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# Dairy calf and replacement heifer mortality on a single intensively managed dairy farm in Jordan: A 3-year-long study (2016–2018)

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**Abstract**

**Background:** Pre-weaning dairy calf and replacement heifer mortality represents significant economic loss, limits genetic improvement and growth of the herd, and indicates poor management and animal welfare status on the farm.

**Aim:** Currently, the rates and causes of the dairy calf and replacement heifer mortality in Jordan are not known. Therefore, the objective of this study was to determine the incidence rates and causes of mortality of pre-weaning calves and replacement heifers in Jordan. In addition, the age and seasonal distribution of mortality are determined in the study.

**Methods:** Data extracted from the farm management record software over 3 years (January 2016–December 2018) were used in this study. Calf-specific data included the day and month of birth and sex. Health-related data included age at death, necropsy findings, laboratory findings if available, and the presumptive diagnosis. Descriptive analysis was performed to determine the 3-year overall mortality rate as well as the yearly mortality rate in pre-weaning calves and replacement heifers using excel spreadsheets of Microsoft Word 10.

**Results:** Only female calves ($n$ = 724) born alive during the study period were used in the analysis. The overall calf mortality rate was 8.9% with a yearly rate ranging between 5.9% and 12%. The majority of deaths occurred in calves less than 50 days of age with an average age of 17 days. There was a seasonal pattern for calf mortality with the majority of deaths occurring during the colder months of the year (December, January, February, and March). The highest number of pre-weaning calves died because of enterotoxemia (39%) and pneumonia (30%). Other causes of calf mortality were abomasal ulcer (8%), enteritis (6%), septicemic salmonellosis (5%), meningitis (4%), rumen drinkers (3%), aspiration pneumonia (3%), septic arthritis (1%), and omphalitis (1%). The overall 3-year heifer mortality rate was 4%. The average age of dead heifers was 8 months (range 3–23 months). The highest number of heifers died because of neurologic disease (37%) and enterotoxemia (33%). Other causes of heifer mortality were abomasal ulcer (11%), enteric salmonellosis (7%), chronic rumen tympany (7%), and chronic pneumonia (4%).

**Conclusion**: Data presented in this study are essential to construct and implement effective preventative health programs and improve farm management practices to reduce calf and heifer losses.

**Keywords:** Dairy herds, Calf health and welfare, Replacement heifers, Genetic improvement.

## Introduction

Neonatal calf mortality is defined as the death of the newborn between 1 day of age and weaning while heifer mortality is the death of heifers after weaning to the first calving (Compton *et al.*, 2017). Neonatal mortality in dairy cattle represents major health and animal welfare issues in addition to significant economic losses (Boulton *et al.*, 2017; Hyde *et al.*, 2020). It also negatively affects the future growth and genetic improvement of the herd due to the loss of genetically valuable replacement heifers (Boulton *et al.*, 2017; Hyde *et al.*, 2020).

In dairy herds, good health and survival of neonatal calves are a direct result of farm management and calf-rearing practices such as calving and pre-calving management, biosecurity, sanitation, vaccination, housing, and feeding (Hultgren and Svensson, 2009; Cuttance *et al.*, 2018). Etiologically, calf and heifer mortality can be caused by infectious and non-infectious causes (Mandal *et al.*, 2019). Among the infectious diseases, the majority of calves die every year because of enteritis (diarrhea) and pneumonia caused by bacteria, viruses, and protozoa while the majority of non-infectious causes are dystocia, improper feeding of colostrum, low birth weight, and poor management practices (Mandal *et al.*, 2019). Other specific known herd- and animal-level risk factors for calf and heifer mortality include dystocia, sex, twinning rate, dam parity, herd size, and birth season (Lombard *et al.*, 2007; Stull *et al.*, 2008).

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Accurate estimates of calf and replacement heifer mortality rates are essential before effective preventative health programs and general farm management improvements could be implemented. Currently, the rates and causes of calf and heifer mortality in Jordan dairy farms are not known. Therefore, the objective of this study was to determine the incidence rates and causes of mortality of pre-weaning calves and replacement heifers in Jordan. In addition, the age and seasonal distribution of mortality rates and mortality causes are determined in the study.

## Materials and Methods

### *Study area*

There is approximately 80,000 head of dairy cattle in Jordan, all of which belong to the Holstein-Friesian dairy breed (Department of Statistics, 2020). Approximately 65%–70% of dairy products in Jordan are produced in the Al-Dhlail region with farm sizes ranging between 100 and 10,000 lactating cows. All farms in this region share similar management and feeding practices. The dry season in this region is long and dry (April through November) while the rainy season is short and cold (December through March) with an annual rainfall of about 100 mm (Al-Halabi, 2019).

