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The occurrence of diseases and their relationship with passive immune transfer in Holstein dairy calves submitted to individual management in southern Brazil

[*Ocorrência de doenças e sua relação com a transferência de imunidade passiva em bezerras Holandês criadas em sistema individual no sul do Brasil*]

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ABSTRACT

Calves are extremely dependent on colostrum intake for the acquisition of passive immunity. This study aimed to determine the occurrence of diarrhea and respiratory diseases and the impact of Failure of Passive Immune Transfer (FPIT) on the health and zootechnical performance of Holstein dairy calves in individual management. This study has been carried out in five commercial farms in Rio Grande do Sul State, Brazil, from March 2017 to January 2018. In this study, 131 calves were followed from birth to 60 days of age. Total Plasmatic Protein (TPP) has been performed to determine passive immune transfer quality in 53 calves (53/131). A daily clinical follow-up has been accomplished aiming at diagnosing diseases and their incidences, and zootechnical measures such as withers height, width of the croup and weight have been evaluated. FPIT rate was 32.07%, diarrhea occurrence and respiratory diseases were 77.9% and 49.6%, respectively. FPIT increased the chances of calves presenting diarrhea and developing respiratory diseases, but no differences on zootechnical performance were found. The frequency of FPIT is still high and is a factor that corroborated the increased risk for diarrhea and respiratory disease but did not influence the performance of calves in the preweaning phase.

Keywords: health, neonatology, immunoglobulins, diarrhea, respiratory disease

RESUMO

Bezerras são extremamente dependentes da ingestão de colostro para adquirir imunidade passiva. Este estudo teve o objetivo de determinar os índices de ocorrência de diarreia e de doença respiratória, assim como o impacto da falha na transferência de imunidade passiva (FTIP) no desenvolvimento de doenças e no desempenho zootécnico de bezerras Holandês criadas em sistema individual. O estudo foi desenvolvido em cinco propriedades comerciais no Rio Grande do Sul, Brasil, entre março de 2017 e janeiro de 2018. Assim, 131 bezerras foram acompanhadas, do nascimento aos 60 dias de idade. Em 53 animais, foi realizada avaliação de proteínas plasmáticas totais para determinar a qualidade na transferência de imunidade passiva. Acompanhamento clínico diário foi realizado, a fim de diagnosticar doenças e suas incidências, assim como avaliações zootécnicas, como altura de cernelha, largura de garupa, perímetro torácico e peso. O percentual de FTIP foi 32,07%, a ocorrência de diarreias e de doenças respiratórias foi, respectivamente, 77,9% e 49,6%. A FTIP aumentou as chances de as bezerras apresentarem diarreia e doenças respiratórias, mas não alterou o desempenho zootécnico. Conclui-se que a frequência na FTIP ainda é elevada, fator que corroborou o aumento do risco para as diarreias e doença respiratória. Apesar disso, a FTIP não influenciou no desenvolvimento das bezerras na fase de aleitamento.

Palavras-chave: saúde, neonatologia, imunoglobulinas, diarreia, doença respiratória

INTRODUCTION

Bovine neonates are agammaglobulinemic at birth and are, therefore, dependent on absorption of immunoglobulins (Ig) delivered through maternal colostrum (MacFarlane *et al*., 2015). The Igs in colostrum (IgG, IgA and IgM) are considered essential for good neonate performance and health, especially in the first month of life (Smolenski *et al*., 2007). When there is an inadequate transfer of Igs through colostrum, it characterizes Failure of Passive Immune Transfer (FPIT); this occurs when serum IgG concentrations are below 10mg/mL in neonates between 1 and 9 days of age (Wilm *et al*., 2018), or when Total Plasma Protein (TPP) concentrations are below 5.5g/dL between 24 and 48 hours of life (Buczinski *et al*., 2018). In addition, colostrum is a source of important cells such as monocytes, lymphocytes, neutrophils, eosinophil (Gomes *et al.,* 2017), and also cytokines (Chase *et al.,* 2008) and growth factors (Godden, 2008) which also has important function on neonate's health.

