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Evaluation of the impact of COVID-19 on dairy cattle farming in Brazil

Avaliação do impacto da COVID-19 na pecuária leiteira no Brasil

Evaluación del impacto del COVID-19 en la ganadería lechera en Brasil

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Abstract
COVID-19 has brought numerous challenges for the dairy industry. This research aimed to analyze the impact of the COVID-19 pandemic on Brazilian dairy cattle farming. The study was conducted from December 2020 to February 2021 via Google Forms® platform. Data obtained were tabulated and evaluated using descriptive and multivariate analysis, Shapiro-Wilk, Kruskall-Wallis, Variance Analysis (ANOVA), and Dunn's post-hoc comparison. The study was approved by the Committee for Ethics in Research with Human. In total, 73 viable responses were obtained, with participations from the Brazilian regions Midwest, Northeast, South, and Southeast. Among the biosecurity measures adopted during the study, 86% of farm employees began to sanitize their hands more often to prevent the transmission of COVID-19. Use of masks during work was required all the time during work by employees in 17 properties (23%), although the use of masks was not required in 40 (55%) farms and 16 properties required them during part of the work (22%). Regarding milk production, 99% of the respondents had no problems with milk collection and more than half of the producers had difficulties in acquiring animals. Moreover, thirty-seven percent of the interviewees said they were unaware of how the virus was transmitted. Regarding the size of the dairy farms, small farms were more likely to have no veterinary medical care. The pandemic brought positive and negative impacts to dairy properties, which was influenced by the number of animals, the presence of veterinary care, and average daily milk production.
Keywords: Biosecurity; COVID-19; Dairy farming; Questionnaire.

Resumo

A COVID-19 trouxe inúmeros desafios para as fazendas leiteiras. Esta pesquisa teve como objetivo analisar o impacto da pandemia de COVID-19 na pecuária leiteira brasileira. O estudo foi realizado de dezembro de 2020 a fevereiro de 2021 via plataforma Google Forms®. Os dados foram tabulados e avaliados por meio de análises descritivas e multivariada, Shapiro-Wilk, Kruskall-Wallis, Análise de Variância (ANOVA) e comparação post-hoc de Dunn. O estudo foi aprovado pelo Comitê de Ética em Pesquisa com Seres Humanos. No total, foram obtidas 73 respostas viáveis, com participações das regiões Centro-Oeste, Nordeste, Sul e Sudeste do Brasil. Dentre as medidas de biossegurança adotadas, 86% dos empregados das fazendas passaram a higienizar as mãos com mais frequência para evitar a transmissão da COVID-19. O uso de máscaras durante o todo o trabalho foi exigido em 17 propriedades (23%), apesar do uso da máscara não ter sido exigida em 40 (55%) fazendas e 16 propriedades exigirem durante parte do trabalho (22%). Em relação à produção de leite, 99% dos entrevistados não tiveram problemas com a coleta do leite e mais da metade dos produtores tiveram dificuldades em adquirir animais. Além disso, trinta e sete porcento dos entrevistados afirmaram desconhecer as formas de transmissão do vírus. Com relação ao tamanho das propriedades, as pequenas fazendas foram mais propensas a não ter assistência médica veterinária. A pandemia trouxe impactos positivos e negativos para as propriedades leiteiras, dependendo de fatores como número de animais, atendimento médico veterinário e produção média diária de leite.

Palavras-chave: Biossegurança; COVID-19; Pecuária de leite; Questionário.

Resumen

COVID-19 ha traído numerosos desafíos para la industria láctea. Esta investigación tuvo como objetivo analizar el impacto de la pandemia de COVID-19 en la ganadería lechera brasileña. El estudio se realizó de diciembre de 2020 a febrero de 2021 a través de la plataforma Google Forms®. Los datos obtenidos se tabularon y evaluaron mediante análisis descriptivo y multivariado, Shapiro-Wilk, Kruskall-Wallis, análisis de varianza (ANOVA) y comparación post-hoc de Dunn. El estudio fue aprobado por el Comité de Ética en Investigación con Humanos. En total, se obtuvieron 73 respuestas viables, con participación de las regiones del Medio Oeste, Nordeste, Sur y Sudeste de Brasil. Entre las medidas de bioseguridad adoptadas durante el estudio, el 86% de los empleados de las fincas comenzaron a higienizarse las manos con más frecuencia para evitar la transmisión de la COVID-19. El uso de mascarillas durante el trabajo fue requerido todo el tiempo durante el trabajo por parte de los empleados en 17 propiedades (23%), aunque el uso de mascarillas no fue requerido en 40 (55%) fincas y 16 propiedades las requerían durante parte del trabajo (22%)). En cuanto a la producción de leche, el 99% de los encuestados no tuvo problemas con el acopio de leche y más de la mitad de los productores tuvieron dificultades para adquirir animales. Además, el treinta y siete por ciento de los entrevistados dijo que desconocía cómo se transmitía el virus. Con respecto al tamaño de las granjas lecheras, las granjas pequeñas tenían más probabilidades de no tener atención médica veterinaria. La pandemia trajo impactos positivos y negativos en las propiedades lácteas, en las que influyó el número de animales, la presencia de atención veterinaria y la producción diaria promedio de leche.

