







**Review Article****Impact of COVID-19 on Dairy Herd Profitability: A Review at the Global Level**

Alireza Rahmani Shahraki<sup>1</sup> , Ahmadreza Mirzaei<sup>1,\*</sup> , Arya Badiei<sup>2</sup> , Joao H Jabur Bittar<sup>1</sup> , Kristina Ruth Mueller<sup>3</sup> , Abasali Naserian<sup>4</sup> , and Seyed Amin Razavi<sup>5</sup> 

<sup>1</sup> Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL, 32610, United States

<sup>2</sup> Department of Clinical Sciences, Faculty of Veterinary Medicine, Karaj Branch, Islamic Azad University, Karaj, Iran

<sup>3</sup> School of Veterinary Science, Massey University, Private Bag, Palmerston North, New Zealand

<sup>4</sup> Department of Animal Science, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran

<sup>5</sup> Department of Clinical Sciences, School of Veterinary Medicine, Shiraz University, Shiraz, Iran

\* **Corresponding author:** Ahmadreza Mirzaei, Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL, 32610, United States. Email: ahmadrez.mirzaei@ufl.edu

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**ABSTRACT**

The occurrence of several pandemics in recent decades has posed a significant threat to human and animal health. The COVID-19 pandemic, which rapidly spread to 187 countries, has caused significant economic disruption in various industries, including the dairy industry. The dairy industry has been affected by supply chain disruptions, consumer behavior changes, and global demand shifts due to the pandemic. The present review aims to evaluate the impact of the COVID-19 pandemic, mainly from the dairy farm level, and propose strategies for mitigating the effects of future global crisis events. The dairy industry, a major source of income for many dairy herds, was significantly impacted by the COVID-19 pandemic. The consumption patterns of milk and dairy products underwent substantial alterations, leading to decreased profitability of dairy farms due to disruptions in the supply chain, increased transportation costs resulting from transportation restrictions, and a shift in consumer purchasing behavior. These factors collectively resulted in reduced revenue from selling milk and dairy products. Heifer replacement considerations also impacted the economic viability of dairy farms. The pandemic caused a shortage of meat (beef, pork, poultry) and a surplus of milk. In addition to the abovementioned factors, the COVID-19 pandemic also impacted other economic indicators, such as gross returns from the sale of culled dairy animals and dairy feed costs. These impacts further amplified the financial challenges faced by the dairy industry and dairy farmers, underscoring the need for robust mitigation strategies and resilient policies to minimize the economic impact of pandemics and other crises. In conclusion, the COVID-19 pandemic has profoundly impacted the dairy industry, affecting supply chains and international commerce. Governments are encouraged to implement measures to mitigate the impact of future pandemics on the dairy sector. The authors of this review propose several recommendations for dairy farmers and veterinarians to increase their resilience in the face of future outbreaks. These recommendations include sourcing feed from reliable local farms, acquiring internet connectivity equipment to facilitate communication during travel restrictions, maintaining a sufficient supply of personal protective equipment, incorporating mechanization in farm operations, stockpiling essential veterinary medications and vaccines, and training technicians to perform veterinary procedures in emergencies when veterinary services are unavailable.

**1. Introduction**

At the time of writing this review, over a year has passed since the last wave of the COVID-19 pandemic, and the global community has emerged from the limitations

imposed by COVID-19 restrictions. To successfully recover from the crisis and achieve a stable and productive state, it is crucial to learn from past experiences. With this in mind,

the authors reviewed the literature on the impact of the COVID-19 pandemic on dairy farms and have made recommendations for developing resilient policies and strategies to mitigate the effects of future pandemics on the dairy industry. The aim is to minimize the damage caused to dairy farms by pandemic diseases in the future. In recent decades, several pandemics have arisen, presenting a threat to both human and animal health. According to studies, some of these diseases, such as Ebola, SARS, and Zika, are zoonotic emerging infectious diseases (EIDs) that can potentially cause the emergence of new zoonotic diseases or the resurgence of previously known diseases due to potential genetic modifications in the future. It has been estimated that the likelihood of a pandemic similar to COVID-19 occurring in any given year is approximately 2%<sup>1-3</sup>.

The COVID-19 pandemic, caused by a highly contagious pathogen, rapidly spread across 187 countries globally and profoundly impacted multiple aspects of society, including public health, agriculture, and the dairy industry<sup>4-13</sup>. The implementation of government restrictions as a measure to prevent the spread of the disease significantly impacted the global economy and food processing and market outputs<sup>14,15</sup>. The dairy industry, in particular, was affected by the changing demand for dairy products, disruptions in the supply chain, and increasing transportation costs. These factors resulted in a decline in the profitability of dairy farms.

