, crude mortality and morbidities were also apparently lower in this district than the other three (Bahir Dar Zuria, Mecha and Bahir Dar special Zone). However, there was no previous report done on the same study areas, thus comparison was not made. But this variation might be arisen due to agro-climatic factors, varied herd size and management practices. In Yilmana Densa district the climatic factor (Altitude= >2200 m.a.s.l) seems favorable for crossbred dairying and no large sized dairy farms found in this location. Furthermore, non-conventional feed staffs (local beer byproducts) are widely used as regular animal feeds in Yilmana Densa and Mecha districts and many respondents were witnessed the advantage of these feed staffs. It might be good if further research can explore the nutritive value of such feed staffs.

Breed was found significantly associated with calf diarrhea, but not for crude mortality, crude morbidity and pneumonia. Crossbred calves were found at higher risk for diarrhea than that of local ones. The effect of exotic genetic influence under the tropics environment on calf mortality has been widely addressed. The effect of breed on mortality and morbidity has been detailed by many researchers. In general, the higher mortality and morbidity in crossbred calves might be associated with the susceptibility of *Bos taurus* breeds to climatic and disease stress in tropical environments (Debnath *et al*., 1990; Wudu, 2004; Swai *et al*., 2010). During the follow up period, particularly in Bahir Dar town, crossbred calves with high exotic blood level (>50%) were frequently diarrheic and being unthrifty later in life. Thus it is important to reconsider the recommendation of Yahya *et al.* (2011), which suggested that keeping crossbred dairy cows of the intermediate exotic blood (62.5%-75%, Friesian inheritance) is better for health and production in the tropics. Further grading up above 75% towards the *Bos taurus* breed has given variable and often disappointing results (Ababu *et al.,* 2006).

Another differed finding in this study was, being previously treated against any disease was found as a risk factor for pneumonia. Calves with history of previous treatment were found at higher hazard for pneumonia than those who did not receive any previous medical treatments. Some dairy farmers complained about the poor treatment responses and, reinfection was the

common squeal in many previously treated calves during the observation period. This might be associated with failure in following treatment guidelines, indiscriminate use of self-antibiotics and poor efficacy of drugs (problem of drug resistance) by many dairy producers. As diarrhea was the leading cause of morbidity and mortality in this study, it is likely to take the great share of previous treatment. If so, this finding is congruent with one previous report (AHI, 2012), reported calves that have suffered from scour (diarrhea) are more likely to develop pneumonia later in life.

## 5.4. Passive Transfer of immunity in Dairy Calves

Passive transfer was determined by Zinc sulfate (ZnSo4.7H20) turbidity test. According to the test result, prevalence of failure of passive transfer (FPT) in those selected farms of Bahir Dar milk shed was 8.7%. Adequate protection (34.8%) and partial protection (56.5%) were also recorded among study calves. Although the method (ZnSo4) classifies the degree of Ig protection level in to three main categories, it could be better to group those slightly protected calves in to FPT, as they are not fully protected and hence the likelihood of infection is certainly be higher either in neonatal or older life. Partial or complete failure of passive transfer of maternal antibodies is an important host factor related to development of pneumonia in young calves (Campbell, 2012; Windeyer *et al*., 2014). Therefore it can be concluded that about 65.2% of calves were not immunologically protected against infection in this study. This finding is also consistent with the work in the central highland of Ethiopia by Amoki (2001) indicating a high percentage of failure of passive transfer of immunity in market oriented smallholder dairy farms. As the sample size was little, statistical comparisons between level of passive transfer and mortality, morbidity, diarrhea and pneumonia were not made. Although the issue of failure of passive transfer in many dairy farms is a crucial matter, no published report found in Ethiopia so far. Thus this finding can be considered as the first one and proved its applicability in small-holders' condition. As the laboratory protocol is quite simple, cheaper and easy to apply, dairy producers can use this test to evaluate their colostrum management practices on regular basis

## 5.5. Herd level findings based on interview questionnaire and observation

According to herd level findings based on interview questionnaire and observatory findings, calf morbidity (mainly diarrhea) and mortality, reproductive and metabolic disorders (milk fever), mastitis were the major problems of many urban dairy farms next to feed shortage as compared to

peri-urban dairy farms. Most peri-urban small-holders complained that inadequate Artificial Insemination (AI) service and mastitis were their major problems. Previous studies have also reported a similar finding that, reproductive inefficiency, young mortality and mastitis, lameness, pneumonia and ketosis are major health problems in intensive dairy production (ILCA, 1994).