### *Study farm*

The farm used in this study is located in Al-Dhlail city located in the North-Eastern region of Jordan. The yearly average number of cows in the farm in this farm was 500 lactating cows, 450 heifers (aged 2 months to first calving), and 420 calves aged between 1 and 60 days (pre-weaning). Lactating cows are housed in free stall barns on dirt floors with outside sheds available freely for the cows to use during sunny days. The cows are fed a total mixed ration composed mainly of corn silage, alfalfa hay, and various grain supplements. The average milk production in this herd ranges between 35 and 40 kg per cow per day (range 25–55 kg). Cows are milked 3 times per day in a 36-double herringbone milking parlor. Various hormonal-based reproductive protocols are used on the farm. The cows are bred using artificial insemination which is routinely performed by an outside contractor expert technician.

### *Calving management*

Twenty-four hours before the expected calving date, cows are moved to a clean maternity pen. Maternity pens are bedded with shredded cardboard paper. The bedding is removed between calvings. The calving process is closely monitored by trained farm caretakers. Immediately after calving, colostrum is milked using an aseptic technique. The quality of freshly collected colostrum is determined using a colostrometer. Only high-quality colostrum (specific weight > 1,050 mg/ml equal to immunoglobulin concentration of >50–140 mg/ml) is fed to the calves for the first meal. Colostrum was fed in the amount of 10% of body weight divided into two equal meals. Excess high-quality colostrum is divided into aliquots of 2 l each in sanitized plastic bottles. The bottles are labeled with the date of collection and quality of colostrum before they are stored at −18°C for future use.

### *Calf rearing practices*

Immediately after birth, the newborn body is dried and the calves are removed from the maternity pen and placed in small groups (3–5 calves) in clean straw-bedded stalls for 48 hours. The calves are then examined for any congenital abnormalities, identified by ear tags, the umbilicus is dipped using an iodine-based disinfectant, and administered the first meal of colostrum using stomach tubing within 2–4 hours after birth. At 48 hours, whole blood samples are drawn from all calves and total serum protein is determined using a refractometer. The calves are then moved to an individual housing using wooden boxes raised above the ground by about 50 cm and kept there until weaning. The floor under the boxes is concrete with an adequate slope for drainage. The floors are flushed with clean water and disinfected twice per day. Biosecurity measures in the calf rearing area consist of in and out shoes brushing and disinfection and caretakers wearing clean coveralls and disposable gloves while working with calves. Calf caretakers are not allowed to work with older cows.

Following colostrum, calves are fed milk replacer (10% of body weight) divided into two equal meals per day during the summer and (15% of body weight) divided into three equal meals per day during the winter. Milk is freshly reconstituted before feeding using warm water and fed using plastic bottles. Fresh water and calf concentrate starter ration is offered free of choice starting at day 3 of age. Good quality hay is offered to calves starting at 21 days of age. All utensils used in calf rearing are subjected to strict cleaning and sanitization procedures following each use.

Calves are typically weaned at about 60 days. After weaning, heifers are moved to outside lots with dirt floors where heifers are housed in multiple groups averaging 50–100 heifers per group according to age (3–8, 9–13 months, and 13 to first calving). Heifers are fed good quality alfalfa hay ad libitum with occasional additional grain-based supplements.

### *Cow and calf preventative health programs*

The routine vaccination protocol for cows on the farm consists of the following vaccinations: *Escherichia coli*, rotavirus, coronavirus, and *Clostridium* spp. polyvalent vaccines are administered twice per year at 7 weeks and 3 weeks before calving. For calves and heifers, the vaccination protocol consists of the following vaccinations: foot and mouth diseases at 2 and 3 months of age and twice annually thereafter, *Clostridium* spp. polyvalent vaccine at 3 and 6 weeks of age and twice annually thereafter, infectious bovine rhinotracheitis (IBR), bovine parainfluenza-3, bovine respiratory syncytial virus, and bovine virus diarrhea type 1 and 2 at 2 and 3 months of age and once per year thereafter 3 weeks before calving. Deworming program

