MORBIDITY AND MORTALITY RATE OF LAMBS AND KIDS: ASSESSMENT OF MAJOR ASSOCIATED RISK FACTORS IN DALOCHA WEREDA, SILTE ZONE, CENTRAL ETHIOPIA

MSC THESIS

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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 Redwan Anwar entitled "**Morbidity and Mortality Rate of Lambs and Kids; Assessment of Major Associated Risk Factors in Dalocha Wereda, Silte Zone, Central Ethiopia"** and recommend that it be accepted as fulfilling the thesis requirement for the degree of **Master of Science in Veterinary Epidemiology**

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I declare that this thesis is my genuine work and all sources of materials used for this thesis have been duly acknowledged. I solemnly declare that this thesis is not submitted to any other institution anywhere else for the award of any academic degree, diploma or certificate.

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ABBREVATIONS (ACRONYMS)

CI	Confidence Interval
DFEDSM	Dalocha Finance and Economic Development Socio-economic Main process
ESGPIP	Ethiopia Sheep and Goat Productivity Improvement Program
GIT	Gastrointestinal Tract
Ig	Immunoglobulins
LR	Likelihood Ratio
Obs	Observation
WBC	White Blood Cells

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ABSTRACT

Lamb and kid morbidity and mortality are serious constraints in the success of small ruminant production. Thus, the current study was carried out with the objective to estimate the incidences of lamb/kid morbidity and mortality, and identify the major associated risk factors responsible for the two (morbidity and mortality), in the study area. Cross-sectional survey and then prospective cohort study were employed from 10 February to 10 May 2023. A total of 130 (74 lambs and 56 kids) were recruited by simple random sampling method. During the survey, those target farmers (130) were interviewed to get flock level health and overall management related data. Most farmers (64%) replied that lamb/kid mortality was a common problem in their flock in which neonates (44%) were more frequently died age groups probably due to starvation (48%) followed by unknown causes (20%), disease (13%), predator (12%) and finally accident (7%)(flood and animal kick). In the present study, overall incidences of kid/lamb morbidity and mortality were 22.31% and 10% respectively. Mortality was higher in males (69.23%)(males may be more susceptible to pathogens) compared to females (30.77%), but the inverse is true for morbidity (41.38% and 58.62%, respectively)(males may be more competent in suckling). Slightly higher deaths of lambs/kids were seen in Golecheba Kebele (38.46%) than the rest two kebeles (Wanjashola and Enqatagam) with similar figure of 30.77%. However, smaller morbidity was recorded in case of Wanjashola kebele (27.58%) than the two. Most frequently encountered health events were emaciation/malnutrition, diarrhea and pneumonia/respiratory problem. Accident and circling disease were the least important ones. Multivariable Cox regression analysis

revealed statistically significant association ($p<0.05$) for age, health events, litter size, species and skm (interaction factor) with morbidity, while age, health events, colostrum feeding and skm with mortality in which health disorders were risk of both morbidity and mortality, but age was not (protective factor). The outcome of the study showed that knowhow of when and how lamb/kid morbidity and/or mortality occur could be helpful and to reduce them, proper management of lambs/kids particularly at early age is imperative.

Key words: Dalocha, Morbidity, Mortality, Lamb/kid, Incidence, Risk factors.

1. INTRODUCTION

1.1. Background

Approximately 1 billion poor people globally are dependent on livestock for their livelihoods. However, the benefits derived from livestock ownership, including income and household nutrition, are constrained by poor animal health and low productivity. Livestock mortality impacts farmer livelihoods and household nutrition (Wong *et al*., 2022). Globally, high pre-weaning mortality limits sheep production with the proportion of lamb deaths across many countries and systems remaining stable at 15–20% over the past 40 years (Flinn *et al.*, 2020).

The nature of an ecological zone also has a major influence on animal husbandry, which, in turn, can affect morbidity and mortality. For example, animals reared on rangelands throughout the world experience marked climatic and nutritional changes, and inadequate nutrition therefore occurs. Localized environments, such as night enclosures and watering points, become heavily contaminated with microorganisms that are responsible for septicaemias in neonatal kids and lambs in some African pastoral systems. Pre-weaning and post-weaning mortality rates are therefore often high: in sheep and goats reared extensively on tropical rangelands in Africa, India and Australia can exceed 30% (Thrusfield, 2018).

Small ruminants help to provide extra income and support survival for many farmers in the tropics. It is projected that by the year 2025, they will account for half the red meat production in sub-Saharan Africa (Mukasa-mugerwa *et al.*, 2000). Within African society, small ruminant comprise a greater proportion of the total wealth of the poor families, because of the low input requirements (Dessie and Tilahun, 2022).

However, young stock mortalities constitute the larger share of constraints to herd expansion and genetic improvement (Mohammed *et al.*, 2020; Fentie *et al*., 2016). The few studies in Africa, including Ethiopia, in young stock morbidity and mortality indicate high calf, lamb and kid mortalities both in the subsistence and market-oriented production systems (Fentie *et al*., 2016). The mortality rate of lambs in sub-Saharan Africa is within the range of 9% to 76% across sheep populations of mixed age, breeds and a range of production systems (Mthi *et al.*, 2020).

Ethiopia is the second in Africa and sixth in the world in terms of sheep population. However, it has benefited little from this enormous resource owing to a multitude of problems. Lamb mortality accounts for serious losses in sheep production and is thus a major factor reducing profitability of sheep farming (Woldemariam *et al.*, 2014). Contribution of the livestock subsector in Ethiopia is below its potential, and is mainly due to low genetic quality of local breeds, poor nutrition, animal health problems, poor husbandry, and poor infrastructure of the livestock sector of the country (Hadgu *et al.*, 2021). Low product per animal and flock off take, impact the overall contribution of sheep and goats to households in the rural areas of Ethiopia.

Production efficiency of a flock is directly related to the number of kids and lambs produced (Alemayehu *et al.*, 2021). High annual losses of young stock from birth-to-weaning age and premature losses were reported and the mean annual birth-to-weaning mortality in the mixed crop- livestock system is in the range of 9.2–14% in calves, 14.9–33.5% in lambs and 17.6–24% in kids (Hadgu *et al.*, 2021). The annual direct losses from ruminant mortality are generally estimated at about 8–10% of the cattle herd, 14–16% of the sheep flock, and 11–13% of the goat flock (Tifashe *et al.*, 2017).

Mortality in lambs may result from a variety of climatic, nutritional, management, infectious, genetic and other factors. Associated with death are other factors which could be of maternal or lamb origin that predisposes the young to early death (Ahmed *et al*.,2010). Economic losses because of lamb and kid mortality in Ethiopia are huge. Improving the survival of lambs/kids is essential for the economic viability of a flock and for its long- term genetic improvement (Hamito, 2011).

Increasing reproductive performance of small ruminants is an important pathway to reduce poverty, improve nutrition and may help to empower women given their role in small ruminant production. However, lamb and kid mortality is a major problem that makes this goal difficult. The death of lambs and kids before weaning is likely among the biggest causes of economic loss to sheep and goat producers in Ethiopia. About 50% of all lambs/kids born die due to various causes (CGIAR, 2017). Therefore, the objective of the current investigation was to estimate the incidences of lamb/kid morbidity and

mortality, and identify the major associated risk factors responsible for the outcome of interest, in the study area.

1.2. Statement of the problem

The impact of livestock disease has been cited in many publications, but the ability to monitor change is limited as the available data is contained in disparate publications and reports, and there are few longitudinal studies of disease prevalence and impact (Wong *et al*., 2022). Very little work on mortality rate in goats has been published to date (Snyman, 2010). There is a pressing need to improve sheep production efficiency in low input farming systems by reducing lamb mortality rate (Mthi *et al.*, 2020).

Very little work on mortality, morbidity and their causes in goat kids has been published from Ethiopia (Dessie and Tilahun, 2022; Petros *et al*., 2014). In general, there is shortage of information on diseases, mortality and morbidity rates and constraints in goat production in Ethiopia (Petros *et al*., 2014).

Livestock is characterized by high mortality in Ethiopia (Hadgu *et al.*, 2021). The few studies in Africa, including Ethiopia, in young stock morbidity and mortality indicate high calf, lamb, and kid mortalities both in the subsistence and market-oriented production systems (Mohammed *et al*., 2020: Fentie *et al*., 2016).

According to SZLFRD 2021 data, 10% bovine, 8% equine, 12% sheep, 13% goat, and 50-56% poultry deaths are recorded every year at zonal level because of animal diseases. As a result, the zone losses more than 1.14 billion birr every year. This represents a great share of the zone's budget (this time, the price of livestock increased at least by three fold). As part of Silte zone, Dalocha wereda shares the pre-described phenomena. Thus it becomes necessary to carry out this longitudinal study to estimate the incidence rate of kid/lamb mortality and morbidity, identify the associated risk factors which influence morbidity and mortality, and evaluate the predictors using a scientific approach in the study area.

1.3. Significance of the study

The current study provided/will provide the following benefits:

- Practical knowledge and skill of the researcher was improved by observing the actual evidences about animal health issues.
- It provided the first and general information regarding lamb/kid morbidity and mortality investigation of the study area and thus it will serve as a spring board for further studies about small ruminant productivity constraints.
- It will be used as an evidence for policy makers that aim to analyze the interaction of livestock and economic development of farming community.
- The study wereda can utilize this finding to estimate economic losses attributed to lamb and kid wastage so that to take an intervention measures.

- Participants of this study (specially members of the study households) were awared of animal welfare and proper young stock management (importance of good flock health management; colostrum, navel treatment, vaccination, hygiene).

1.4. Limitations

Some of the limitations encountered during this particular investigation were:

- Shortage of reference materials (books, journals). i.e. scarcity of research materials conducted on both lamb/kid morbidity and mortality at a global as well as national level.
- Unability to arrive at mortal cases and observe it with my naked eye so that to employ even simple laboratory examinations.
- Some study animals lost of the follow-up because of; for example sales.
- Difficulty to select one among twins of same coat colour, sex, species.
- Need of clients a continuous support of the reasercher for the treatment of cases.
- Refusal of some farmers not to be interviewed as they have grievance with the local government because of infrastructure (pure drinking water).
- Fast growth of some lambs/kids to the extent that it seams more than 3 months of age.
- Remoteness of the study kebeles and associated logistic and budgetary challenges.

1.5. Research questions

- What is the incidence of kid/lamb morbidity and mortality in the study area?

- How frequent are each predisposing factors of morbidity and mortality in the study area?
- Which factors are major causes of morbidity? Mortality? in lambs/kids?

1.6. Objectives

1.6.1. General objective

This investigation was carried out to estimate the incidence rate of lamb and kid morbidity and mortality, and to identify the associated risk factors in the study area.

1.6.2. Specific objective

- To estimate the incidence of kid/ and lamb morbidity and mortality
- To determine the major predictors responsible to lamb and kid morbidity and mortality.
- To create awareness about the general animal health and walfare issues.

2. LITERATURE REVIEW

2.1. Small Ruminant Production Trend in Ethiopia

Most of the small ruminant population of the country is kept by smallholder farmers, and the production is basically traditional (Hadgu *et al.*, 2021). About 85% to 90% of mixed crop-livestock farmers and 21.6 million agro-pastoralists and pastoralists depend on livestock as a major economic activity for their livelihoods. However, the production system is severely affected due to the low genetic quality of local breeds, poor nutrition, animal health problems, poor husbandry, and poor infrastructure (Mohammed *et al*., 2020).

The sheep enterprise in the Ethiopian highland crop and livestock system is the most important form of investment and source of cash income and provides social security in bad crop years. However, the country has benefited little from this enormous resource owing to a multitude of problems, disease being the most important. Lamb mortality accounts for serious losses in sheep production and is thus a major factor reducing profitability of sheep farming (Woldemariam *et al.*, 2014).

The country owns huge number of small ruminants, estimated to be 42 million heads of sheep and goats. Small ruminants are found mainly in the lowland agro-ecology. Sheep and goats cover more than 30% of all domestic meat consumption and generate cash

income from export of meat carcass, edible organs, live animals and skins (Dessie and Tilahun, 2022).