An adequate transfer of passive immunity is important because calves with FPIT are more susceptible to developing enteric diseases (Lora *et al.*, 2018), and calves which survive are more susceptible to develop other diseases, such as respiratory complex disease, which negatively impact performance and lead to economic losses (Raboisson *et al*., 2016). Thus, inadequate amounts of colostrum administered to calves resulted in higher mortality rates, more severe diarrhea, and lower weight gain in affected calves (Quigley *et al*., 1995). Weight gain in dairy cattle is extremely important, since it directly influences the age at first service and subsequently at first calving, thus impacting animal productivity and profitability (Morrison *et al*., 2013).

Once FPIT is responsible for a higher level of disease, longer rearing period, and increased use of antimicrobials in calves, it constitutes an economic, public health, and animal welfare issue. There is a need in most different world regions to determine the incidence of FPIT and its real impact on disease development, considering the different types of calf management that can be employed. Although individual pens reduce the direct exchange of pathogens between animals, this does not avoid environment effects on disease occurrence (Costa *et al.*, 2016).

Thus, we conduct this cohort study aimed to determine the impact of FPIT on diarrhea, respiratory disease and zootechnical performance of Holstein dairy calves from Rio Grande do Sul state submitted to individual management.

MATERIAL AND METHODS

An observational cohort study was carried out in five commercial dairy farms, in Rio Grande do Sul state, Brazil, from March 2017 to January 2018. During this period, daily follow-up was accomplished on 131 Holstein calves from birth to 60 days of age. One of the farms was located in the South region (32°16' S, 52°32' W), and the others in the Northwest region (27°51′ S, 53°46′ W), all under humid subtropical climate. The number of farms to involved was conveniently established in order to meet the minimum number of calves needed for the study.

The farms included in the study were similar in terms of cow breed reared (Holstein), herd size (200–600 lactating cows), production (around 35L/cow), housing (individual calf pen or stake system), feeding (total mixed ration) and milking (milking parlor) systems, management of calving (use of calving pen; parturition monitored by the farmer at least twice a day; calf separated from dam immediately after birth, up to 6 hours) and calves (navel disinfection using iodine; at least 4 L of colostrum of the own dam provided by nipple-bottle; single housing until at least 5 wk of age, receiving water *ad libitum*, concentrate was provided the calves from the three/fourth day of life according to NRC recommendation).

All of the farms had veterinary assistance, and all data were collected in the same period as well. The procedures performed during this study have been previously authorized by the Animal Experiment Ethics Committee of Federal University of Pelotas, under registration 28396-2018.

Health status from 131 calves under study were monitored on each visit to the farm, daily or eventually every two days, from birth to 60 days of age, and always by a trained veterinarian. For this purpose, initially all animals were observed, and at a sign of any clinical changes, such as drooping ears, apathy, tachypnoea, presence of secretions, or reduction in milk intake (according to trainer's report), calves were evaluated

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clinically. During clinical examination heart rate, respiratory rate, rectal temperature, capillary perfusion time, mucosal staining, cough reflex, attitude (alert/apathetic), and presence of ocular/nasal secretions were evaluated to set a clinical diagnosis. Physiological parameters under examination were those proposed by Dirksen *et al*. (1993).

Among 131 animals included in this study, 53 calves were randomly selected (according to parturition) and submitted to an evaluation of passive immunity transfer. The sample size needed to develop this cohort study (53) was based on Fleiss *et al*. (2013), considering an incidence of 75% between unexposed and 99% between exposed, based on the expected incidence of diarrhea in these groups, through the OpenEpi program, with 95% significance and 80% power (Dean *et al*., 2014).

Thus, from passive immune transfer diagnosis, two cohorts were formed: one consisting of calves that received satisfactory passive immune transfer (36 calves), and another cohort of animals that did not receive satisfactory passive immune transfer (17 calves); this was done to compare the incidence of health problems or differences in zootechnical parameters between cohorts.

Passive immunity transfer quality was evaluated in 53 calves (53/131). To that end, blood samples were collected via puncture of the jugular vein, from 24 to 48 hours after colostrum intake, using a 10mL Vaccutainer tube with EDTA anticoagulant (CRAL, São Paulo, Brazil). Immediately after blood collection, samples were stored in Styrofoam containing ice and sent to the laboratory for centrifugation. Blood was centrifuged for 10 minutes at 3500rpm. After centrifugation, plasma was aspirated using a Pasteur pipette (KASVI, Paraná, Brazil). TPP concentrations were evaluated in a portable optical ATC refractometer (Instrutherm, São Paulo, Brazil), which had been previously calibrated with distilled water and used as recommended by the manufacturer. Passive immunity was considered a failure in calves that had TPP concentrations below 5.5g/dL (Buczinski *et al*. 2018).