About 13.8% (24/174) of farms raised their calves by hired calf care takers. In this type of farms apparently higher calf mortality was observed than those calves raised by owners. This observational finding is also found congruent with some reports. Personal closeness between the owner and the animal may play an important role for the animal's welfare and health (Wymann *et al.*, 2006). Fewer losses due to death were observed on farms where the owner managed the calves than on farms where employees or hired labor performed the duties (Jenney *et al.*, 1981; Britney *et al.*, 1984). This suggests that owners might be motivated sufficiently to provide the care necessary to insure high survival

About 17.2% and 11.5 % of respondents from urban and peri-urban dairy has been experienced calf mortality during for the last one year, respectively. This herd level figure was found slightly consistent with the present calf level study. Of total 183 recruited calves in urban dairy, about 18.5% died. The relatively lower death record (9.7%) of calves was observed among 257 calves in peri-urban dairy farms. However, the present herd level survey figure seemed lower as compared to Wudu (2004), reported 36% of market oriented small-holders experienced calf mortality in and around Debre Zeit. This variation might be explained by herd size, agro-climatic condition and small-holder's management practice.

Separate calving pen facility was not observed except the two large sized farms. Calving was made either in cows' barn or outdoor/field that could increase the likelihood of getting diarrhea and pneumonia. Although on time colostrum feeding is very important to enhance calf health and performance, about 31.6% of small-holders lack basic knowledge of colostrum feeding. Thus, awareness creation works in these areas shall be the primary concern to devise a sound colostrum management practice.

# 6. CONCLUSION AND RECOMMENDATION

The present study has revealed higher morbidity and mortality rates of calves in urban and peri-urban dairy farms of Bahir Dar Milk-shed. This morbidity and mortality magnitude is therefore found higher than economically tolerable level. More importantly, small-holders in the present study areas kept smaller herd size and their part of livelihood was dependent on livestock agriculture. Thus, these higher rates of calf morbidity and mortality will decrease their replacement stock and ultimately hinders the success of small-holder dairy business. Calf diarrhea was the predominant calf health problem responsible for the majority of calf illnesses and deaths. This study has investigated a multitude of determinant factors that are significantly involved in calf health and survival. Among the potential risk factors investigated, vigor status at birth, age and breed from calf factors, dam age from dam factors, and volume and method of colostrum feeding from management and farming system and study locations from environmental factors, were found significantly associated with crude mortality, crude morbidity, diarrhea and pneumonia.

Of the aforementioned risk factors, vigor status at birth and age of the calf were found the most determinant factors affecting almost all disease conditions in this study. However, most of these host, management and environment associated factors are amenable for intervention. Therefore, making tailor-made interventions against these determinant factors can certainly improve calf health status and production performances. This can be achieved via understanding and manipulating of causes and risk factors associated with morbidity and mortality with subsequent application of improved calf management practices.

Lower degree of passive transfer of immunity was recorded in newborn calves in the study herds. Accordingly, special emphasis should be given to feeding complete colostrum (10% of calf's body weight) as early as possible within 6-12 hours of birth through sustained awareness creation and rising. As diarrhea was the predominant case encountered in this study, investigating its etiology would have enabled complete understanding of the case. Therefore, further detail research in investigating etiology of diarrhea is recommended. Moreover, the sample size taken during passive transfer was not as such representative to the general population in the study area. Therefore future comprehensive research in this area is also suggested; thereby conclusive remarks can be achieved.

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# 8. ANNEXES

Annex I. Questionnaire for herd level management data collection associated with dairy calf morbidity and mortality in Bahir Dar milk-shed.

*1. General information*

Date of interview……………………….