One factor driving a reduction in dairy farm profitability was supply chain limitations and transportation restrictions caused by government restrictions, leading to increased transportation costs. Consumers also changed how they purchased dairy products, further compromising the profitability of dairy farms. Some small dairy farms could not sell their milk at even reduced rates, resulting in the need to discard it. These factors have caused a significant challenge for the dairy industry<sup>16-21</sup>.

Another factor that may impact the economic profitability of dairy farms is the replacement of heifers. Due to the meat shortage and milk surplus caused by the pandemic, US dairy farmers slaughtered 2.3% more milking cows in April 2020. This increase in culling is projected to result in a decline of up to 90,000 milking cows in the US in 2020<sup>22</sup>. It can add up to a significant portion of the dairy farm's budget, accounting for approximately 15-20% of the total dairy budget<sup>23</sup>.

Gross returns from the sale of culled dairy animals are another source of dairy herd profitability compromised due to the COVID-19 pandemic. With the closing of numerous restaurants and fast-food chain stores, consumers' regular pattern of protein demand was changed, and the production-consumption cycle was impacted<sup>24-28</sup>.

This review aims to assess the impact of the COVID-19 pandemic on dairy farms from an internal perspective (dairy farm level) and discuss potential suggestions for developing more resilient policies and strategies to minimize the magnitude of the damage in the case of devastating worldwide crises.

## 2. Impact of COVID-19

The key sources of revenue for a dairy farm include milk sales, the primary source of income for dairy farms, and the sale of livestock, including young animals referred to as heifers and dairy cows that are no longer productive. Additionally, dairy farms with milk processing facilities may generate income from selling dairy products such as cheese, yogurt, and butter. Some dairy farms may also engage in crop production and earn income from selling crops such as corn, hay, and silage. Another potential source of income for dairy farms is agri-tourism<sup>17</sup>.

Surveys among stakeholders in the milk value chain in the USA have shown a significant decrease in milk prices, primarily due to the disruption of the school and catering industries. For example, dairy producers saw a nearly 50% decrease in milk prices at the beginning of the COVID-19 pandemic<sup>17</sup>. Farmers who can process milk on their farms have reported an increase in the price they sell their products, which is not the case for those who only produce milk<sup>29</sup>. In response to the decline in demand for milk products, a surplus of milk was observed in some regions. In Canada, certain European countries, and some states in the USA, dairy farmers had to discard their milk or find alternative uses. These alternatives included the supplementary feeding of calves with milk, utilizing it as a fertilizer for irrigation purposes, and even incorporating it into the diet of lactating cows<sup>30</sup>. According to a report by the Department of Animal Husbandry and Dairying (DAHD), India is the leading milk producer globally<sup>31</sup>. However, the COVID-19 pandemic had a minimal effect on milk production in India. The Executive Director of the National Dairy Development Board and Managing Director, Sangram R. Chaudhary, stated that the presence of numerous small-scale milk producers in India was instrumental in reducing the impact of the pandemic on milk production. To adapt to the decreased demand from commercial channels, milk producers in India redirected a portion of their milk supply towards processing traditional products with higher retail sales (such as cheese and kefir), thereby accommodating increased consumption within households<sup>32</sup>.

The COVID-19 pandemic also had a significant impact on meat industries, as well as the animal and meat-producing sectors such as slaughterhouses. The pandemic resulted in a substantial reduction in the activity of slaughterhouses, as seen in a study conducted in Spain. The study showed a decrease in the number of goats and lambs slaughtered in two major slaughterhouses in April 2020, with reductions of 28.5% and 25.9%, respectively. Seasonal comparisons also indicated that the COVID-19 pandemic led to declining slaughterhouse activities during specific seasons. The closure of many restaurants and fast-food chain stores also changed consumers' regular pattern of protein demand<sup>22,33,34</sup>.

### 2.1. Effect of Covid-19 at the dairy farm level

From an internal perspective, the COVID-19 pandemic

profoundly affected dairy farms. The everyday activities related to dairy products have been disrupted due to labor shortages, customer shifting demands, and transportation issues. As a result, feeding, milking, and veterinary care practices have been negatively impacted, causing stress to dairy cattle and reducing their health. Furthermore, the added health and safety measures implemented to curb the spread of the virus have added extra stress to dairy farmers and their staff. In Senegal, COVID-19 impacted the livestock sector by limiting access to food sources, the capacity to feed animals, and the ability to sell livestock<sup>35</sup>. In Ghana, COVID-19 has negatively impacted the availability of feed resources, the import of livestock products, and the capacity to control animal diseases<sup>36</sup>.