Regarding clinical diagnosis, diarrhea was based on observing aqueous feces (presence of feces in the perineal region or the hock region) and presence of associated clinical signs, such as dehydration, apathy, increased intestinal peristalsis, fever, tachycardia, tachypnea, and increased capillary perfusion time. Respiratory disease cases were diagnosed through pulmonary auscultation and suggestive clinical signs of respiratory disease, such as fever, dyspnea, tachypnea, presence of nasal and/or ocular secretion, apathy or inappetence (Lorenz *et al*., 2011).

From clinical follow-up and diseases diagnosis, it was possible to obtain incidence rate (number of animals that became sick during the study/total of animals (n=131)) x 100, mortality rate (number of animals that died/total of animals (n=131)) x 100, recurrence rate (number of calves that became sick more than once/number of calves that became sick) x 100, and lethality (number of animals that died/number of animals that became sick) x 100, for each of the diseases observed throughout the study (diarrhea and respiratory diseases). Sick animals were treated according to protocols adopted by each farm, and always under veterinarian supervision.

Birth weight was measured in all 131 calves. In 117 calves (131 calves except 14 that died), zootechnical parameters such as withers height, width of the croup, thoracic perimeter, and body weight were measured. Besides, we compared these zootechnical parameters between cohorts aiming to determine if FPIT may influence the results. Measurements were performed at birth, and at 7, 14, 21, 28 and 60 days of age. For width of the croup and withers height measurements, a hypo-meter was used. For thoracic perimeter we used a tape measure. Calf weights were estimated with a heart girth tape placed vertically at the point of the elbow (Heinrichs *et al*., 2007). All parameters were evaluated in triplicate, and measurement means were recorded in a specific worksheet.

For each calf, we calculated the Average Dailygain (ADG) dividing weight gain over 60 days by 60. At the end of the experiment we calculated the number of calves that could double their body weight in 60 days of age, subtracting the final weight from birth weight. From data obtained in the field, we determined the incidence, mortality and lethality for both diarrhea and respiratory disease. Comparisons of these incidences between cohorts were performed using

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Pearson's chi-square test. Relative risk was calculated (incidence of exposed / incidence of unexposed) with 95% of confidence interval. For both, we used the Open Epi program.

Using graph Pad Prism 5, we performed survival analysis to compare curves between cohorts using Kaplan-Meier method. Similarly, continuous variables were compared between cohorts (weight gain, ADG, wither height, width of the croup, thoracic perimeter) using ANOVA repeated measures; these were done only after testing for normality and homoscedasticity of variance by Kolmogorov-smirnov and Levene tests, which are prerequisites for the analysis. Differences were considered significant when P value ≤ 0.05, and when P values were between 0.06 and 0.09, it was considered a tendency.

RESULTS

FPIT rate was 32.07% (n=17/53). Total Plasmatic Protein (TPP) values followed by standard error for each of the groups, with FPIT *vs.* without FPIT, were 4.97±0.08g/dL *vs.* 6.82±0.16g/dL, respectively. Disease incidence throughout the study was 77.9% (102/131) for diarrhea and 49.6% (65/131) for respiratory diseases. When we analyzed diarrhea incidence between calves with or without FPIT, we observed differences between groups (P=0.05); all calves with FPIT (17/17) had at least one episode of diarrhea during the first 60 days of age, whereas in those who did not present FPIT, the incidence was 75.0% (27/36).