Zone……………Woreda……..……Kebele………..Village…………..…..Tel…………

Altitude of the area (M.a.s.l)     a) high altitude (>2000)     b) mid altitude (1500-1800)

c) low altitude (<1500)

*2. Farm, household and land holding characteristics*

2.1. Name of the household head/respondent……………

2.2. Sex of house hold head     a) male     b) female

2.3. Age of house hold head………………

2.4. Marital status     a) married     b) single     c)Widow     d)Divorced

2.5. House hold educational status     a) illiterate   b) read and write     c) elementary school

d) high school graduate   e) professional,

If professional     a) related to animal production   b) unrelated to animal production

2.6. Family size:     Male…….Female……….Total……..……

2.7. System of Agricultural production   a)livestock   c)mixed crop- livestock

2.8. Land holding: Cultivable/farming land (ha)……Private grazing land (ha)…. Total……

*3. Dairy Production System*

3.1. What are your major livestock activities?

a) Dairy production     b) Small ruminant production     c) poultry production

3.2. Dairy production as a source of income     a) primary     b) secondary/side line activity

3.3. How long have you engaged in dairy production?...................

3.4. Dairy farm location

a) Urban     b) peri-urban

3.5. Herd size and composition

| Herd composition | | local | Cross | Total |
|---|---|---|---|---|
| Calves (<6m) | Male | | | |
| | Female | | | |
| Calves (6-12m) | Male | | | |
| | Female | | | |
| Heifers | | | | |
| Lactating cows | | | | |
| Dry cows | | | | |
| Bull | | | | |
| Bullock | | | | |
| *Total herd size* | | | | |

*4. Calf Management data*

4.1. Breeding methods used        a) AI      b) natural mating      c) both

4.2. Calf caretaker (attendant)

    4.2.1. Ownership              a) owner (family member)        b) hired

    4.2.2. Sex           a) male            b) female

    4.2.3. Experience      a) <= 5 years      b) >5 years

4.3. Pregnant cow management and periparturient care   a) yes   b)no

    4.3.1. If   yes, what kind of management? ………………

    4.3.2. Calving facilities    a) calving pen         b) the same barn

    4.3.3. Bedding in maternity area   a) yes           b)no

        4.3.3.1. if yes, type of bedding    a)stalks         b) straw

    4.3.4. Calving assistance           a) routinely         b) rarely      c) never

        4.3.4.1. When do you provide calving assistance?....................................

    4.3.5. At what time do you separate the calf from his dam………………………….

    4.3.6. Navel treatment     a) practiced         b) not practiced

        If practiced, type of treatment/chemical used…………………………….

4.4. Awareness about the importance of colostum to neonatal calves     a) yes       b) no

    4.4.1. Do you feed colostrum to your calves        a) yes     b)no

4.4.2. If yes,   a) partial colostrum   b) complete colostrum

4.4.3. Method of feeding          a) suckling               b) hand feeding

4.4.4. Time of first colostrum feeding     a) with in 6 hour   b) 6-24 hour   c) > 24 hours

4.4.5. Duration of feeding          a) for 24 house     b) 24 hour-4 days        c) > 4 days

4.4.6. If hand feeding, source of feeding      a) dam        b) another cow        c) both

4.5. Feeding and watering management

4.5.1. Type of feed               a) milk               b) milk replacer

4.5.2. Amount of milk/milk replacer given

a) Known, amount (Lt)………………          b) unknown, residual milk

4.5.3. Frequency of milk feeding/day     a) once a day    b) twice a day      c)…………

4.5.4. Time (in days) of introducing feed other than milk or milk replacer ……………..

4.5.5. Mode of feeding        a) free grazing          b) stall feeding      c) partial grazing

4.5.5.1. If free grazing, time (hr) of grazing………………..

4.5.6. Could you mention major types for each of the following classes of feeds you are

using for dairy cows and calves?

| Classes of feeds | a)yes          b)no | If yes, type of feed |
|---|---|---|
| 1. Improved forages | | |
| 2. Crop residues | | |
| 3. Concentrates | | |
| 4. If others (specify) | | |

4.5.7. Watering             a) free access        b) periodic

4.5.8. Source of water     a) tap water      b) river     c) open well    d) other……

4.6. Housing management

4.6.1. Housing type       a) indoor               b) outdoor/hutch

4.6.2 .Location of the calf pen       a) In cow shed            b) in separate pen/shed (cubicle)