The impact of the COVID-19 pandemic on the internal factors of dairy farms varied across countries. From a dairy farm standpoint, multiple factors, including dairy cattle health, may influence operations and compromise production capacity. The supply of raw animal feed materials was disrupted during the lockdowns due to the COVID-19 pandemic, as reported by some studies<sup>25,38,39</sup>. While the demand for animal feed remains relatively stable, the COVID-19 crisis negatively impacts feed components such as soybeans, bakery products, flour, corn, barley, and wheat<sup>40</sup>.

Moreover, the interference in the supply chain exacerbates the already limited feed resources<sup>41</sup>. This shortage of feed ingredients resulted in a compromise of dairy cows' health. Studies reported that the disruptions in the food service supply chain and export markets resulted in a reduction in the live weight of cows and a subsequent decrease in milk production<sup>40,42</sup>. Due to the limitations on the availability of diet ingredients like soybean and corn, and restrictions on animal movements in pastures, some farmers needed more feed resources. This situation made farmers have to keep their animals on a minimal nutritional plan or use alternative feed sources, another source of animal welfare conflict<sup>43</sup>. A study reported that Indonesian farmers aim to reduce feeding costs for their livestock by utilizing locally available feed sources and using rice straws and corn straws as alternative feed for ruminants<sup>44</sup>.

The sudden restrictions on the activities of farmers, workers, and veterinary professionals caused a shortage of daily routine farming work. The situation created challenges in monitoring the health and needs of animals, making it harder to take timely action in case of any problems. Furthermore, the restrictions on transportation during the pandemic prevented dairy cows from being transported to the slaughterhouse for processing, leading to a rise in the stocking density on dairy farms. This increase in stocking density resulted in increased stress levels, reduced body condition scores, and a high occurrence of diseases commonly associated with high stocking density<sup>45,46</sup>.

## 2.2. Effect of veterinary services

Livestock owners are at risk of incurring significant

financial losses due to their animals' death, disease occurrence, and production reductions<sup>47,48</sup>. Veterinary services play a vital role in the health and productivity of dairy farms. Veterinary service shortages have been reported to negatively impact production and reproduction performance, including delays in artificial insemination due to limited access to frozen semen during the COVID-19 pandemic<sup>15,24,38,49,50</sup>. According to reports, timely veterinary care from livestock experts was sometimes limited due to lockdowns and movement restrictions<sup>51</sup>. The closure of borders during the COVID-19 pandemic in Australia has also been shown to impede the breeding of farm animals, resulting in reduced production performance and increased cost of services<sup>52</sup>. In addition, the shortage of frozen semen or AI technicians has affected artificial insemination services, causing farmers to resort to natural mating methods<sup>42</sup>, which may have negative implications on the reproductive health status of dairy cows, such as an increase in the risk of diseases being transmitted to the cow population<sup>53</sup>.

As a result of the COVID-19 pandemic, there has been a significant decrease in the availability of veterinary care and animal health prevention services<sup>51</sup>. A study conducted in Ghana demonstrates the impact of COVID-19 on farmers' access to veterinary services due to restrictions, the shortage of veterinarians, and an increase in the cost of medicines and services<sup>36</sup>. Due to movement restrictions and disruptions in national and international trade routes, producers faced limited access to breeding materials, replacement stocks, feed additives (vitamins, minerals, and probiotics), vaccines, and drugs. This has resulted in some farmers having to cull animals due to the suspension of animal movement to veterinary hospitals or the inability of veterinarians to visit due to restrictions or veterinary professionals being affected by COVID-19<sup>37</sup>. The Centers for Disease Control and Prevention and the Food and Agriculture Organization of the United Nations have reported this limited access to animal health resources<sup>24,50,54</sup>. It has been reported that certain government vaccination programs were restricted during the COVID-19 pandemic, such as Foot and Mouth Disease vaccination<sup>55</sup>. A study reported that the UK's foot and mouth disease (FMD) outbreak in 2001 impacted the routine control measures on cattle tuberculosis (TB) and caused a reduction in herd tests for tuberculosis in 2001 and an increase in the incidence of the new cases of TB in 2002<sup>56</sup>. A lack of veterinary monitoring and disrupted access to vaccines in farms may increase the prevalence of new epidemics, which causes significant livestock losses<sup>50</sup>. The restriction of certain vaccination programs, including Foot and Mouth Disease, during the COVID-19 pandemic, has been documented<sup>55</sup>. The COVID-19 Pandemic has already caused delays in numerous international and national programs to prevent and control animal diseases, potentially putting global animal disease eradication programs at risk<sup>48</sup>. The COVID-19 outbreak is expected to negatively affect the control of diseases already present in Europe, particularly African swine fever (ASF). This is due to the likelihood of increased contact between wildlife and