Failure of immunoglobulin transfer increased relative risk of calves presenting diarrhea throughout the study by 33% (RR=1.33, 95% CI=1.03–1.59; Table 1), when contrasted to those without FPIT. Calves with FPIT had risk estimated at 94.7% in developing diarrhea (IC:73.52% - 100%). In relation to reoccurrence, animals with FPIT presented 2.11 times greater risk of presenting a new case of diarrhea (RR=2.11, 95% CI=1.09–4.09, P=0.03; Table 1)

Linked to respiratory disease, we also observed a difference (P=0.04) between animals with or without FPIT: 76.5% (13/17) of calves with FPIT showed clinical signs of respiratory diseases, whereas the incidence was lower (47.2%; 17/36) in those without FPIT. FPIT increased the risk of developing respiratory disease by 62% (RR=1.62, 95% CI=1.04–2.50; Table 2), and calves with FPIT had risk estimated in 76.47% (IC: 53.23% - 90.95%) to develop respiratory disease. There were no differences in recurrence of respiratory diseases (P=0.28) between cohorts.

Survival curves for the interval from birth to 60 days of life showed that calves with FPIT have greater rate of diarrhea compared with calves without FPIT (hazard ratio: 2.68; 95% CI=1,27-5,65; Figure 1). For respiratory diseases, there were no differences in survival curves for the interval from birth to 60 days of life between cohorts (with or without FPIT; Figure 2).

Table 1. Incidence and relative risk of disease and death in Holstein dairy calves with or without Failure of Passive Immunity Transfer (FPIT) in southern Brazil

Parameter	Overall (n=131)	Cohort incidence (n=53)	With FPIT (n=17)	Without FPIT (n=36)	Relative risk	95% CI	P value
Diarrhea Incidence	77.9%	83%	100%[a]	75.0%[b]	1.33	1.03–1.59	0.05
Respiratory disease Incidence	49.6%	56.6%	76.50%[a]	47.20%[b]	1.62	1.04–2.50	0.04
Recurrence of diarrhea	36.3%	37.7%	58.8%[a]	27.8%[b]	2.11	1.09–4.09	0.03
Recurrence of respiratory disease	37.9%	20.8%	29.40%	16.70%	1.76	0.66–4.97	0.28
Death by diarrhea	6.9%	13.2%	23.50%	8.30%	2.83	0.70–11.24	0.12
Death by respiratory disease	4.6%	7.5%	11.76%	5.55%	2.11	0.32–13.7	0.42
Overall death	10.7%	17%	29.40%	11.10%	2.64	0.81–8.62	0.09
Diarrhea lethality	7.8%	11.3%	17.65%	8.33%	2.11	0.47–9.42	0.31
Respiratory disease lethality	9.4%	7.8%	11.76%	5.88%	2.0	0.30–12.99	0.46

P values are derived from Pearson's chi square tests and are considered significant when *P≤0.05*. Different superscript letters indicate that there are statistical differences between cohorts.
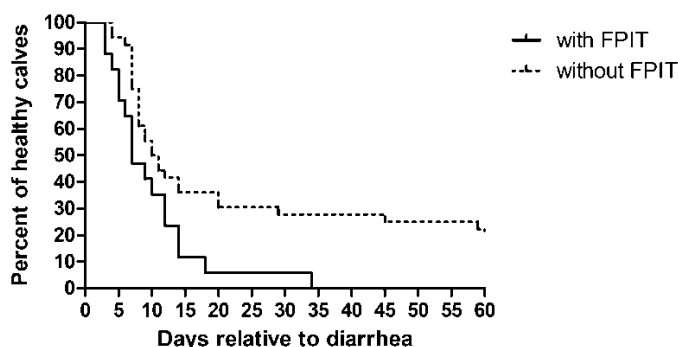
Figure 1. Survival curves for the interval from birth to 60 days of life, for diarrhea disease. Cows with FPIT had (P=0.02) greater rate of diarrhea (adjusted hazard ratio=2,68; 95% CI=1.27 to 5.65) compared with calves without FPIT

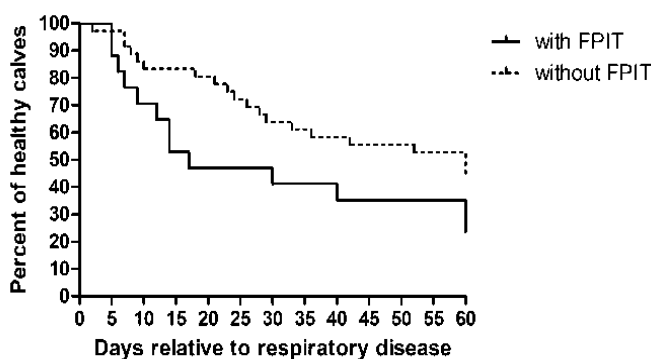Figure 2 Survival curves for the interval from birth to 60 days of life, for respiratory disease. No differences were found between groups (P= 0.11).