Productivity of sheep is low compared to temperate breeds under on station and on farm management condition. This is because of sheep production is constrained by the compound effect of diseases, poor feeding, poor management and low genetic endowment (Ferede *et al.*, 2014). Small ruminants are widely reared in a crop-livestock farming systems and are distributed across different agro-ecological zones of Ethiopia. Sheep and Goat production is an important activity for smallholders, particularly for resource poor farmers in many parts of the country (Tifashe *et al.*, 2017).

2.2. Importance of sheep and goat production

Within African society, small ruminant comprise a greater proportion of the total wealth of the poor families, because of the low input requirements such as small initial capital, fewer resources and maintenance cost, produce milk and meat, require marginal lands, poor pasture, and crop residues, have short production cycle and thus need short periods to reconstitute flocks after disaster and respond quickly to the demand. They contribute to the attainment of food self-sufficiency (in response to protein requirement) for the growing human population as well as to enhance the export earnings. They play an important role in generating employment, income, capital storage and improving household nutrition. They have broad feeding habit, and adaptation to unfavorable environmental conditions (goats) (Dessie and Tilahun, 2022).

Sheep and goat provide immediate cash income, meat, milk, skin, manure, and social functions. They are also sources of foreign currency (Tifashe *et al.*, 2017). At the household level, sheep serve as a source of food, cash income, saving, fertilizer, source of employment and foreign currency, and has the potential to play a role in poverty reduction in most rural communities. They contribute enormously towards promotion of farmer livelihoods as an investment and insurance to cope with crop failure where mixed farming is common (Mthi *et al.*, 2020).

In addition, in smallholder production systems, goats and sheep are important because they require low initial capital and maintenance costs and are easily cared for by most family members. They are prolific and need only short periods to increase flock sizes after catastrophes or in periods of high prices and thus off take rate can respond to price increases (Woldemariam *et al.*, 2014).

2.3. Immunity of Kids/lambs and Importance of Colostrum Feeding

After birth, the kids face a number of physiological, behavioral and immunological challenges affecting their survival (Chauhan *et al.*, 2019). Following birth, an offspring is exposed to bacteria and pathogens that its immune system is unfamiliar with. That means, it is extremely vulnerable to infectious diseases as it is born immunologically naïve since the Igs (maternal antibodies) do not cross the placental barrier and the offspring is born without any circulating antibodies (Demis *et al*., 2020; Koyuncu *et al*., 2018).

A major factor affecting neonatal sensibility to pathogens is the permeable immature gut which allows pathogens to enter. Lambs are dependent entirely on antibodies received via colostrum. The passive immune transfer from the ewes' colostrum to the lamb is of utmost importance for the survival of the offspring (Demis *et al*., 2020).

A newborn have to receive adequate colostrum (milk produced up to 5 days after postpartum) during the first two to three hours of life because during pregnancy, placental barriers in ruminants do not allow the passage of Igs from dams to neonates, and therefore the neonate is entirely dependent on antibodies received via colostrum (has attributes far exceeding that of regular milk). i.e. it contains high levels of Igs (antibodies), macro and micronutrients, leukocytes (WBC), enzymes, growth factors and hormones; provides protection against diseases in early life until own immunity becomes functional, and also used to maintain body temperature, source of vitamin E, and has laxative qualities which allows easy defecation of fecal matter (Koyuncu *et al*., 2018).

2.4. Lamb/kid Morbidity and Mortality and Associated Risk Factors

Morbidity is the amount of disease in a population (commonly defined in terms of incidence or prevalence while mortality is a measure of the number of deaths in a population. Malnutrition and high levels of morbidity and mortality are more common in the dry season (Thrusfield, 2018).

Half of lamb mortality occurs within the first 24 hours of life (Bond, 2020). According to Robertson *et al (*2020), on average, 20% of lambs born die. The untimely exits restrict the

number of animals available for future replacement and impact the number of animals reaching marketable age. Numerous studies focusing on mortality in goats have concluded that generally a higher number of pre-weaning animals die than adults and mortality during the weaning period may reach as high as 37% of the total mortality (Chauhan *et al.*, 2019).

Predominant causes of death can differ between regions depending on exposure to risk factors such as disease or extreme weather. In extensively grazed flocks, around half of all losses are parturition-related, followed by starvation, mis-mothering, predation, and cold exposure. Birth weight, litter size, and dam breed, are the main risk factors. More deaths occur in lambs born with weights outside the ideal range of 4.0–6.0 kg (Flinn *et al.*, 2020).

Neonatal mortality in ruminants has remained stubbornly unchanging since long years, and represents a significant loss of farm income and affects animal welfare. In lambs, kids, and calf most deaths occur in the neonatal period (first few months). Causes include starvation, injuries, infectious conditions and difficult birth, among others (Koyuncu *et al*., 2018). Studies in Ethiopia indicate a perinatal lamb mortality of 18%. Losses have been attributed to starvation, exposure to cold stress, infectious diseases, accidental death, predators and congenital defects (Woldemariam *et al.*, 2014).

One of the most important production factors that adversely affect small ruminant production is the high pre-weaning mortality of young lambs/kids (Dessie and Tilahun,

2022; Hadgu *et al.*, 2021). Studies indicate that up to 50% of the lambs born can die, mainly due to diseases and other causes such as adaptation failure, dystocia, cold stress, starvation, and mis-mothering. Malnutrition is the major cause of lamb mortality followed by diarrhea, respiratory problem, skin disease (sheep pox, orf, and others), septicemia, and miscellaneous causes. Likewise, diarrhea is the leading cause of lamb morbidity followed by respiratory and skin disease (Hadgu *et al.*, 2021).

Mortality of neonates of ruminants is mainly attributed to conditions like diarrhea and pneumonia associated with poor housing, hygiene, and nutrition (Mohammed *et al*., 2020). Several factors affect mortality rate in goat kids such as type of birth (litter size), sex of lamb/kid, birth weight, parity order, season of lambing/kidding, and age of the lamb/kid. Mortality increases with parity. Mis-mothering is the most frequently suspected cause of mortality followed by pneumonia, enzootic ataxia, diarrhea, goat pox and predators. Generally, higher kid mortality occurs at birth and from birth to weaning while mortality is relatively low from weaning to breeding age in many production systems (Dessie and Tilahun, 2022; Hamito, 2011; Petros *et al*., 2014).

The predisposing factors may be lack of colostrum, poor mothering, poor nutrition of the dam during pregnancy and nursing leading to low milk production. The most important causes of lamb mortality reported in Ethiopia include starvation, hypothermia, pneumonia, malnutrition, digestive and gastrointestinal problems (scours), infectious diseases, internal parasites, accidents and predators (Hamito, 2011). Parity, season of birth, sex of a lamb, breed, type of birth, and birth weight are the major factors directly

associated with high lamb mortality rate from birth to weaning and these are highly influenced by factors such as disease, shortage of feed, production system, environmental variables and poor management practices (Mthi *et al.*, 2020).

2.4.1.Effects of Twin Birth and Birth Weight on Lamb/kid Mortality and Morbidity

Lighter lambs are slower to stand and suckle after birth, and less able to maintain homeothermy. A greater loss among twins is attributed to birth weight (Flinn *et al.*, 2020). More kids die in triplets than in twins and single litters (Petros *et al*., 2014).

2.4.2. *Some Diseases Affecting Lambs and Kids*

One of the management challenges most often encountered by sheep, goat and cow breeding is maintaining the survival and health of the newborn. The number of newborn per female is certainly an economically important trait in a commercial enterprise. Following birth, the lamb or kid is exposed to bacteria and pathogens that its immune system is unfamiliar with. Calves, lambs, and kids mortality is the most frustrating part of keeping cows, sheep and goats (Koyuncu *et al*., 2018).

a) Pneumonia/respiratory Problem

Pneumonia is one of the most important causes of lamb/kid morbidity and mortality in Ethiopia. It is an infectious disease of young lambs/kids. Most newborn lambs/kids are exposed, but do not develop the disease because of antibodies received through colostrum

(Hamito, 2011). Kids and lambs are more susceptible than adults. Pasteurella spp are the most common bacteria isolated from cases of clinical pneumonia (Kusiluka and Kambarage, 1996).

b) Diarrhea/Enterotoxaemia/Dysentery

Diarrhoea in new-born farm animals under 21 days of age is one of the most common diseases. That means, it is an important problem in young domestic animals although its aetiology is not well understood since several agents may be involved concurrently (Munoz *et al*., 1996; Ozmen *et al*., 2006).

It is caused by the genus Eimeria that invade the cells of the intestinal wall. Severely affected animals become unthrifty, fail to grow, and may die. Sheep and goats acquire coccidiosis by ingesting feed and water contaminated with the droppings of infected animals (Hamito, 2011; Kusiluka and Kambarage, 1996). Rotaviruses are nonenveloped, dsRNA viruses pertaining to the family Reoviridae and are a primary cause of diarrhea in humans, calves, lambs, kids, piglets, and foals. Rotavirus has been associated with diarrhea in lambs 7 to 30 days of age (Constable *et al*., 2007).

Enterotoxaemia/dysentery is one of the most common and costly disease problems in the sheep and goat industry worldwide. It is caused by commensal bacteria (*Clostridium perfringens*) and is triggered by an increase in the amount of grain, protein supplement and/or milk rich in starch, sugar, and/or protein. The bacterium then undergoes explosive growth and releases toxins that harm the animal particularly newborn lamb/kid whose

dam has not been vaccinated (Hamito, 2011). *Clostridium perfringens* type B causes lamb dysentery and enterotoxaemia in goats (Constable *et al*., 2007; Kusiluka and Kambarage, 1996).

c) Pulpy Kidney Disease

This is a toxaemic of sheep caused by toxin produced by *Clostridium perfringens* type D in the intestine and it is characterized by diarrhoea, paralysis, convulsions or sudden death. Lambs and kids of 3-12 weeks and 6-12 months old have been found to be the most susceptible groups (Kusiluka and Kambarage, 1996).

d) Helminth parasites

Lungworms such as *Dictyocaulus filaria*, *Muellerius capillaris* and *Protostrongylus rufescens* cause parasitic bronchitis particularly in young animals. *M. expansa* infection is very common in kids and heavy infection with the parasite causes unthriftiness (Kusiluka and Kambarage, 1996).

Sheep and goat mostly affected by the same parasites. The most deadly internal parasites to small ruminants in Ethiopia are the gastrointestinal roundworm *Haemonchus contortus*, and the liver fluke *Fasciola hepatica*. Other helminth parasites that affect sheep and goats are those of the *Trichostrongylus* genus (particularly *Trichostrongylus axei*), *Teladorsagia circumcincta* and *lungworms* (Hamito, 2011). *Haemonchus contortus* lead to lamb/kid mortality by affecting the ewe/doe through blood feeding. The dam thus becomes anaemic and produce inadequate milk for the new born lamb/kid; die.

e) Others

Malignant oedema (gas gangrene), infectious necrotic hepatitis, colibacillosis, contagious ecthyma (orf), goat and sheeppox, mange, and flea and louse infestation all affect lambs and kids (Kusiluka and Kambarage, 1996).

2.5. Economic Impact of Lamb/kid Morbidity and Mortality

Mortality during pre and post weaning is possibly the single primary cause of low productivity and economic loss in small ruminants. The number of marketable kids/lambs is dependent on pre and post- weaning survivability which later influence the viability of goat and sheep enterprise (Assan, 2020). As stated by Chauhan *et al (*2019), mortality among the pre-weaning animals is one of the major factors causing significant economic losses to the goat producers.

A significant portion of the world protein requirement is met by ruminants (sheep, goat, cattle) (Koyuncu *et al*., 2018). The death of kids before weaning is perhaps the single biggest cause of economic loss to goat farmers (Petros *et al*., 2014). Economic losses because of lamb and kid mortality in Ethiopia are huge. Up to 28% of lambs and 47% of kids die before weaning (Hamito, 2011).

Even if reports indicate that there is high morality in lambs and kids, results are underestimated because births and deaths which occur when animals are bush grazing

and causes of the death of offspring usually are not recorded and go unnoticed (Woldemariam *et al.*, 2014).

The annual direct losses from ruminant mortality are generally estimated at about 8% to 10% of the cattle herd, 14% to 16% of the sheep flock, and 11% to 13% of the goat flock. Young stock mortalities constitute the larger share of constraints to herd expansion and genetic improvement (Mohammed *et al.*, 2020; Fentie *et al*., 2016).