Palabras clave: Bioseguridad; COVID-19; Ganadería lechera; Cuestionario.

1. Introduction

Brazil stands out for being the world's third largest milk producer and for the country's favorable climate, market, and geography for milk production. Minas Gerais is the largest dairy-producing state in the country and have many world-renowned dairy properties (Embrapa, 2019), which demontrate Brazil's importance in the global scenario of milk, and Minas Gerais' role in this productive sector (Brazilian Institute of Geography and Statistics [IBGE], 2017).

In 2019, severe acute respiratory syndrome caused by coronavirus 2 (SARS-CoV-2) became a pandemic affection and caused COVID-19 disease (Dhama et al., 2020). COVID-19 started in December 2019 in Wuhan, China, and reached a global scale in one month, followed by several governments initiating measures to contain its spread (Karwasra et al., 2021). Restrictive and sanitary measures were necessary due to the worldwide advance of COVID-19 cases, which affected many economic activities, leading to their recession and decline in production, such as agribusiness and milk production. (Soendergaard et al., 2020).

COVID-19 has brought with it many challenges for the dairy industries, such as reduction in productive efficiency due to social distancing measures; adoption of safety measures, such as travel restriction, resulting in staff shortages and reduced supply of raw materials; blocking of supply routes creating delays in the delivery of supplies and harming the sector's

performance. In addition, reduced access to markets caused by the lockdown impacted the pattern of demand, creating instabilities (Karwasra et al., 2021).

After the World Health Organization (WHO) decree of the pandemic, demand for foods of high nutritional value, such as milk and its derivatives, grew fast, impacting the consumerist behavior of Brazilians (Almeida & Almeida, 2021). Data showed that the demand for dairy products in 2020 was higher than in 2019 (IBGE, 2020). COVID-19 pandemic affected countries differently (Qingbin et al. 2020; Rahman & Chandra Das, 2021; Alam et al., 2022; Valldecabres et al., 2022), and in Brazil, it was not evaluated the impact of COVID-19 on dairy cattle farming. In this context, this study aimed to analyze the impact of the COVID-19 pandemic on Brazilian dairy cattle using a questionnaire survey applied directly to producers in the dairy sector.

2. Materials and Methods

2.1 Data Collection

In this cross-sectional observational survey data on self-reported impact of the COVID-19 pandemic on country's dairy properties were collected using an electronic questionnaire survey, which contained 48 questions. The questionnaire was applied from December 2020 to February 2021 via the Google Forms® platform, distributed online by sharing in social networks and private groups and field professionals, directed mainly to dairy farms, owners, or those responsible for the farm's dairy operation. All persons gave their informed consent prior to their inclusion in this study (protocol numbers 33629320.1.0000.8158/57307822.1.0000.8158). Participation in the study was voluntary.

The questionnaire consisted of two sections: the first 16 questions focused on the identification of the property and 32 multiple choice questions collected information on the actions adopted in the properties due to the pandemic and the impacts for the dairy property.

2.2 Classification of Properties

The dairy farms were classified regarding milk production, according to Santos e Bittar (2015), as small (1), medium (2), and large (3), in which farms with a daily milk production of <200 L/day were classified as small; from 201 to 700 L/day as medium; and higher than 700 L/day as large. The size of the farms was also classified regarding the number of dairy cows, according to Leite et al. (2015) in four stratifications: < 30 animals; 30 to 70 animals; 70 to 200 animals; > 200 animals. A third classification was used, according to Gargiulo et al. (2018). The properties were classified as small when they had <150 cows; medium when they had 151 to 300 cows; large when they had 301 to 500 cows; extremely large when they had 501 to 700 cows; and XX-large when they had more than 701 cows. These classifications were used to understand the relation between the variables studied and the size of dairy properties.