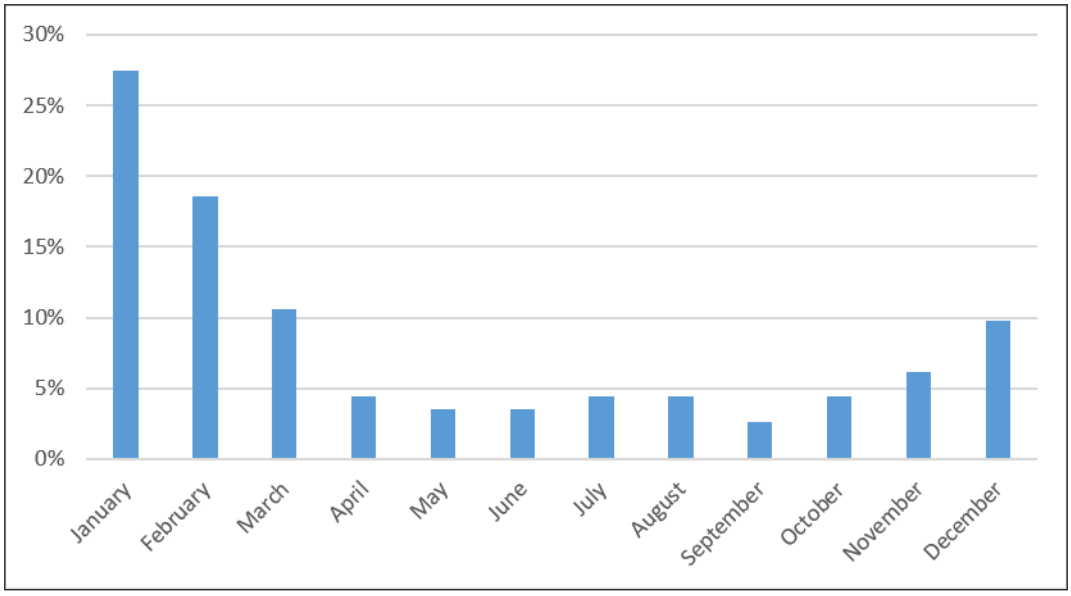


**Fig. 1.** Distribution of calf mortality rate over the months of the year during the 3-year study period (2016–2018) in Jordan.

for calves consists of administering anthelmintic drugs to calves at 8, 12, and 16 months of age and at drying off (60 days before the calving date) to pregnant heifers and cows.

Sick calves are housed separately, fed, and treated last until are recovered. Calves are monitored during feeding and any calf that shows loss of appetite or depression is subjected to a comprehensive physical examination by the farm resident veterinarian. Physical examination includes determination of heart rate, respiration rate, rectal temperature, and listening to the lung sounds, palpation of the umbilicus. Treatment of sick calves follows prescribed standardized protocols that involve multiple daily follow-up evaluations. All dead or euthanized calves on the farm are subjected to complete necropsy procedures during which tissue samples are collected for microbiology and histopathology evaluations if deemed necessary by the consultant veterinarian.

***Data collection***

Data used in the study were collected from the calf-raising records on the farm. Calf-specific data included the day and month of birth and sex. Health-specific data included age at death, necropsy and laboratory findings if available, and the presumptive diagnosis.

***Data analysis***

Pre-weaning calf mortality was defined as calf death occurring between the age of 1 day to weaning (at 60 days of age). Males are typically sold for beef production at 3–5 days of age and therefore they were not included in the analysis in this study. Because the total number of dead heifers over the 3-year study period was small (27), the total heifer population was placed in one age group (3 months to first calving). Descriptive analysis was performed to determine the 3-year overall mortality rate as well as the yearly mortality rate in pre-weaning calves and replacement heifers using excel spreadsheets of Microsoft Word 10.

***Ethical approval***

No ethical approval was required in this study since no live animals were used.

## Results

***Pre-weaning calf mortality rate***

The total number of claves (males and females) born alive on the farm during the study period (2016–2018) was 1,270. The total number of female calves born alive on the farm during the study period (2016–2018) was 724. The number of female calves born alive per year was 288, 220, and 216 calves in 2016, 2017, and 2018, respectively.

The overall 3-year pre-weaning calf mortality rate was 8.9%. The yearly pre-weaning calf mortality rates were 12%, 8%, and 5.9% in 2016, 2017, and 2018, respectively. The average age of dead calves was 17 days (range 1–50 days). The distribution of calf mortality over the months of the year showed that the majority of calf mortality occurred during the colder months (Fig. 1). The mortality rate was highest during January and February (27% and 19%, respectively) while the lowest mortality was reported during September (3%).