Lamb and kid survival rates are the most important traits influencing income (Koyuncu *et al*., 2018). Lamb mortality amongst rural communities is a serious problem that threatens sustainable sheep farming with a huge economic impact on farm income and genetic improvement (Mthi *et al.*, 2020).

Lamb mortality accounts for serious losses in sheep production and is, thus, a major factor in reducing the profitability of sheep farming. Studies indicate that up to 50% of the lambs born can die. Kids' mortality, in addition to the immediate economic loss, has a direct effect on genetic progress by its effect on selection pressure (% of kids), as a replacement. More over high kids' mortality rate can seriously affect the economic viability of small ruminant farming; jeopardize the beneficial impact of fecundity and litter size of the flocks (Dessie and Tilahun, 2022; Hadgu *et al.*, 2021).

2.6. Solutions to Reduce Lamb/kid Morbidity and Mortality

Reproduction and kid survival rate are the most important traits influencing income (Snyman, 2010). Improving the survival of lambs/kids is essential for the economic viability of a flock and for its long-term genetic improvement (Hamito, 2011). Kid morbidity and mortality may be reduced by improvements in the management and feeding of the kidding flock (Petros *et al*., 2014). A great deal of effort should be put toward the care of pregnant and newborns before, during, and after birth (Koyuncu *et al*., 2018). Correct diagnosis of cause of death is essential if effective management interventions are to be applied in an attempt to reduce mortality (Robertson *et al.*, 2020).

Newborn lambs require adequate intake of colostrum as soon as possible after birth to combat disease and optimize health (Bond, 2020). Mortality of kids and lambs could be reduced by changing the traditional production system to a semi-intensive type that will allow a better management of the young ones, especially during the pre-weaning stage (Turkson, 2003).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was undertaken in Dalocha district, Siltie zone of Central Ethiopia. The agro-climate zone of the area is midland (Woina-dega), and the livelihood of the district is based on crop and livestock production. The major crops grown in the area were pepper, wheat, maize, sorghum, teff, bean and barley, and the livestock reared in the area include cattle, small ruminants, chicken and donkey. The altitude of the area ranges from 1000 to 1980 m.a.s.l. (Lagiso, 2020).

It covers an area of 32072 hectares and is bordered on the south by Sankurra, on the west by Wulbareg, on the north by Silti, and on the east by Lanfuro. Dalocha town is the wereda center and is located 14 kms far from zonal center Werabe. 90% and 10% of the population lives in rural and urban areas respectively of which 99 % is Muslim. The average annual temperature of the Wereda ranges from 24-29˚C and the average annual rainfall ranges from 700-900mm. 95% of the population engaged in agriculture (DFEDSM, 2021). Map of Ethiopia depicting the location of the study area is presented under figure 1 below.

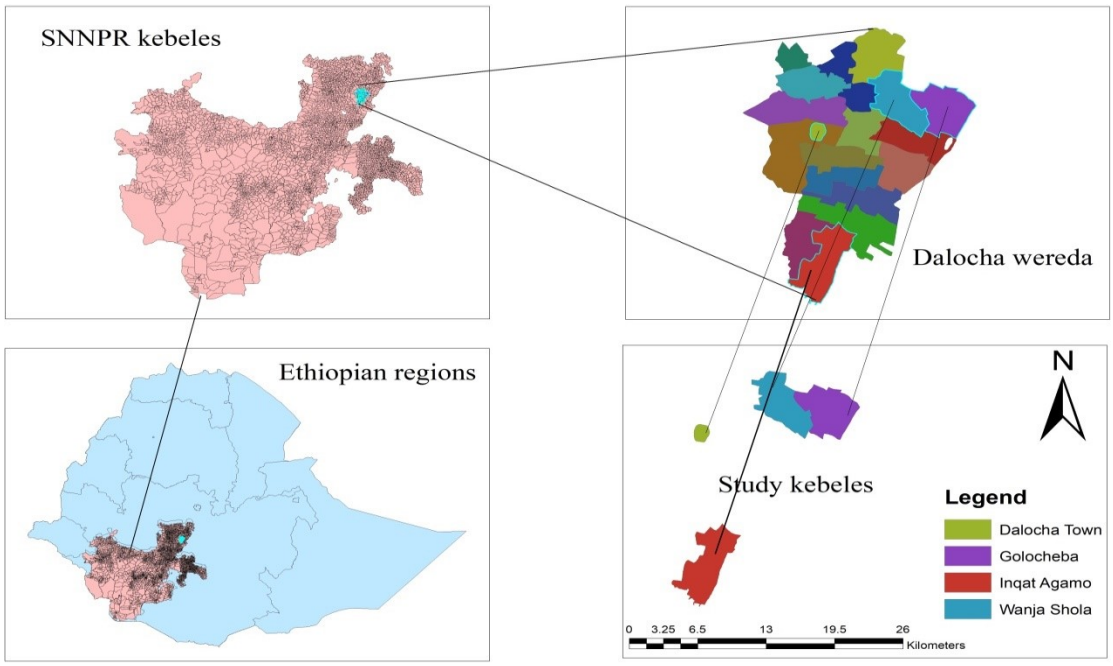

Figure 1: Map of Ethiopia depicting the location of the study area

3.2. Study Design and Study Subjects

Cross sectional study through observation and interview of study subjects, and prospective cohort study (that means regular every two weeks' time monitoring of selected lambs and kids from 10 February to 10 May 2023) were carried out.

The target population, study population, and study subjects/animals for the survey (interview) and cohort investigation were: total households, and sheep and goat of Dalocha Wereda; total households, and sheep and goat of the three kebeles (Wanjashola, Golecheba and Enqatagam); and selected (130) households/farmers, and selected (130) lambs and kids under three months of age from sample (12) villages, respectively. The detail is presented in the following figure below.

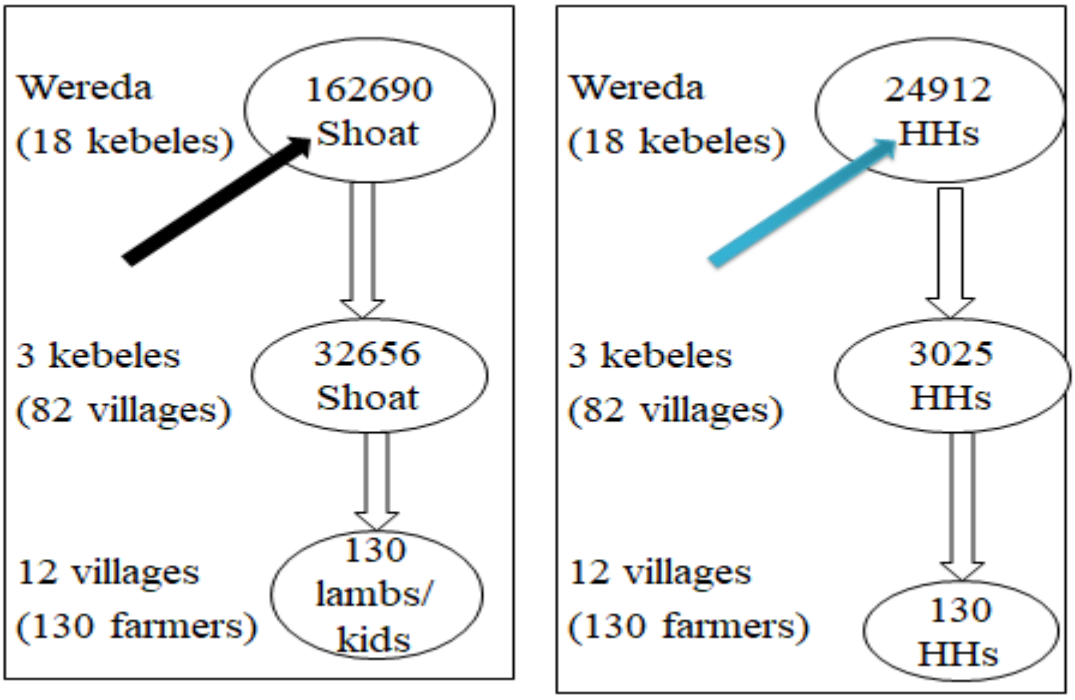

Figure 2: Way of selecting study subjects; the circles from the top to bottom shows the target population, study population, and study subjects/animals. The one on the left is for lambs/kids (shoat: mean sheep and goat) while that from the right is for small holder study participants (HHs: mean households).

The age of study animals were determined based on birth history and both sexes of apparently healthy lambs and kids were included, but those animals above three months of age and with any health problems were not considered. Only lambs and kids with the age of two weeks before and after the start of this study were selected i.e. while selecting the study subjects, only those lambs/kids born two weeks prior to the selection time, and those born 1-15 days later (i.e. February 10-25, respectively) were included.

3.3. Sampling Technique and Sample Size determination

Three Kebeles namely: Enqat Agam, Golecheba and Wanjashola were selected purposively based on their potential for small ruminants, mixed crop-livestock production system and access to transport (even though, they are far from the center). From each Kebele, four villages (limat budns) were selected using simple random (lottery) sampling method in order to obtain adequate number of newly born lambs/kids. The selected villages were Ajersa, Agam, Meyaf and Koshame from Enqat Agam Kebele; Achere, Anamo, Tachfuge and Chimiso from Golecheba Kebele; and Turemo, Gibe, Bonya and Bokicho from Wanjashola Kebele.

With regard to study animals, one lamb or kid under 3 months of age was selected randomly among the sheep and/or goat flock of the selected household; meaning: one lamb or kid per household was selected randomly for the purpose of the current study.

The sample size required for the interview was calculated by using Arsham (2020) formula as: $N = 0.25/SE^2$; where N = the required sample size, SE = standard error (5%) at 95% confidence level. Thus a total of 100 smallholder farmers were selected for the study. However, in order to increase the quality of information gathered, 30% was added and becomes 130. The computed sample size was allocated proportionally to the three Kebeles and their respective villages on the basis of household data. Thus, 45, 43 and 42 farmers were selected from Enqat Agam, Golecheba and Wanjashola, respectively for face to face interview.

To determine the sample size for a cohort study Epi info V. 7 software was employed to investigate potential risk factors associated with lamb/kid morbidity and mortality, with an assumption of 95% confidence level, 80% power (chance of detecting the factor of interest), 1.74 ratio of exposed (died before 1 month of age; 80) to non-exposed (not died/alive before 1 month of age; 46), 63.492% hypothetical proportion of mortality with exposure (death under 1 month of age; 80/126), and 36.51% hypothetical proportion of mortality with non-exposure (death after 1 month of age or those alive until 1 month of age only and then died; 46/126) from previous research finding of (Dessie and Tilahun, 2022). Therefore, a total of 130 kids/lambs calculated that fulfilled the inclusion criteria, were recruited out randomly and enrolled until they are excluded from the follow-up.

3.4. Data collection

Data was collected primarily by interview of farmers and regular monitoring of selected study animals. During the follow-up, disease conditions were identified on the basis of their common symptoms (i.e. clinical signs).

3.5. Data Management and Statistical Analysis

The data collected by regular visits and interview were properly handled, coded, entered and stored in Microsoft Office Excel spreadsheet (2010) and analyzed using STATA version 14 software. The data summarized by descriptive statistics like proportion, and presented by using tables and graphs. Qualitative data were subjected to narrative

analysis. Cox proportional hazard model was used for the analysis of risk factors associated with kid and lamb morbidity and mortality.

The incidence rates (IR) were calculated by dividing the number of events that happened during the observation period by the total number of lamb/kid days at risk by using the following formula:

$$\text{IR} = \frac{\text{Number of incident cases}}{\text{Amount of at-risk experience}}$$

The denominator is the number of kid/lamb days at risk, whereas the numerator is the number of instances of the outcome of interest. True rates calculated for mortality, morbidity, and other specific disease conditions were converted into risk rates based on the formula ($\text{RR} = 1 - \text{e}^{-\text{true rate}}$) to facilitate result comparisons with other findings and because directly taking true rate results tend to overestimate morbidity and mortality rates (Tora *et al*., 2021).

Kaplan–Meier (K-M) curve analysis, to compute and describe the cumulative survival and failure probability of lamb/kid morbidity and mortality from birth to three months of age was used. Log-rank test at $P<0.05$, the likelihood of generating the observed hazard curves was also assessed to test the null hypothesis which says "K-M curves are the same/similar for different risk factors, that is no difference between them".