2.3 Statistical Analyses

The analyses were performed in Stata/14 (2015). The data were exported to the program containing 81 respondents, but 73 were considered viable (90%), as tit contained all the answers of the questionnaire and city of the dairy property. The Shapiro-Wilk test was used to verify normality. The analyses of the continuous variables (number of calves, heifers, cows, bulls, and daily milk production per property) according to the type of influence by COVID-19 (not influenced, positively, and negatively influenced) were performed by the Kruskal-Wallis test and Analysis of Variance (ANOVA) for the parametric variable "Daily milk production," followed by Dunn's post-hoc comparison procedure (Fávero & Belfiore, 2017). The comparisons between categorical variables regarding the type of influence by COVID-19 and the category of herd size were performed using Fisher's exact test and standardized residuals (cutoff point -1.96 and 1.96) (Dohoo et al., 2012). In all cases,

p≤0.05 values were considered statistically significant. The type of influence (not influenced, positively, and negatively influenced) was obtained from the question: "What kind of influence has the pandemic scenario caused in the livestock sector?".

3. Results

3.1 Number of respondents and location of Dairy Farms

The study obtained 73 questionnaire responses, with participations from the following Brazilian regions: Midwest (5), Northeast (6), South (4), Southeast (58). Among the 58 participating properties in the Southeast, 53 (92%) were in the state of Minas Gerais, 2 (3%) in São Paulo, 2 (3%) in Rio de Janeiro, and 1 (2%) in Espírito Santo.

Regarding the producers' experience in dairy activity, 58 (79%) stated they had more than 10 years of experience in the activity.

3.2 Herd Characteristics and Impact of COVID-19

The number of calves, heifers, and cows was lower among properties that had not been influenced by COVID-19 compared to those reported to have been positively influenced by COVID-19. Table 1 presents data of farm size according to the number of calves, heifers, cows, bulls and daily milk production and the type of influence. Stands out from the results presented the negative influence repported in larger farms.

Table 1 - Characteristics of herds regarding the number of animals by categories (calves, heifers, cows, bulls) according to the type of influence by COVID-19 on the property.

Type of influence	Number of farms	Calves [mean (SD)]	Heifers [mean (SD)]	Cows [mean (SD)]	Bulls [mean (SD)]	Daily production in liters [mean (SD)]
Did not influence	53	33.44 (36.4)[a]	32.4 (38.1)[a]	71.8 (69.9)[a]	1.86 (2.9)[a]	817.5 (1518.8)[a*]
Positive	10	81.4 (96.8)[b]	52 (54.16)[b]	123.0 (96.5)[b]	1.6 (1.7)[a]	2376.0 (2062.9)[a]
Negative	10	112.8 (239.7)[b]	127.2 (242.7)[ab]	195.8 (389.6)[ab]	1.8 (3.01)[a]	4120.5 (10863.05)[b]
Total	73	52.5 (102.5)	48.3 (99.7)	96.1 (160.8)	1.8 (2.8)	1483.5 (4283.8)

*Different lowercase letters represent statistically significant differences, considering significance of 5%. Source: Authors.

3.3 Biosecurity practices against the Pandemic

Table 2 apresent data fo respondents' perceptions regarding biosecurity practices adopted during the COVID-19 pandemic. It is noticied mainly that farms in general adopted biosecurity measures, such as sanitary and prophylactic actions carried out by employees and visitors.

Table 2 - Respondents' perceptions regarding biosecurity practices adopted during the COVID-19 pandemic according to the questionnaire applied from December 2020 to February 2021.

Questions	YES		NO	
	N	%	N	%
Do farm employees work on or visit other farms?	24	33	49	67
Were employees required to change their clothes and shoes upon arriving?	8	11	65	89
Did you start washing your hands more often during the pandemic?	63	86	10	14
Do visitors wash their hands upon arriving at the property?	37	51	36	49
Is there a bathroom for workers and technicians visiting the farm?	46	63	27	37
Do you have veterinary medical care?	62	85	11	15

Source: Authors.