4.6.3 If separate pen        a) individual pen        b) group pen

4.6.4 If group pen, number of calves kept /pen………….

4.6.5. Bedding in calf house        a) present             b) absent

4.6.6. If present what is the bedding material       a) straw             b)stalk

4.6.7. Frequency of calf pen cleaning     a) every calf entry    b) daily     c) twice a day

4.6.8. Which group of calves are often receive better managerial attention?

a) male calves    b) female calves    c) both                If male/female…………

4.6.9. Weaning age (m)          a) local…………..b) cross…..

## 5. *Calf morbidity and mortality data*

5.2. Is calf mortality the problem of your farm?      a) yes          b) no

5.3. Total number of calves (<1yr) the farm lost during the last one year:

Local……Cross…………Total………

5.4. At which age group mortality is higher?

a) perinatal age (until 24 h after birth)

b) neonatal age (death between 1 and 28 d of age

c) older age (death between 1 and 6 month of age)

5.5. Diseases which are responsible for sickness and death of calves in order of importance.

a)……………...…b)……………..…..c)………..……….d)……………..…..e)………………

5.6. Which breeds of calves are highly susceptible to diseases?      a) local        b) cross

5.7. Measures taken to prevent disease problems……..……………..…….…..…….……

5.8 .Calf weaning practices

5.9.1. Who weans the calf mostly?

a) The cow refusal      c) Owner      d) Refusal of the calf        e) Others

## 6. *Dairy cow health disorders and health management activities*

6.1. Major Dairy cow health disorders…………..……….…..

6.2. Pregnant cow vaccination        a) yes            b) no

6.3. Dry cow therapy        a) yes          b) no

## 7. *Milk production, marketing and constraints*

7.1. Current total milk produced/day (Lt)………Sold/day……...current price/liter…………

7.2. Mode of milk selling    a) to milk cooperatives    b) to local retailers   c) direct selling

d) house hold consumption

7.3. Do you have an access to veterinary service?      a) yes      b) no

distance from home (Kms)…………

7.4. Could you mention major constraints of dairy production……………………….

Annex II. Calf level data recording off sheet associated with dairy calf morbidity and mortality in Bahir Dar Milk-shed

Name of the owner……………………..Woreda……….…..kebele……..…Tel….……….

          Calf ID……………………..Dam ID……….………………….

*I. Calf and management associated factors*

1. Date of birth                date…………………month……..…year…………...

2. Condition of birth     a) Easy      b) Dystocia/assisted

    2.1. If assisted, who assist the calving process?    a) owner      b) Veterinarian

3 Time of birth              a) night          b) day

4. Site of birth         a) indoor/cow's barn     b)outdoor /field

5. Sex             a) male           b) female

6. Breed          a) local         b) cross

7. If cross, exotic blood level    a) <=50%     b) 50-75%      c)>=75%

8. Navel disinfection       a) yes  b) no    If yes, chemical used…………

9. The calf fed with maternal colostrum    a) yes    b) no

       If no, why…………………………………………..

10. If yes, time of colostrum ingestion  a) before 6 hr     b) 6-12hr  c) 12-24    d) >24hr

11. Method of colostrum feeding      a) suckling    b) hand feeding/bucket    c) both

    11.1. If hand fed, amount given……………..

    11.2. Source of colostrum    a) dam      b) another cow    c)both

    11.3. Was the dam presented to the calf during hand feeding    a) yes      b)no

12. Vigor status as soon as birth

    a) good vigor/quick suckling

    b) poor vigor/ delayed suckling

13. Time of separation of the calf from dam/postpartum hr ?

     a ) before 1st nursing     b) after 1st nursing    c)before 24 hr age    d)after 24 hr age

14. Birth weight: Kg………….., Weaning weight: Kg…………

15. Weaning age (m)………………………

## II. Dam associated factors

16. Mothering instinct      a) good mothering      b) poor mothering

17. Parity of the dam     a) primiparous/first     b) multiparous/second and above

18. Dam breed     a) local     b) cross

19. If cross, exotic blood level     a) <=50%     b) 50-75%     c)>=75%

20. Dam age………………………..

21. Lactation length (LL)…………Length of dry period (days)………..Open days……………

22. Age at first calving ……………Calving interval…

23. Milk yield(L/day): Early…..................mid……..…..……late……..……

24. Other dam health disorders………………………………………………..

## III. Sire associated factors

25. Source of breeding service     a) AI     b) natural mating/bull service

   25.1. If AI, source of semen,     a) H. fresian     b) Jerssy     c)…………………..

   25.2. If natural mating, source of bull

      a) home breed     b) neighboring bull     c) community bull

   25.3. If home breed, is the bull relative to the calf?     a) yes     b) no

   25.4. If yes, degree of relationship     a) full sibs brother     b) half sibs brother     c) others

## VI. Calf case incidence record

  26. Date of appearance of clinical signs………………………….……….

  27. Major clinical signs…………………………………………….……

  28. Diagnosis……………………………… Treatment……………………

  29. Treatment out come     a) recovered     b) died

       If died, date of death……………………………………….…

Annex III. Standardized case definitions used during recording of diseases and mortality events between birth and 6 months/180 days of age in Bahir Dar Milk-shed