4. RESULTS

4.1. Description about Study Households

Of 130 respondents, 76% (99) of them were females whereas 24% (31) of them were males. The range of flock size of the study households varied from 2 to 31, and out of which 6-10 animal owners were 55% (71), that of 1-5 accounted for 27% (35) whereas the remaining constitute about 18% . According to the respondents' point of view, raising sheep and goat is an additional (lifetime) farm activity while dairy cows were the most preferred livestock types since they are milk providers.

Almost all (100%) respondents replied that lambs/kids are allowed to suckle the dam freely, there is no bedding neither for the dams (94%) nor for the offspring (95%), they have veterinary service delivery (99%), their preference for dairy cows was as an additional income source (100%), they did not know navel treatment (100%), they feed colostrum for the newborn animals within the first 2-3 hours (100%), they (100%) maintain their lambs/kids in house until they are strong enough, they clean flock house once a day (98%).

Also, they provide pre and postpartum care of dams (94%) through provision of supplementary feed (cereal grains, flour) and separating from the rest of the flock, they use other milk source (95%) if the dam was colostrum deficient, they call for professionals (92%) as a disease management system, and they regularly vaccinate their

flock (95%) against endemic diseases in the area like pneumonic ovine Pasteurellosis, sheep and goat pox.

This study revealed that 98% (127) of the farmers did not know about the benefits of feeding lambs/kids with colostrum (discard the first milk specially those of does) while only 2% (3) of them knew about it (did not discard it). However, they feed colostrum early within the first six hours after birth solely as a culture.

Most 83(64%) farmers replied that lamb/kid mortality was a common problem in their flock in which neonates were more frequently died age groups probably due to starvation (which may be the result of unability to compute between twins, milk deficiency of the dams, dam refractory of the young, congenital defects which make suckling difficult, and other problems) followed by unknown causes (20%), disease (13%), predator (12%) and finally accident (7%).

About 83.1%, 7.7%, and 0.8% lamb and/or kids died mostly because of unknown condition (i.e. without disease sign), disease (i.e. mainly respiratory problem), and miscellaneous causes, respectively. Flea was reported as a problem in the study area. Flocks were kept nearby house (78%) and provided drinking water at home (87%). Table 1 below shows the overall flock level management practices, household characteristics and other associated risk factors with lamb/kid morbidity and/or mortality of the study area.

Table 1: Significance of flock level exposure factors with lamb/kid morbidity and/or mortality of the study site.

Variable	Value	Freq	percent	P-value
Kebele	Enqat Agam	45	34.62	
	Golecheba	43	33.08	0.574
	Wanjashola	42	32.31	
Flock size	1-5	35	26.92	
	6-10	71	54.62	
	11-15	17	13.1	0.167
	16-20	5	3.85	
	>20	2	1.54	
Pre and postpartum care of dams	neglected/ignored	8	6.15	
	care given	122	93.85	0.433
Colostrum knowhow	no	127	97.69	
	yes	3	2.31	-
Solution for colostrum deficiency	neglected	6	4.62	0.091
	use another milk source	124	95.38	
Feed types consumed	bush	4	3.08	
	forage	28	21.54	
	forage and grain	83	63.85	0.663
	bush and grain	9	6.92	
	forage and bush	5	3.85	
	all	1	0.77	
Flock keeping area	nearby house	101	77.69	
	bushy area	23	17.69	0.229
	left free	6	4.62	
Water management	house	113	86.92	
	nearby river/pond	17	13.08	0.881

	trucking long distance	-	-	
Flock housing	with human being	79	60.77	0.883
	in separate house	51	39.23	
Lamb/kid housing	together with the	62	47.69	
	dam	68	52.31	0.471
	apart from the dam			
Bedding for dams	no	122	93.85	
	yes	8	6.15	0.766
Bedding for lambs/kids	no	123	94.62	
	yes	7	5.38	0.661
Frequency of house cleaning	once a day	128	98.46	
	twice a day	2	1.54	0.953
	every two days	-	-	
Lamb/kid mortality	No	47	36.15	
	yes	83	63.85	0.002
	perinatal	10	7.69	
Age group mostly died	neonatal	57	43.85	
	both	-	-	0.001
	older	26	20.00	
	none	37	28.46	
Cause of mortality	disease	17	13.08	0.002
	starvation	62	47.69	
	predator	16	12.31	
	accident (flood)	9	6.92	
	unknown	26	20.00	
Disease symptoms	diarrhea	11	8.46	
	respiratory problem	10	7.69	-
	miscellaneous	1	0.77	

	nothing	108	83.08	
Way of disease management	self-treatment	3	2.31	
	call for professionals	120	92.31	0.661
	ignore it	7	5.38	
Vaccination of the flock	no	6	4.62	
	yes	124	95.38	0.613
Ectoparasite infestation	no	82	63.57	
	yes	47	36.43	0.059
	fleas	50	38.46	
Type of the parasite	louse	6	4.62	0.833
	both	7	5.38	
	none	67	51.54	

Remark: Min=minimum, Max=maximum.

4.2. Prospective Cohort (open) Study

A total of 130 animals of which 74 lambs (40 F and 34 M) and 56 kids (29 F and 27 M) were selected from smallholder farmers in rural areas of Dalocha district. At the start of the study 112 (86.15%) of kid/lambs were recruited based on birth history and the remaining 18 (13.85%) were born within a month of the study time period.

Table 2: summary of morbidity records due to some factors studied (by follow-up)

Variable	Category	code	Morbidity		
			yes	no	total
Sex	Male	0	12	49	61
	Female	1	17	52	69
Species	Kid	0	8	48	56
	Lamb	1	21	53	74
Litter size	Single	0	11	45	56
	Two	1	18	56	74
Kebele	Enqatagam	1	11	34	45
	Golecheba	2	10	33	43
	Wanjashola	3	8	34	42
Age group	Under 1 month	0	9	7	16
	1-2 month	1	12	8	20
	Above 2	2	8	86	94

The overall male and female lambs/kids followed over the observation period were 61 (46.92%) and 69 (53.08%) respectively. This number of lambs/kids contributed a total of 10386 (1296+9090) and 10959 (429+10530) lamb/kid-days at risk for morbidity and mortality respectively. Therefore, the value of lamb/kid morbidity and mortality rates according to the findings of this investigation were 0.0028 cases per lamb/kid days/0.084

cases per lamb/kid months and 0.0012 deaths per lamb/kid days/0.0356 deaths per lamb/kid months respectively**.** This means that approximately 3 out of 1,000 lambs/kids were morbid and 12 out of 10,000 lambs/kids were mortal per day or there were approximately 84 morbid cases and 36 deaths for every 1000 lambs/kids per month.

Table 3: summary of mortality records due to some factors studied (by follow-up)

Variable	Category	code	Mortality		
			yes	no	total
Sex	Male	0	9	52	61
	Female	1	4	65	69
Species	Kid	0	4	52	56
	Lamb	1	9	65	74
Litter size	Single	0	2	54	56
	Two	1	11	63	74
Kebele	Enqatagam	1	4	41	45
	Golecheba	2	5	38	43
	Wanjashola	3	4	38	42
Age group	Under 1	0	7	9	16
	1-2 month	1	3	17	20
	Above 2	2	3	91	94

The temporal pattern of the study cohort is shown in tables 6 and 7 below for morbidity and mortality, respectively.

4.3. Estimates of Morbidity and Mortality

Incidence of morbidity

The crude morbidity and cumulative incidence (incidence risk) of various disease conditions/ syndromes recorded in the study is presented in Table 6. Among health

problems observed during the follow-up period, emaciation/ malnutrition was the greatest factor associated with morbidity (41.38%), followed by respiratory problem (37.93%), diarrhea (17.24%) and circling (3.45%) out of the total morbid cases. The circling disease observed will be the result of bacterial infection (*Listeria monocytogenes*; listeriosis) or parasitic infection (coenurus cerebralis; coenurosis). The risk rate for these factors was 89.1%, 84.4%, 83.3% and 96.4%, respectively. The log rank test (testing the null hypothesis which says "there is no difference between survival curves) of the lamb/kid age and health events was statistically significant ($p < 0.05$) (table 4 and 5).

Table 4: Stratified log-rank test for equality of survivor functions with regard to health events (chi2(4) = 41.30, Pr>chi2 = 0.0000).

Health problem	Events observed	Events expected
0	0	13.47
1	5	1.54
2	11	5.76
3	12	7.59
4	1	0.64
Total	29	29.00

Remark: 0=none, 1=diarrhea, 2=respiratory problem, 3=emaciation, and 4=circling.

Table 5: Stratified log-rank test for equality of survivor functions with regard to age of animals (chi2(2) = 16.00, Pr>chi2 = 0.0003).

Age of animals	Events observed	Events expected
0	9	3.95
1	12	7.21
2	8	17.84
Total	29	29.00

Note: 0 = under one month, 1 = between one and two months, and 2 = above two months

Table 6: The incidence of morbidity due to different diseases and disease conditions/syndromes in lambs and kids.

Diseases condition/ syndromes	**Number of cases**	**Lamb/kid days at risk**	**Per lamb/kid month**	**Lamb/ kid three months at risk**	**Incidence**	
					True rate (3 lamb/kid month at risk)	Risk rate
Diarrhea	5	251	8.37	2.79	1.79	0.833
Respiratory problem	11	531	17.7	5.9	1.86	0.844
Emaciation	12	487	16.23	5.41	2.22	0.891
Circling	1	27	0.9	0.3	3.33	0.964
Crude morbidity	29	1296	43.2	14.4	2.01	0.866

Remark: *Risk rates estimated from true rate using formula,* $\text{Risk rate} = 1 - e^{-\text{true rate}}$

The median survival times for health events: emaciation, respiratory problem and diarrhea were 69.94, 35.32, and 43.63 respectively (figure 3) and the median survival times for age categories of lambs/kids; that is less than 1 month and 1-2 months were 58.17 and 80.33 respectively (figure 5). The overall median survival time with regard to morbidity was 84.485. These finding indicated that health problems mostly occur in lambs/kids within 1-2 months of age (12) accounting for 41.38% morbidity followed by under 1 month (9) and above 2 months of age (8) with morbidity of 31.03% and 27.58 % respectively.

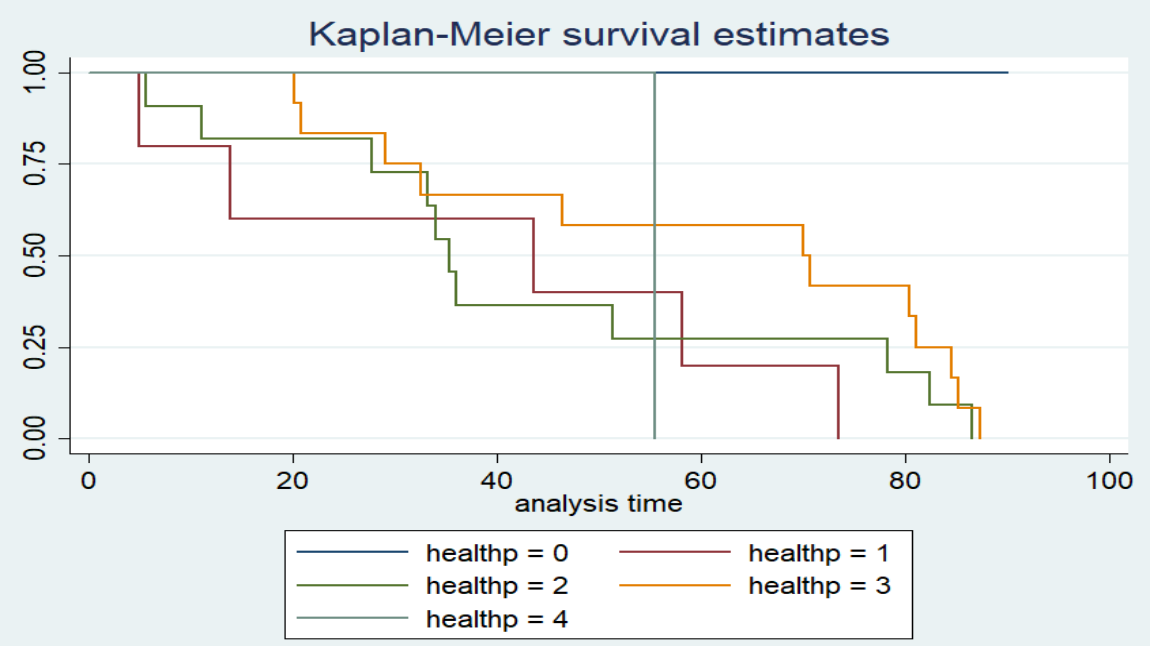

Figure 3: Description of the median survival time (i.e. average time to morbidity) of morbidity by health events in days. Vertical line indicates the occurrence of morbidity while the horizontal line indicates the absence of morbidity (if long, it indicats ttehre is/are censored case/s)