***Causes of pre-weaning calf mortality***

The different causes of pre-weaning calf mortality are presented in Figure 2. The highest percentage of calves died because of enterotoxemia (39%) and pneumonia (30%). Other causes of calf mortality were abomasal ulcer (8%), enteritis (6%), septicemic salmonellosis (5%), meningitis (4%), rumen drinkers (3%), aspiration

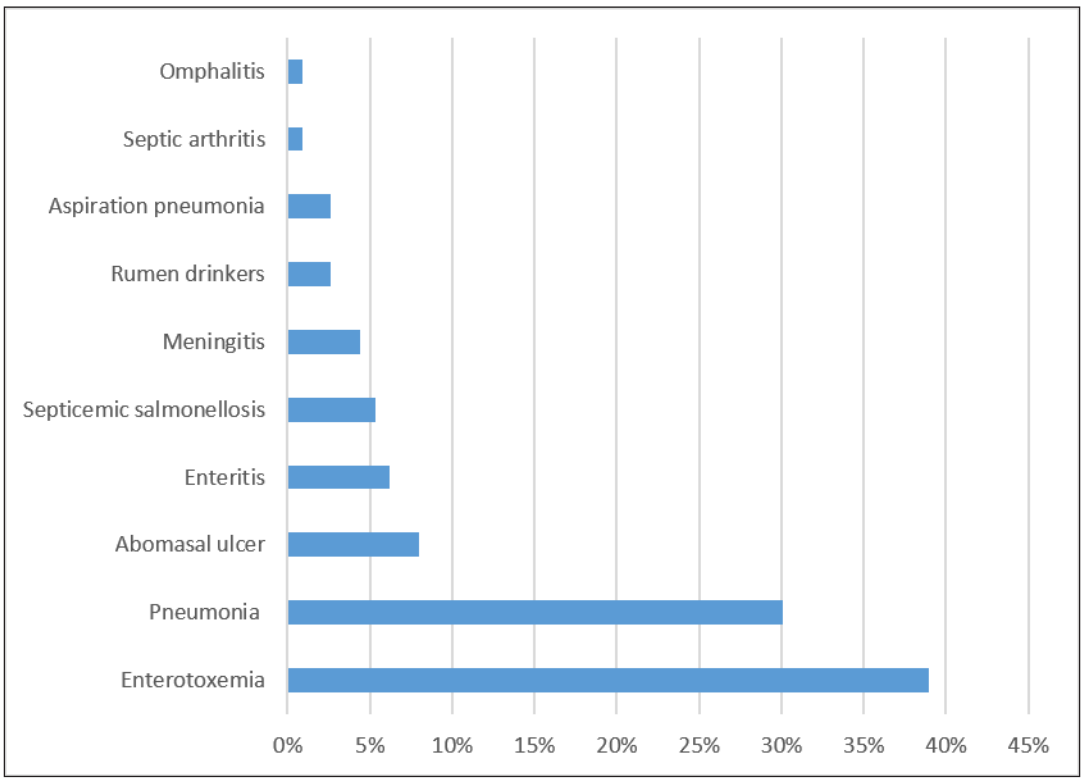


**Fig. 2.** Causes of dairy calf mortality over a 3-year study period (2016–2018) in Jordan.

pneumonia (3%), septic arthritis (1%), and omphalitis (1%).

***Causes of calf mortality distributed over months of the year***

During January, the highest percentage of calves died because of enterotoxemia (13%) followed by pneumonia (8%) and enteritis (3%). In February, the highest percentage of calves died because of enterotoxemia (10%) followed by pneumonia (4%). In March, the highest percentage of calves died because of pneumonia (4%) followed by enterotoxaemia (2%). In April, the highest percentage of calves died because of neurologic disease and enterotoxaemia (2% each). In May, the highest percentage of calves died because of enterotoxaemia (2%) and pneumonia (1% each). In June, the highest percentage of calves died because of septicemic salmonellosis (3%) followed by enterotoxaemia (1%). In July, the highest percentage of calves died because of enterotoxaemia (2%) followed by pneumonia (1%). In August, the highest percentage of calves died because of enteritis, pneumonia, enterotoxaemia, rumen drinkers, and neurologic disease (1% each). In September, the highest percentage of calves died because of abomasal ulcers, omphalitis, and septic arthritis (1% each). In October, the highest percentage of calves died because of pneumonia and abomasal ulcers (2%). In November, the highest percentage of calves died because of abomasal ulcers (3%) followed by enterotoxemia (2%). In December, the highest percentage of calves died because of abomasal ulcers (4%) followed by pneumonia (3%).