Throughout the study, the percentage of deaths due to diarrhea was 6.9% (9/131), and deaths due to respiratory disease was 4.6% (6/131). The total number of deaths was 10.7% (14/131). One calf died of both, respiratory disease and diarrhea. There was a tendency for a higher death rate in calves with a failure of passive immune transfer when compared to calves with adequate passive immune transfer (29.40% *vs*. 11.10%, P=0.09), and animals with FPIT presented 2.64 greater chance of death in relation to those with successful passive immune transfer (RR=2.64, 95% CI=0.81–8.62).

Calves mean birth weight were 39.92±2.83kg (n=131). Mean weight gain throughout the study was 35.48±8.9kg (n=117), while average daily gain (ADG) was 0.603±0.15kg (n=117). After 60 days of the experiment, 36.8% (n=43/117) of animals doubled their weight compared to their birth weight.

Comparisons between calves that did not present FPIT *versus* those with FPIT showed no differences in all evaluations (weight, wither height, width of the croup and thoracic perimeter) performed on days 1, 7, 14, 21, 28 and 60 (P>0.05) As a consequence, the same pattern occurred for ADG (P=0.73), where calves with FPIT presented similar values (ADG: 0.64±0.60kg) compared to calves that did not present FPIT (ADG: 0.62±0.48kg). Also, there were no differences in relation to percentage of calves that doubled their weight at the end of 60 days of study. Zootechnical differences have been observed over the weeks. (Table 2).

Table 2. Zootechnical performance of Holstein dairy calves with or without failure of passive immunity transfer (FPIT) in southern Brazil

	Born		7 days		14 days		21 days		28 days		60 days		Treat.x day	P day	P treat
	Withouth FPIT	With FPIT	Withouth FPIT	With FPIT	Withouth FPIT	With FPIT	Withouth FPIT	With FPIT	Withouth FPIT	With FPIT	Without FPIT	With FPIT			
BW	40.0 ± 0.35	40.2 ± 0.53	42.7 ± 0.35	42.7 ± 0.53	45.2 ± 0.36	44.6 ± 0.53	49.1 ± 10.37	47.7 ± 0.6	53.3 ± 0,37	52.6 ± 0.61	77.8 ± 0.37	76.3 ± 0.63	0.42	<0.01	0.68
TP	75.5 ± 0.10	75.7 ± 0.15	77.4 ± 0.10	77.9 ± 0.15	79.3 ± 0.11	78.8 ± 0.15	82.2 ± 0.11	81.1 ± 0.18	84.1 ± 0.11	84 ± 0.18	95 ± 0.11	93.8 ± 0.19	<0.01	<0.01	0.74
WH	75.05 ± 0.18	76.7 ± 0.27	76.2 ± 0.18	77.8 ± 0.27	77.3 ± 0.18	78.7 ± 0.27	79.3 ± 0.19	81 ± 0.31	81.4 ± 0.19	81.1 ± 0.31	87.8± 0.19	88.4 ± 0.32	<0.01	<0.01	0.24
WC	22 ± 0.53	21.2 ± 0.78	22.7 ± 0.53	21.8 ± 0.78	23.3 ± 0.54	22.3 ± 0.78	25.5± 0.55	23.6 ± 0.9	24.5 ± 0.55	24.25 ± 0.9	27.53 ± 0.55	27.18 ± 0.94	0.92	<0.01	0.27

BW= body weight; TP= Thoracic perimeter, WH= withers height and WC= Width of the croup Results are expressed as means±standard error. *P* values≤0.05 are considered significant. We used repeated measure analysis of variance.