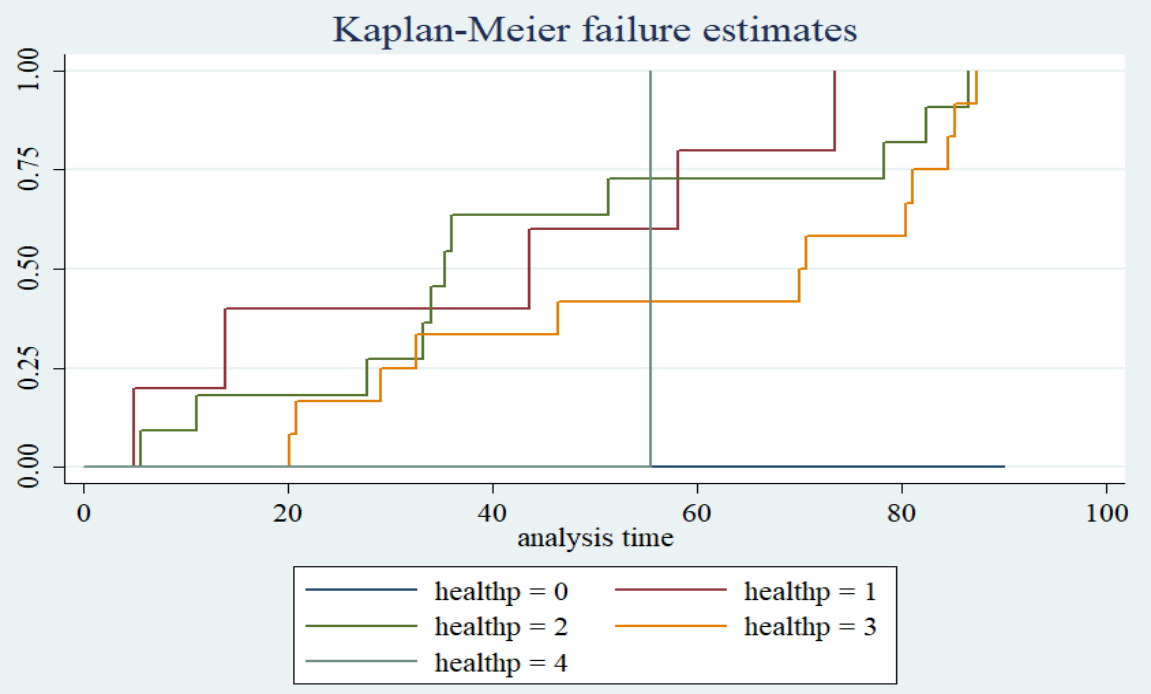

Figure 4: Description of the median failure status of morbidity by health events in days.

Remark: From the two figures above; healthp=health problem recorded, *0=none, 1=diarrhea, 2=respiratory problem, 3=emaciation, and 4=circling*.

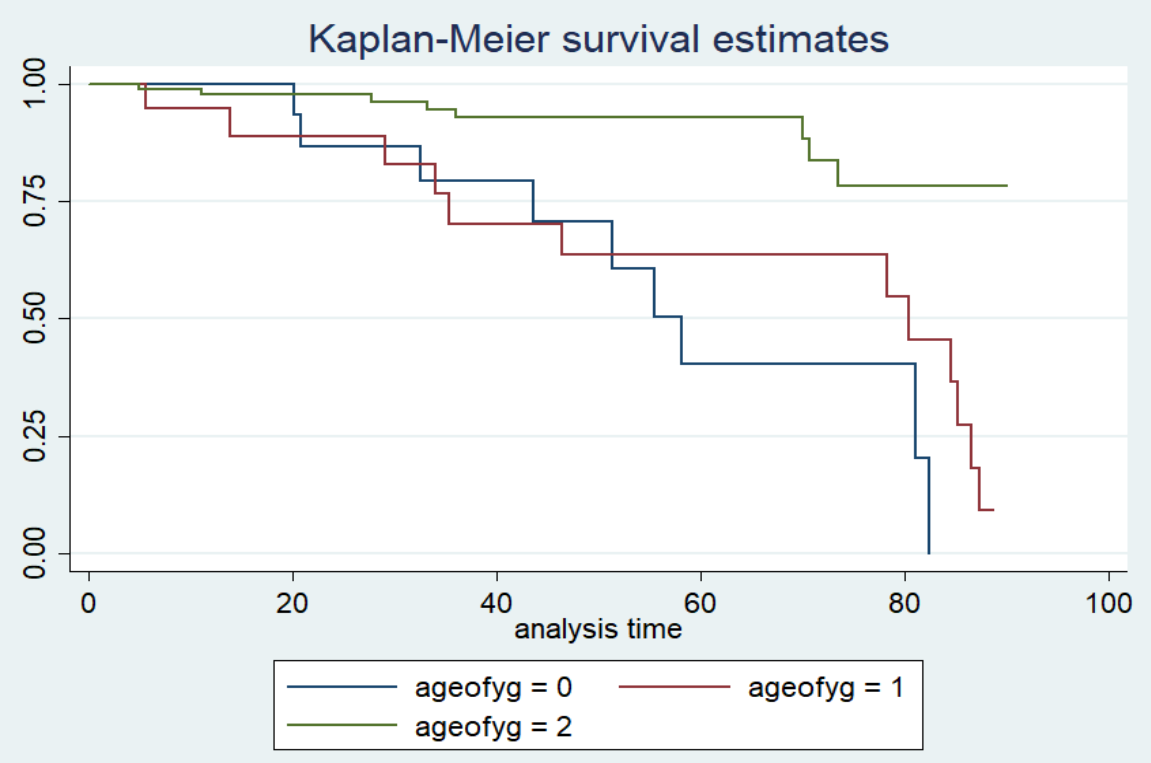

Figure 5: Description of the median survival age of morbidity by age categories in days.

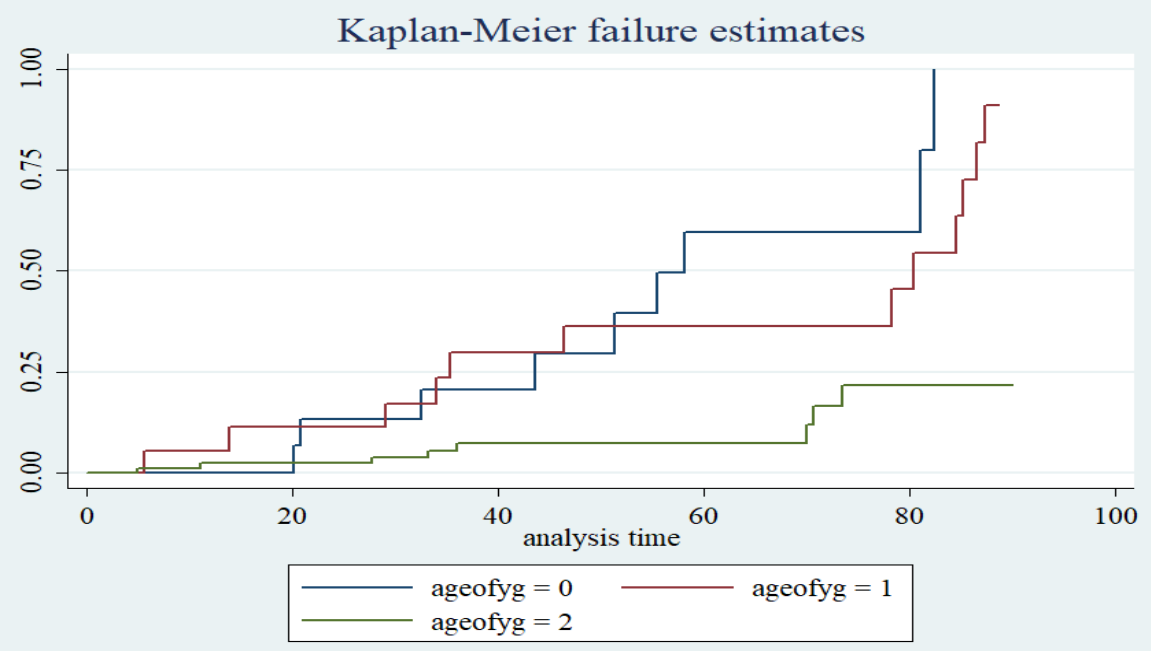

Figure 6: Description of the median failure status of morbidity by age categories in days.

Remark: From the two figures above; ageofyg=age of the young, *0=under 1 month, 1=1-2 months, 2=above 2 months*

Incidence of mortality

The incidence of lamb/kid mortality associated with different risk factors are displayed under table 7.

Table 7: Incidence of mortality due to different diseases and related conditions in lambs and kids.

Diseases condition/ syndromes	**Number of deaths**	**Lamb/kid days at risk**	**Per lamb/kid month**	**Lamb/kid three months at risk**	**Incidence**	
					True rate (3 lamb/kid month at	Risk rate
Diarrhea	5	112	3.73	1.24	4.03	0.982
Resp. problem	3	113	3.77	1.26	2.38	0.907
Emaciation	1	15	0.5	0.17	5.88	0.997
Circling	1	29	0.97	0.32	3.13	0.956
Accident	3	160	5.33	1.77	1.69	0.815
Crude mortality	13	429	14.3	4.76	2.73	0.935

Remark: Risk rates estimated from true rate using formula, $\text{Risk rate} = 1 - e^{-\text{true rate}}$.

The crude mortality in the present study is 13. In this prospective cohort (open/dynamic) study, the median time for death of lambs/kids for the incidence of mortality was 63.02 days for less than 1 month of age (figure 7) while the median times for death due to health events: respiratory problem, diarrhea, and accident (flood) were 15.93, 42.94, and 65.10 respectively (figure 9).

The principal disease syndrome associated with lamb/kid mortality was diarrhea, directly accounting for 5 out of 13 total mortal cases. As shown in figure 7, neonates (lamb/kid < 1 month of age) are more susceptible to health events. This reflects that this stage of lambs/kids is a critical time for their health. However, in lambs/kids older than 1 month

of age, the health events were less severe and gradually decline. This, relatively higher risk of mortality observed in neonates, is suggestive of that there is a need of more careful management of neonates as compared to older ones.