Still in context of biosecurity measures, respondents were asked whether the farm's employees work or visit other farms, thus, it was found that 67% of respondents did not have employees with occupations in other farms. On the same theme, it was found that in most farms (86%) their visitors washed their hands more frequently.

Respondents were also questioned about other biosecurity points, such as the control of visitors in animal facilities. Fifty farms (69%) adopt free access of visitor and 11 properties (15%) adopt prior authorization as a control method. Twelve farms (16%) restricted entry into their property.

As a means for preventing the transmission of the virus, the use of masks during work was required by employees in 17 properties (23%). But masks were not required in 40 farms (55%) and 16 properties (22%) required masks during part of the work. Regarding the use of masks by visitors, 23 farms (32%) required their use and 52% did not. However, visitors voluntarily used masks in 38 properties. Finally, the use of masks was not present in 12 properties (16%).

3.4 Economic aspects of the pandemic in dairy properties

Table 3 present the respondents' perceptions regarding economic aspects in the pandemic scenario, and it is noticed that the main economic changes were caused by the increase in the price of gloves and disinfectants.

Table 3 - Respondents' perceptions regarding economic aspects in the pandemic scenario according to the questionnaire applied from December 2020 to February 2021.

Questions	YES		NO	
	N	%	N	%
Did you have to discard milk during the pandemic?	2	3	71	97
Did you have difficulty collecting milk for dairy products?	1	1	72	99
Did you have to purchase animals during the pandemic?	19	26	54	74
Did you have to sell animals during the pandemic?	37	51	36	49
Did you have difficulty purchasing disinfectant and/or alcohol at any time during the pandemic?	21	28	52	72
Did you have difficulty purchasing gloves at any time during the pandemic?	26	36	47	64
Did you notice an increase in the price of gloves and disinfectants during the pandemic?	57	78	16	22
Did you have difficulty purchasing other supplies at any time during the pandemic?	28	38	45	62

Source: Authors.

Since in a dairy farm the main source of income is the sale of milk, table 3 shows that the vast majority of the farms (97%) did not discard milk, or had difficulty in milk collection by dairy products (99%). In addition, more than half of the respondents had no difficulty in purchasing supplies, which highlights that logistics were not so affected during the pandemic and may have contributed for the sector to continue its economic activities.

Respondents were also asked about the impact of the pandemic on dairy activity. Of the 73 respondents, 53 (72%) reported they were not affected, ten respondents (14%) reported a positive impact and 10 respondents (14%) felt impaired. Among the respondents who affirmed the impact of the COVID-19 pandemic on their production (positively or negatively), in general, they reported difficulties in acquiring raw materials, variation in demand and price of milk and its products, and the lack of employees and/or their relay.

Concerning milk demand, it did not change for 40 respondents (55%). On the other hand, milk demand increased in 24 properties (33%) and decreased in 9 (12%).

Regarding purchase of animals during the pandemic, since the current situation could have hindered animal transit as well as their acquisition, 19 of the interviewees (26%) had to purchase animals, 10 (53%) had no difficulty in acquiring new animals, whereas purchase was hampered in nine properties (47%). Among the interviewees, 37 (51%) had to sell animals during the pandemic and most did not report difficulties in sales [31 properties (84%)]. In addition, sale was more difficult for six farms (16%).

In total, 38% of the respondents had difficulty in purchasing supplies, whereas 62% did not. Among the supplies with greater difficulty for acquiring were foods for animal nutrition, products for plant production, medicines, and materials for structural restoration.

3.5 Knowledge about COVID-19 and other impacts

Table 4 shows information on the knowledge about the COVID-19 pandemic, and the impact of health measures on veterinary medical care and on employees affected with the disease. The questions were made considering the important role dairy cattle farming plays in the food industry.

It stands out from the results presented in the table 4 that 85% of farms stated that no employee was absent from work due to COVID-19, 75% had no technical service difficulty and 79% seek information on the prevention of COVID-19.

Table 4 - Respondents' perceptions regarding COVID-19 and its health impacts according to the questionnaire applied from December 2020 to February 2021.

Questions	YES		NO	
	N	%	N	%
Do you consider yourself an important part of the food chain?	70	96	3	4
Did you seek information on the prevention of COVID-19 on your property?	58	79	15	21
Has any recommendation been made to the employees who live outside the farm regarding COVID-19?	30	41	43	59
Do you have access to the internet?	60	82	13	18
Did you seek technical support via the internet during the pandemic?	28	38	45	62
Did you have any technical service difficulty because of COVID-19, directly or indirectly?	18	25	55	75
Did any employees have to miss work due to COVID-19?	11	15	62	85

Source: Authors.