| Disease condition | Case definition |
| --- | --- |
| Diarrhea/scours | Manure is of looser consistency than normal calves. Any condition characterized by passing of lose or watery feces with increased frequency, which could or could not be accompanied by other systemic signs like dehydration, decreased appetite or fever |
| Respiratory disease | Increased resting respiratory rate, fever ($>39.5^0$c) with one or more additional signs such as coughing, nasal discharge, depression, decreased appetite or rough hair coat |
| Naval ill/Omphalitis | Warm enlargement of umblical cord, or foul smelling discharge from the umblical structures due to infection |
| Septicaemic cond. | Any condition characterized by depression, anorexia and fever without any distinct involvement of specific body system |
| LSD | Characterized by skin nodules, fever, necrotic plaques in mucosae and lymphadenopathy. |
| Rabies | A history of rabid dog bite preceded nervous signs like drooling of saliva, aggressiveness and beat their heads by any inanimate objects, extended recumbence and complete loss of appetite then ended up with death |
| Congenital problems | Any problems that was acquired inborn. |
| Miscellaneous cases | Different health problems that could not be grouped in any one of the other groups mentioned before and diagnosed relatively less frequently (traumatic injury, birth defects, ring worm, warts e.t.c…) |
| Perinatal mortality | Live-births that died until 24 hr of birth of life without an obvious disease |
| Neonatal mortality | Death between 1 and 28 days of age |
| Older calf mortality | Death between 1 and 6 month of age |

Source: (Heinriches and radostitis, 2001; Wudu, 2004; Windyer et al., 2014)

Annex IV. Potential risk variables, their categories and coding

| Variables | Description of category and codes |
|---|---|
| *Calf factors* | |
| Breed | 0 = cross |
| | 1 = local |
| Age | 0 = bellow 3 month of age (younger) |
| | 1 = above 3 months of age (older) |
| Vigor status at birth | 0=good |
| | 1=poor |
| Birth condition/ease of birth | 0=normal delivery |
| | 1=dystocia |
| History of previous treatment | 0=no |
| | 1=yes |
| Calving site | 0=outdoor |
| | 1=barn |
| *Dam factors* | |
| Age of the dam | 0=<5yr |
| | 1=>5yr |
| Dam vaccination during gesta. | 0=no |
| | 1=yes |
| Mastitis at early lactation | 0=no |
| | 1=yes |
| Birth related disorder | 0=no |
| | 1=yes |
| Birth type | 0=single |
| | 1=twin |
| *Management factors* | |
| Colostrum feeding | 0=partial feeding |
| | 1=complete feeding |
| Age at firist colostrum ingestion | 0=<6hr |
| | 1=>6hr |
| Breeding method | 0=AI |
| | 1=Natural mating |
| Mode of feeding | 0=stall feeding |
| | 1=grazing |
| Method of colostrum feeding | 0 = suckling from its dam |
| | 1 = hand feeding |
| Calf housing condition | 0 = separate calf pen |
| | 1 = in the same barn with cows |
| House cleanness | 0 = clean |
| | 1 = unclean |

*Farm attributes*

| | |
|---|---|
| Age of the farm | 0 = ≤5 years |
| | 1 => 5 years |
| Farm as source of income | 0 = primary source of income |
| | 1 = secondary source of income |
| Ownership of the calf caretaker | 0 = owner |
| | 1= hired |
| Sex of calf caretaker | 0 = male |
| | 1 = female |
| Experience calf caretaker | 0 = ≤ 5 years experience |
| | 1 = >5 years experience |