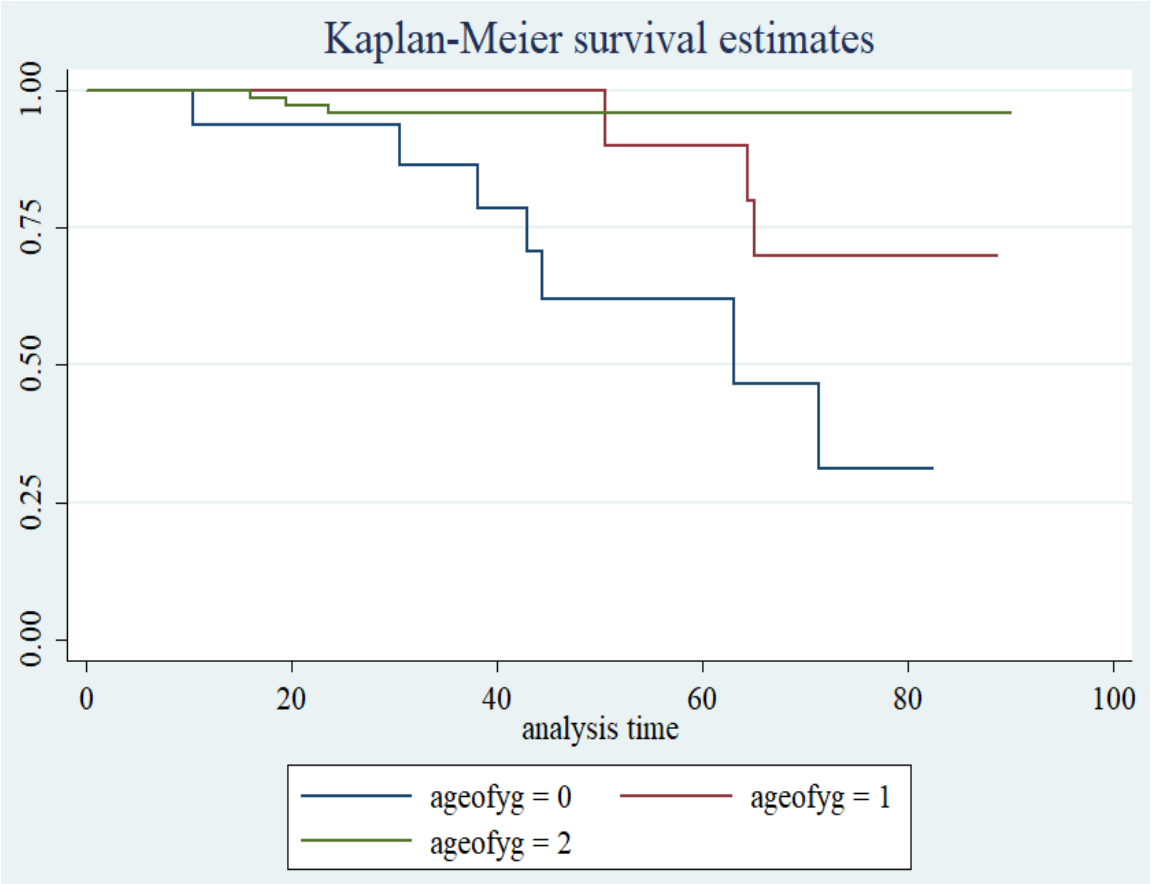

Figure 7: Description of the median time for mortality by age categories in days. Vertical line indicates the occurrence of mortality while the horizontal line indicates the absence of mortality (if long, it indicats ttehre is/are censored case/s)

Remark: From the figure above; ageofyg=age of the young, *0=under 1 month, 1=1-2 months, 2=above 2 months*

The incidence risk of lamb/kid mortality for different factors was 0.982, 0.907, 0.997, 0.956 and 0.815 for diarrhea, respiratory problem, emaciation, circling and accident respectively (Table 7).

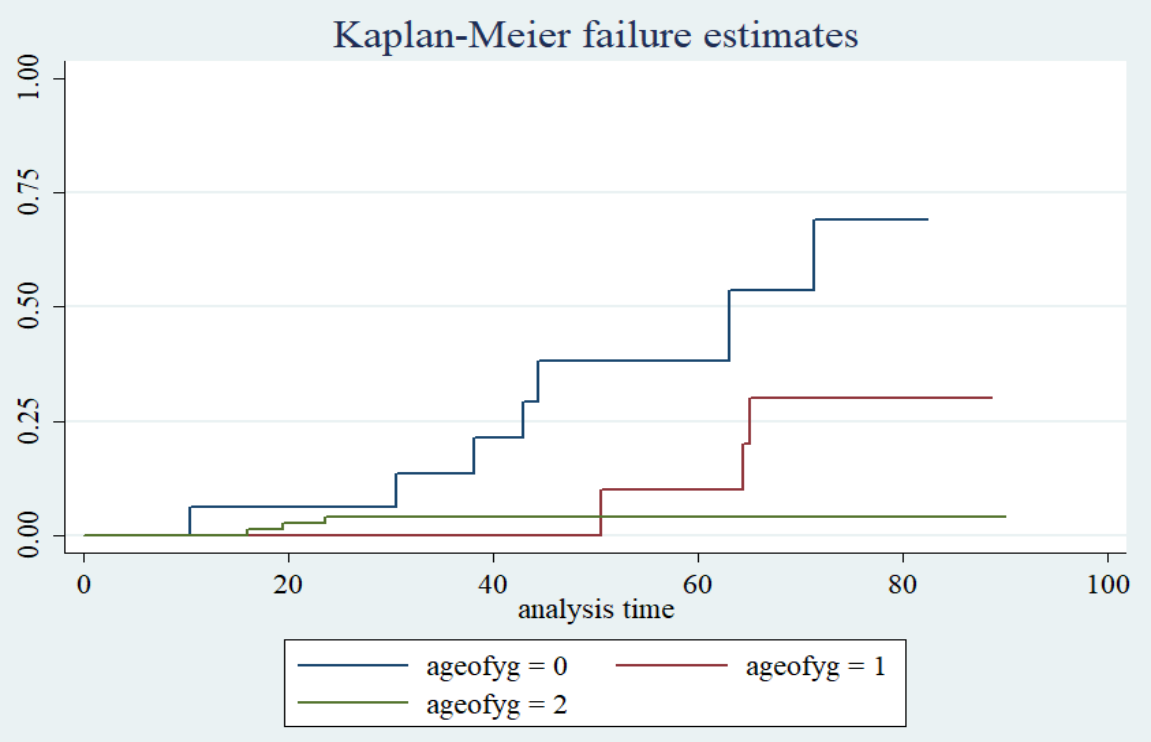

Figure 8: Description of the median failure status of mortality by age categories in days.

Remark: From the figure above; ageofyg=age of the young, *0=under 1 month, 1=1-2 months, 2=above 2 months*

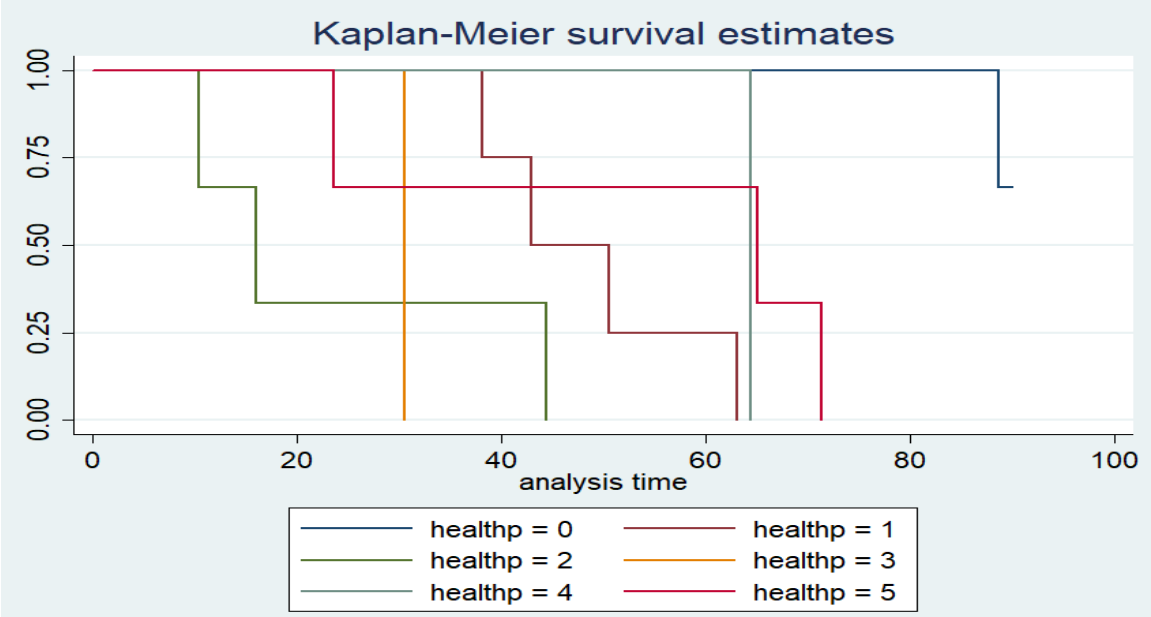

Figure 9: Description of the median time for mortality by health events in days. Vertical line indicates the occurrence of mortality while the horizontal line indicates the absence of mortality (if long, it indicats ttehre is/are censored case/s)

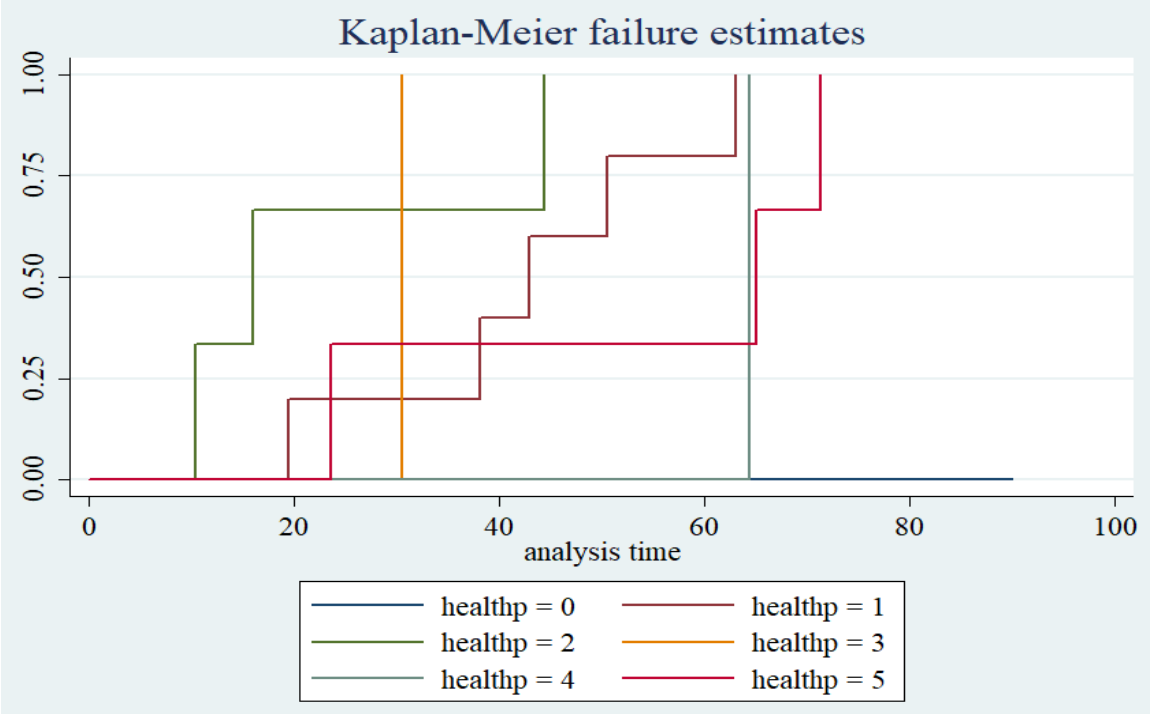

Figure 10: Description of the median failure time of mortality by health events in days.

Remark: From the last two figures above; healthp=health problem recorded, *0=none, 1=diarrhea, 2=respiratory problem, 3=emaciation, and 4=circling*.

4.4. Association of Risk Factors with Incidence of Morbidity and Mortality

Determinants/risk factors of lamb/kid morbidity

Multivariable Cox regression analysis revealed that: health problems, age of animals, litter size, species of animals, and skm (interaction variable) (table 8) were significantly associated with lamb/kid morbidity ($P < 0.05$). The temporal distribution of the hazard of lamb/kid morbidity across three months of study period is presented in figure 11 (by health problems), and figure 12 (by age categories), respectively.