DISCUSSION

When calves receive satisfactory amounts of quality colostrum, total protein concentration will be 5.4g/dL or more. In our study, we considered that FPIT calves had TPP concentrations below 5.5g/dL (Buczinski *et al.*, 2018). Thus, we found higher failure of passive immune transfer rates (32.07%) than those previously described by Feitosa *et al.* (2001), who observed FPIT rates between 22% and 25%, when values of 5.5g/dL were used as a cutoff. However, our rates are very close to 34.6%, observed by Lora *et al.* (2018), in commercial dairy farms in Italy. In the first study (Feitosa *et al.*, 2001), the location of the study was not described, but evaluations were performed on 40 male and female Holstein calves, which remained with their mothers for a period up to 24 hours (16 to 24 hours), ingesting colostrum *ad libitum*, with serum evaluations performed at 24 hours of life.

According to Weaver *et al.* (2000) and Zakian *et al.* (2018), the 5.5-g/dL cutoff may be preferable in clinically ill calves. In a healthy adequately hydrated calf a serum total protein of 5.2g/dL or greater is associated with adequate passive transfer. For this reason, some variations in percentage of calves with FPIT may be observed, depending on the cutoff used. Besides differences in methodology used to measure IgG concentration by different studies, the methodology used by us (refractometry) provides an indirect measure that is highly correlated with blood IgG concentration and is more practical for use on-farm (Wilm *et al.* 2018).

One satisfactory ingestion of quality colostrum is essential to protect neonates against pathogens during their first weeks of life (Chase *et al.*, 2008), since it has compounds such as antibodies and several immune cells (Godden, 2008) that are known to increase the mechanisms of defense in the neonate (Cortese, 2009). Our study has shown that when calves receive a satisfactory amount of Igs from colostrum, the occurrence of diseases like diarrhea and respiratory disease are reduced. The importance of feeding colostrum to prevent development of diseases has already been demonstrated in several studies.

In a study carried out by Arsenopoulos *et al.* (2017), the effect of colostrum ingestion on the occurrence of diarrhea caused by *Cryptosporidium* spp. Was determined, and failures in the quantity and quality of colostrum supplied to neonates have been related to an increase in the occurrence of cryptosporidiosis. Bok *et al.* (2018) showed that calves that had received a satisfactory absorption of colostrum from calves vaccinated against bovine coronavirus (BcoV) had less percent of

soroconversion to BcoV when contrasted to calves that had not received a satisfactory passive immune transfer, indicating that calves without FPIT are more protected against viral infection. The same results were observed by Foster *et al.* (2019) who also demonstrated that calves receiving colostrum from cows vaccinated against *Salmonella* sp. had higher serum titers, but in this study, higher titers were not sufficient to protect against disease development. As we saw in our study, Lora *et al.* (2018) have also found that FPIT directly influences the incidence of diarrhea in neonates, and it is a risk factor for mortality in animals.

Considering the 23% incidence of diarrhea in a study with newborn calves on farms in Canada and the United States (Windeyer *et al.*, 2014), the percentage of animals with diarrhea in this study was high (77.9%). However, it is in accordance with the Brazilian reality, where the incidence of diarrhea has ranged from 53.65 to 100% (Langoni *et al.*, 2004). The large variation in morbidity rates for different diseases in Brazil is a reflection on the diversity of milk production systems in the country. Santos and Bittar (2015) have carried out surveys related to production systems in different states of Brazil, such as: São Paulo, Paraná, Minas Gerais, Ceará, Goiás, and Distrito Federal, showing differences in milk production at different farms, in drying processes of the cows, in location of maternity pens, in volume of colostrum supplied (many offered colostrum volumes below the recommended level), among others. All these differences in management are factors that, to a greater or lesser degree, influence the development of diseases, therefore, justifying the great variation of disease incidences in Brazilian herds.

In our study, the only differences between farm structures are linked to calves' houses. However, when we contrasted farms with individual calf pen or stake system, there were no differences on occurrence of diarrhea. We also didn´t observe differences on incidence of diarrhea when all farms were compared (incidence range from 76.9% to 88.9%). This leads us to believe that there are many different factors that are influencing the high occurrence of diarrhea, such as high rates of FPIT, management failures, and climate, and all these factors may interact with each other interfering in disease incidence. The reduced number of calves with passive immunity

transfer evaluation in this study may also have contributed to no statistical differences.