livestock caused by human confinement, resulting in increased populations of wildlife reservoirs (wild pigs). The outbreak is also predicted to disrupt ongoing testing programs for endemic diseases and decrease disease surveillance efforts<sup>51</sup>.

### 2.3. Effects of labor supply on dairy cow health

The COVID-19 pandemic has significantly impacted several industries, including the labor supply system, a critical component of agriculture and farming<sup>57</sup>. The impact of COVID-19 on dairy farms in high-income countries during the initial months after the outbreak was significant, primarily due to factors such as labor shortages and logistical difficulties<sup>20</sup>. The dairy industry requires constant supervision of cows on a 24/7 basis<sup>58</sup>.

The worker's role is crucial in dairy farming, including feeding and caring for calves, detecting estrus, identifying sick cattle, milking, and calving procedures. A shortage in the labor force can result in a loss of revenue for producers. According to a study, 60-70% of commercial dairy farms experienced a labor shortage in February 2020<sup>57</sup>. The impact of COVID-19 on dairy farms was particularly severe for those with more than 1000 cows, as opposed to smaller dairy farms with fewer than 500 cows and medium-sized farms with 500-1000 cows<sup>59</sup>. The availability of labor was affected by several factors related to the COVID-19 pandemic, such as quarantine measures, transportation restrictions, national and international border closures, and COVID-19 among workers<sup>15</sup>. A report has indicated that most small farms in China were affected by the COVID-19 pandemic<sup>16,59</sup>.

In contrast, a study reported that large and medium-sized dairy producers in California were the most concerned about the impact of the pandemic on their dairy farms, while producers from small dairies expressed the least concern<sup>58</sup>. The difference in the reaction of dairy farms with varying sizes might be associated with the reliance of large dairy farms on external labor sources. The COVID-19 pandemic has been reported to have caused a labor shortage in the Czech Republic, attributed to the quarantine measures imposed on workers. This shortage had a detrimental effect on dairy cows' milking and feeding procedures, as reported by the Czech Beef Breeders' Association<sup>60,61</sup>. This was partly due to producers being wary of reporting COVID-19 outbreaks among their staff, as they feared potential government intervention and further worsening of the labor shortage issue<sup>58</sup>. To mitigate the risk of a labor shortage, producers in the US were reported to have conducted health training sessions for their workers to prevent the spread of COVID-19, according to a survey study<sup>58</sup>.

However, developed countries fully recovered from the initial crisis within a few months and displayed strong resilience to external shocks. Nevertheless, low and middle-income countries experienced more persistent detrimental effects. According to a study, the livestock sector in the United States and Canada resumed its normal production and price stability operations within a brief

period following the COVID-19 pandemic<sup>20</sup>. This reversion to the normal state might be attributed to the augmentation of automation aimed at alleviating concerns regarding labor supply. The lack of labor-related problems was less pronounced in family-run dairy farms as they utilize family labor and are independent of external labor forces<sup>62</sup>. In Australia and New Zealand, the impact of COVID-19 on the livestock and agriculture sectors was limited, and resilience was primarily attributed to the favorable institutional environment in which farms operated<sup>63</sup>. This included adopting new technologies, including widespread access to dependable and high-speed internet and telecommunications, adopting new technologies, including widespread access to reliable and high-speed internet and telecommunications, and the availability of autonomous and remotely controlled vehicles and machinery.

Alternatively, dairy farms in Latin America and Asia experienced a more severe impact from the COVID-19 pandemic<sup>64</sup>. In the Caribbean, farmers reacted to the crisis mainly by reducing farm size due to labor shortages. Previous research has emphasized how the pandemic has strengthened the sense of community and cooperation among farmers and people in overcoming the challenges brought on by COVID-19<sup>65</sup>.