***Rate and causes of mortality of replacement heifers***

The overall 3-year heifer mortality rate was 4%. The average age of dead heifers was 8 months (range 3–23 months). The causes of heifer mortality in this study are presented in Figure 3. The highest number of heifers died because of neurologic disease (37%) and enterotoxemia (33%). Other causes of heifer mortality were abomasal ulcer (11%), enteric salmonellosis (7%), chronic rumen tympany (7%), and chronic pneumonia (4%).

## Discussion

The incidence rates, causes, age, and season distribution of mortality of pre-weaning calves and replacement heifers are determined in this study for the first time in Jordan. The overall pre-weaning calf mortality rate was 8.9% with a yearly rate ranging between 5.9% and 12%. Worldwide, the incidence rates of mortality of neonatal dairy calves and replacement heifers are known to vary according to country, geographic regions within countries, and production systems (Zhang *et al*., 2019). The results of this study indicate that rates of calf mortality in this farm fall within the range of calf mortality rates reported globally. For example, the neonatal calf mortality rate was estimated at 3.9% in

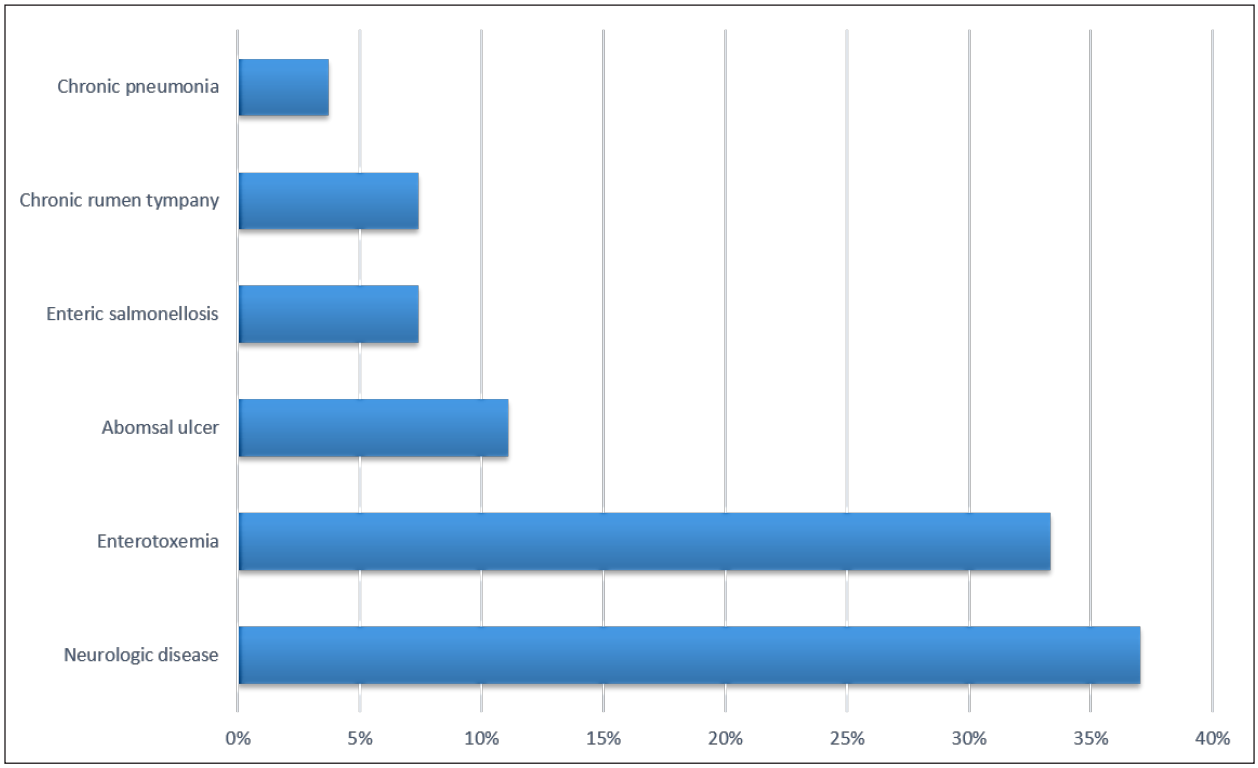


**Fig. 3.** Causes of dairy heifer mortality over a 3-year study period (2016–2019) in Jordan.

British dairy herds, 5% in the USA, and 5%–6% in Denmark (Norberg *et al*., 2013; USDA, 2014; Hyde *et al*., 2020).