Among the respondents, 27% stated that COVID-19 is not transmitted by food and 36% stated that the virus can be transmitted by food. Finally, the rest did not know if the virus can be transmitted by food [27 (37%)]. Among the properties, 15% (11) stated that at least one employee had to miss work due to COVID-19. Employee absence affected the production of 6 (55%) properties and did not affect it in 5 (45%).

3.6 Study of the influence of COVID-19 on dairy properties

To better understand changes in the dairy sector and to verify the type of influence that COVID-19 had on dairy properties, Table 5 gathers the the studied variables of the questionnaire arranged in categories about the type of creation, type of milking, herd size, demand for milk, biosecurity practices, economic aspects and preventive measures adopted by respondents during the pandemic scenario. The main associations according to the type of influence were detected with respect to the herd size, biosecurity practices, economic aspects, milk demand and purchase of gloves.

Table 5 - Study of the association between herd characteristics and the type of COVID-19 influence observed among respondents in the properties according to the questionnaire applied from December 2020 to February 2021.

Studied variables	Type of Influence						Total		P value
	Did not influenced		Positively influenced		Negatively influenced				
	N	%	N	%	N	%	N	%	
Type of Creation									
Extensive	16	22%	1	1%	2	3%	19	26%	
Intensive	7	10%	4	5%	2	3%	13	18%	0.314
Semi-intensive	29	40%	5	7%	7	9%	41	56%	
Type of milking									
Manual Milking	11	16%	1	1%	1	1%	13	18%	0.700
Mechanical Milking	41	57%	9	12%	10	13%	60	82%	
Herd size according to GARGIULO et al. (2018)									
Small	46	63%	7	9%	10	13%	63	87%	
Medium	5	7%	3	4%	0	0%	8	11%	0.112
Large	1	1%	0	0%	0	0%	1	1%	
Extremely large	0	0%	0	0%	1	1%	1	1%	
Herd size according to LEITE et al. (2015)									
< 30 animals	21	30%	3	4%	3	4%	27	37%	
30 to 70 animals	16	22%	0	0%	1	1%	17	23%	0.039*
70 to 200 animals	13	17%	5	7%	6	8%	24	33%	
> 200 animals	2	3%	2	3%	1	1%	5	7%	
Herd size according to SANTOS and BITTAR (2015)									
Small	15	21%	2	3%	1	1%	18	25%	
Medium	23	32%	1	1%	7	9%	31	42%	0.042*
Large	14	20%	7	9%	3	4%	24	33%	
Biosecurity practices									
Do farm employees work on or visit other farms?	32	44%	7	9%	10	14%	49	67%	0.043*
Do employees change their clothes and shoes upon arriving at work?	3	4%	2	3%	3	4%	8	11%	0.040*
Do visitors wash and disinfect their hands when they arrive at the property?	22	30%	7	10%	8	11%	37	51%	0.043*
Did you start washing your hands more often during the pandemic?	45	61%	10	14%	8	11%	63	86%	0.417
Do you consider yourself an important part of the food chain?	51	70%	10	14%	9	12%	70	96%	0.623
Do you believe that COVID-19 can be transmitted by food?	22	30%	1	1%	3	4%	26	35%	0.130
Does not know if COVID-19 can be transmitted by food	17	23%	4	5%	6	8%	27	36%	
Visitors' access to the property									