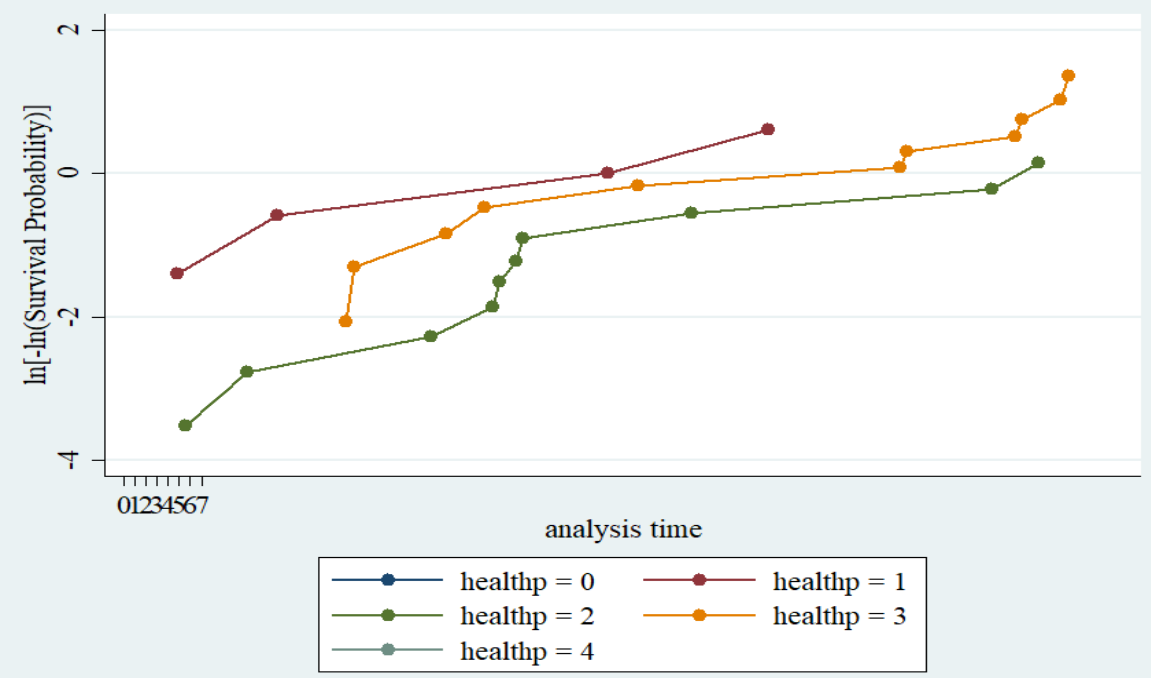

Figure 11: hazard of morbidity compared by health events that affect lambs/kids.

Remark: From the figure above; healthp=health problem recorded, *0=none, 1=diarrhea, 2=respiratory problem, 3=emaciation, and 4=circling*.

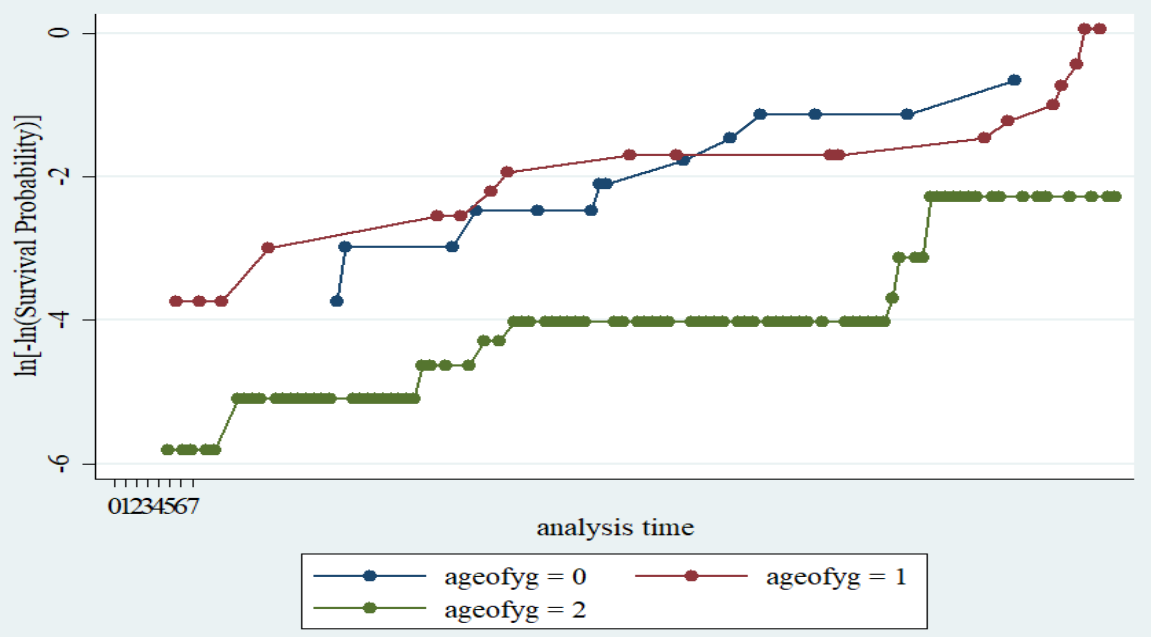

Figure 12: hazard of morbidity compared by age categories of lambs/kids.

Remark: From the figure above; ageofyg=age of the young, *0=under 1 month, 1=1-2 months, 2=above 2 months*

Skm (age interacted with other factors), health events, litter size and species were the most important exposure factors responsible for morbidity of lambs/kids in the study area. However, age of the animals was protective rather than risk factor of morbidity (meaning: as age increases, morbidity declines). For example, keeping the effect of other factors constant, for every unit increase in morbidity due to health events, it decreases by 13.76 times due to age increment. The difference in hazard of morbidity between explanatory and/or protective factor/s is presented in table 8.

Table 8: Factors significantly associated with incidence of morbidity based on multivariable Cox regression analysis.

Variable	HR	Std. Err.	z	P>|z|	[95% CI]	
spp	3.192294	1.80412	2.05	0.040	1.054502	9.664026
litsize	3.382266	1.706875	2.41	0.016	1.257897	9.094322
ageofyg	.2768916	.1031782	-3.45	0.001	.1333909	.5747689
healthp	3.810218	.8452869	6.03	0.000	2.466681	5.885545
skm	2669.311	4338.399	4.85	0.000	110.3956	64542.64

Note: HR=Hazard ratio, CI=Confidence Interval, spp=species, litsize=litter size, ageofyg=age of young, healthp=health problem, skm=survival Kaplan-Meier (interaction variable).

Table 9: Potential risk factors significantly associated with incidence of mortality based on multivariable Cox regression analysis.

Variable	HR	Std. Err.	z	P>|z|	[95% CI]	
ageofyg	.042766	.0310708	-4.34	0.000	.0102961	.1776327
healthp	3.618053	1.020459	4.56	0.000	2.081597	6.288589
colfeeding	.0908675	.0888519	-2.45	0.014	.0133687	.6176301
skm	1696881	6418645	3.79	0.000	1023.021	2.81e+09

Remark: HR=Hazard ratio, ageofyg=age of young, healthp=health problem, colfeeding=colostrum feeding, skm=survival Kaplan-Meier (interaction variable).

Determinants of crude mortality

Table 9 displays significantly associated (P< 0.05) predictors with mortality with regard to multivariable Cox regression analysis. Keeping the effect of skm constant, the hazard of mortality due to health events was 84.6 times higher than that of age, and 39.8 times than that of colostrum feeding. This implies that, age and colostrum feeding are protective factors rather than risk of mortality. Meaning: as lambs/kids get older and older, and if they are normal so that they can suckle the colostrum by self, incidence of mortality decreases and vice-versa. The difference in hazard of mortality between lamb/kid age categories was evident in the hazard function curve (Figure 13).

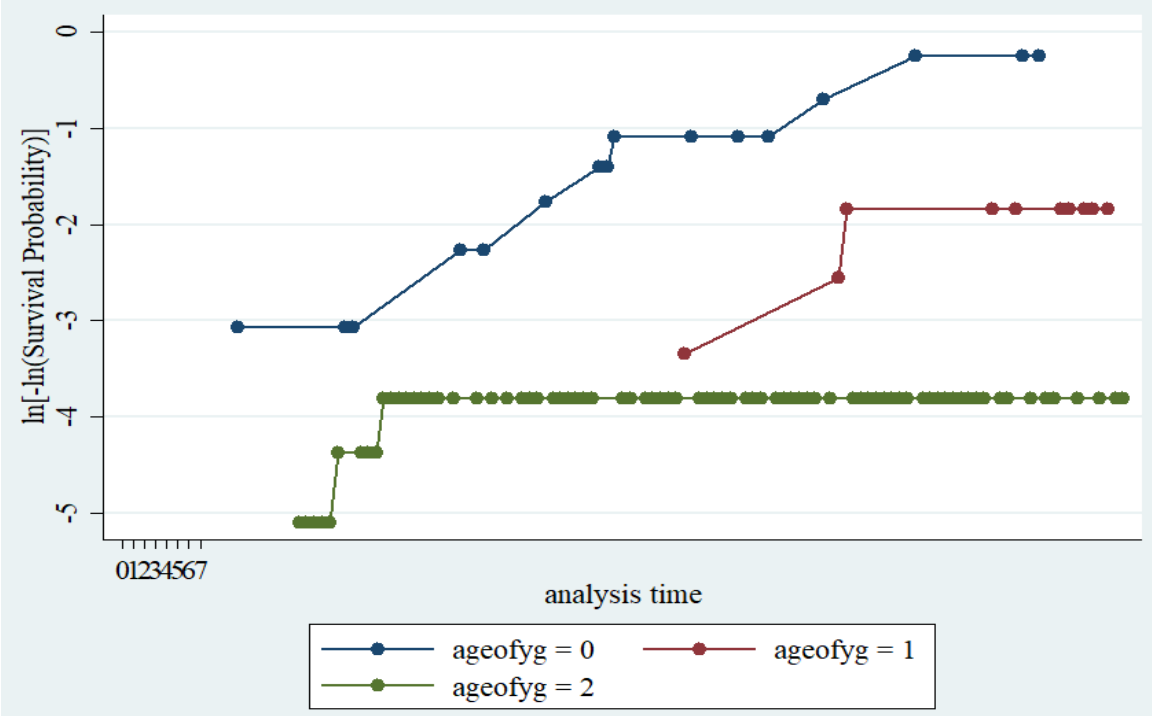

Figure 13: difference in the hazard of mortality between age categories of lambs/kids.

Remark: From the figure above; ageofyg=age of the young, *0=under 1 month, 1=1-2 months, 2=above 2 months*

This finding demonstrates that there is a higher hazard of mortality in lambs/kids under I month of age followed by those between 1-2 months and then those above 2 months.

5. DISCUSSION

The present study was conducted to estimate the incidences of lamb/kid morbidity and mortality, and also to identify the major associated risk factors in the selected 130 households at Dalocha Wereda. An overall cumulative incidences of 22.31% (29/130) lamb/kid morbidity and 10% (13/130) lamb/kid mortality were established in the current investigation.

10% cumulative mortality of lambs/kids observed in this study was in contrast to 46.8% cumulative mortality reported by Petros *et al* (2014) for Arsi-Bale kids, 24.4% reported by Dessie and Tilahun (2022) on kid mortality in Boer goats and their cross with native Ethiopian goats, 32.5% lamb mortality according to Hadgu *et al* (2021), 33% lamb mortality as of Mthi *et al* (2020), and that of 30.59% lamb mortality reported by Ahmed *et al* (2010), but it is in agreement with Tifashe *et al* (2017) for 9.6% finding of lamb mortality and 11.5% pre-weaning mortality of kids by Snyman (2010). The mortality rate recorded in this study (0.12%) is contradictory (lower than) to that reported by Sharif *et al* (2005), with 3.2% neonatal mortality rate of lambs and kids.

This may be attributed to the length of the study period being short (three months only) and seasonal variation (almost rainy months; March, April and May) during which this research was conducted where green forage was available unlike that of the former two journals (Petros *et al.,* 2014 and Dessie and Tilahun, 2022) since they were conducted for

six months' time of dry and rainy season where the dry months are scarce in forage which is critical for the young's survival.

22.31% incidence of morbidity encountered in the present study is lower than the report of Hadgu *et al* (2021) with 27.3% morbidity for lambs in Jamma District, South Wollo, Ethiopia. However, it is higher than that of Chauhan *et al* (2019) with 7.8% kid mortality (which may be due to geographical variation), and Tifashe *et al* (2017) with 10% kid morbidity.

Potential risk factors significantly associated ($P<0.05$) with lamb/kid morbidity were health related problems (emaciation, respiratory problems and diarrhea). This may be due to the fact that, since the study was carried out during the start of the rainy season and they have no well-developed digestive system (no more feeding adaptation), they become diarrheic due to lush (newly growing) grass, pneumonic, and wasting (i.e. emaciated) due to the changing weather condition.

This means that, of the determinants investigated in the current study, skm (age interacted with other factors), age, health events (especially emaciation, respiratory problem and diarrhea), litter size and species were significantly associated with lamb/kid morbidity whereas skm, age, health events (especially diarrhea and respiratory problem) and colostrum feeding were significant factors for lamb/kid mortality.

Skm (survival Kaplan-Meier) implies that the interaction (combined, collaborated) effect between different exposure factors has strong (increased) effect than does their individual effect. It was generated as: “sts generate skm=s, by (ageofyg)” under STATA software. Why it becomes important here is that to make some factors “significant” which were very important, but left insignificant without the use of an interaction.