*Environmental factors*

| | |
|---|---|
| Total herd size | 0=<20 animal/house hold |
| | 1=>20 animal/house hold |
| Study district | 0=Bahir Dar town |
| | 1=Bahir Dar zuria |
| | 2=Mecha |
| | 3=Yilmana Densa |
| Farming system | 0=specialized livestock |
| | 1=mixed crop-livestock |
| Dairy production system | 0=urban |
| | 1=peri-urban |
| Altitude (m.a.s.l) | 0=<2000 |
| | 1=>2000 |

Annex V. Pictures taken during the study period



A) Twin calves (both male, 87.5%)
   Survivors

B) Twin calves (both male, 62.5%)
   both were died before they reached 3 month of age



C) Good vigored calf

D) Diarrhea survivor (poor vigored co-twin)



E) Congenital defect (Complete loss of tail)

F) Unthriftness (diarrhea survivor)

# 9. CURRICULUM VITAE



# Personal information

| | |
|---|---|
| Surname | Alemu |
| First name | Yeshwas Ferede |
| Nationality | Ethiopia |
| Current address | Amhara Regional Agricultural Research Institute (ARARI) |
| | Andassa Livestock Research Center |
| Telephone | +251(0) 910 15 07 16/0945575380 |
| E-mail | yeshwasferede@yahoo.com |
| Date of birth | 25 April 1985 |
| Place of birth | Gondar, Ethiopia |
| Sex | Male |
| Marital status | Married |

**Educational background**

**2001-2002 G.C**: High school education completed and passed national examination for preparatory school from Dabat secondary school, North Gondar

**2003-2004 G.C**: Preparatory education program completed and passed national examination for University study from Dabat preparatory school, North Gondar

**2005-2009 G.C**: Earned DVM degree in Veterinary Medicine with great distinction grade point average (CGPA 3.59/4.00), From University of Gondar, Faculty of Veterinary Medicine, Ethiopia

- **DVM thesis Title**: Sero-Epidemiological investigation of Small-ruminant Brucellosis in and around Bahir Dar, Ethiopia .

  *-Thesis defense is done successfully and got 'Very good/B$^{+}$'*

**2013/14-2015 G.C**. Earned MSc degree in Veterinary Epidemiology with (CGPA 3.78/4.00) from Addis Ababa University, Ethiopia

- **MSc thesis Title**: Epidemiological Determinants and Magnitude of Dairy Calf Morbidity and Mortality in Bahir Dar Milk-shed, Ethiopia (Supported by LIVES project)

  *-Thesis defense is done successfully and got 'Excellent/A'*

| **Work Experience** | **25 Jan 2010 – 08 Feb 2012**: Animal health Assistant Researcher I, Amhara Regional Agricultural Research Institute, Andassa Livestock Researcher Center, Ethiopia |

*Duties and responsibilities*

Worked as animal Health Assistant Researcher I
- Conduct field data and specimen collection under the supervision of senior researchers
- Conduct laboratory investigation

**08 Feb 2012-08 Feb 2014** – Animal Health Assistant Researcher II, Amhara Regional Agricultural Research Institute, Andassa Livestock Researcher Center, Ethiopia

*Duties and responsibilities*
- Proposal writing and executing
- Coordinate and direct Veterinary technicians in field work and laboratory protocols
- Organize and deliver community based animal health trainings
- Conduct on station and on farm animal health research activities

**08 Feb 2014-up to now** – Animal Health Associate Researcher , Amhara Regional Agricultural Research Institute, Andassa Livestock Researcher Center, Ethiopia

*Duties and responsibilities*
- Designing, planning and executing animal health projects and/ or proposals
- Coordinate animal health (small-ruminant and dairy health) research projects at national and regional level
- Organize and conduct Epidemiological surveys
- Organize and deliver trainings on scientific paper writing, data management and analysis for junior researchers
- Organize and deliver community trainings on improved animal health management issues
- Provide advisory service to DVM externship students
- Prepare and disseminate technology usage manuals and guidelines

**Trainings taken(short-term)**

Inductive training on basic concepts of statistics and biometry, Principles of experimental design, research proposal and scientific paper writing, data management (SPSS and SAS Soft-ware), and the concept of gender and gender mainstreaming in Agricultural research at Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia

Training on Oestreous synchronization and sex fixing technologies from 20-28 Nov, 2011 at Andassa Livestock Research Center (Organized and delivered by ILRI)

**Technical skills and competences**

Good ability in identifying problems (problem diagnosis), proposal writing/designing and reviewing as I spent most of my time in doing research