Do visitors have free access?	40	54%	5	7%	5	7%	50	68%	
Can visitors enter upon prior permission?	7	9%	2	3%	2	3%	11	15%	0.093
Is entry restricted in the property?	6	8%	3	4%	3	4%	12	17%	
Is there a bathroom for workers and technicians visiting the farm?	30	42%	7	9%	9	12%	46	63%	0.325
Mask use by employees									
Mask use by workers was not required	33	46%	3	4%	4	5%	40	55%	
Mask use was required during part of the work	11	15%	2	3%	3	4%	16	22%	0.145
Mask use was always required during work	9	12%	5	7%	3	4%	17	23%	
Mask use by visitors									
Visitors did not wear masks	12	16%	0	0%	0	0%	12	16%	
Visitors wore masks voluntarily	31	43%	4	5%	3	4%	38	52%	0.003*
Visitors wore masks at the farm's requirement	10	14%	6	8%	7	10%	23	32%	
Economic aspects									
Did you notice an increase in the price of gloves and disinfectants during the pandemic?	41	56%	8	11%	8	11%	57	78%	1.000
Have you had difficulty purchasing other supplies at any time during the pandemic?	17	23%	6	8%	5	7%	28	38%	0.194
Did any employees have to miss work due to COVID-19?	5	7%	2	3%	4	5%	11	15%	0.030*
If they missed work due to COVID-19, did this affect production?	1	9%	2	18%	3	27%	6	54%	0.113
Milk demand									
Milk demand has not changed	34	47%	3	4%	3	4%	40	55%	
Milk demand has increased	15	21%	5	7%	4	5%	24	33%	0.046*
Milk demand has decreased	4	5%	2	3%	3	4%	9	12%	
Did you have difficulty collecting milk for dairy products?	52	71%	10	14%	10	14%	72	99%	1.000
Did you have to discard milk during the pandemic?	1	1%	1	1%	0	0%	2	2%	0.476
Animal trade									
Did you have to purchase animals during the pandemic?	14	19%	3	4%	2	3%	19	26%	1.000
If so, did you find it more difficult to purchase animals during the pandemic?	5	27%	2	10%	2	10%	9	47%	0.276
Did you have to sell animals?	26	36%	4	5%	7	10%	37	51%	0.456
If so, did you find it more difficult to sell animals during the pandemic?	3	8%	0	0%	3	8%	6	16%	0.134
Purchase of disinfectant and alcohol									
Had no difficulty purchasing disinfectant and/or alcohol during the pandemic	39	54%	6	8%	7	9%	52	71%	
Had difficulty purchasing disinfectant and/or alcohol at some point during the pandemic	9	12%	2	3%	1	1%	12	16%	0.665
Purchase of gloves									
Had no difficulty purchasing gloves due to market shortage	37	51%	4	5%	6	8%	47	64%	
Had difficulty purchasing gloves at times during the pandemic due to market shortage	8	11%	0	0%	2	3%	10	14%	0.037*
Access to information									
Has access to the internet	44	60%	9	12%	7	10%	60	82%	0.604

Did you seek technical support via the internet during the pandemic?	19	26%	4	5%	5	7%	28	38%	0.742
Do you have veterinary care?	44	60%	10	14%	8	11%	62	85%	0.564
Did you have any technical service difficulty because of COVID-19, directly or indirectly?	41	56%	8	11%	6	8%	55	75%	0.469
Did you seek information on the prevention of COVID-19 on your property?	39	53%	9	12%	10	14%	58	79%	0.146
Has any recommendation been made to employees who live outside the farm regarding COVID-19?	17	23%	6	8%	7	10%	30	41%	0.138

*Statistically significant associations with Fisher's exact test with 5% significance. Source: Authors.

4. Discussion

This study is the first report to explore the impact of the COVID-19 pandemic on dairy properties in Brazil and its immediate results. In particular, this study addressed the type of influence of sanitary measures and the disease in the dairy cattle sector in Brazil and four Brazilian regions (Midwest, Northeast, South, and Southeast) participated in the questionnaire mainly dairy properties in the state of Minas Gerais, the largest milk producing state in the country, with many word-renowned properties (Embrapa, 2019). Although the response rate was low and there was no follow up after the questionnaire was applied, the results herein presented are important to understand how sanitary problems can impact the dairy sector in Brazil and how Government and Stakeholders can act to reduce the impacts. Besides, it is a reference study for other research worldwide.

Most of the interviewees (79%) reported having more than 10 years of profession in dairy activity, and of these, 21 (28%) had more than 30 years. In the study, no influence of COVID-19 was perceived on fifty-three (73.60%) farms evaluated, contrary to what happened in Bangalore, India, where the sector was affected and the price of milk dropped after the first lockdown, resulting in a decrease in the size of dairy herd, especially in medium and large properties, because milk producers sold their animals as a mitigation strategy (Alam et al., 2022).