Health related events were statistically significant with both morbidity and mortality of lambs/kids as of this particular investigation. Emaciation/malnutrition/wasting and diarrhea were the leading causes of morbidity and mortality respectively. Most of the mortalities were due to infectious causes like diarrhea (38.5%; 5/13) followed by pneumonia/respiratory disease (23.1%; 3/13), unlike the report of Petros *et al* (2014) where pneumonia comes first, and accident (23.1%; 3/13) (Table 7). This is in agreement with the work of Woldemariam *et al* (2014), Hadgu *et al* (2021) and Sharif *et al* (2005) with regard to the symptoms/causes (with the exception of figurative variation). This implies that a morbid animal has the chance to survive if effective health intervention is carried out.

Emaciation would be the result of ecto-parasites (fleas), dry season during which the study animals were born, or other maternal associated factors while respiratory syndrome would be due lack of due attention to lambs/kids. Diarrhea on the other hand would be the result of newly growing grass at the start of the study and infectious agents (poor sanitation) in the study area.

Age had a statistically significant ($p<0.05$) association with both lamb/kid morbidity and mortality. According to this particular investigation, mortality decreases as the study animals' age increase. That means, the age at which death of lambs/kids mostly occur is under 1 month. This is in-line with the finding of Ahmed *et al* (2010); "mortality in lambs aged 0-7 days was 48.78%", and Assan (2020); mortality is highest during the initial phase of kid/lamb life and have a propensity to decline as age progresses. Poor mothering (such as stimulation of respiration and thermoregulation), dam parity, litter size, weather condition, and many other factors will contribute for this.

Colostrum feeding was identified as statistically associated protective factor for mortality of lambs/kids. This means, they are inversely proportional (i.e. if a lamb/kid is heathy and capable of suckling by it self, it is less likely to die). This is in agreement with the statement of (Radostits, *et al*., 2006); up to 31% of mortality is associated with ineffective colostrum feeding, and that of (Koyuncu *et al*., 2018); in neonatal lambs, the acquisition of passive immunity by the early ingestion and absorption of maternal immunoglobulins from colostrum is critical for survival. This is because colostrum is not only rich in immunoglobulins as compared to milk but also an excellent source of energy, vitamin A and essential minerals that help the new born to survive and grow well.

Species as a factor was significant ($p<0.05$) with regard to lamb/kid morbidity unlike that of mortality (insignificant). Genetic and/or hormonal differences will contribute for this fact. In this particular study, about 69% of lambs and 31% of kids were died (table 3). This is in contrary with the finding of (Turkson, 2003) who stated that "significantly

higher proportions of kids (80.2%) and lambs (75.6%) up to 3 months of age died compared to kids and lambs from 4 to 12 months of age. This supports the general belief/perception of farmers that goats are hardier and survive better than sheep and must, therefore, be the preferred small ruminants. Indeed, this is consistent with the local belief that goat are more resistant to different challenges than sheep.

Type of birth (litter size) had insignificant ($p > 0.05$) effect on pre-weaning mortality of kids/lambs. This agrees with the work of Petros *et al* (2014) who reported type of birth had insignificant effect on kid mortality. As of the current result, there was more death for twins than single litters. This is in agreement with Dessie and Tilahun (2022), who reported "high mortality in twins compared to singles", Chauhan *et al* (2019) whose statement was as: "single-born kids had lower risks of death compared with twin-born kids", report of Snyman (2010): single-born kids had the lowest mortality rate (10%), followed by twin-born (13%) and triplet-born (22%) kids, and Ibrahim *et al* (2020): "mortality tended to increase with a larger size litter where single kids had always a higher birth weight hence higher survival rate than twins and triplets".

This implies that mortality in lambs/kids' increases with litter size (birth type), a relationship that is associated with a decline in birth weight as litter increase, (i.e., twins have lower energy balance than singletons and lambs with lower birth weight are less vigorous, are slower to stand at birth and they suckle less frequently which may lead to starvation resulting in higher deaths).

Besides, it also takes the dam a longer time to lick and dry 2 or 3 lambs. Furthermore, the milk requirement of twins is higher than that of single lambs and starvation is more likely among them leading to starvation and death (Ahmed *et al*., 2010). Dam parity had an influence on pre-weaning lamb/kid mortality. Mortality was generally found increasing with increasing parities.

This result is consistent with reports of Petros *et al* (2014), and Dessie and Tilahun (2022) who reported an increase in mortality with parity in kids which may be due to increase in multiple births as parity increased, but contradicts with the statement of Assan (2020); who says: kids/lambs delivered to low parity order dams have low chances of survival due to poor maternal instinct since the advancement of maternal behavior gets better with parity order, as parity order progresses maternal instinct is consolidated.

The high number of mortality in twins in the present study may be because more (74) twin lambs/kids were born from multiparous dams (102) compared to primiparous dams (28). The reason for this may be associated with a decline in birth weight as litter increase and the milk requirement of twins is higher than that of single lambs in which starvation is more likely among them leading to starvation and death.

The effect of sex on pre 90 days mortality was insignificant ($P>0.05$), which is in line with the reports of Dessie and Tilahun (2022), and Petros *et al* (2014). However, this contradicts with the report of Woldemariam *et al* (2014) who stated as there was a

significant variation (P=0.050) in mortality between the two sexes; high number of deaths was noticed in female lambs rather than in male lambs.

Even though it was insignificant, the current study showed that high numbers of males (61.5%) were died as compared to females (38.5%). This is in agreement with the report of Chauhan *et al* (2019) who stated that "male kids had higher hazards of death compared with female kids", Ahmed *et al* (2010); "more male lambs died compared to females", Mthi *et al* (2020); mortality rate was higher in the male lambs (61%) compared to female lambs (39%), Snyman (2010); mortality rate in male kids was higher than that recorded for female kids, Assan (2020); male kids/lambs have lower survival rates and higher mortality hazard ratios as compared to female kids/lambs, and Ibrahim *et al* (2020); "male kids recorded higher mortality rate than female kids, this might reflect higher immunity of female". Meaning, this may be due to differences in natural defense (because of hormonal variation) to different risk factors that cause disease and result in fatality.

As of the owners' reply, lambs/kids suffered from diarrhea showed loose and bad smelling feaces, in-appetence, weakness, dullness, dehydration (sunken eyes) and depression with subnormal temperatures. The other group of lambs/kids died of respiratory problem showed signs of coughing, sneezing and nasal discharge. Diarrhea and pneumonia are most commonly associated with an endemic condition in the area whose causative agents could vary (example: *Pastuerella*, *Salmonella*, *E. coli*, Coccidia, *Cryptosporidium*, *Clostridium perfringens*, Helminths and Rotavirus.

6. CONCLUSION AND RECOMMENDATIONS

In conclusion, the study reported various factors responsible for morbidity as well as mortality of lambs and kids in Dalocha Wereda. According to the present study, lamb/kid morbidity and mortality represent slight loss in sheep and goat husbandry practices of farmers. Emaciation and respiratory syndrome were responsible for morbidity while diarrhea was the leading cuase of mortality. Therefore, in general, attention must be given to proper management, sanitation (maintain hygienic environment), and improved health care of lambs/kids to minimize their morbidity as well as mortality. Does/ewes are better to acquire all vaccines available in the area. Dams of lambs/kids should receive adequate and quality diet in order to provide their off spring/s enough milk. All lambs/kids should be kept in close vicinity and apart from other livestock so as to avoid accidental deaths. Beside, I suggest that a more comprehensive and laboratory based (further) studies to identify the major pathogens of specially diarrhea and pneumonia would be carried out.

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8. APPENDICES

8.1. Appendix I: Illustrations about survey/cross-sectional part of the study

Table 1: Summary of some variables studied in relation with study kebeles

Variable	Value	Kebele		
		Enqatagam	Golecheba	Wanjashola
Morbidity	no	34	33	34
	yes	11	10	8
Mortality	no	40	38	39
	yes	5	5	3
Flock size	1-5	13	7	15
	6-10	21	26	24
	11-15	8	6	3
	16-20	3	2	0

	>20	0	0	0
Species	kid	14	15	27
	lamb	31	28	15
Sex	male	23	20	18
	female	22	23	24
Age of young	< 1 month	4	9	3
	1-2 months	9	5	6
	> 2 months	32	29	33
Ecto-parasite	no	17	26	20
	yes	28	17	22
Health problem	diarrhea	3	5	2
	respiratory problem	3	6	5
	emaciation	7	3	3
	circling	1	1	0
	accident	2	0	1

Table 2: Summary of different risk factors in associated with lamb/kid morbidity and mortality

Variable	**Category/value**	**Morbid**	**Died**	**Univariable cox regression**	
				LR chi2	P-value
Kebele	Enqat Agam	11	5	82.79	
	Golecheba	10	5		-
	Wanjashola	8	3		
Flock size	1-5	6	3	0.16	0.684
	6-10	15	7		
	11-15	7	3		
	16-20	1	0		
	>20	0	0		
Species	kid	8	3	3.63	0.068
	lamb	21	10		
Sex	male	12	8	0.29	0.588
	female	17	5		

Littre size	single	11	2	3.23	0.081
	two	18	11		
Floor type	smooth & dry	21	12	0.44	0.514
	rough & dusty	8	1		
Age of young	< 1 month	9	7	34.80	0.000
	1-2 months	12	4		
	> 2 months	8	2		
Ecto-parasite	no	8	9	0.18	0.676
	yes	21	4		
Dam parity	primiparous	3	3	1.69	0.221
	multiparous	26	10		
Health problem	diarrhea	5	5	37.74	0.000
	respiratory problem	11	3		
	emaciation	12	1		
	circling	1	1		
	accident	-	3		

Birth condition	by self	27	10	0.00	0.952
	assisted	2	3		
Birth time	day	12	2	2.42	0.128
	night	17	11		
Place of birth	indoor	21	12	0.10	0.754
	outdoor	8	1		
Colostrum feeding	self	27	9	0.51	0.491
	assisted	2	4		
Colostrum source	dam	29	13	0.00	-
	another	-	-		
Vigour	good	28	11	0.89	0.380
	poor	1	2		
Mothering behavior	normal	29	12	0.10	0.738
	poor	0	1		

8.2. Appendix III. Case definitions used during the recording of diseases and morbidity/mortality events between birth and 3 months of age in the study area

Disease condition	Case definition
Hypothermia	• Is a condition when body temperature drops below the normal (39-40^{o}C). It occurs when the lamb/kid loses heat to the environment at a rate faster than the body can produce it. • Lowering of body temperature
Starvation	✓ Critical depletion of body energy reserves ✓ A total or partial failure to ingest sufficient colostrum or milk ✓ Occurs when lambs/kids fail to suck adequately owing to weakness, competition with litter mates or inadequate mothering, or when colostrum/milk production is deficient.
Pneumonia	• Is an infectious disease of young lambs/kids especially those born and reared in confinement. • It refers to the inflammation of the pulmonary parenchyma usually accompanied by the inflammation of bronchioles and often pleurisy and, it is characterized by respiratory embarrassment or sometimes toxaemia.
Coccidiosis	• Is an enteric disease affecting particularly kids and lambs and it is characterized by debility,

	malaise, inappetance, diarrhoea or sometimes dysentery, dehydration and death in untreated animals.
Dystocia	✣ Failure of the cervix to dilate (ring womb), mal-presentation or posture of the fetus(es) and fetal oversize.
Diarrhea	• Any condition characterized by the passing of loose or watery feces with increased frequency, which could or could not be accompanied by other systemic signs like dehydration, decreased appetite, or fever
Naval ill (Omphalitis)	❖ Warm enlargement of the umbilical cord, or foul-smelling discharge from the umbilical structures due to infection
Congenital problems	• Any problems that were 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
Perinatal mortality	• Live births that die within 24 hours of birth without an obvious disease
Neonatal mortality	✓ Death between 1 and 28 days of age
Older kid/lamb mortality	• Death between 1 and 3 months of age
Morbidity	• The amount of disease in a population (commonly defined in terms of incidence or

	prevalence
Mortality	• A measure of the number of deaths in a population.

Source: (Aitken, 2007; Hamito, 2011; Kusiluka and Kambarage, 1996; Temesgen, 2004; Thrusfield, 2018).

8.3. Appendix III: Some pictures taken during field work


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