Good ability in clinical case handling and doing basic laboratory works in accordance with basic laboratory safety issues.

| **Computer Skill** | Basics of Microsoft word, Excel, Power point |
|---|---|

Data management and analysis  (SPSS, STATA, EPINFO, SAS)
>    -Survival analysis (Cox-proportional hazard model)
>    -Linear and Logistic regression

**Social skill competences**

I am an active learner and have team work spirit
Enhanced social relationship/personal communication skill and motivation

**Research Interest**

Epidemiologic Research; Small-ruminant and cattle health

**Leisure time activities**

Reading psychological and spiritual books
Talking about scientific findings, watching football games and movies

**Publications**

1. **Yeshwas Ferede,** Almaz Habtamu and Sisay Gebresellasae**.** Confirmatory diagnosis of contagious ecthyma (Orf) by Polymerase Chain Reaction (PCR) at Adet Sheep Research Sub-Center, Ethiopia. 2014. *Journal of Veterinary medicine and Animal health,* 2014. *Vol 6(7), 187-191*

2. **Yeshwas Ferede**, Shigdaf Mekuriaw, Hailu Mazengia and Agraw Amane. Sero-typing and evaluation of the level of protective antibody titer in northwest Ethiopian sheep before and after ovine pasteurellosis vaccination. 2013. *Int. J. Pharm. Med. & Bio. Sc. 2013, Vol. 2(4)*

3. **Yeshwas Ferede**, Agraw Amane, Hailu Mazengia and Shigdaf Mekuriaw. Prevalence of major sheep diseases and analysis of mortality in selected model sheep villages of South Gondar Administrative Zone, Ethiopia. 2014. *Ethiop. Vet. J, 2014, **18**(2), 83-97*

4. **Yeshwas Ferede**, Desalegne Mengesha, Gebreyesus Mekonen and Mussie H/melekot. 2011. Study on the sero-prevalence of small ruminant brucellosis in and around Bahir Dar, North West Ethiopia. *Ethiop.Vet. J, 2011, **15**(2), 35-44*

5. **Yeshwas Ferede**, Hailu Mazengia, Tewodros Bimrew, Addisu Bitew**,** Mohammed Nega and Adebabay Kebede. 2014. Pre-weaning morbidity and mortality rates of crossbred calves in Bahir Dar Zuria and Gozamen Districts in Amhara Regional State, Northwest Ethiopia. *Open Acess Library Journal (OALib). June 2014 | Volume 1 | e600*

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10. Adebabay Kebede, Tewodros Bimrew, Addisu Bitew, Yihalem Denekew, Asresu Yitayew, **Yeshwas Ferede** and Getinet Zeleke, 2011. Comparative evaluation of the fattening potential of some selected cattle breeds of Amhara Region, Ethiopia. *Int. J. Pharm. Med. & Bio. Sc. 2013. Vol. 2, No. 4*

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12. Agraw Amane, **Yeshewas Ferede** and Tewodros Bimrew: 2014. On-Farm Growth Performance and Evaluation of Farta Sheep under the Existing Farmers Management at Estie District of Amhara National Regional State, Ethiopia. Proceedings of the 21th annual conference of the Ethiopian Society of Animal Production (ESAP) Conference on Livestock and Economic Growth: Value Chains as Pathways for Development Held in Addis Ababa, Ethiopia, August 28-30, 2013

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**References**

1. Dr. Reta Duguma , Addis Ababa University, college of Veterinary Medicine and Agriculture
    Telephone: +251 (911) 883809
    E. mail: retaduguma@gmail.com

2. Dr. Zeleke Mekuriaw, ILRI, LIVES regional livestock expert
    Telephone: +251(918) 70 69 50
    E. mail: mekuriawzeleke@gmail.com

3. Dr.Wudu Temesgen, University of Gondar, Faculty of Veterinary Medicine

    Telephone: +251 (918) 78 72 35
    E. mail: temesgenha@yahoo.com

4. Dr. Azage Tegegne, ILRI, Deputy to Director General's Representative in Ethiopia
    Manager, Livestock and Irrigation Value chains for Ethiopian Small holders (LIVES) Project, International Livestock Research Institute
    Telephone: +251 (911) 246442
    E. mail : a.tegegne@cgiar.org