Based on the results on respondents' perceptions regarding biosecurity practices adopted during the COVID-19 pandemic, most employees (67%) did not work on or visit other farms, but in 62 (85%), employees had to miss work because of COVID-19, due to isolation measures to contain the virus advance, which is a positive point regarding the possibility of spreading the virus during the period of study. In total, 63 respondents (86%) reported an increase in the frequency of hand washing, and 37 respondents (51%) stated that visitors also washed their hands upon arriving at the property. In addition, 46 farms (63%) had a bathroom for workers and technicians who visited the farm, a good practice for preventing disease spreading and fifty-eight respondents (79%) said they sought information on the prevention of COVID-19. Similarly, in a study conducted in California, one of the most implemented measures to contain the advance of COVID-19 was providing disinfectant and hand washing instructions to employees; besides, most respondents in this study reported having implemented social distancing and restriction of group meetings (Valldecabres et al., 2022). The characteristic here reported are not important only for COVID-19 but highlight the importance of biosecurity in dairy farms for preventing human and animal disease transmission.

According to the results presented, 71 farms (97%) did not need to discard milk during the pandemic and 72 farms (99%) had no difficulty in milk collection. Regarding milk demand, average herds did not observe changes in milk demand, besides having a lower probability of increase, while larger herds had a decrease and/or increase in their demand. On the other hand, in Bangladesh, the lockdown led to the lack of means of transportation of milk and the absence of drivers or

intermediaries, resulting in difficulties in the distribution of the product, which had to be discarded, as it is perishable and had no alternative ways for commercialization (Rahman & Chandra Das, 2021).

In addition, according to Vall et al. (2021) the impact of COVID-19 in Africa was greater for small farms due to the measures to contain the virus, which led to temporary interruptions in the supply of milk caused by the reduction in the transportation of the product from small producers to dairy products. In China, the main reasons for the economic losses in the dairy sector were production and transportation issues, insufficient supplies, and an increase in their price. About 27.34% of farms failed to sell all their milk production and 6.25% of farms had their milk rejected by factories. In addition, about 12.50% of farms had to discard some of their milk during the disease's outbreak (Qingbin et al. 2020).

Seventy respondents (96%) consider themselves an important part of the food chain, and although this sector faced phases of vulnerability in production, which affected the price of the products such as milk, it kept the transportation and logistics of the product to the final consumer (Coluccia et al., 2021). This is important, and explain the results presented, such as the influence of COVID-19, the need for milk discard, and difficulty for purchasing supplies. Besides, for future sanitary measures, it demonstrates the importance to understand the country's economic sectors and how to apply appropriate economic and health measures without impacting sectors so much.

Sixty farms (82%) had access to the internet and only 28 farms (38%) sought technical assistance via the internet during the pandemic. Fifty-five properties (75%) did not have difficulty on technical service due to COVID-19, directly or indirectly. In a study carried out in India, most of the producers responding to the survey consulted veterinarians by telephone for technical assistance, mainly due to disorders such as enteritis and acidosis (Saravanan et al., 2021). In Brazil, it was only in June 2022 that The Federal Council of Veterinary Medicine (CFMV) approved virtual medical-veterinary care, and the pandemic period accelerated this process of technological development that was already underway but now reaches the practice of veterinary medicine with greater Legal certainty, just as it happened with the practice of human medicine.

Results indicated a lower probability of having veterinary care in small herds when compared to larger herds. Farms classified as 1 according to IBGE methodology, showed that small farms (< 30 lactating cows) were less likely to have veterinary medical. Borges et al. (2016) reported that in Brazil there are approximately 4,367,902 family production establishments, thus comprising 84.4% of all establishments in the country. In addition to these family productions, 78% never received a visit from a technician. This study corroborates our study. Due to the knowledge of veterinarian professionals about animal health and disease prevention, in the context of One health, their work is essential, and farms without technical assistance may be negatively impacted.

Futhermore, in Bangladesh, the result of the pandemic was the absence of some essential services, including veterinary assistance, due to social distancing measures and prohibition in the transportation of some supplies (Rahman & Chandra Das, 2021). On the other hand, a study conducted in different Brazilian states found that during the pandemic, most veterinarians adopted biosecurity measures to protect themselves, team members, and patients, increasing the use of masks, face protectors, and TNT coats. Most important, Veterinary medical care was considered an essential activity in Brazil (Barreto et al., 2022). The results herein presented are important to understand how COVID-19 affected the dairy sector in Brazil, and how in future cases of sanitary problems, the Govern can mitigate issues in the sector to prevent economic losses together with preserving human and animal health.