The presence of migrant labor is another factor that affects labor availability in dairy farms. The COVID-19 pandemic has reversed labor migration, causing farms with a high concentration of migrant workers to experience a more pronounced labor shortage<sup>55</sup>. A survey conducted in the US in 2015 found that immigrants made up 51% of the dairy farm wor

kforce<sup>66</sup>. A study revealed that COVID-19 negatively impacted labor in China and contributed to the cost of milk production in dairy farms<sup>59</sup>. The study also identified that national quarantine measures, transportation restrictions, and labor shortages were all issues faced by Chinese dairy farms due to the pandemic.

### 3. Conclusion

Amidst limited transportation during the COVID-19 pandemic, the transmission of zoonotic diseases remained a possibility. Due to the transportation restrictions and shortage of feed and labor for monitoring the health of dairy cows and accessing veterinary services, the health of dairy cattle was put at risk. Furthermore, due to budget constraints, some countries had to divert funding for disease control during the COVID-19 pandemic. To address these challenges, veterinarians have a crucial role in disease prevention and management, including those diseases that impact dairy production and can be transmitted to humans. They can also play an important role in educating farmers and farm staff by conducting extension programs that consider the effects of future pandemics on dairy production and cow health. Governments also have a key role in providing budget support for disease control and prevention programs that may negatively impact dairy production and profitability

after the COVID-19 pandemic. Moreover, governments should undertake methods to offset the impact of COVID-19 on supply chains and international commerce in reaction to its effects on the dairy sector.

The authors of this review propose some recommendations for dairy farm producers and veterinarians to improve resilience in the face of future outbreaks. These suggestions involve making investments in automated operations, such as milking machines, feed dispensers, and manure management systems, which can reduce the need for manual labor. Optimizing Barn and Cow Comfort Design (BCCD) by designing barns and comfort areas that encourage natural behaviors like group feeding and resting can also minimize the manual labor needed for cow movement and management. Efficient breeding techniques, like activity monitoring or genomics, can also decrease manual labor for breeding decisions. On-farm training programs can increase employee productivity, reduce manual labor, and enhance overall dairy farm performance. Best management practices for herd health, such as vaccination and parasite control programs, can also improve herd health and decrease the manual labor required for health-related tasks. Lastly, incorporating technology such as remote monitoring, data collection, analysis, and decision-making tools can reduce reliance on manual labor for decision-making and management tasks.

To mitigate the impact of transportation restrictions during the COVID-19 pandemic, it is recommended that producers provide on-site housing for workers near the husbandry facilities. This would eliminate the need for workers to travel, ensuring a steady and reliable food supply for dairy farms.

Dairy farmers can implement several strategies to address the impact of transportation restrictions on their food supply. These strategies include diversifying their food sources by sourcing food from multiple suppliers, including alternative feed components and local suppliers. By doing so, dairy farms can reduce their dependence on a single food source and limit the effects of transportation restrictions. Developing alternative feed sources, such as using by-products from local food processing industries, can also minimize the negative impact of transportation restrictions on food supplies.

Expanding storage facilities is another strategy that dairy farmers can consider to manage their food supply better and mitigate the effects of transportation restrictions. They can store more food and better prepare for transportation disruptions by having more storage capacity.

Forming strategic alliances with nearby farms or feed providers is also useful. By partnering with others, a dairy farm can guarantee a reliable and steady food supply, regardless of transportation limitations. This can help ensure they have sufficient food for their herd and maintain business operations during challenging times.

The current study's authors recommend that veterinarians estimate semen requirements and reserve storage as part of their recommendations. This helps to

ensure that pandemic-related restrictions or lockdowns do not hinder reproductive management. Additionally, veterinarians are advised to train technicians and farm workers to improve their ability to handle emergency cases when veterinary visits are not feasible. Protocols should be prepared for more common diseases on each farm, and the farm staff should be educated on managing and treating animals under a veterinarian's guidance.

## Declarations

### *Competing interests*

There is no conflict of interest.

### *Authors' contributions*

Abasali Naserian created the idea. Alireza Rahmani Shahraki, Seyed Amin Razavi, and Ahmadreza Mirzaiy contributed to the final draft's writing. Ahmadreza Mirzaiy and Arya Badiei are editing the manuscript. Joao Bittar and Kristina Ruth Mueller revised the manuscript. All authors approved the article's final version before publication in the journal.

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### *Availability of data and materials*

The information collected to write this review was based on the published literature that is presented in the reference section.

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