Our study has shown a greater tendency of death due to diarrhea in calves that presented deficits in immunoglobulins transfer. This is in accordance to Chigerwe *et al.* (2009), who have demonstrated that calves that do not receive colostrum are 74 times more likely to die within the first three weeks of life. Moreover, we have observed that calves with FPIT are 1.33 times more likely to develop diarrhea, and 1.62 times more likely to develop respiratory disease. This is because colostral immunoglobulins provide a double line of passive immunological defense for the calf, providing protection against both septicemia and enteric disease. Defense against enteric infection appears to be predominantly a local effect involving IgA as the principle immunoglobulin acting at the paramucosal surface, but this localized protection may involve other immunoglobulins as well. Immunoglobulins IgM and IgG in the neonatal serum are generally regarded primarily as protective against septicemia, especially against Escherichia coli (Rischen, 1981). The severity of diarrhea has also been related to failures in immune transfer (Furman-Fratczak *et al.*, 2011).

A morbidity rate of 7.6% and a mortality rate of around 2.3% for respiratory diseases have been reported by Sivula *et al.* (1996), in calves from birth to 14 weeks of age, in Minnesota State. According to the United States Department of Agriculture, incidence of respiratory diseases in this category has remained around 20% (Heifer…, 2007), with respiratory diseases accounting for about 24% of deaths in suckled calves, and 58.9% of deaths in weaned calves; these values are lower than those found in our study, where the incidence of respiratory disease was 49.6%, with a death rate of 4.6%. Differences in incidence rates between studies can occur due to influence of geographic factors, climate, farm size, type of system, feeding, and genetics (Gulliksen *et al.*, 2009).

All the farms included in the study are under humid subtropical climate, characterized by hot and humid summers, and cool to mild winters, and the medium temperatures in winter and summer are, respectively, 13°C and 24°C. The climate may have interfered with the occurrence of diseases, especially in the properties that kept the calves exposed to the elements (stake system - 2

from 5 farms). Calves in this case are susceptible to thermic stress, and it can lead to hyper- or hypothermia, and in extreme cases death (Roland *et al.,* 2016). At the same time, we could observe that some calves in individual calf pens were under bad air conditions, with high concentration of ammonia or poor ventilation. According to Rolland *et al.* (2016), all these factors may contribute to respiratory disease. Daily follow-up in the farms in this study allowed us to diagnose both bronchitis and pneumonia, and these early diagnoses may also have contributed to a high incidence of respiratory diseases, as well as high FPIT indexes, compared to North American data.

Besides, studies have shown that both diarrhea and respiratory diseases may cause great financial losses to the breeding system due to treatment costs and animal losses, as well as several negative effects on zootechnical performance of future dairy cattle, which includes low growth, decreased reproductive performance, decreased milk production, and decreased longevity (Poulsen and Mcguirk, 2009). We have not found a difference in animal weight gain or a difference in other growth parameters between animals with or without FPIT, and since a veterinarian was always caring for the animals, and always providing care when a disease was diagnosed, the animals were quickly treated in such a way that a difference in zootechnical performance was not evident.

Regarding losses generated by FPIT, an experiment carried out with 3,479 calves showed that FPIT was responsible for more than 40% of animal deaths (Tyler *et al.*, 1999), and economic consequences were estimated to be €52 (best case scenario) to €285 (worst case scenario) (Raboisson *et al.*, 2016). In our study, economic analysis was not performed, however, we noticed that there was a higher incidence of respiratory diseases in calves with FPIT. In addition, calves with FPIT presented a higher incidence of diarrhea and higher diarrhea recurrence, corroborating the literature, which demonstrates that FPIT is directly related to economic losses within the farms.

Thus, the importance of adequate passive immune transfer to dairy calves' health has been demonstrated in this study. Ensuring adequate passive immune transfer to calves is extremely relevant to reduce costs, because it reduces the risk of severe infections and decreases the need of using drugs. Furthermore, data related to the incidence of diseases in calves in Rio Grande do Sul State is extremely important, because it can provide a more concrete idea on the situation of animal health in commercial dairy farms, allowing the development of prevention and control strategies.

From this point of view, we may conclude that diarrhea and respiratory diseases are disorders with a high incidence in bovine neonates from dairy farms in Rio Grande do Sul. FPIT increases the risks of calves in individual management, developing diarrhea in 33% and respiratory disease in 62%, but does not impact animal performance. This study serves as a warning for the high rate of failure in passive immunity transfer and disease in Brazilian commercial dairy farms.

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