Regarding the use of masks by visitors, they wore masks voluntarily or by the farm's requirement on farms with larger herds, as it is one of the main security measures to contain COVID-19. Also in this context, regarding the difficulty in acquiring masks due to market shortage, farms with smaller dairy herds had less difficulty in purchasing them, whereas larger herds had greater difficulty. For the acquisition of gloves, the same trend was observed due to market shortage, farms with smaller dairy herds had less difficulty in purchasing them, whereas larger herds had greater difficulty.

Saraiva et al. (2020) observed an increase in the consumption of products needed to cope with COVID-19, such as alcohol gel 70%, alcohol 70%, disposable aprons, procedure gloves, surgical masks, N95 masks, goggles, and disposable caps. Thus, the observation of larger farms' greater difficulty in acquiring masks and gloves due to market shortage can be justified due to society's greater demand for these products in coping with the pandemic and possibly by the greater demand in larger properties, either by the number of employees, visitors, or adoption of herd biosecurity practices, which includes the personal protection of employees.

Regarding the measures to contain the advance of COVID-19 and its impacts on production, they were less likely to impact the production of medium and larger herds, since these farms' routine often encompasses prophylactic measures aiming to reduce the risk of contamination, with a better structure in both equipment and work force, whereas small herds have had an impact on production, where employees are generally limited to performing certain routine functions. A study conducted in China and the United States showed that during the pandemic the difficulty in moving milk within supply chains, lack/shortage of workers, increased cost of supplies, and lack of operational capital strongly influenced dairy industries (Qingbin et al., 2020). According to Weersink et al., (2021), in Canada, the dairy and poultry sectors were less affected by the availability of labor and health problems related to COVID-19, on the other hand, the red and processed meat sector was more affected.

COVID-19 pandemic has speeded the implementation of biosecurity in dairy farms, since, although cattle do not transmit this specific virus, there are several viral agents - including the Coronavirus group - that can affect production animals, being essential to establish biosecurity practices (Franco et al., 2021). Studies on the impact of the pandemic show the importance of a global surveillance system and disease monitoring based on the One Health approach to detect new emerging diseases and pandemics, particularly those with important zoonotic infectious agents, and strengthen local, national, and international networks to prevent further pandemic outbreaks (Rahman & Chandra Das, 2021).

The main limitation of this study is the participation rate and the absence of follow up on the participants. Researchers have tried different methods to improve response rates, such as monetary and non-monetary incentives, changes in the survey length, mode of administration and appearance of questionnaire (Booker et al., 2021; Lavidas et al., 2022; Smith et al., 2019). Our study was voluntary and in Brazil is not allowed monetary incentives. Before the application of the questionnaire, we tested it with some dairy farms to adequate the length. Possible reasons for the low response rate in our study may include concerns about privacy and confidentiality (despite assurances in the consent letter), lack of interest, low engagement, high demanding work schedules, age and internet (Booker et al., 2021; Smith et al., 2019). Additionally, one study revealed that the respondents are more likely to participate in survey when the web survey sponsorship has a reputation or is known to the participants (Lavidas et al., 2022). Moreover, cultural characteristics of sector should be considered, and if the target population do not find the research relevant, it could significantly reduce response rate (Booker et al., 2021).

Despite the restraints of our study, it is the first study carried out in Brazil and few have been carried out in the world, which makes it difficult to discuss the results. But our work showed that some measures such as maintaining veterinary care and the distribution of milk by dairy products may have influenced positively the sector, while the size of the herds, especially small herds, can be more negatively affected The results are important to demonstrate how the dairy sector responded to the COVID-19 pandemic, the presence of biosecurity measures and to better understand how Government can help dairy industry when facing sanitary problems.

5. Conclusion

The COVID-19 pandemic affected the dairy sector in Brazil which is more perceived the lower the activity regarding daily milk production and number of animals. COVID-19 containment measures had less impact on larger dairy herds, as they did not suffer as much impact regarding veterinary care (considered an essential service), and milk demand even increased.

Biosecurity in dairy farming is very important and large herds often implemented measures to contain the disease's progress, which persisted during the pandemic situation.

For future studies it is suggested the need to evaluate the real changes that have occurred in the dairy sector that is still present and tend to be permanent due to the COVID-19 pandemic, not only in dary farming, but also the dairy sector, its related activities and stakeholders.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

Author Contributions

All authors contributed to the study conception and design and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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