In this study, the majority of calf deaths occurred in calves less than 50 days of age (average age of 17 days). These results are in congruence with previously published reports that suggested that the major number of calves on dairy farms die within the first month of life (Gates, 2013; Santman-Berends *et al*., 2014). The results of this study also indicated that the majority of dead replacement heifers died at an average age of 8 months (range 3–23 months). These results are also in agreement with previous reports that indicated about two-thirds of heifer mortality occurs within the first 4 months of life (Struchen *et al*., 2015). It has been reported that calf and heifer mortalities increase early in life because of several factors including immunity, housing, and environment (Windeyer *et al*., 2014).

In this study, the results showed that the majority of calves died during the colder months of the year (December, January, February, and March). These results are similar to previous reports that indicated a tendency of increased calve mortality during winter months (Svensson and Liberg, 2006; Pannwitz, 2015). This seasonality in calf mortality has been attributed to environmental and weather-related factors such as temperature and rain (Raboisson *et al*., 2013). Calves during winter months are more likely to be housed indoors in crowded conditions and unsanitary floors resulting in increased pathogen loads and pathogen exposure stress (Raboisson *et al*., 2013).

Calf mortality is multifactorial and can be a result of infectious and non-infectious causes (Mandal *et al*., 2019). In this study, the most likely causes of pre-weaning calf mortality were infectious in nature. Specifically, over two-thirds (69%) of calves died because of enterotoxemia and pneumonia. Other minor infectious causes included enteritis (diarrhea), septicemic salmonellosis, and meningitis. The major non-infectious causes of pre-weaning calf mortality in this study involved the gastrointestinal system (abomasal ulcers and rumen drinkers). In replacement heifers, the majority of cases died because of neurologic disease and enterotoxemia accounting for 70% of all deaths in this study. On the other hand, the majority of non-infectious causes of replacement heifer mortality were abomasal ulcers and chronic rumen tympany. Previous reports have indicated that the two most frequent diseases causing heifer mortality are gastrointestinal disorders (diarrhea) and respiratory disease (pneumonia) (Torsein *et al*., 2011; Fruscalso *et al*., 2020). Moreover, disorders involving the gastrointestinal system have been reported as the most prevalent causes of death in cattle at 3–6 months of age (Mandal *et al*., 2019).

In this study, enterotoxemia, a fatal disease caused by several strains of *Clostridium perfringens* was the number one cause of mortality in pre-weaning calves

and the second most common cause of mortality in replacement heifers. Enterotoxemia or clostridial gastroenteritis (enteritis, abomasitis, and abomasal ulcers) is considered an important cause of sudden death in dairy calves and growing heifers worldwide with a case fatality rate approaching 100% in certain situations (Simpson *et al*., 2018). It has been elucidated that the most likely predisposing factor for *Clostridium* spp. overgrowth and exotoxin production in the gastrointestinal tract of young cattle are sudden changes in the intestinal tract microenvironment due to inconsistent milk feeding practices, excessive feeding of highly fermentable carbohydrates, and altered gastrointestinal motility associated with feeding large amounts of liquid milk (Simpson *et al*., 2018). Although treatment of enterotoxemia is proven futile, prevention can be achieved by improving feeding and general calf management and routine vaccination (Simpson *et al*., 2018).

In this study, the non-specific neurological disease was the most frequently reported cause of death in replacement heifers. Although, a specific diagnosis was not sought in this study, the most likely infectious neurologic diseases responsible for high mortality in this group of growing calves could be thrombotic meningoencephalitis caused by *Histophilus somni*, otitis media/interna caused by *Mycoplasma* spp., meningoencephalitis caused by an IBR virus while the most likely non-infectious disease could be polioencephalomalacia (Peek and Divers, 2017).

## Conclusion

The incidence rates, causes, age, and season distribution of mortality of dairy calves and replacement heifers are determined in this study for the first time in Jordan. These data are essential to understand farm management factors that may affect calf health and mortality in order to construct and implement effective preventative health programs and improve farm management to reduce calf and heifer losses.

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***Conflict of interest***

The authors declare no conflict of interest.

***Authors' contributions***

Zuhair Bani Ismail: Designed the study, analyzed the data and prepared the manuscript. Mohammad Musab Muhaffel: Collected the data. All authors have read and approved the final manuscript.

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